Dynamic Name Resolution Service for Dual-Channel IP-to-NDN Translation Gateway

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1 Introduction

The dual-channel IP-to-NDN translation gateway requires that the Internet Protocol (IP) address and port number be bound to a specified prefix name [1]. Dynamically or statically, binding processes can be performed. Static binding is only acceptable for small-scale networks, but dynamic bidding is appropriate for large-scale networks. As a result, we investigate the effects of dynamic Name Resolution Service (NRS) [2] in the dual-channel translation gateway. The numerical evaluation are given using an emulator to show the outcome of maximum throughput for different α value.
The dual-channel translation gateway is extended version of conventional NDN router, with the addition of an IP address and prefix name binding table known as the REG table. To forward packets between IP and NDN networks, the REG table collaborates with the Content Store (CS), Pending Interest Table (PIT), and Forwarding Information Based (FIB) [3]. The NRS server can implement dynamic binding at the REG table to provide the prefix name registration. The NRS architecture is similar to that of an IP network's Domain Name System (DNS), but with the added capability of distinguishing queries. When a gateway requests a prefix name for an interest type, the invocation looks up the prefix name in the consumer database. Alternatively, if the gateway requests a prefix name for the producer type so it retrieves the information from the producer table.

2 Dynamic Name Resolution Service

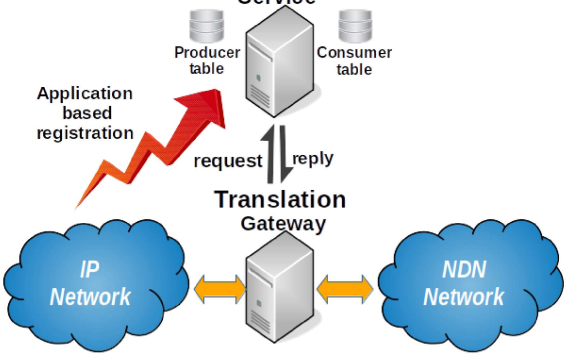


Figure 1: NRS and Gateway topology

Figure 1 shows the architecture of NRS and the link to the dual-channel translation gateway. The IP endpoint registers the prefix name and its IP address to NRS using application layer-based registration before sending the interest packet as a consumer or data packet as a producer. The dual-channel translation gateway partially stores the associated IP address and prefix name to its local table (Producer/Consumer Table) due to its limited memory size. The limited memory cache size results in miss-hit in the local table. Therefore, the gateway invokes a datagram request to NRS and updates the local table. The invocation creates a particular delay since it requires a look-up process in the NRS server and propagation time in the communication link.

3 Delay analysis

Let's τ is the total processing time at the gateway for translation. The throughput is the function of delay so the throughput can be defined as $Throughput = f(\tau)$. Hence, the smaller the τ, the higher is the throughput. We identify that the formula of τ is different for each process and scenario. We denote t_{hit} as a success data content searching time in CS, t_{reg} as a success local prefix name look-up, t_{miss} as a failure data searching time in CS, t_{reg_neg} as a failure local prefix name look-up, t_{enc} as encoding/decoding process time, t_{resp} as a producer response time, and t_{resv} as a prefix name resolving time from NRS server. In the case of a scenario where IP becomes producer and NDN becomes consumer (scenario 1), the value of τ can be described by

$$\tau = \begin{cases} t_{hit}(\equiv \tau_1) & \text{if CS hit} \\ 2t_{reg} + t_{miss} + 2t_{enc} + t_{resp}(\equiv \tau_2) & \text{if CS miss,REG hit.} \\ t_{reg\_neg} + t_{miss} + 2t_{enc} + t_{resp} + t_{resv} + t_{reg}(\equiv \tau_3) & \text{if CS miss,REG miss.} \end{cases}$$

However, in the case of a scenario where IP becomes a consumer and NDN becomes producer (scenario 2), the value of τ can be defined by

$$\tau = \begin{cases} 2t_{reg} + t_{cs} + 2t_{enc}(\equiv \tau_4) & \text{if CS hit,REG hit.} \\ t_{reg\_neg} + t_{resv} + t_{cs} + 2t_{enc} + t_{reg}(\equiv \tau_5) & \text{if CS hit,REG miss.} \\ 2t_{reg} + t_{miss} + 2t_{enc} + t_{resp}(\equiv \tau_6) & \text{if CS miss,REG hit.} \\ t_{reg\_neg} + T_{resv} + 2t_{miss} + 2t_{enc} + t_{resp} + t_{reg}(\equiv \tau_7) & \text{if CS miss,REG miss.} \end{cases}$$

If the probability of cache-hit in CS is β, and the probability of successful requested prefix name in REG table is γ then the average processing time $\overline{\tau}$ with N packets in second can be denoted by

$$\overline{\tau} = (\beta\tau_1 + (1-\beta)\gamma\tau_2 + (1-\beta)(1-\gamma)\tau_3)N \quad (1)$$

for scenario 1. In regard to scenario 2, $\overline{\tau}$ can be characterized by

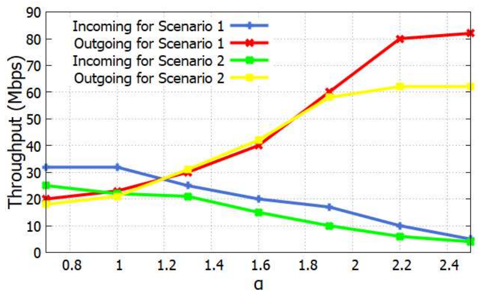
$$\overline{\tau} = (\beta\gamma\tau_4 + \beta(1-\gamma)\tau_5 + (1-\beta)\gamma\tau_6 + (1-\beta)(1-\gamma)\tau_7)N. \quad (2)$$

4 Numerical evaluation

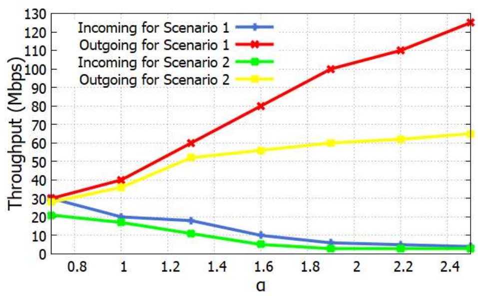
We use the emulation result to shows the maximum throughput performance instead of mathematical simulation. The emulation uses a virtual box with four guest Operating System (OS) and Python 3.7 as the programming language. The emulation topology derives from the network in Figure 1. We set the β and γ obeying the LRU replacement algorithm. Table 1 summarizes the setting values of parameters.

Table 1: Setting values of main parameters

Paramater	Value
Number of content items	1000
Cache-size	10 and 100
REG-size	10,100,1000
Zipf parameter (α)	0.7 - 2.0
Interest rate	6000/second
t_{resv}	10 ms



(a) CS = 10

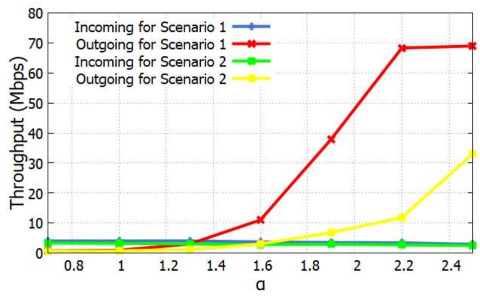


(b) CS = 100

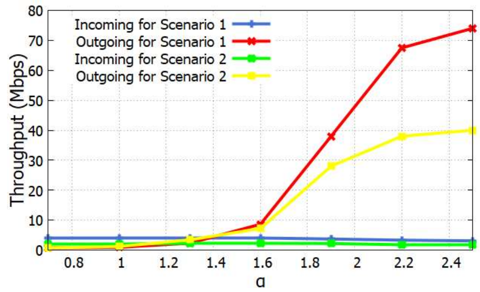
Figure 2: Maximum throughput at different CS size

Figure 2 shows the maximum throughput for the inbound and outbound packet at the translation gateway for scenarios 1 and 2 with different CS sizes. The REG capacity was set to 1000 prefix names. The inbound packet, the total packet received by the gateway, consists of the data packet from the producer and the interest packet from the consumer. The outbound packet, the total packet sent by the gateway, contains data packets from CS, forwarded interests, and data packets from the producer. The outbound throughput increases gradually along with the increase of α when CS size is about 1% and 10% from the total prefix names. On the contrary, the inbound throughput decreases constantly following the increase of α. This is because the increase of α causes the increase of content provided by the CS instead of the producer. As the CS size increases, the upturn of outgoing throughput and the downturn of incoming throughput for both scenarios are accelerated. Furthermore, the outbound throughput in scenario 1 is higher than scenario 2 due to the additional time overhead, as shown by the formula 2. Figure 2 also confirms that the increase of α and CS size affects the increase of β.

Figure 3 shows the characteristics of the maximum throughput in inbound and outbound packets with different REG sizes. We put the CS size to about 100 prefix names for this emulation. As the α increases, the outbound packet for scenario 1 is relatively indifferent when REG size equals 10 and 100. However, the outbound throughput in scenario 2 increases significantly when REG size increases from 10 to 100. This behavior occurs because γ does not affect $\overline{\tau}$ when β is high for scenario 1 as shown by equation 1. On the contrary, γ strongly affects $\overline{\tau}$ when β is high for scenario 2 especially from τ_4 as shown by equation 2. The increase of α and REG size contributes to increase of γ.



(a) REG size= 10



(b) REG size = 100

Figure 3: Maximum throughput at different REG size

5 Conclusion

The dynamic NRS has increased the processing time in the gateway that causes maximum throughput decline. As a trade-off, the consumer or producer has more flexibility to set and change the prefix name associated with the IP address and port number. Based on the emulation, the content skewness, α, significantly contributes to the throughput by increasing the value of β and γ. Besides α, the increase of CS size and REG size can increment the value of β and γ, respectively. We will compare the emulations result with mathematical simulation for future work.

Acknowledgement

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References

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