Performance Enhancement of Information Centric Networking by Deploying Virtualization Concept

Kyi Thar, Saeed Ullah, Rim Haw, Anselme NDIKUMANA, Rossi Kamal, Choong Seon Hong
Department of Computer Engineering ,Kyung Hee University
{kyithar, saeed, rhaw, anselme, rossi, cshong}@khu.ac.kr

Abstract

In this paper, we combine Network Functions Virtualization (NFV) and Content Centric Network (CCN) concepts, in order to forward the request (Interest) efficiently and cache the content (Data) effectively. So, we introduce a model that is consisted of virtualized devices which are capable of working together with physical devices. For the virtual environment, the virtual gateway router is connected with virtual controller that assist the regional routers for content forwarding and retrieving process. For the physical environment, regional routers are deployed at a place that is nearest to the users in order to improve the network performance.

1. Introduction

Network Functions Virtualization (NFV) introduces a new approach to manage the network devices and services. The network devices, such as routers, switches and servers, etc. are virtualized in order to reduce the cost. Another interesting concept is the Information Centric Network (ICN) which has changed the current Internet concept from location based, to information specific. There are several proposals for ICN architecture. Among them, Content Centric Network (CCN) is one of the most popular architecture and it is proposed by Jacobson et al. [2]. The CCN routers are different with traditional routers and that can store the Data (content object) temporarily and give the copied of stored Data to the users when they request. Thus, the traffic inside the network and also the fetching delay will be reduced.

In this paper, we deployed NFV concept into CCN. By using NFV, we can virtualize a central controller and content gateway router. Virtual Central Controller (VCC) updates the Decision Algorithms (DA(s)), such as Cache Decision, Cache Replacement and Forwarding. Also VCC stores the information of the router, such as router R4 is in region A. So Virtual Content Gateway Router (VCGR) can directly forward the request (Interest) and content (Data) to the target region. There is no central controller in the original CCN. So, this design is poor to manage the network. For example, it is not an easy case when a network administrator want to change the DA(s) of the routers. So that, we proposed VCC into CCN network to solve this kind of problem and forwarding problem.

In [3], the authors proposed the way to virtualize the routers to deploy various ICN projects inside one network. Also, they show how to deploy Software Defined Network (SDN) concept into ICN. In [4], authors attached cache storage to the base station, in order to reduce traffic.

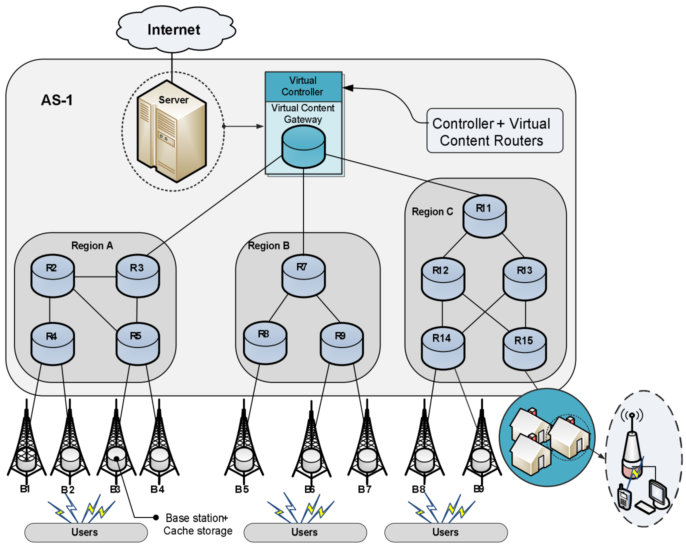

Figure 1 NFV deployment on CCN architecture

2. System Model

The proposed system model is shown is Fig. 1 and it consists of two parts, Virtualized Architecture (*VA*) and Physical Architecture (*PA*). The VA is on the Server and it consists of VCC and VCGR. All *regions* deployed the Physical Content Router (PCR) and some PCR(s) are connected with the Base Station (*BS*) or wireline (optical fiber, ADSL and so on). BS(s) are also attached with cache storage, in order to store the requested content temporally. In this proposal, the PCR(s) inside each region are also formed as a group. The PCR(s) store only the contents that hash value is same as their keys and these PCR(s) are called custodian routers. The process of keys distribution,

Algorithm 1: Search Inside AS First Forwarding (SIASFF)

1: When Virtual Content Gateway Router (*VCGR*) receives a request (*Interest*) and it finds the requested content (*Data*) in its Content Store (*CS*).
2:   **If** Requested content is found in the *CS*, *VCGR* sends back the content immediately.
3:   **else** Forwards the request (*Interest*) to all regions to the requested content and waiting the reply from all regions. Reply may be content (*Data*) or updated request (*Direct Forward Interest*).
4:   **If** The reply is content (*Data*), *VCGR* saves it and also forwards to the initial custodian router.
5:   **else** All the reply are updated requests, *VCGR* forwards the request to another AS.
6: end

constructing the consistent hash ring and duplicate content elimination are explained in our previous proposal [5]. Therefore, each PCR inside the region stores non-duplicate contents and each router knows the custodian of the contents. So, the PCR(s) inside one region can directly forward the Request (Interest) and retrieve the content (Data) efficiently.

3. Request (*Interest*) Forwarding Process

When the BS receives requests from the users, it checks the requested content is inside its cache storage or not. If the requested content is there, reply the content immediately to the user. If there is no requested content inside its cache, BS will forward the request to the regional routers (regional PCRs).

When regional routers receive a request, these can reply the content data instantly if the data is stored in their content store. If there is no requested contents in current region, PCR forwards the request to the VCGR. At first, VCGR find the requested content in its CS. If the requested content is inside its CS, reply content only to custodian router and custodian router redistributes the content to the requester nodes or users. If the requested content is not in the VCGR, it will forward the request to all regions except the requested region. When all the regions do not have the requested data, the VCGR which connected with controller will request the requested content to another AS(s). Algorithm 1 is the forwarding algorithm for VCGR and Algorithm 2 is for regional routers.

4. Cache Decision and Data Forwarding

In this part, we would like to solve two things. First one is to send the requested content only to the initial requested region or targeted region or targeted PCR. The second one is to cache the content effectively.

For the first issue, we add a new field “Initial_Custodian_ID”

Algorithm 2: Regional Router Forwarding (RRF)

1: When regional router receives a request (*Interest)*, router finds out the custodian of the requested content.
2:   **If** The current router is the custodian of the requested content, search the requested content in its Content Store (*CS*).
3:   **If** The requested content is found in its CS, the requested content is returned.
4:   **Else** Update the request (*Interest*) as a Direct Forward Interest and forward directly to the VCGR.
5:   **else** Current router directly forwards the request (Interest) to the custodian router.
6: end

Algorithm 3: Regional Router Caching (RRC)

1: When regional router receives a content (*Data*), router finds out the custodian of the requested content.
2:   **If** The current router is the custodian of the requested content, it save the content and also sends the content directly to the requested nodes or users.
3:   **else** **Current router** directly forwards the content (Data) to the custodian router.
4: end

inside the request (Interest) packet and content (Data). In this model, each PCR has a unique id or unique name. And also, VCGR know the information of the PCR(s). So VCGR can send the content directly to the targeted PCR.

There are three scenarios to send back the requested content to the requested node or requested region. For the first case, if the requested content is found in VCGR and it will send directly back to the custodian router (targeted PCR). Custodian router will redistribute the content to the requested node or user inside its region. For the second scenario, the data is found in another region and the requested content will send back through the VCGR to the targeted PCR. VCGR cache one copy of the content and forwarded the content directly to the targeted PCR. For the third case, the requested content is not inside current AS and VCGR forwarded the request to another AS. When the GWR receives the requested content, it will save one copy on its CS and forwards one copy to the targeted PCR.

The second issue is the caching problem. VCGR and BS(s) (B1 to B9) use Leave Copy Everywhere (LCE) algorithm [2] which is the original cache decision algorithm for CCN. These will store

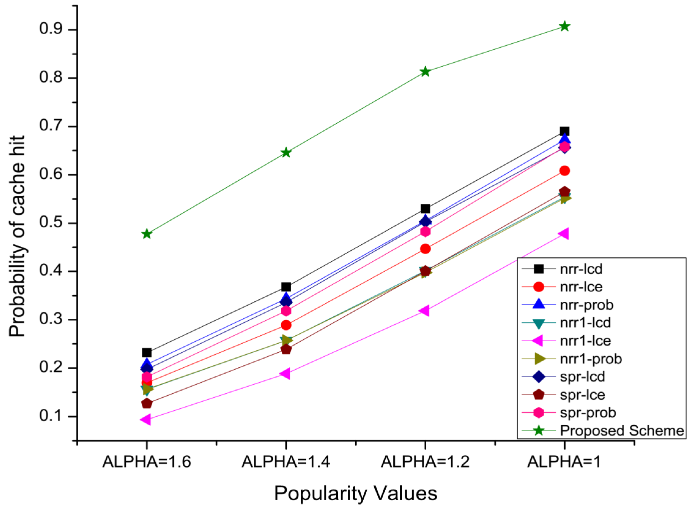

Figure 2 Cache Hit (Success hit) comparison between proposed scheme and others

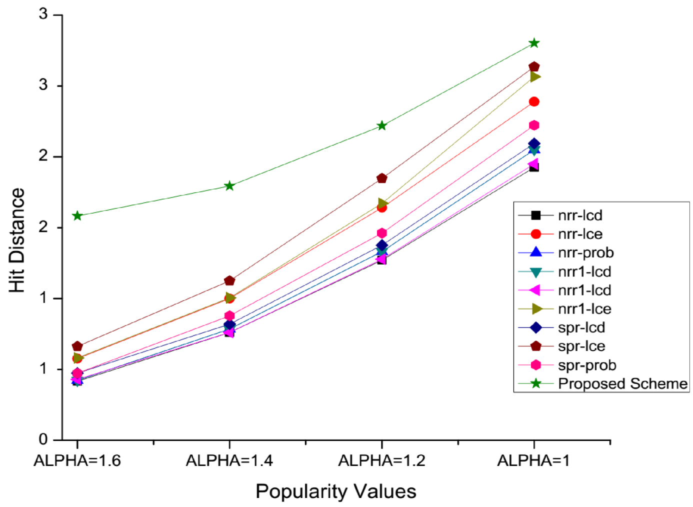

Figure 3 Hit distance comparison between proposed scheme and others

Table 1 Parameters used in the experiments

Parameters	Values
num repos	1
replicas	1
num clients groups	6
lamda	1
file size	20
alpha	1, 1.2, 1.4, 1.6, 1.8
objects	1000
CDS	RRC, LCE, LCD, PROB
RS	LRU
FS	RRF ,SIASFF,NRR , NRR1, SPR
Cache	200, 300, 400, 500, 600

all the contents that are passing through. The cache decision for regional routers are different form the VCGR and BS(s). For regional router, the custodian router just only store the dedicated contents by using Consistent hashing [5]. Regional routers use Algorithm 3 to cache the content (Data).

4. Experiment and Analysis

In this section, the performance of our proposed schemes is evaluated by using chunk-level simulator, ccnsim [1] which was developed under Omnet++ simulator. We used heterogeneous group size and heterogeneous cache size for simulation. Clients request the contents in a random manner governed by the zipf distribution. The performance of the proposed scheme and others are measured by success hit defined in (1) and hit distance. The success hit or cache hit measures the network performance which can keep on how much the routers can cache (store) the popular contents inside the network. Furthermore, the result of cache hit also reflects the server hit. If the cache hit is high, the server hit will below. Server hit is also a measure of the traffic passing through to outside of the CCN network. Hit distance shows the number of hops that the Interest travels. Fig.2 displays the average cache hit comparison of our proposed scheme with other schemes. In here our proposed scheme outperforms that other because our schemes stores only single copy of content in each region. Fig.3 shows the drawback of the proposed scheme. Our scheme cannot reduce the hit distance because just only custodian routers store the related contents by using Consistent Hashing.

3. Conclusions

We have presented a combination of NFV and CCN concepts in this paper. This work enables the router to stores contents without duplicate within one group, find the requested content effectively by using virtual router which connected with controller. BS(s) also cache the contents and provide the contents when the users request. So, our proposal can reduce the delay for sending contents and also reduces the transit traffic to other AS(s). In our future work, we will do a detailed analysis of the proposed mechanism by using CCNx software.

4. Acknowledgement

This work was supported by the ICT R&D program of MSIP/IITP, Republic of Korea. (2014-044-011-003, Open control based on distributed mobile core network) *Dr. CS Hong is the corresponding author.

References

[1] Chiocchetti, Raffaele, Dario Rossi, and Giuseppe Rossini. ”ccnSim: AHighly Scalable CCN Simulator.”, 2013 IEEE International Conferenceon Communications (ICC)..

[2]V. Jacobson, D. K. Smetters, J. D. Thornton, M. F. Plass, N. H. Briggs, andR. L. Braynard, “Networking named content,” in Proc. of ACM CoNEXT, 2009

[3] Ren, Jing, et al. "VICN: a versatile deployment framework for information-centric networks." Network, IEEE 28.3 (2014): 26-34.

[4] Wang, Xiaofei, et al. "Cache in the air: exploiting content caching and delivery techniques for 5g systems." IEEE Communications Magazine 52.2 (2014): 131-139.

[5] Kyi Thar, Saeed Ullah, Choong Seon Hong, "Consistent Hashing Based Cooperative Caching and Forwarding in Content Centric Network," The 16th Asia-Pacific Network Operations and Management Symposium(APNOMS 2014).