논문 17-42-11-11 The Journal of Korean Institute of Communications and Information Sciences '17-11 Vol.42 No.11
https://doi.org/10.7840/kics.2017.42.11.2135

NDN Testbed with an Applied Congestion Control Algorithm for Scientific Data

Alexandr Ni◆, Huhnkuk Lim°

ABSTRACT

Initially based on IP architecture, scientific applications are strongly affected by complicated data management, redundant network utilization, and weak security measures. Named Data Networking (NDN) is going to solve the problems of current architecture and improve it in general. And one of the existing approaches in NDN is congestion control. We have set up an NDN testbed with climate science application and applied an NDN congestion control algorithm. As a contribution, we have made a practical comparison between an existing NDN congestion control algorithm and TCP based schemes such as BIC, HTCP, and New Reno. In this experiment, we utilized real climate data with a parallel retrieving method.

Key Words : NDN, congestion control, climate applications, big data

Ⅰ. Introduction

Congestion control in NDN is seen as a one existing issues, and by being a data-centric architecture, it is moving from host to host functionality to hop by hop and can also apply congestion control in this setting. By using hop-by-hop structure, congestion control could happen between each node inside network when IP based approaches are mostly receiver driven. It is also improving congestion detection because of the explicit knowledge of congestion point location that it provides. At the same time, NDN serves only one interest for one data which makes transmission control less complicated and predictable. And native multipath support is opening the better way congestion avoidance. On the other side, there are various IP based congestion control schemes, but all of them are limited by IP architecture[1].

NDN is a future internet architecture which is targeting to overcome the existing issues in IP architecture. By utilizing the hierarchical naming scheme and name based forwarding with the hop-by-hop connection, including in-network caching and inbuilt security, which in overall is a data-centric approach of Named Data Networking. In NDN network packets are divided on Interest and Data, and to get a certain amount of Data packets requester should send the same amount of Interest packets[4].

We already have established an NDN testbed for climate science with NDN based data-intensive science application and have performed various climatic data delivery experiments based on NDN on it[3]. Figure 1 shows a topology between testbeds in KISTI and Colorado State University (CSU) with link speed and RTT between each hop. NDN platform initially didn't contain any schemes to control congestion in NDN based network and was utilizing a congestion control based on IP architecture and only in an overlay network. So

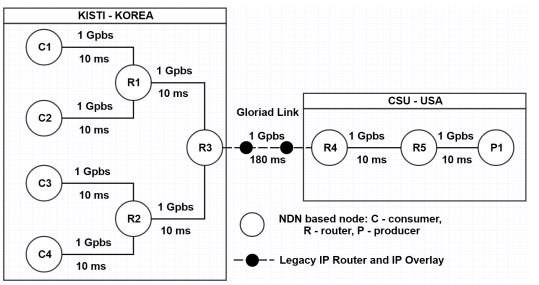

Fig. 1. Network topology

※ This research was supported by the "Computational Science and Engineering R&D based on HPC and Implementation on National R&D Activities", 2017 funded by the Korea Institute of Science and Technology Information (KISTI) (K15-L05-C02-S01).

◆ First Author : University of Science and Technology (UST), alexni1992@gmail.com, 학생회원
° Corresponding Author : Korean Institute of Science and Technology Information (KISTI), hklim@kisti.re.kr, 정회원
논문번호 : KICS2017-09-244, Received September 8, 2017; Revised October 11 2017; Accepted November 6, 2017

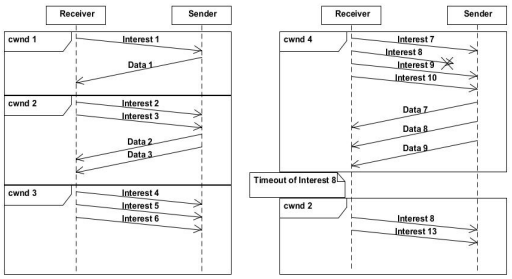

Fig. 2. AIMD in NDN based congestion control

recent practical implementation of NDN based congestion control scheme is believed to improve throughput performance as well as delivery time of climate data sets compare to only TCP based congestion control mechanisms. At this work, we have used the congestion control scheme developed in NDN platform and practically compared it with IP based. It was performed by parallel real data delivery experiment between to remote testbeds and with use of the actual climate data sets.

Ⅱ. Related Work

One of the approaches in NDN congestion control is stateful forwarding algorithm and is told to be well fit into basic NDN forwarding mechanism. At the same time, stateful forwarding congestion control algorithm based on negative acknowledgments (NACK) where upstream inform the downstream node about possible congestion on the path by using the NACK messages. Those acknowledgments are called congestion-NACKs and will be sent after the expired timeout of previously sent interest. After receiving NACK downstream node will reduce the interest sending rate which will also reduce the data flow due to the NDN one interest one data way of serving[2].

Ⅲ. Congestion Control Schemes

In the performed experiment, we have used several most utilized congestion control schemes to compare them with NDN based approach. BIC, CUBIC, HTCP and Reno schemes are widely spread in different operating systems and networking technologies and already showed their effectiveness in a network with TCP based connection[5-7]. At the same time, NDN uses stateful forwarding congestion control scheme, which was created with the use of the additive-increase/multiplicative-decrea se (AIMD) feedback control algorithm. It is used in such TCP based algorithm like HTCP. There are several main types of congestion control schemes in NDN:

- Multipath approach when congestion event occurs is handled it by changing the interest sending path.
- The hop-by-hop approach is targeting to manage the congestion on each hop separately without involving the receiver.
- The hybrid method which is a combination of receiver and hop-by-hop and existing to overcome problems of two previous approaches.

The current implementation of NDN congestion control is affecting the interest sending rate by controlling the window size that will be reduced or increased based on the round trip time monitoring. For the window control NDN utilize the AIMD feedback control algorithm which increases window size until a loss occurs then it will reduce it. Figure 2 represents the window size control in NDN based congestion control where the window (cwnd) will be increased until interest timeout will occur. Then cwnd will be decreased, and lost interest will be retransmitted.

Ⅳ. Experimental Results

For our experiment we have used four consumers that are located domestically and one producer located in CSU. Between them, we placed multiple NDN routers as well as legacy IP routers that are a part of Gloriad link. Each of four consumers was requesting the different climate data file in size of 4 GB. Moreover, all four consumers retrieve their data in parallel with maximum link utilization. We believe that such method is the most suitable way to

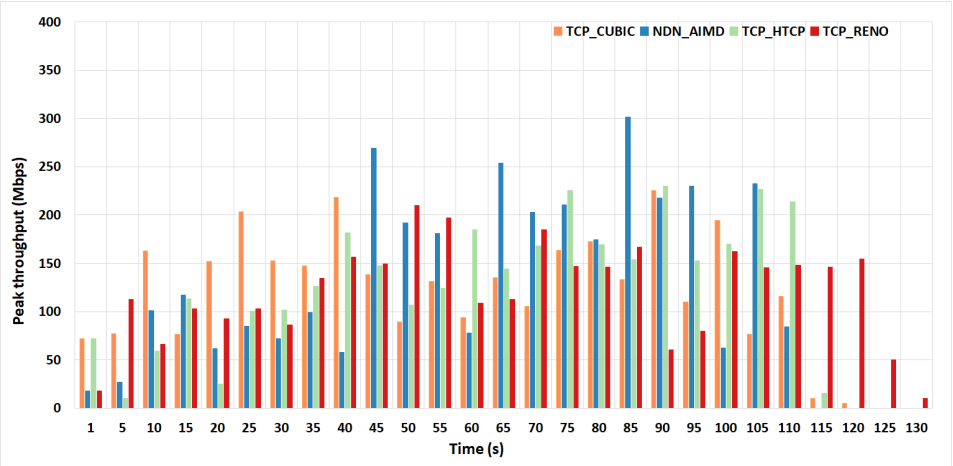

Fig. 3. Network throughput comparison in a parallel delivery experiment (parallel fetching from 4 consumers).

show congestion control performance. At this test, we utilized 1Gbps network connections between all nodes. In the each trial, we have recorded the throughput by each second and total time of each delivery test.

Figure 3 represents the delivery test result, and where we can see that all four schemes have different ending time. Among IP based schemes Reno have a longest delivery time when HTCP and BIC have shorter delivery time due to the optimization in scheme for high speed networks with high latency. NDN based retrieval has the shortest delivery time compare to the IP based ones, due to the hop-by-hop based congestion control between NDN routers. More over NDN_AIMD is applied in NDN network together with basic congestion control in IP overlay, when other three scheme covering only IP overlay of the network between Consumers and Producer nodes.

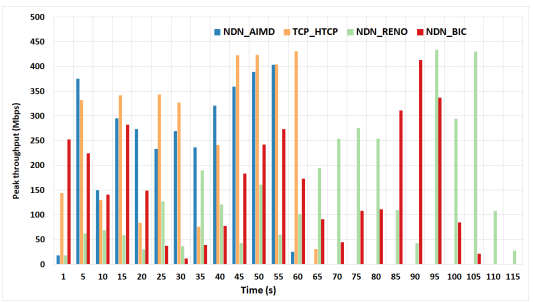

Fig. 4. Network throughput comparison in a parallel delivery experiment (parallel fetching from 2 consumers).

In the Figure 4 result show a throughput performance with only two consumers that request data in parallel. At the same time, datasets that each of them has fetched were different. In both graphs, we show throughput from only one of the requesting nodes.

V. Conclusion

The peformed congestion control scheme comparison was done with use of the only piratical implementation of congestion control scheme in NDN. And the data that was utilized in experiment was based on real scale climate data. Experiment was done between producer in US and consumers in Korea including multiple middle routers. A practical performance comparison between the different congestion control schemes showed that the NDN based congestion control scheme resulted in throughput improvement compared to the IP based analogies, due to the hop-by-hop based congestion control between NDN routers.

References

[1] R. Yongmao, J. Li, S. Shi, L. Li, G. Wang, and B. Zhang, “Congestion control in named data networking – A survey,” *Computer*

Commun., vol. 86, pp. 1-11, Jul. 2016.

[2] Y. Cheng, A. Afanasyev, I. Moiseenko, L. Wang, B. Zhang, and L. Zhang, "A case for stateful forwarding plane," *Computer Commun.*, vol. 36, no. 7, pp. 779-791, Apr. 2013.

[3] A. Ni and H. Lim, "A named data networking testbed with global NDN connection," *J. KICS*, vol. 40, no. 12, pp. 2419-2426, 2015.

[4] A. Afanasyev, et al., "Named data networking," *ACM SIGCOMM Comput. Commun. Rev.*, vol. 44, no. 3, pp. 66-73, 2014.

[5] L. Xu, K. Harfoush, and I. Rhee. "Binary increase congestion control (BIC) for fast long-distance networks," in *INFOCOM 2004*, vol. 4, pp. 2514-2524, Mar. 2004.

[6] D. Leith, R. Shorten, and Y. Lee, "H-TCP: A framework for congestion control in high-speed and long-distance networks," in *PFLDnet Workshop*, Aug. 2005.

[7] S. Ha, I. Rhee, and L. Xu, "CUBIC: a new TCP-friendly high-speed TCP variant," *ACM SIGOPS Operating Syst. Rev.*, vol. 42, no. 5, pp. 64-74, Jul. 2008.