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

In this group work, we take a look at the challenges faced by space communication. More and more exploration of the Mars means better forms for communication like, the transfer of packets from Earth to Mars. Different factor affects the smooth packet transfer such as time, distance and Sun. Due to distance from Earth to Mars, some packets are damaged, and these damaged packets requires retransmission. The retransmission is addressed in a way that, it should take less time to be retransmitted.

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# Introduction

The constant growth in technology gives the ability for extreme discoveries and explorations. One of this very ambitious exploration, is the settling of humans in Mars in the nearest future. Before now, lots of different space expeditions have been carried out, and this therefore means the explorers have to communicate with people on Earth. Space communication has been a very big challenge when it comes to transfer of data, based on vary factors, for example distance.

The distance from Earth to Mars is very vast and the time taken from Earth to Mars differs. Both the Earth and Mars do orbit the Sun which also makes it challenging for communication due to noise produced by the Sun. The transfer of packets from Earth to Mars can sometimes fail and retransmission is needed. The idea of retransmission can lead to huge latencies which make human-to-human interaction greatly unbearable.

In this group work, a solution is proposed to address the problem of overall communication latency between Earth and Mars. The problem is latency based on retransmission. To address latency, we must address retransmissions.

The solutions we propose are: forward error correction (FEC) and the use of relay stations. Both combined should reduce the number of retransmissions needed and also the time spent for each retransmission.

# Challenges

Setting up a communication between Earth and Mars is not really a trivial matter because of the wide varieties of obstacles such as vast distance between Earth and Mars, noise from the Sun, long time delays and other disturbances. However, mainly our concerns are the vast distance from Earth to Mars, noise from the Sun and long time delays.

## Vast Distance

In communication systems, distance plays a vital role. It’s particularly tricky when trying to communicate between Earth and Mars since the distance between the two planets can be anywhere between 50-400 million km. The actual distance depends on where Earth and Mars are respectively in their orbit around the Sun [1].

Hence, the signal needs to travel approximately aforementioned distance to reach Mars. We know the speed of light is 3x10 km/sec. Assuming the signal travels at the speed of light, it takes approximately 3 to 30 minutes for the information to reach the other end.

# Proposed Solution

Data propagation between Earth and Mars can be anywhere from 3 to 30 minutes. This is assuming there are no errors in transmission which is highly unlikely. With errors, there will be additional delays due to retransmissions. With retransmissions, the overall latency can be up to 75 minutes. To make any sort of human-to-human interaction reasonable, the overall latency needs to be 45 minutes or less.

The proposed solution aims to meet this latency requirement by using Forward Error Correction in the transmitted data and also by adding multiple relay stations between Earth and Mars.

## 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) [2].

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 Stations

The proposed relay stations operate 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 [3].

When relay stations are introduced in communications between Earth and Mars, retransmissions will be 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 within the scope of this proposal. Enough satellites will be deployed as necessary to maximise the efficiency.

One example would be to deploy 9 relay stations. With 9 relay stations, we are essentially dividing the distance into 10 chunks. That means the distance between transmission hops will only be one tenth distance between Earth and Mars. In other words, instead of 400 million kilometres, it will be 40 million kilometres. And this is only when the two planets are furthest from each other.

# References

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

[2] https://books.google.fi/books?id=PNEGt99uMBwC&pg=PP1

[3] 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.