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E-mail Application on Named Data Networking using Long Lived Interest

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Abstract

Background/Objectives: The current IP based internet architecture may not fulfill the needs of the future. The major problem being that the IP addresses are exhausting at a faster rate. **Methods/Statistical Analysis**: The proposed architecture for E-mail application on Named Data Networking uses SMTP and IMAP protocols to transfer mails over NDN. To enhance the overall performance, concept of long lived interest is used for implementing PUSH protocol for communication between the user agent and the servers. Further to retrieve the lost packets selective reject mechanism is used instead of the go back N mechanism. **Findings:** One major advantage of the NDN architecture is its Content Store. Content Store plays a vital role in minimizing the traffic in the network through the caching system. The major improvement in our E-mail application is the introduction of the concept of long lived interest. We have recorded our results by varying the number of mail segments. Results showed drastic performance improvement with long lived interest as the total number of packets is reduced drastically. We have measured performance by calculating the time required for the segments to reach the receiver mail server with and without the packet drops and by varying the number of mail segments. The results clearly indicate that the performance is better when there is no packet drops as there is no packet retransmission. **Improvements/Applications:** Packets from the mobile node takes longer time than the wired nodes because of the air medium interference, thus we intent to reduce the time taken to transfer packets in the mobile nodes.

Keywords: IMAP, Receiver Mail Server, Receiver User Agent, Sender Mail Server, Sender User Agent

1. Introduction

1.1 Overview of NDN

The number of devices using the internet exceeded the population on earth by 2012. It is clear that the current IP based internet architecture may not fulfill the needs of the future. The major problem being that the IP addresses are exhausting at a faster rate. Named data networking[1,2] is a network layer protocol that replaces IP in the current internet architecture. NDN transforms 'where' (IP address, host...) to 'what' (content). NDN uses interest and data packets instead an interest packet. Unlike IP which has a stateless data plane, NDN has a state full data plane with a forwarding strategy. NDN routers have three data structures: Content Store (CS), Pending Interest Table (PIT) and Forwarding Information Base (FIB).

Figure 1 The content store caches the data packets that have passed through that router. The FIB is used to forward interest/data packets to the best next hop based on the name prefix. The difference between this FIB and that in IP's is that here FIB not only contains the best next hop, but also multiple next hops ranked in the order of their reach ability to the destination.

1.2 Interest and Data Packets in NDN

NDN uses two types of packets: interest and data packets. The interest and data packet formats are shown in Figure 2. Every interest packet has a unique name prefix that identifies the content requested. The publisher details follow

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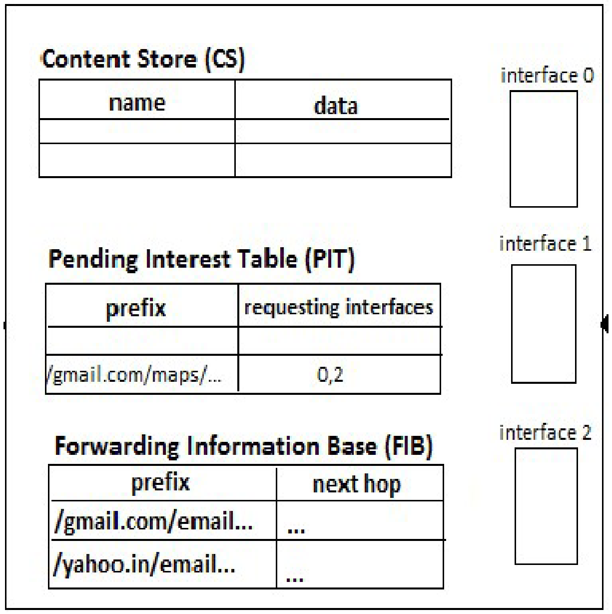

Figure 1. Components of an NDN router.

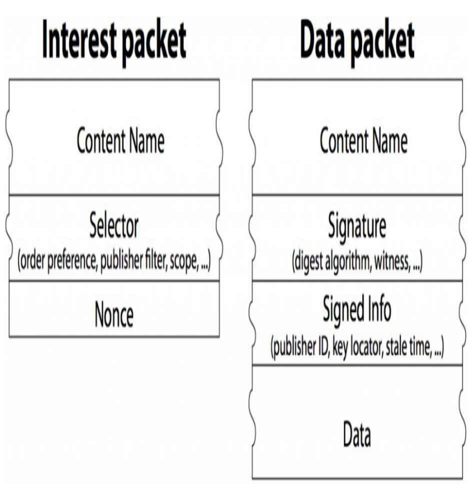

Figure 2. Interest and Data packet formats.

the name prefix, which is then followed by nonce. Every data packet is signed by the publisher, thereby securing the data and not its container. The content requested is also appended to the data packet.

1.3 Packet Forwarding Model in NDN

The primary components of NDN are Content Store (CS), Pending Interest Table (PIT) and Forwarding Information Base (FIB). The DNS lookup is eliminated in the Named Data Networking as all the data are transmitted based on the names give to the data rather than the end points of communication. NDN is based on producer-consumer model of communication. All the communications are through the Interest/Data packets transfer. If a machine in NDN network requires data it sends an interest packet for that data. If the interest is present in the content store of the router, then the data is given by fetching from the content store. If the data is not in the CS, then the interest packed is added to PIT or forwarded using the FIB based on the presence in the PIT entry and the returned data is stored in the CS and then send to the interfaces in the PIT. Various efforts are made towards porting the current applications from the IP based architecture to the NDN based architecture. The feasibility of video conferencing[3] over NDN architecture has been studied. The results showed that the NDN architecture could provide more support and reduce traffic for the videos that are streamed over NDN as the routing is based on the data and not on the end-host. The data is more secure in the NDN architecture than in the IP based architecture as all the routing are directly based on the data. As the NDN architecture supports better caching through content store, the traffic is reduced tremendously. An implementation of server less chat application[4] was done over NDN. This showed that the group chat can be done in the NDN architecture without the help of a centralized server. This is possible because the NDN architecture forwards data based on the name given to the data rather than the receivers of the data. All the participants of a group can be given a group name and the receivers can be made to listen the data that are named with the group name. Other attempts are made to enable vehicle to vehicle transmission[5] in the NDN architecture. One prominent application is the E-mail application on the IP based architecture. The current E-mail application on NDN[6] solves the problem of naming the hosts on the NDN architecture for sending and receiving of mails over the internet based on the NDN architecture. It provides the solution for implementing PUSH and PULL protocols in the NDN architecture. But it has not given solutions to big issues like mobility and reliability. Moreover the proposed E-mail application uses POP3 protocol. So it is mandatory to design and test the E-mail application by using IMAP on NDN architecture. There are various routing algorithms proposed for the NDN architecture like OSPFN[7] and link state based routing[8]. Link state based routing is used for our E-mail application. our work is intended towards enhancing the performance of the E-mail application on NDN by using long lived interest for PUSH protocol and implementing

IMAP for the communication between the receiver mail server and the receiver user agent.

2. System Design

This section gives the architectural design for the E-mail application in NDN. The system shows how normal E-mail names could be converted to E-mail names that can work on the NDN architecture. The system aims at extending IMAP protocol to NDN. The system implements selective reject instead of go back N to retrieve lost packets. The overall working of the E-mail application is shown in Figure 3. Figure 4 describes the interaction between various components of the application.

2.1 Initial Setup

The initial setup requires three steps. First one is the assignment of names to all peripheral components in the network, second one being populating FIB and the final one being converting the normal mail id into NDN compatible id.

2.1.1 Assigning Names to all Peripheral Components of the Network

Assigning names to all the components is mandatory in the NDN architecture as all the communications are done by using the names of the components unlike IP addresses in the IP based architecture. This implies that host names can be used as NDN names and DNS-lookup for IP address

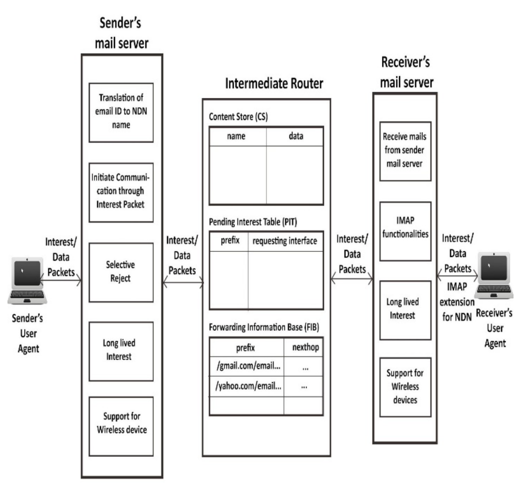

Figure 3. High level block diagram.

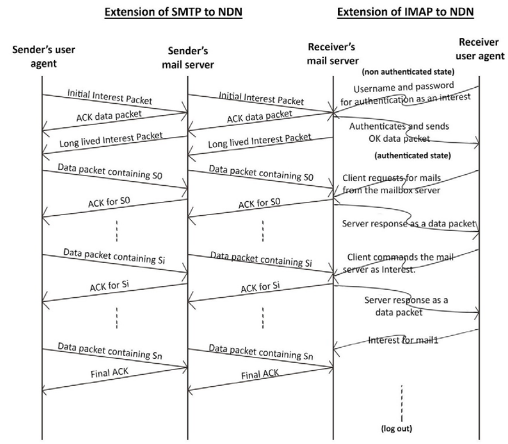

Figure 4. Timeline diagram for E-mail application on NDN.

is avoided. Since that cannot be unique, it can be prefixed with /<network >/<site >/Computer name. The mail servers can retain their domain names as NDN names. For example, a yahoo server in India can have a name /yahoo.in/. The routers can be named similarly to the end hosts, for example: /< network >/<site >/router1.

2.1.2 Populating FIB

The FIB contains information regarding the name prefix and the next hop to which any interest/data packet with that prefix has to be forwarded. This is populated by using routing protocols that have been developed for NDN. OSPF protocol used in IP has been extended for NDN as OSPFN. Routing protocols must record both adjacency and name reachability.

2.1.3 Conversion of E-mail Names to NDN Names

The normal mail-id has to be converted into a format that is supported by the Named Data Networking. The normal mail-id will be in the format recipient@domain.com. The domain name following the '@' becomes the first part of name prefix. It is followed by the name E-mail rcpt which indicates that it is E-mail application. Then it is followed by the sender's name. For example: csefypg13@gmail.com yields g-mail/E-mail rcpt/csefypg13. Following this, sender's information is added to the name prefix to facilitate the receiver's mail server to send a response.

Once the initial setup is done the following three types of communications are needed for the delivery of the mail:

communication between the sender user agent and the sender mail server, communication between the sender mail server and the receiver mail server and communication between the receiver mail server and the receiver user agent

2.2 Communication between Sender User Agent and Sender Mail Server using SMTP

This system uses SMTP for transferring the mail between the sender user agent and the sender mail server. This section gives the methodology involved for the communication between the sender user agent and the sender mail server.

2.2.1 Authentication of the Sender

The Sender has to log in to the mail account to send a mail. The SenderUA prompts the user for the mail id and the password. The user enters the credentials. SenderUA checks for the correctness of the credentials with the SenderMS. When the credentials are correct the user is logged in and Sender is now ready to compose mail. If it is not successful, SenderUA again prompts for the mail id and the password.

2.2.2 Sender's User Agent

The E-mail application should obtain the receiver's mail id and the content that is to be sent to the receiver. The sender's computer creates an interest packet with the name prefix and sends it to the Sender's Mail Server. This indicates the SenderMS that the SenderUA is ready to send the mail and the number of segments fragmented. Now the SenderMS will send the Long lived Interest Packet to receive the mail. When the sender's computer receives the long lived interest from the sender's mail server. The sender's computer now sends the fragmented segments to the sender's mail server.

2.2.3 Sender's Mail Server

The sender's Mail Server receives the Initial Interest Packet from the User Agent and it acknowledges it with the OK packet. The sender's Mail Server now receives the segments sent by the sender's User Agent. Selective reject mechanism is used to retrieve the lost packets.

2.3 Communication between Sender Mail Server and Receiver Mail Server

First the Receiver's Mail Server is identified and if the Receiver's Mail Server is same as the Sender's Mail Server, the mail is delivered directly to the Receiver User Agent. Else the following actions are carried out.

2.3.1 Sender's Mail Server

The sender's Mail Server creates an interest packet with the name prefix and sends it to the Receiver's Mail Server. This indicates the ReceiverMS that the SenderMS is ready to send the mail and the number of segments fragmented. Now the ReceiverMS will send the long lived Interest Packet to receive the mail. The sender's Mail Server now sends the fragmented segments to the Receiver's mail server after receiving the long live interest from the Receiver's mail server.

2.3.2 Receiver's Mail Server

The Receiver's Mail Server receives an Initial Interest Packet from the User Agent and it acknowledges it with the OK packet. Then the Receiver's Mail Server receives the segments sent by the sender's Mail Server. Selective reject Mechanism is used to retrieve the lost packets.

2.4 Communication between Receiver Mail Server and Receiver User Agent using IMAP

The Receiver has to log in to the mail account to retrieve a mail. The ReceiverUA prompts the user for the mail id and the password. The user enters the credentials. Receiver UA checks for the correctness of the credentials with the ReceiverMS. When the credentials are correct the user is logged in and Receiver is now ready to compose mail. If it is not successful, ReceiverUA again prompts for the mail id and the password.

2.4.1 Receiver User Agent

When the receiver enters the authenticated state after successful login the user is ready to fetch the mail for the server. The Receiver User Agent initially sends the interest packet to the Receiver Mail Server indicating its request to fetch the mails in the inbox.

2.4.2 Receiver Mail Server

The Receiver Mail server receives the interest from the Receiver User Agent for the fetch of inbox mails. Now the Receiver Mail server sends the data packet which is requested by the Receiver User Agent.

2.5 Selective Reject

Packet drop could arise in the network due to several factors. It maintains a stack to keep track of the received segments. If a particular segment is not received for a certain period of time it requests only for that segment instead of sending the whole mail again. The interest for the lost packet can be prefixed as follows:*<host-name>/ndnid/mailid/s_REJ/pkt_no.*

This section has given the system design for the application and the following section gives the performance analysis based on the experimental outcomes.

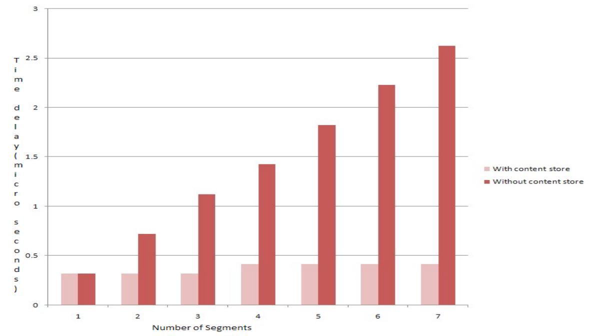

Figure 5. Caching vs. no caching.

3. Performance Analysis

The E-mail application that has been built is tested under various scenarios and the performance has been validated. The results are discussed in the following section. In order to validate our work, we have made the following comparisons and observations.

3.1 Significance of Content Store

One major advantage of the NDN architecture is its Content Store. Content Store plays a vital role in minimizing the traffic in the network through the caching system. Consider a scenario where multiple users from a same group request for the same mail. Without Content Store for each user mail has to be retrieved from the server. Whereas in the case of enabling the caching system the time taken for retrieving the mail could be reduced drastically as the mail is cached in the intermediate routers and can be retrieved directly without much delay. To analyze the performance of the content store as shown in Figure 5, we have measured the time taken for the segments to reach the server by enabling and disabling the caching system. Results showed that mail retrieval is much faster with caching system as compared with the non-caching system.

3.2 Significance of Transmission using Long Lived Interest

The major improvement in our E-mail application is the introduction of the concept of long lived interest. We have analyzed our performance as shown in Figure 6 with and without long lived interests. We have analyzed our performance by measuring the time taken for the mail to reach the server with and without the long lived interest.

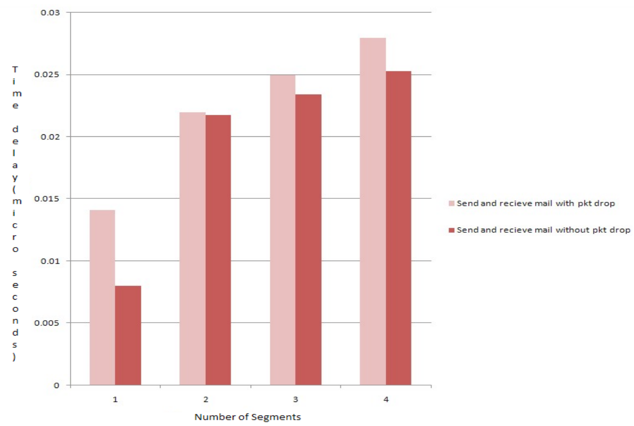

Figure 6. Significance of transmission using long lived interest.

We have recorded our results by varying the number of mail segments. Results showed drastic performance improvement with long lived interest as the total number of packets is reduced drastically. This is mainly due to the fact that the number of packets transmitted are reduced by using the long lived interest at the instance of communication.

3.3 Retrieval of the Lost Packet

We have analyzed the performance of the system with the time taken for the mail to reach the receiver mail server under various situations as shown in Figure 7. We have measured performance by calculating the time required for the segments to reach the receiver mail server with and without the packet drops and by varying the number of mail segments. The results clearly indicate that the performance is better when there is no packet drops as there is no packet retransmission.

3.4 Communication between the Sender and the Receiver Mail Servers

There would be various situations where an user agent of a particular mail server like 'gmail' may want to sent mail to another user agent of the same 'gmail' server or to an user agent of a different mail server like 'yahoo'. With the use of Efficient Proactive Routing Protocol (EPSR) which avoids the link breakage and mobile nodes are chosen based on signal strength instead of choosing idle nodes.[9] Hence performance of the system must be analyzed by measuring the time required to reach the receiver mail server when mail is sent from the same server or from the different server. We have analyzed the performance as shown in Figure 8 by measuring the time delays by sending mails to same and different servers. As the packets have to be forwarded from one mail server to another mail server, the delay is high for different servers.

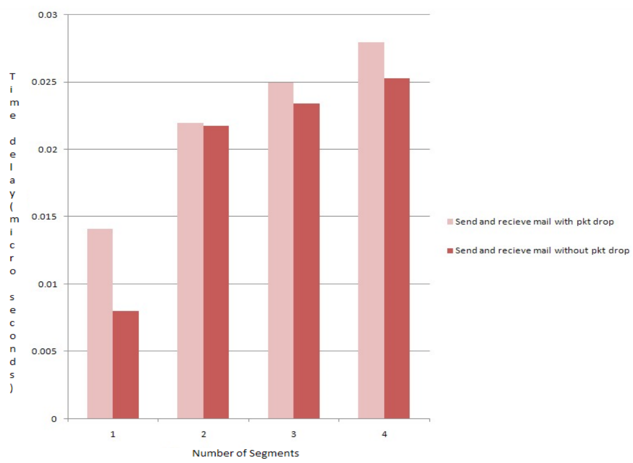

Figure 7. Retrieval of the lost packet.

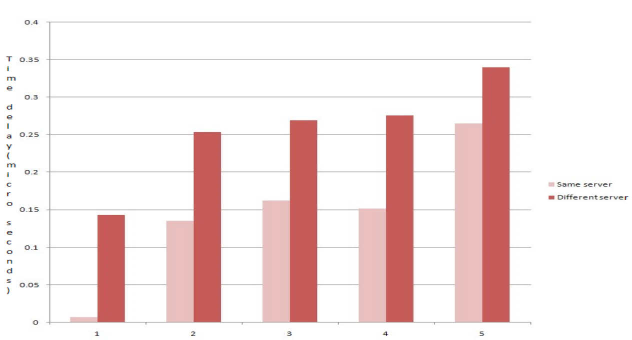

Figure 8. Communication between the sender and the receiver mail servers.

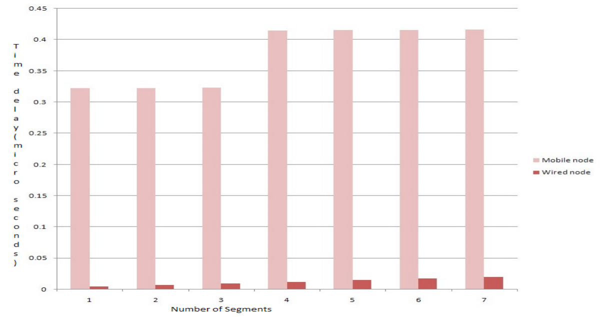

Figure 9. Performance of the wired and the mobile nodes.

3.5 Performance of the Wired and the Mobile Nodes

With the advent of technological advancements, mail can be accessed from multiple devices and those devices can be stationary and mobile. Hence performance of the system must be analyzed by installing the application on all these devices as shown in Figure 9. We have analyzed the performance by installing our application on the mobile and the wired nodes. Packets from the mobile node take longer time than the wired nodes because of the air medium interference.

4. Conclusion

Simulation of the working of email application on NDN has been done. SMTP and IMAP protocols are implemented. To enhance performance, the concept of long lived interest is used for the transmission of mails between the user agent and the servers. We have implemented our system on various types of nodes like wired and mobile nodes to ensure that the system works on all types of devices. Furthermore, we have used the concept of selective reject to re-transmit the lost packets.

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