DTN-SMTP: A Novel Mail Transfer Protocol with Minimized Interactions for Space Internet

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DTN-SMTP : A Novel Mail Transfer Protocol with Minimized Interactions for Space Internet*

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Abstract. The communication paradigms for Delay/Disruption Tolerant Networks (DTN) have been modeled after email. Supporting email over DTN in a backwards compatible manner in a heterogeneous environment has yet to be fully defined. In the Simple Mail Transfer Protocol (SMTP) based on TCP/IP used in the existing terrestrial Internet, the protocol works through multiple interactions between the sender's mail server and the receiver's mail server. However, in the space Internet environment, since the contact times are limited, reliability cannot be guaranteed for the interaction between the server and the client used in the existing SMTP. Therefore, this paper proposes a novel mail transfer protocol, DTN-SMTP for space Internet over DTN. To minimize the interaction of the existing SMTP, it relies on one-way transmission and optionally performs retransmission mechanisms. Finally, we have built and configured two DTN nodes to implement DTN-SMTP. Also, we have confirmed the mail's reception and the file attachment from the external mail client with minimized interactions between the SMTP messages.

Keywords: Delay/Disruption Tolerant Network · Simple Mail Transfer Protocol · One-Way Transmission.

1 Introduction

Space internet environment presents high propagation delays, low data rates and frequent network disconnections may occur. Therefore, in environments such as the space Internet there are limitations of network protocols such as TCP/IP used in the terrestrial Internet [1]. DTN was designed as a protocol that can be applied in a special network environment as in [2]. DTN is a proposed network to guarantee the reliability of end-to-end connection in the extreme environments and frequent disconnection of the network.In DTN, each node on the network has

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a bundle layer that can store messages and uses a bundle protocol to overcome the special environment [3]. The Bundle Protocol transmits data in units of bundles and guarantees reliability between data transmission even when the end-to-end connection is disconnected using Store-and-Forward [4]. In contrast to the DTN environment, SMTP is a protocol used to transmit e-mail in a terrestrial Internet environment and operates based on TCP/IP. Sending and receiving message between the sender's and the receiver's mail servers, the process of transmitting the SMTP header containing the information of the mail the sender wants to send and the SMTP body containing the mail content to the receiver's mail server [5]. It is SMTP that implements the above process as a protocol, and is a core protocol for sending mail in a terrestrial Internet environment where the network infrastructure is well constructed compared to the space Internet environment. In this paper, we propose a DTN-SMTP suitable for the extreme Internet environment, which is an extreme network environment, by securing the reliability of data between interruptions and efficiently reduce interactions using the Bundle Protocol, one of the characteristics of DTN.
The paper is organized as follows: Section 2 presents related work where DTN, Bundle Protocol and Postfix will be explained. Section 3 describes our proposed architecture of DTN-SMTP and the flow chart according to the roles of the sender and receiver. The following Section 4 explains the implementation of the proposed DTN-SMTP and provides the result by comparing the transmission speed of SMTP and DTN-SMTP. Finally, Section 5 concludes this paper.

2 Related Works

2.1 Delay/Disruption Tolerant Network (DTN)

DTN is a network used in lack continuous network connectivity and low data rates for communication between nodes, such as disaster situations or deep space environments where the network infrastructure is not sufficiently equipped. Stable data transmission of end-to-end connection, such as typical network protocol TCP/IP, cannot be guaranteed. DTN is reliability can be guaranteed in situations where high propagation delay, low data rate and frequent network disconnection occur. In addition to the space Internet or interplanetary communication, the DTN technologies can be applied to a variety of challenged networks.

2.2 Bundle Protocol

In the DTN environment, the Bundle Protocol is used to guarantee end-to-end reliability. The Bundle Protocol is implemented in the Bundle Layer between the Application Layer and the Transport Layer, and transmits data in bundle units. DTN cannot guarantee end-to-end connectivity due to frequent network delays and interruptions. However, the Store-and-Forward technique is used in case of network interruption in the Bundle Layer [6]. DTN node uses persistent storage of the Bundle Layer to store data when the link is disconnected and transmit it when the link is restored. As a result, DTN can secure end-to-end data transmission reliability using the Bundle Protocol.

2.3 Simple Mail Transfer Protocol (SMTP)

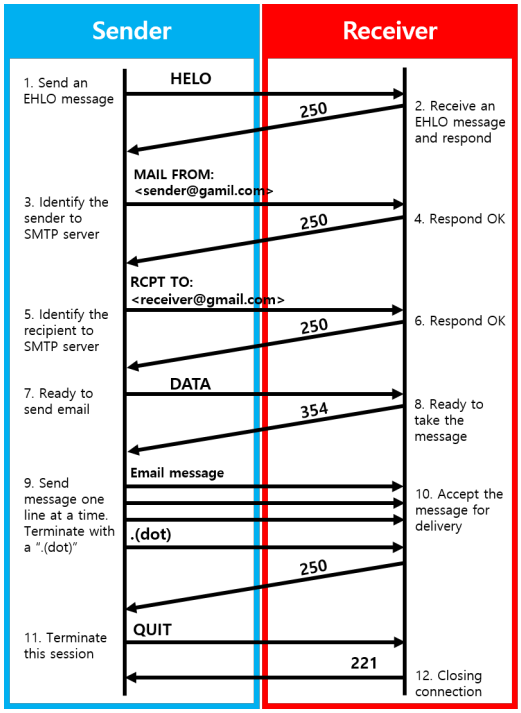

Fig. 1. SMTP Sequence Diagram

SMTP is a TCP/IP based email transmission protocol and uses port 25. As shown in Fig. 1, the commands MAIL, RCPT and DATA are sent. The MAIL and RCPT commands define the email sender and receiver. Send the contents of the mail to the receiver through the DATA command. The receiver responds by sending a request command complete code of 250. When the data of the sender ends, the message is terminated through .(Dot). Sender can send e-mail to Receiver through the procedure as shown in Fig. 1 [7].

2.4 Postfix

SMTP can transmit e-mail data from the sender's mail server to the receiver's mail server by exchanging simple messages in a TCP/IP-based terrestrial Internet environment. To use SMTP, this paper used Postfix Mail Transfer Agent. Postfix is an open source Mail Transfer Agent (MTA) written in C language and is used as an alternative to Qmail and Sendmail [8]. It supports SMTP authentication using Simple Authentication and Security Layer and can easily construct a mail server [9].

3 DTN-SMTP

Existing SMTP is a protocol that operates based on TCP/IP. However, if SMTP is used in a space Internet environment where network delays and interruptions occur frequently, the number of interactions between mail servers increases, resulting in network delays and overloads.

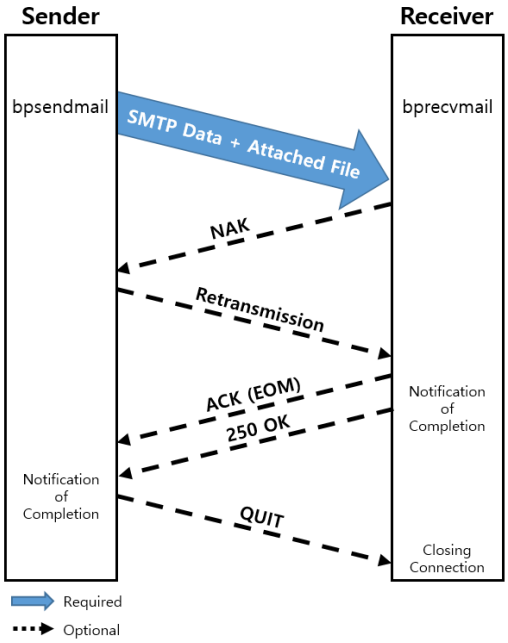

Fig. 2. DTN-SMTP Sequence Diagram

In this paper, we propose DTN-SMTP that can be applied in the space Internet environment as shown in Fig. 2. Sender and Receiver are DTN nodes, which can send mail between DTN nodes using *bpsendmail* and *bprecvmail* applications respectively. In order to implement the proposed DTN-SMTP, the interplanetary overlay network (ION) that implemented DTN in NASA was used [10]. However, *bpsendmail* and *bprecvmail* applications were added for DTN-SMTP, because none of the applications provided by ION is for sending mail. Each application was created based on *bpsendfile* and *bprecvfile* provided by ION, and was implemented to attach files in email transmission between DTN nodes. In ION, file transmission or reception is possible through *bpsendfile* and *bprecvfile* application. However, there is a limitation in applying SMTP because the file name and extension are not managed.

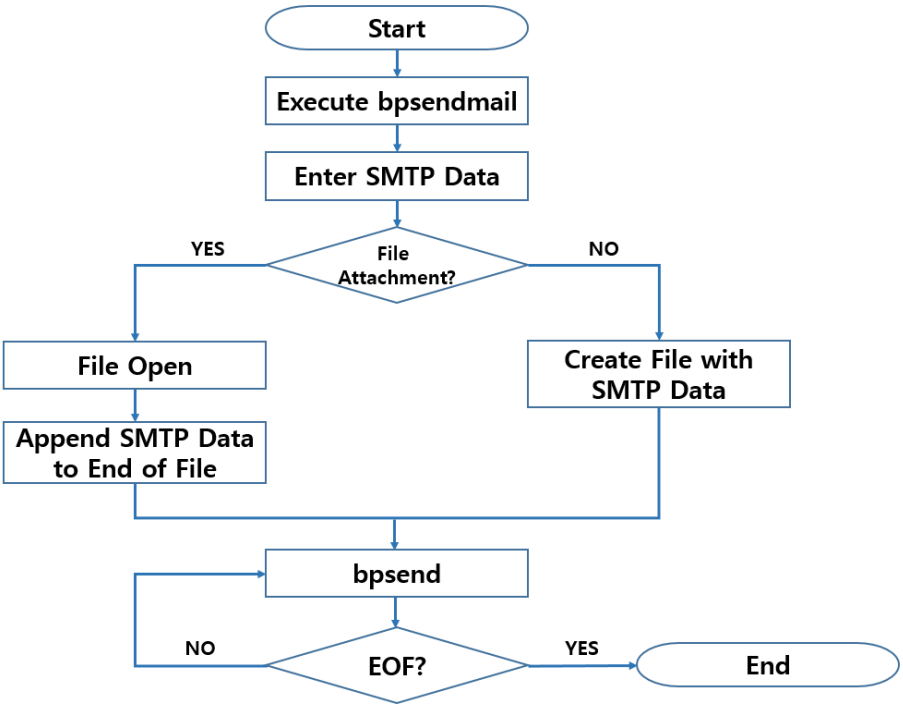

Fig. 3. Sender side Flow Chart

To send email between DTN nodes, as shown in Fig. 3, the *bpsendmail* application is executed first on the Sender side. After that, enter the SMTP data. Enter the email address and name of the sender and receiver the information that goes into the SMTP header and enter the contents of the email corresponding to the SMTP body. After that, it will have a branch on whether to attach the file. If a file is attached the SMTP header and body are added to the end of the file through the file descriptor for the attached file. If no file is attached metadata is generated and transmitted through the received SMTP header and body. Depending on whether or not a file is attached the SMTP header and body can be located at the end of the original file or a file consisting of only the SMTP header and body can be created. Send the file or metadata including the SMTP header and body and the role of *bpsendmail* ends.

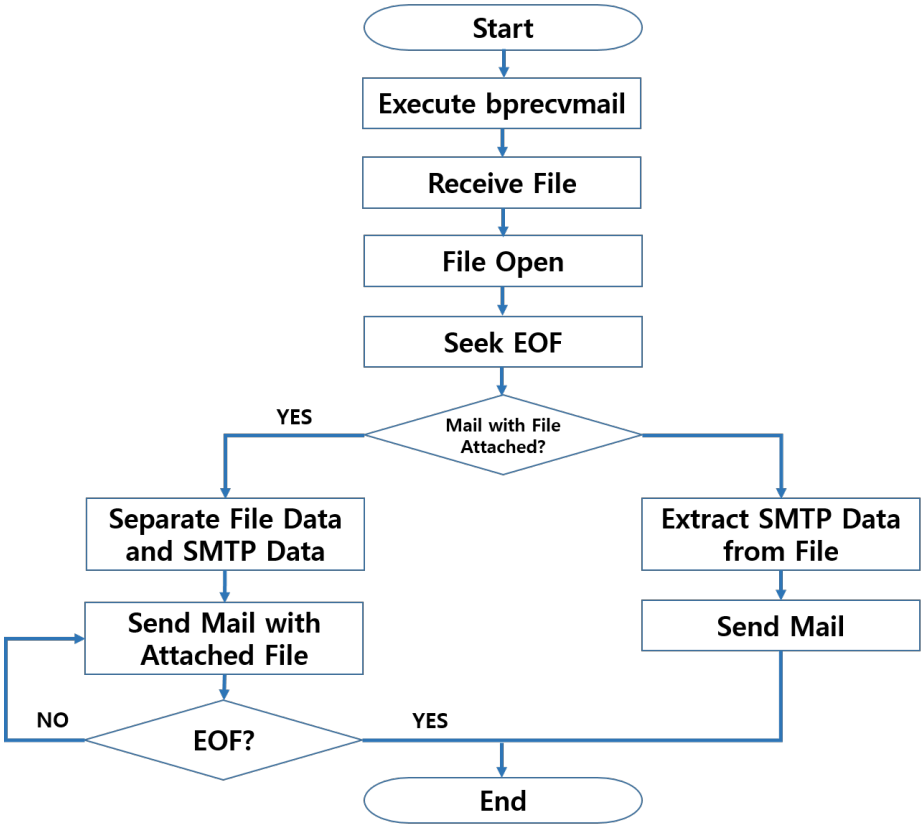

Fig. 4. Receiver side Flow Chart

In the Receiver, SMTP header and body can be received through *bprecvmail*. As shown in Fig. 4, when a file is first received from the sender the operation differs depending on whether a file is attached or not. Since the Sender inserts the SMTP header and body at the end of the file, it is necessary to find the EOF and separate the file content and the SMTP data based on the offset of the SMTP data and the file contents. Conversely, if there is no file attachment the received file itself contains only the SMTP header and body, and is transmitted to the external mail client using the corresponding SMTP data. DTN-SMTP using *bpsendmail* and *bprecvmail* is resistant to frequent network delays and interruptions provided by DTN, and operates on the basis of Licklider Transmission Protocol (LTP) [11], which checks whether data is transmitted in hops, thereby guaranteeing long-distance data transmission and data reliability.

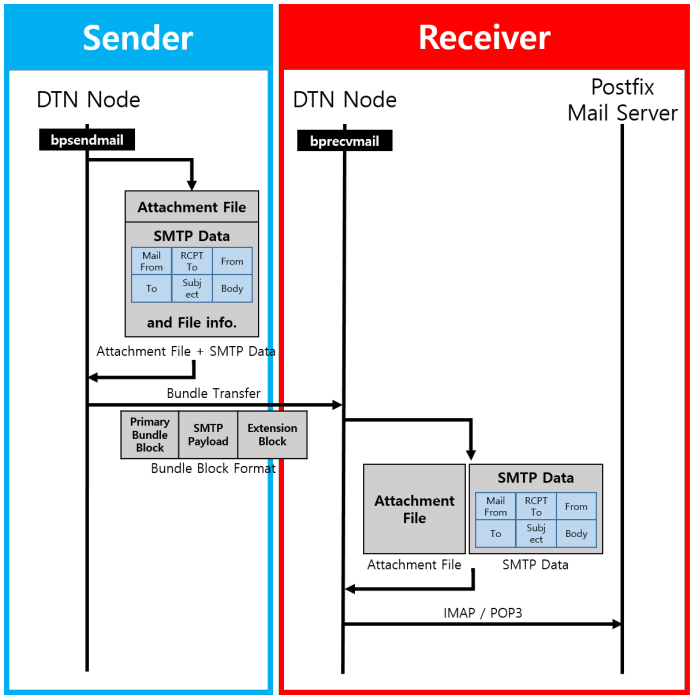

Fig. 5. DTN-SMTP Sequence Diagram

When sending an email with DTN nodes including attachments, it can be divided into the roles of Sender and Receiver as shown in Fig. 5 to confirm the sequence diagram. The sender attaches the SMTP data to the attachment using the *bpsendmail* application and sends the file using the Bundle Protocol between DTN nodes. After separating the file received from the receiver into the original file and the SMTP data area, the attachment is transmitted to the external mail client using the information of the SMTP data. Using the above method, it is possible to effectively communicate SMTP data and attachments in a limited space Internet environment through one-way transmission while guaranteeing reliability using DTN's Bundle Protocol.

4 Implementation

4.1 Test-bed Configuration

For the implementation of DTN-SMTP, using Interplanetary Overlay Network (ION), which implemented the DTN Bundle Protocol at NASA. The DTN node, which acts as a sender and receiver, was installed and configured by installing ION-3.7.0 version on Ubuntu 16.04 LTS Operating System and Postfix 3.1.0

version was installed and used to send emails from the Receiver node to external mail clients. ION's Convergence Layer Adapter (CLA) uses LTP to ensure reliability between DTN nodes. In addition, the Bundle Protocol operation on of TCP was confirmed to be compatible with the terrestrial Internet.

4.2 Implementation of Suggested DTN-SMTP

In order to implement DTN-SMTP, *bpsendmail* and *bprecvmail* were added to the existing ION. *bpsendmail* expands and positions EOF by the length of inserting the SMTP header and body entered by the user after the point at which the file content ends depending on the presence or absence of an attachment. At this time, if there is no attached file, metadata including only the SMTP header and body is generated, and then the EOF is located. *bprecvmail* uses the received file to separate the original file, the SMTP header and the body if an attachment is included and sends the mail and the attachment to an external mail client. If there is no attachment, only the SMTP data is in the received file, so the mail is sent to the external mail client using the SMTP data.

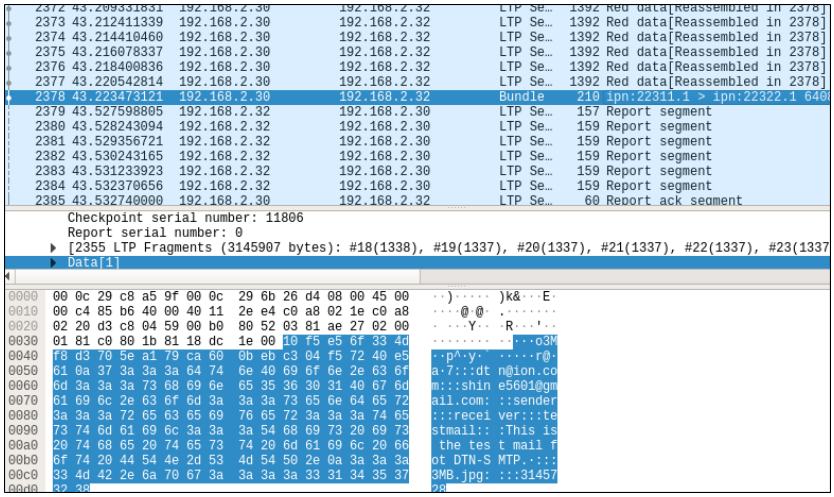

Fig. 6. LTP communication between DTN nodes

Fig. 6 shows the LTP packets communication between the DTN nodes through Wireshark. When checking the payload of the Bundle packet, which is a set of LTP Segments, it was confirmed that the SMTP header and body sent by Sender were received by the Receiver. After completing the transmission between DTN nodes, Fig. 7 show packet capture screen that sends mail to an external SMTP server using the attachment and SMTP data received from the Sender. Confirmed that the SMTP data and attachment sent by Sender are sent to an external mail using SMTP.

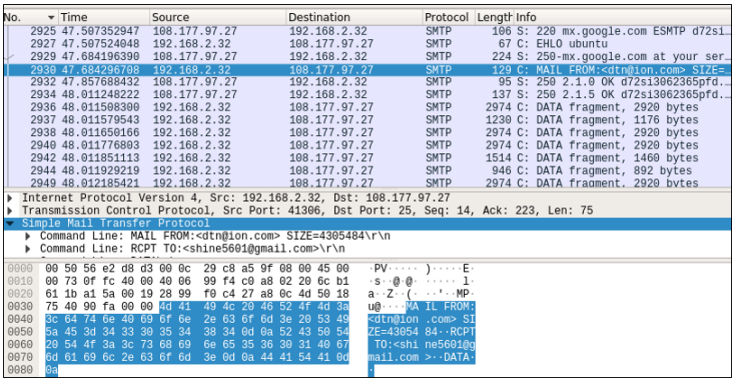

Fig. 7. Communication between DTN node and SMTP server

DTN-SMTP architecture As a result of implementation according to the structure, it was confirmed that the interaction is efficiently reduced when transmitting SMTP data between DTN nodes.

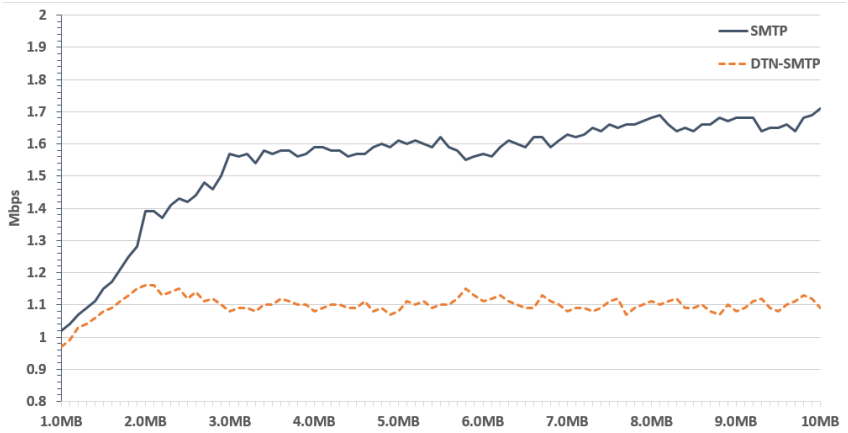

Fig. 8. SMTP and DTN-SMTP data rate Result

As shown in Fig. 8, This is a graph measuring the transmission speed of SMTP and DTN-SMTP with different attachment file size settings from 1MB to 10MB in 100KB increments. When the size of the attached file was 1.7 MB or less, there was no significant difference in performance between SMTP and DTN-SMTP. However, when sending an email with an attachment exceeding 1.7 MB, the SMTP showed a trend of increasing the data rate as the attachment size increased and DTN-SMTP guaranteed an average data rate of 1.1 Mbps

even if the attachment size increased. Due to the nature of DTN, the Store-and-Forward technique is used and the existence of a relay node is essential. As a result, DTN-SMTP has a lower transmission rate than SMTP because it has an additional relay node and LTP retransmission mechanism.

5 Conclusion

Since the existing SMTP operates based on the TCP/IP of the terrestrial Internet environment, it is unsuitable for the space Internet environment where there is lack continuous network connectivity. However, through the application of DTN-SMTP, the interaction of the existing SMTP was effectively reduced and one-way transmission was confirmed. DTN-SMTP is implemented by adding *bpsendmail* and *bprecvmail* application to ION. SMTP data and attachments were transmitted using the Bundle Protocol between DTN nodes. In particular, by determining the presence or absence of an attachment, the original file and SMTP data were transmitted to suit the space Internet environment, and the end-to-end reliability was secured using the Store-and-Forward method and LTP of the Bundle Protocol used by DTN. Through the implementation results, it was confirmed that the proposed DTN-SMTP transmits and receives SMTP data to be suitable for the space Internet environment. As a result of performance evaluation, the transmission speed of SMTP and DTN-SMTP was measured, and the DTN-SMTP guarantees an average transmission speed of 1.1 Mbps. Through future research, the transmission speed of DTN-SMTP can be improved by applying a routing method that can increase the number of forwarding per unit of time in the DTN Store-and-Forward technique.

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