Building IP and ICN/NDN Gateway Based On Network Layer Translation

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1 Introduction

The ICN (information-centric networking) or NDN (named data networking) has gathered wide attention as a new network architecture efficiently delivering contents. However, ICN/NDN requires network providers to replace the IP routers to ICN/NDN routers, so a migration strategy to shift from IP to ICN/NDN is required [1][2]. An incremental translation should be technically designed for migration process because replacing all IP routers to ICN/NDN routers simultaneously is unrealistic. This paper proposes a translation mechanism of IP to ICN/NDN based on L3 (layer 3) Translation. After briefly summarizing some possible scenarios of combinations of producer and consumer, we proposed a translation mechanism at the network layer on the scenario in which an NDN consumer pulls the data packets from an IP producer. Using an experimental testbed system, we show the numerical results of the proposed translation method.

2 Named Data Networking (NDN)

The NDN is a promising candidate to implement the Information Centric Internet architecture. An NDN router consists of three part of components namely Content Store (CS), Pending Interest Table (PIT), and Forwarding Information Base (FIB). The communication primitives are distinguished into two type of packets. A consumer emits an Interest packet consisting the prefix name, and a producer replies data packets to a consumer through NDN routers. Whenever an Interest packet arrives at NDN routers, the prefix name is searched for prefix matching in the CS. If the prefix is found, data cached in the CS is sent to the incoming port, otherwise, it goes to the PIT and the prefix name and interface are added into the queue line. In the FIB, the prefix name is searched to obtain the outgoing interfaces for forwarding the Interest packet to the producer. In reverse, the data is stored at CS and forwarded to the outgoing interface listed in the PIT with its prefix name. Afterwards, the PIT deletes the prefix name on the queue list as a flag that data has been delivered.

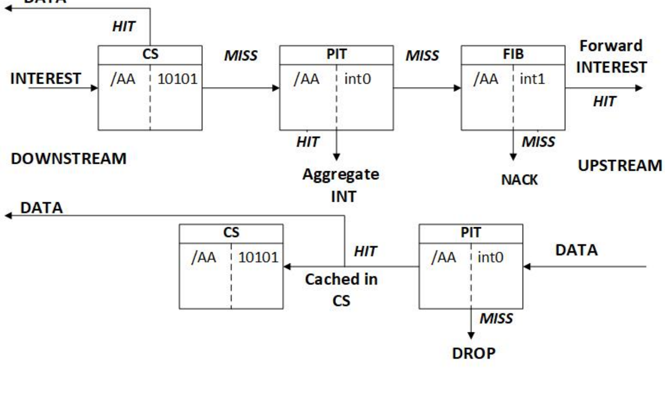

Figure 1: NDN Router Architecture

3 Translation Gateway

In this paper, we propose a translation gateway giving a function of translating packets between IP cloud and NDN cloud. As shown in Fig. 2, the translation gateway is located between the two clouds: the IP cloud and the NDN cloud. Although a translation mechanism can be implemented at network layer, transport, or application layer, we assume the network layer translation in this paper. In the network layer, each packet has the maximum length of 1,514 bytes including the IP header. Packets are translated and stored in the CS of the gateway. In addition to the modules of the NDN router as shown in Fig. 1, an extra table called *REG* is needed at the gateway in order to translate packets from IP to NDN and vice versa.

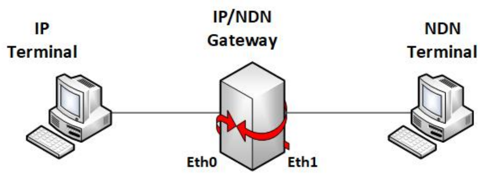

Figure 2: Translation gateway between two clouds

3.1 Scenario

We consider some scenarios of translating packets between IP cloud and NDN cloud depending on the combination of producer type and consumer type. The primitive semantics on IP and NDN cause some limitations in the translation scenarios. For example, although the IP can act as both push and pull mechanisms, the NDN can act only pull mechanism. As a result, there are only three possible scenarios as shown in Table 1. In this paper, we focus on the second scenario in which an NDN consumer pulls data from an IP producer.

Table 1: IP/NDN Translation Scenarios

Scenario	Description	Implementation
IP Producer Push to NDN Consumer	IP producer sends data packets to gateway without waiting request from NDN consumer.	This is only suited for broadcast messages.
NDN Consumer Pull from IP Producer	IP producer sends prefix name to gateway and waits for request from NDN consumer	This scenario is near to NDN packet transmission.
IP Consumer Pull from NDN Producer	IP consumer sends prefix name as Interest packet to gateway, and NDN producer replies by sending data packet	This scenario is near to NDN packet transmission.

3.2 NDN Consumer Pull from IP Producer

IP terminal acts as a producer that waiting an Interest packet from NDN consumers to send data packets. IP producers send prefix names to the gateway in advance. The gateway registers the informed prefix names and broadcast them as special Interests to all the NDN consumers. NDN consumers can now retrieve data from the IP producers by sending Interest packets to the gateway. The followings are the procedures that NDN consumers retrieve data from IP producers, and Fig. 3 shows the procedure executed in scenario.

1. IP producer sends a packet consisting IP header and payload that contain prefix name.
2. Gateway register the prefix name and source IP address to REG database.
3. Gateway broadcasts special Interest packets to NDN terminals.
4. NDN consumer sends Interest packet with the prefix name notified by the special Interest packets.
5. Gateway forwards the Interest packet to IP producer with the IP addresses stored in the REG database and updates the PIT.
6. IP producer sends data packet to the gateway.
7. Gateway forwards the data packet to the NDN consumer and caches the data in the CS with corresponding prefix name.

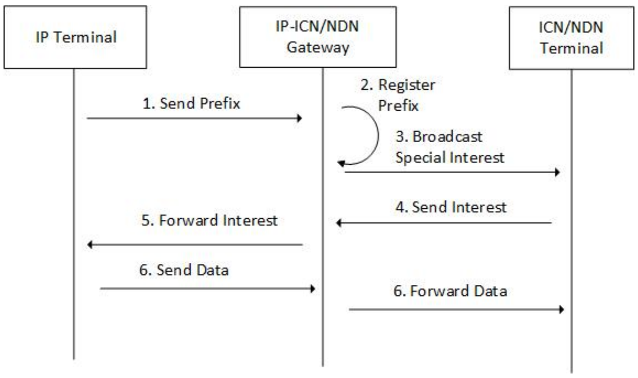

Figure 3: Procedure of data transmission in Scenario 2

4 Numerical Evaluation

An emulator such as virtual machine is used for building the translator gateway between IP and NDN terminal. Table 2 shows all the hardware and software specifications used in the emulator.

Table 2: Hardware and Software Specification

Hardware/Software	Specification
Processor Ryzen 9	64 Cores
RAM	64 GB
Hard Drive	512 GB
Virtual Box	V.6.0
Host OS	Ubuntu 19.10
Guest OS	Ubuntu 19.10
Guest OS Cores	8 cores
Guest OS RAM	8 GB
Programming Software	Python 3.7

In order to measure the throughput of the gateway, a bulk of data packets were transmitted from the IP producer to the NDN consumer. The Interest packets were sent by the NDN consumer to the gateway periodically. X percent of these Interest packets had the identical prefix name, i.e., X represented the concentration ratio of data requested. This percentage X of the Interests with the identical prefix name is called the ratio of popular prefix name. Figure 4 shows the throughput on the downstream direction, i.e., from the NDN consumer to the IP producer, and the upstream direction, i.e., from the IP producer to the NDN consumer, for each value of X. We confirmed that the upstream throughput increased as X increased because the overhead of registering prefix names at the REG database decreased as X increased. We will investigate methods of reducing the overhead caused by registering the prefix names at the gateway in future.

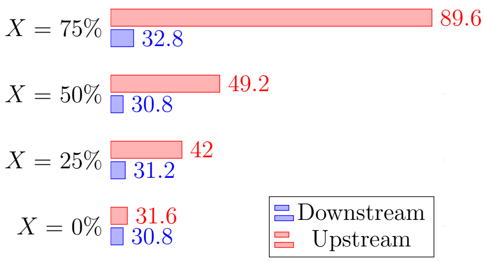

Figure 4: Average Throughput (kbps)

5 Conclusion

In this paper, we proposed a method of translating packets between IP cloud and NDN cloud based on the network-layer translation at the gateway in the scenario when an NDN consumer pulled the data packets from an IP producer. Using the experimental testbed, we evaluated the throughput of the proposed gateway. **Acknowledgement** This work was supported by JSPS KAKENHI Grant Number 18K11283 and MORA 5000 Doktor.

References

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