Simulation and Limitation Analysis of Modern Delay-Tolerant Email

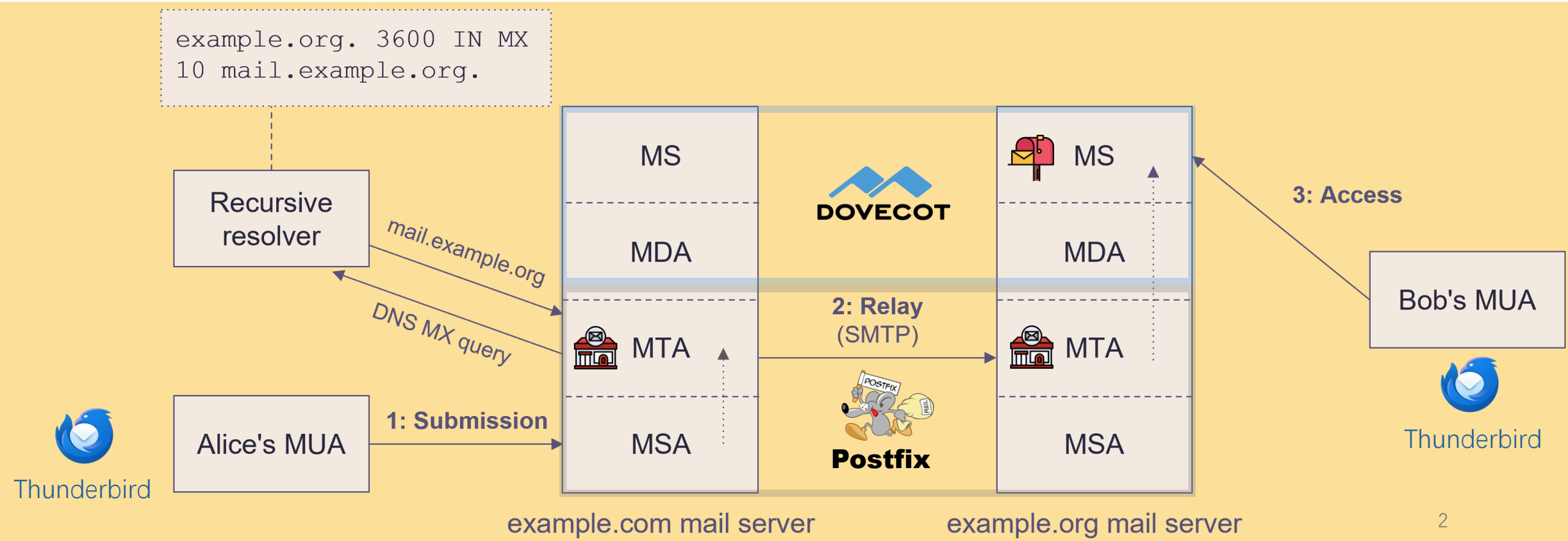
Deng Pan

24358871

CS7NS1(Future Networked Systems)

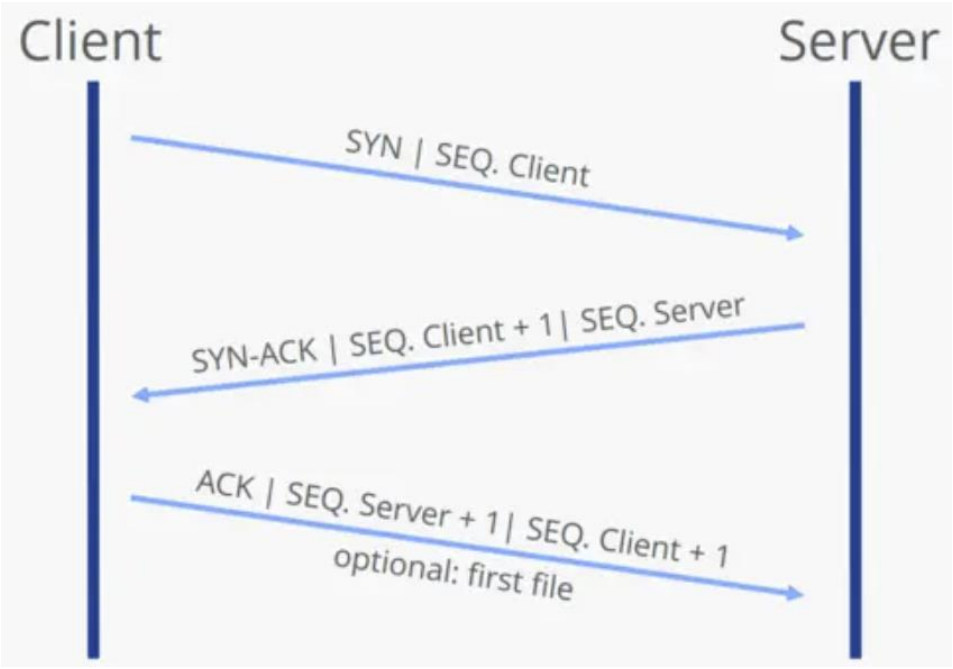
Email system

Client → Mail Server → Mail Server → Client



Space network

Two planets are very far from each other.

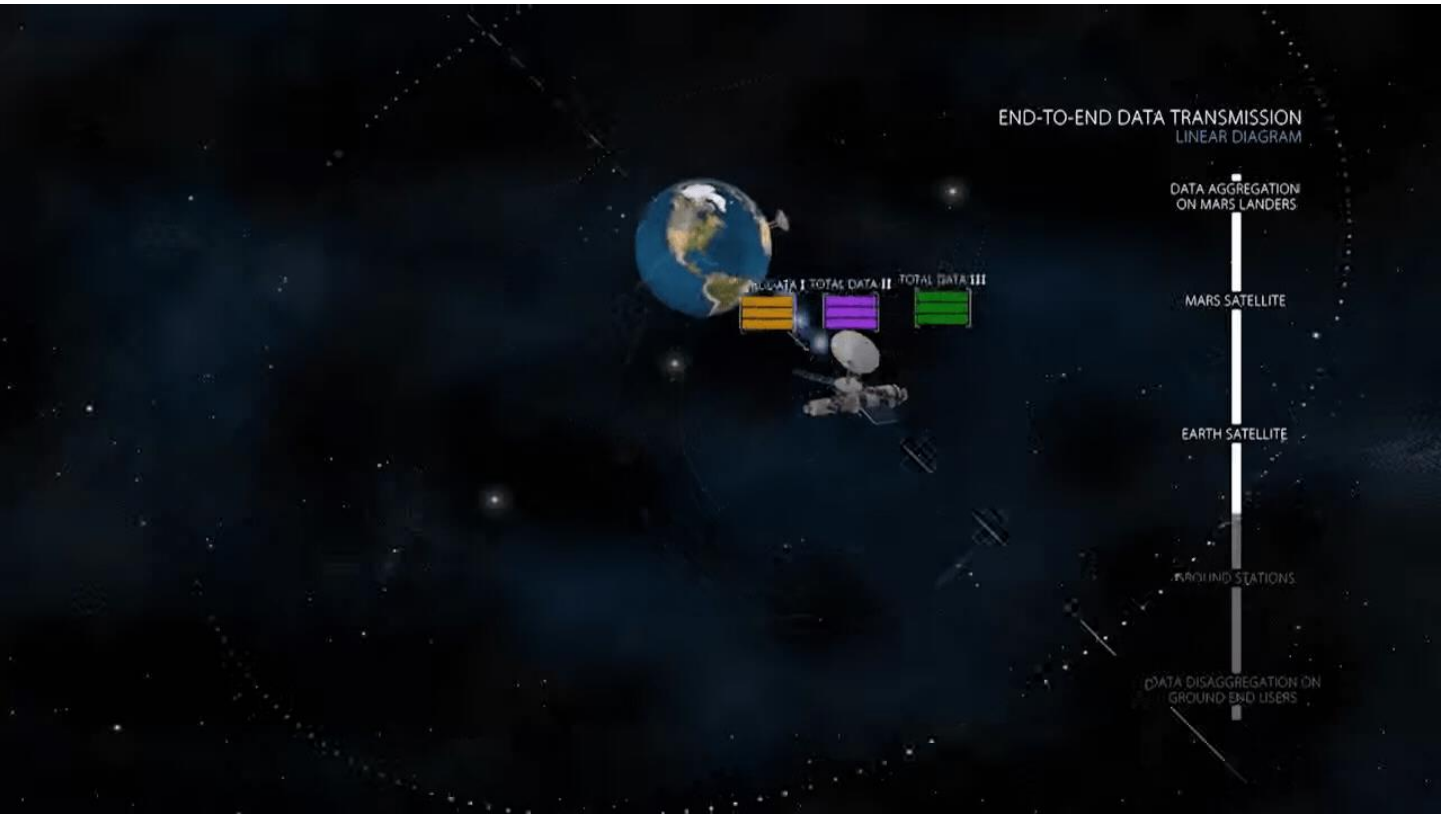


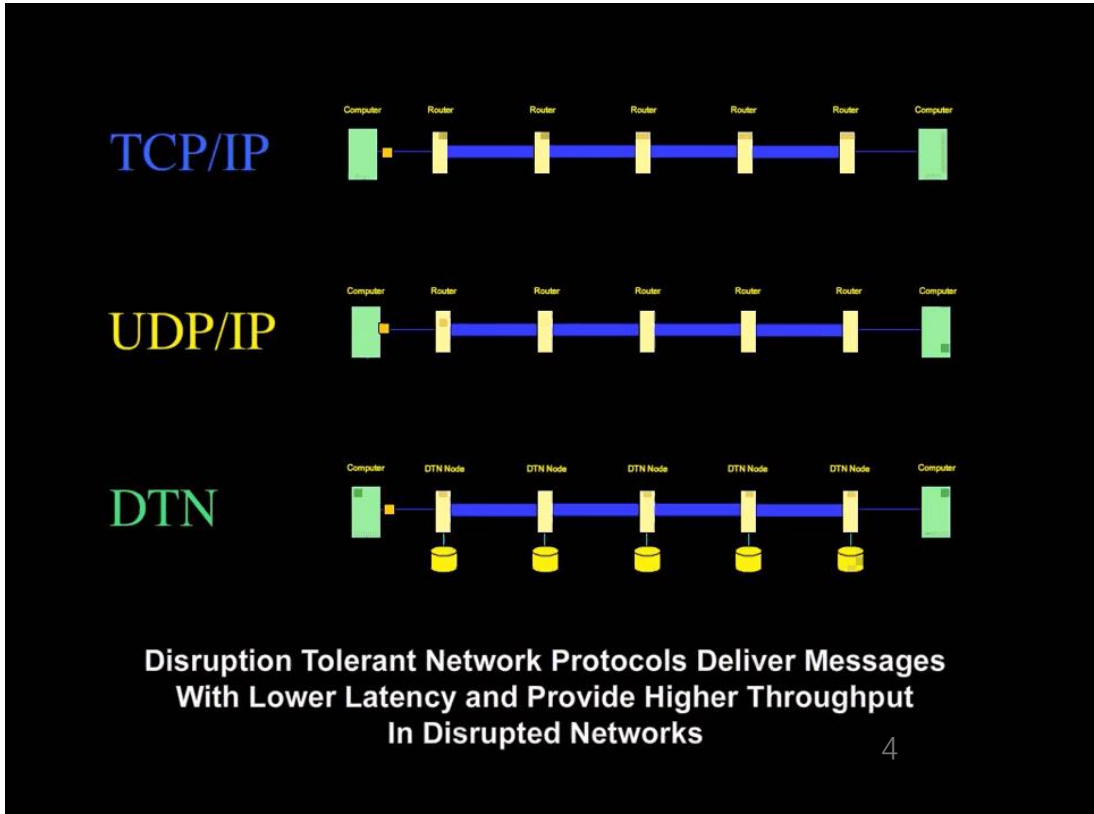
TCP three-way handshake

Features: high **delays** and frequent disruptions.

Delay-Tolerant Networking

The idea of DTN is "**store and forward**." This means that when the network is disconnected, data packets are stored at each node instead of being thrown away. Once the connection is back, the node will keep forwarding the packets to their destination.

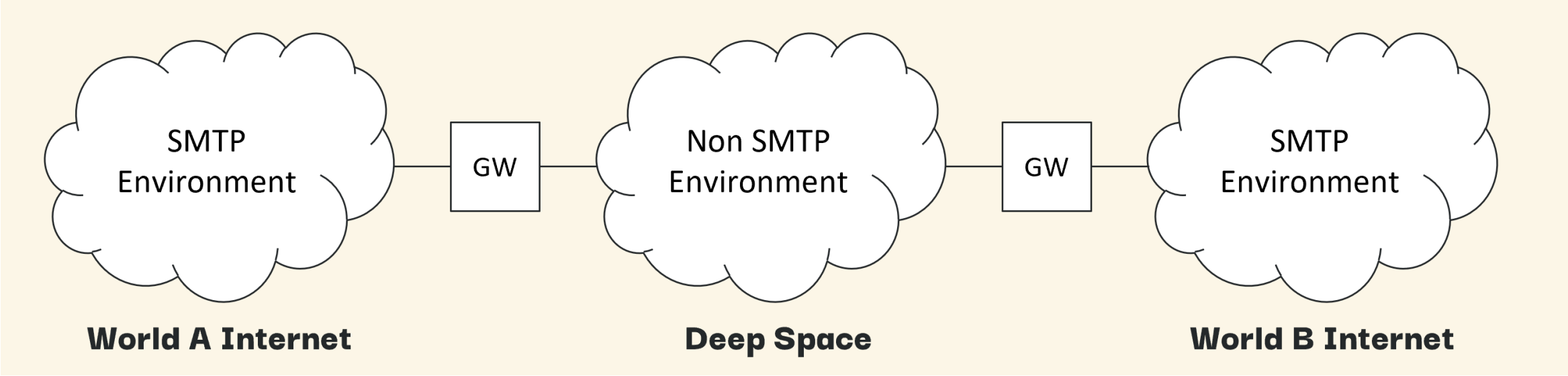




Email system with DTN

draft-johnson-dtn-interplanetary-smtp

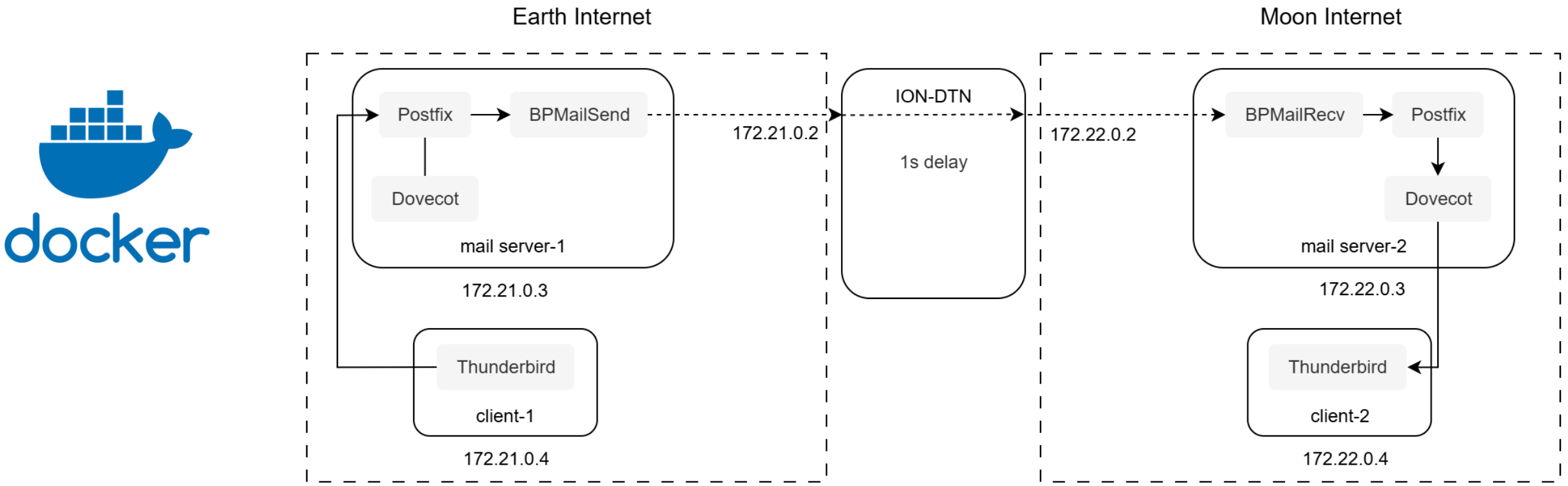
In Johnson's draft, he suggests that every planet has its own TCP/IP network, and DTN is used to connect the different planets together. The DTN and the TCP/IP network on each planet are joined using **gateways**.



Simulation of Johnson's Solution

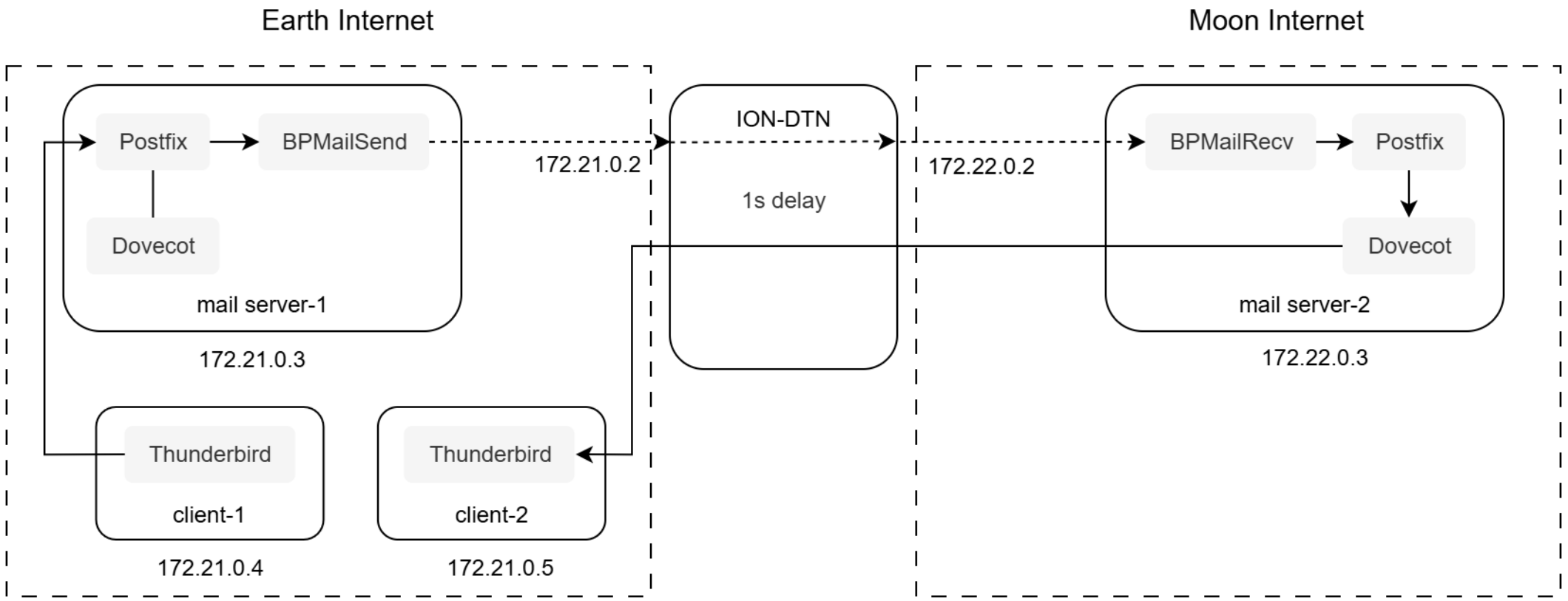
I use 5 Docker containers in total: 2 represent mail servers on different celestial bodies, 1 is a delay container to simulate the space network, and the last 2 are the client container for users.

I made the DNS process simpler by just using the hosts file.



Extreme situation: What if users could travel between celestial bodies? How would they retrieve their email on a different celestial body?

Since this time the email retrieval doesn't go through a gateway, DTN can't help—the client has to connect directly to the mail server on the Moon using TCP over the space network. As a result, getting emails takes much longer than before.



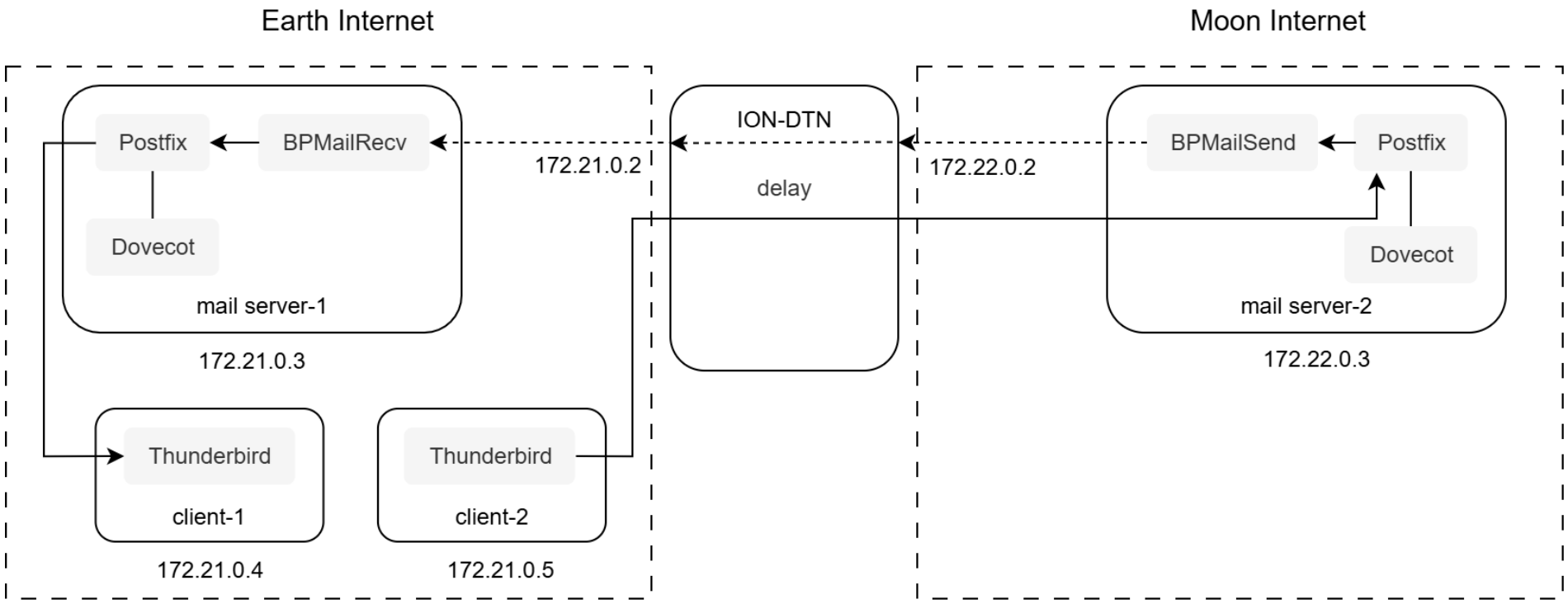
I test different one-way network delays (0s/1s/2s/5s), and record the total time required to retrieve all emails (overall retrieval time).

The overall download time increases linearly with network delay. When the delay is 5 seconds, the email client becomes very sluggish and is almost unusable.

To improve the email retrieval experience in deep space, it is necessary to introduce a DTN retrieval agent or a batch synchronization mechanism during the email retrieval process.

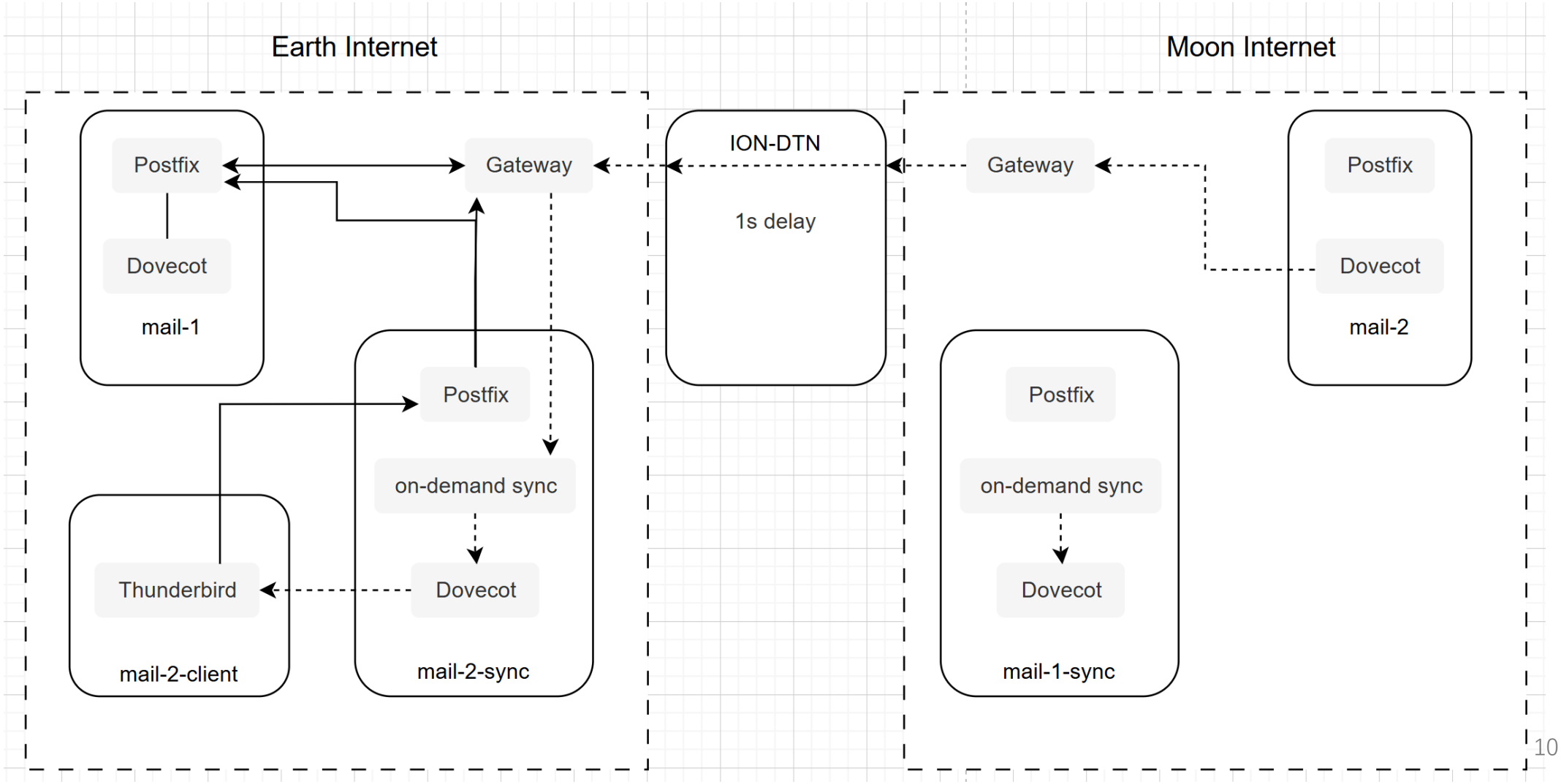
Delay	Body	Number of emails	Overall retrieval time
0s	Hello	1000	19s
1s	Hello	1000	33s
2s	Hello	1000	64s
5s	Hello	1000	153s

Besides receiving emails, sending emails also faces the same problems.



A possible solution

Set up another mail server for sending & synchronizing emails.



What I found

Johnson's solution works well in mainstream scenarios, but it performs poorly in special cases—specifically, when users move between celestial bodies. If the delay is too high, this solution may not even be usable.

In addition, the Johnson solution does not explain how to implement email authentication technologies like Reverse DNS in an interplanetary network environment.

Conclusion

The gateway-based architecture make interplanetary email possible in simple scenarios. However, it cannot handle more complex situations. There are still many issues to solve before existing email systems can reliably send and receive emails across space.