Performance Evaluation of NDN Forwarding Strategies

Anselme NDIKUMANA, Ashis Talukder, Rossi Kamal, Kyi Thar, Saeed Ullah, Rim Haw and Choong Seon Hong*

Department of Computer Engineering, Kyung Hee University
{anselme, ashis, rossi, kyithar, saeed, rhaw, cshong}@khu.ac.kr

Abstract

With the rapid and continuous proliferation of the number of internet users, the common expectation is to get user transactions completed within the possible shortest period of time, in other word, with minimized Flow Completion Time (FCT). The focus of the users in terms of Quality of Service (QoS) is sometimes different from the operators' focus which is on how to minimize the delay, packet loss and maximize the throughput, etc. FCT can be a good metric for congestion control in Named Data Networking (NDN), where, on the other hand, the users pay attention to the contents rather than the destination addresses of the hosts that have the contents. In NDN, there are many forwarding strategies and sometimes it becomes harder to select the best one to use in terms of transaction completion time. In this paper, we have carried out the performance evaluation of the existing NDN forwarding strategies: Flooding, SmartFlooding and BestRoute in term of FCT.

1. Introduction

In the IP network, with the help of IP addresses, the router uses Forwarding Information Base table to route the packet from the sources to the destination. On the other hand, in NDN, the router uses the name to forward the packet, in which each packet requires to have a name that will be used for making forwarding decision. In the NDN, each node has three tables: Forwarding Information Base (FIB), Pending Interest table (PIT) and Content Store (CS). For getting the data content, the user sends an interest, the router forwards it and maintains its state in Pending Interest table (PIT), which is used to bring the data packet back to the user. In NDN, it is possible for a node to have multiples incoming and outgoing faces. In observing the network environment and FIB lookup, the node forwarding strategy takes a decision on which appropriate face to use for forwarding the packets [2].

With the continuous proliferation of Internet usage, the users desire for a network with high QoS to execute their transactions such as downloading files, accessing web content, teleconferencing, networked games, video streaming, etc. within the shortest possible time i.e. to minimize FCT[3]. Most of the end users are not familiar with QoS metrics such as end-to-end delay, delay jitter, link utilization, packet loss, etc. even if their usage contributes in reducing FCT. Previously Nandita and NicKoewn from Stanford University, USA showed that the existing congestion control protocol such as TCP and XCP prolong FCT in IP network [3].

In NDN, there are many forwarding strategies and sometimes it becomes harder to select the best one to use in term of transactions completion time. In this paper, we have carried out the performance evaluation of existing three NDN forwarding strategies namely, Flooding, SmartFlooding and BestRoute in term of FCT. This research would help the users in selecting the forwarding strategy which can return the data chunks faster than other strategies. Secondly, the philosophy of our performance evaluation of NDN forwarding strategies would set up a future direction for researchers to think how user can measure the NDN QoS in term of FCT.

2. NDN Forwarding strategies

In NDN forwarding, the NDN forwarding plane plays an important role supporting name lookup, forwarding strategies and caching policies [2]. In this paper, we have focused on the forwarding strategies. The forwarding strategy in node selects the appropriate face(s) in FIB table to forward the interest packet. Depend on forwarding strategy, one face or many faces may be selected for forwarding the interest packet, and the data chunk comes back in the reverse path of the interest. For our performance evaluation, we used the existing three NDN forwarding strategies: Flooding, SmartFooding and BestRoute [7]. In Flooding strategy, the NDN node, after checking the FIB entries, forwards the interest packet to all available faces except the face from which the interest has come from. In SmartFlooding and BestRoute, the status information of the node faces are ranked with colors, where green indicates that the face is working (always returns data chunks), yellow color indicates that the status of the face is unknown and the red indicates than the face is not working. For the Smartflooding, the NDN node uses at least one green face only for forwarding the interest packet, or all yellow faces if the green face is not available but the node does not use the red faces. On the other hand, in BestRoute, NDN node, after checking the FIB entries, forwards the interest packet to high ranked green face or to a high ranked yellow face if the green face is not available but the node does not use the red faces.

Figure1: NDN node with face ranking

3. Flow Completion Time (FCT)

In NDN, there are two types of the packets, interest for request and chunk for data. One flow may have one or more packets. To get the content, the consumer expresses the interest and the data return back in the reverse path as a response to interest. The time taken for sending and propagating interest and receiving the data back is called Round Trip Time (RTT).
In NDN, node identifies the flow by looking the object name using the fact that the chunks with the same object name belongs to the same flow [6].

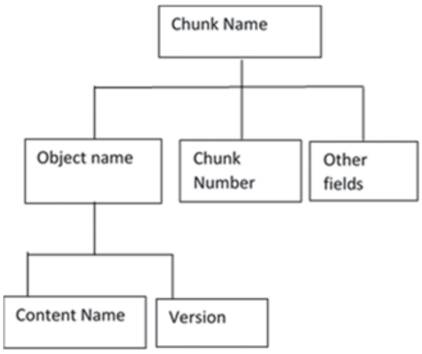

Figure 2: NDN flow

The network traffic is generated differently with different size. The absence of control mechanism may lead to unfair utilization of resources such as computing resources, bandwidth, etc.
In NDN, we define Flow Completion Time as the time duration from the first interest request is send to the reception of the last data chunk as a response to the last submitted interest. This means that initially the Flow completing time is equal to RTT for the reception of the first chunk plus the duration of the remaining packets.

FCT = $\sum_{i=1}^{n} RTT_i + \sum_{i=1}^{k} \mathrm{RT}\, i$

Notation:

FCT	Flow Completion Time
RTT_i	Round Trip time for chunk i
N	Total number of chunks in one flow
RT_i	Retransmission Time of unsatisfied chunk i
k	Total Number of retransmitted chunks in one flow

Table 1: Flow Completion Time (FCT) Notation

From the users' perceptive view, when they are browsing the websites, watching online video stream, downloading or uploading the files through the File Transfer Protocol (FTP), they need transactions to be completed within very short period of time. The FCT may increase for many reasons, such as unfair bandwidth sharing, filled up (or lack of) buffering storage in the presence of bottleneck links, interest retransmission, etc., but the minimization of FCT is out of the scope of this paper. In this paper, we have focused on the performance evaluation of three NDN forwarding strategies.

4. Performance evaluation

For evaluating the performance of the NDN forwarding strategies in terms of FCT, we consider the flows with the same characteristics. The FCT of each flow has been measured through three forwarding strategies: Flooding, SmartFooding and BestRoute where the node(s) share bottleneck link.

4.1 Simulation Scenario

In our simulation, for the first scenario, we used single flow in which one chunk is about 1024 bits. Interest rate is 100 interests/s. The queue size is 30 packets and maximum cache size is 10,000 chunks. The network setup is composed by one consumer, one source of content and one intermediate node. The link capacity between consumer and node1 is 1Mbps, and between node1 and source is 10Mbps.

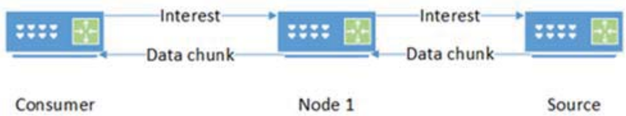

Figure 3: Single flow scenario

In the second scenario, we consider a network with 2 consumers, 2 sources of content and five intermediate nodes. Each link has a bandwidth of 10Mbps, except the link between node1 and node 3 in which is 1Mbps. We have used two flows, where each flow is composed by one chunk of 1024 bits. Interest rate is 100 interests/s. The queue size is 30 packets and maximum cache size is 10000 chunks.

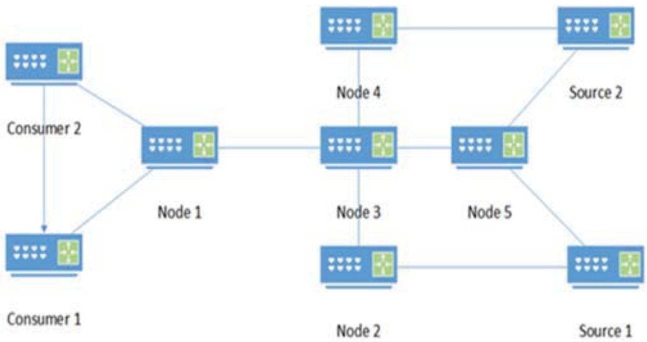

Figure 4: Two flows scenario

4.2 Simulation Results

In our simulation, we have used ndnSIM which is an ns-3 based NDN simulator. The figure 5 shows that during 25s of simulation (Y axis) the FCTs are the same for all forwarding strategies (X axis) but the BestRoute has the practicality of forwarding many chunks than others during that period.

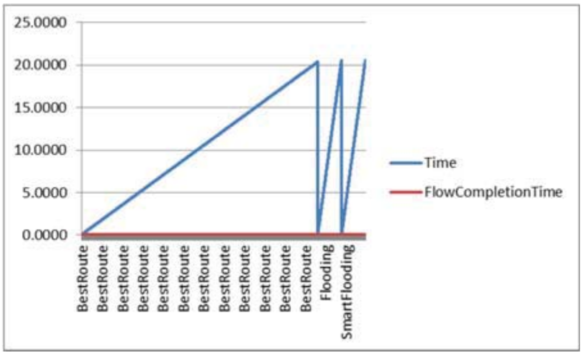

Figure 5: One flow scenario

The figure 6 shows that during 25s of simulation (Y axis), in terms of small FCTs, Flooding Strategy is the best and also has the smallest retransmission rate than that of others, but the BestRoute and SmartFlooding have forwarded many chunks during that period with high FCTs than flooding.

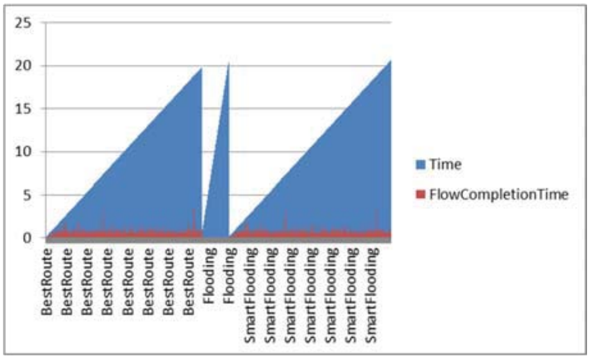

Figure 6: Two flows scenario

The figure 7 shows the FCTs in BestRoute and SmartFlooding keep varying especially for the consumer 2 and this is the consequence of the absence of traffic control mechanisms which may lead to unfair resource sharing in the intermediate nodes. On other hand flooding keeps flow balance with smallest FCTs than other forwarding strategies.

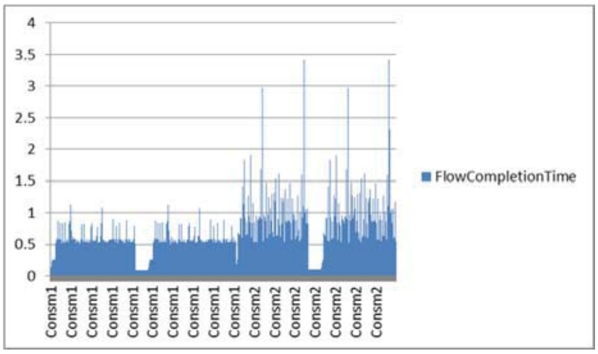

Figure 7: FCT per consumer node

5. Future Scope and Conclusion

In this paper, we have presented a performance evaluation of NDN forwarding strategies in terms of FCT which shows that the Flooding strategy returns data chunks very fast than other forwarding strategies. On the other hand BestRoute and SmartFlooding forwarding strategies have the ability to send and receive many returning chunks with high FCTs but inclusion of traffic control mechanism is evident.

Our idea can extend in consideration of equal share of bottleneck link, where each node will assign a single rate to all outgoing interests and as well as returning chunks passing through it and has been left as a future scope.

6. Acknowledgement

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*Dr. CS Hong is the corresponding author.

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