Uplink To Mars (Latency)  
draft-earth2mars-00.txt

Status of this Memo

This document is a group exam assignment meant for educational purposes.

It represents the consensus of the group.

Abstract

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# Introduction

# Proposed Solutions

The existing Internet on earth is based on TCP/IP protocol suite and assures end to end connectivity, provided that the latencies are relatively small, the connectivity is continuous and the bidirectional data rates are high. However, in many networks such as the interplanetary communications this is not the case; propagation delay can reach up to minutes or even hours, the data rates are asymmetric and relatively low and there is an intermittent connectivity.

Our solution has to involve a combination of position and functionality of relay station(s) plus the functioning of error correction. Propagation time from Mars to Earth is anywhere from 3 to 30 minutes. That is, assuming no error correction and everything fine = 30min.

We want to reduce the amount of time consumed by retransmissions. We don’t need to worry about how many retransmissions, but we want to reduce 75 minutes down to 45 min. So if retransmission doesn’t take too long then we solve the problem. (1) If we reduce the need for retransmission. And that’s what FEC does. And what the relay station will do, it will also reduce the need for retransmission because the distance is shorter (the signal travels a shorter distance) and therefore reduces the errors in transmission. If there are less errors, then there is less need for retransmission.

Then our solution, how to address retransmission is two-fold: (1) to use FEC and (2) introduce relay stations. So then how do these two things reduce the time it takes to do retransmissions?

## Forward Error Correction

Forward Error Correction (FEC) is a sort of self-correcting algorithm. In telecommunication, information theory, and coding theory, FEC or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The central idea is the sender encodes the message in a redundant way, most often by using an error-correcting code (ECC) [4].

FEC involves transmitting extra data so that certain errors can be corrected without data being retransmitted. This approach depends on a measure called Hamming Distance. It is a metric for comparing two bit strings of the same length. For example consider the following two bit strings 000 and 011. The Hamming distance between these two is two strings of equal length is simply the number of positions in which their values differ. So the first are both 0s, but then we have a 0 and a 1, so that is one position where they differ. And the last position they also differ. So the distance between these two bit strings: d(000, 011)=2. Given this knowledge, we can talk about forward error correction.

Thus, FEC error correction increases the tolerance for errors. With a higher tolerance for errors, there will be less need for retransmission. And less retransmission means less latency.

## Relay Station

The proposed relay station operates in a similar way to intermediate stations in store and forward. Store and forward is a telecommunications technique in which information is sent to an intermediate station where it is kept and sent to the final destination or to another intermediate station. The intermediate station verifies the integrity of the message before forwarding it [5].

When relay stations are introduced in communications between Earth and Mars, retransmissions are now with relay stations. This significantly reduces the distances involved, and therefore reduces the retransmission time. That in turn will reduce the overall latency.

The more relay stations that can be deployed between earth and mars, the less distance, and therefore time, there will be between retransmissions. Furthermore, the reduced distance between transmissions will cause fewer errors, which will reduce the need for retransmission.

The number of relay stations, where they will be located, and how they will be deployed, requires further study and is not inside the scope of this proposal. Enough satellites will be deployed as necessary to minimize the distance between each hop.

One example would be to deploy 9 relay stations. With 9 relay stations, then essentially, we are dividing the distance into 10 chunks and more or less we reduce the travel for each hop by one tenth. In other words, instead of 400 million kilometres, it’s only 40 million kilometres.

# References

[1] https://www.space.com/14729-spacekids-distance-earth-mars.html

[2] https://books.google.fi/books?id=PNEGt99uMBwC&pg=PP1#v=onepage&q&f=false

[3] https://www.economist.com/science-and-technology/1999/11/11/the-wire-of-the-worlds

[4] https://www.webcitation.org/65iNkn800?url=http://www.aero.org/publications/crosslink/winter2002/04.html

[5] <https://en.wikipedia.org/wiki/Store_and_forward>

Appendix

“include a "FEEDBACK" section in your final submission text where you may provide information about which reviews you did take into consideration, and which you have rejected, and why. You may choose any number of reviews (e.g. if you have too many to consider).”

From peer reviews

Peer 1

1. “The first two pages follow the styling nicely, after which for seemingly no reason proper formatting disappears into thin air…”

We hope we have done better this time with the formatting.

2. “For example in the third chapter, it is said that a 50% overhead would make sending the data take 50% longer. This is likely not true.”

We have removed this statement, because the explanation was misleading.

3. “How is the proposed retransmission handled?”

The retransmission is between each hop and because the relay station operates at the TCP level. That means that the FEC in combination with the shorter distance between hops should greatly reduce the need for retransmission. But even if retransmission is needed, the shorter distance will introduce significantly less delay compared to retransmissions between Earth and Mars.

4. “Another note, include proper sources. A google search is not a valid source, find the information on the NASA website and link that with proper syntax.”

We have addressed this in the final submission.

Peer 2

2. “Protocol is well explained and documented, it's easy to understand and it addressess the initial problem well except for the fact that it doesn't explain properly how the Relay Stations should be positioned on the space. This is a quite important problem to solve for the initial exam assignment, since the positioning of Mars and Earth relative to Sun plays a key part in the communication (latency and packet loss) problems that arise between an interplanetary communication between Mars and Earth. To solve this problem, I suggest the writers to take a look on the Exam assignment Proposal 10 [1] Chapter 3.2.1. and the article mentioned [2] on that Chapter.”

Agree that it is very important and the whole thing fails without it, but it is beyond the scope of this proposal as it is a physical transmission issue and because the exact words of the teacher to me were:

“You are not expected to solve the physical layer problem. […] How the physical and link layers work is "not your problem" in all aspects except for retransmissions."

Thrusters use power constantly. How do you supply enough fuel? And it’s out of the scope of the assignment, at least according to the teacher, it’s out of the scope.

Peer 3

3. “Key problems: - The given solution doesnt address the problem with using TCP/IP application layer with a propagation delay of up to 30 minutes. As suggested in the given task, couldn't the solution use some kind of proxy server to bring the data closer to Mars? Of course the data stored on the proxy server will become stale and need updating, but this wouldn't be a problem for some applications.”

Our solution uses relay stations that operate at the TCP layer.