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Final Project - Proposal

Delay-Tolerant Networking for the Interplanetary Internet

3rd March 2020

OVERVIEW

I intend to do some research in the area of space-based networking (specifically interplanetary) and the challenges of crafting efficient and robust protocols for store and forward relays in the presence of high latencies and disjoint links. Deep space communication poses several unique challenges for network design, including, but not limited to:

1. Extremely long and variable propagation delays
2. High link error rates for radio-frequency (RF) communication channels
3. Intermittent link connectivity (i.e. blackouts)
4. Asymmetrical forward and reverse link capacities
5. Lack of fixed communication infrastructure

   [1, 2]

My research will revolve around the design and implementation of Delay-Tolerant Networking [1] in the quest for realizing the Interplanetary Internet [2]. In particular, I will focus on the transport layer and the necessary improvements and modifications to existing reliable transport protocols like TCP and techniques like ARQ for efficient operations in deep space. There exist some publications and proposals for solutions to some of the problems faced in this environment, such as TP-Planet [3], as well as techniques for end-to-end acknowledgements and custody-transfer from the DTN architecture [4]. There are also existing models that leverage TCP with some modifications and extensions to meet the needs of deep space systems. One such standard is the Space Communications Protocol Standards-Transport Protocol (SCPS-TP) [5, 6] a set of TCP extensions for space communications developed by the Consultative Committee for Space Data Systems (CCSDS). A more recent variation for file transfer is the CCSDS File Delivery Protocol (CFDP). Some aspects of this protocol have been shown to be independently valuable and potentially modularizable for use in other transport layer protocols, as is suggested with “CFDP-RP” in [1].

GOALS

1. Gain a firm understanding of the challenges to networking across interplanetary distances.
2. Identify the shortcomings of standard Internet protocols in addressing these challenges and operating amidst these constraints.
3. Survey the current research, implementations, and standards that seek to overcome these challenges.
4. Simulate an interplanetary network using Google Cloud Platform to observe the various behaviors of networks in the presence of these obstacles.
5. Identify an area needing improvement and make a research contribution in that area.

STATUS

I have begun researching the field of space-based networking and am starting to stitch together the history of the research and contributions others have made to date. I am starting to see trends across some of these papers and am trying to identify which of those threads to pull on further. To that end, I am still in the early stages of my survey and have yet to decide where exactly I want to focus my efforts. I do believe it will be roughly focused in the transport layer, perhaps in reliable transport protocol implementations, such as TP-Planet. My next step is to do a thorough re-reading of all my current sources, and then expand out from each of those by looking at the references they each cite. I will probably start a spreadsheet of sorts to track the trends and problem spaces across each paper to help me select my focus.

References:

[1] Burleigh, Scott, et al. "Delay-tolerant networking: an approach to interplanetary internet." *IEEE Communications Magazine* 41.6 (2003): 128-136.

[2] Akyildiz, Ian F., et al. "InterPlaNetary Internet: state-of-the-art and research challenges." *Computer Networks* 43.2 (2003): 75-112.

[3] Akan, Ozgur B., Jian Fang, and Ian F. Akyildiz. "TP-Planet: A reliable transport protocol for interplanetary internet." *IEEE Journal on Selected Areas in Communications* 22.2 (2004): 348-361.

[4] Cerf, Vinton, et al. "Delay-tolerant networking architecture." (2007).

[5] Durst, R., P. Feighery, and E. Travis. "Users manual for the SCPS Transport Protocol." *WN 97W0000018, McLean, Virginia* (1997).

[6] Lawas-Grodek, Frances J., et al. "SCPS-TP, TCP and rate-based protocol evaluation for high delay, error prone links." *SpaceOps 2002 Conference*. 2002.

[7] McMahon, Alex, and Stephen Farrell. "Delay-and disruption-tolerant networking." *IEEE Internet Computing* 13.6 (2009): 82-87.