My Venture Capital Firm

Menlo Park, CA

Dear Managing Partner,

I am writing to you regarding the recent funding pitches in the area of the Interplanetary Internet. In this executive summary, I have prepared an assessment of the technology as well as my recommendations. In considering our decision to fund these proposal(s), we must first understand the motivation behind developing a separate networking protocol for interplanetary networking. After which, a discussion of the strengths and weaknesses of this technology will elude specific recommendations for if and how we should fund these proposals.

The communications environment varies greatly between terrestrial internet and interplanetary networking (IPN). Terrestrial networks assume very short round-trip times (RTT's) between communicating hosts over a high bandwidth lines which experience a low number of data bit errors. These assumptions impact design decisions for terrestrial internet; TCP/IP is built for end-to-end transport between hosts using a three way handshake. However, the assumptions change with IPN, which requires a new design.

IPN exists in a very different environment. Transmission across planetary bodies or thru space can involve distances far greater than any terrestrial session. RTT's are much longer (8 – 40 minutes between Earth and Mars and 66 – 100 minutes between Earth and Europa), a high bit error rate is expected and low bandwidth connections are assumptions in IPN. [1] Therefore IPN cannot afford to be chatty; the three-way handshake of TCP would be highly inefficient in these types of environments (due

[1] Interplanetary Internet (IPN): Architectural Definition, NASA/JPL, http://www.ipnsig.org/reports/memo-ipnrg-arch-00.pdf

to the back and forth communication required for the establishment of a session). Given these environmental constraints, IPN cannot effectively support reliable end-to-end *transport*. Instead, IPN relies on Delay Tolerant Networking (DTN) to handle transport between interplanetary nodes. DTN uses a *store-and-forward* mechanism via a *bundle protocol* and *convergence layer* to handle transport (see Figure A); *bundles* are "a serious of contiguous data blocks that contains enough semantic information to allow applications to *make progress* where an individual block may not."[2] They are transported via store-and-forward so that each node is able to sustain long transmission delays or network instability or unavailability. Bundle protocol archives end-to-end communication between interplanetary hosts; it supports authentication/encryption, routing and reliability. A custody transfer function allows the 'ownership' of the bundle to be passed along to different nodes in the IPN. The convergence layer operates just above the transport layer and facilitates the sending and receiving of bundles using lower layers (see Figure A).

While the Interplanetary Internet is based on delay tolerant networking, there are different implementations of DTN. Some interconnection between these different DTN implementations is allowed, but not without applying necessary fixes to allow such interconnection.[3] I believe that the lack of a clear standard for IPN suggests that strategic investment in this area could be beneficial in establishing a standard. Our company has a received number of funding pitches, and it is my recommendation that we review these pitches and consider those who have considered both security and efficiency in their proposals.

NASA's current implementation of IPN/DTN uses the Licklider Transport Protocol (LTP).[4] The protocol has a number of benefits for IPN such as: stateful data transfer, no need for negotiation/handshakes and

[2] http://en.wikipedia.org/wiki/Delay-tolerant_networking
[3] http://www.dtnrg.org/wiki/DtnBone?highlight=%28%28Home%29%29
[4] *Ibid.*

unidirectional sessions. However, LTP is susceptible to denial of service (DoS) attacks.[5] This is because LTP purposely retains state information for extended periods and also has high time-out values.[6] Security in the IPN could be implemented at different layers, and each offers certain benefits and costs. The fundamental differences between IPN and terrestrial internet imply that security must also be re-engineered to work effectively in IPN. Security implemented at the highest layers (Application) on an IPN, still leaves header information exposed (whether it be LTP or another protocol used for transport); this does not resolve the DoS concerns, especially given the long timeout periods required for IPN. Implementing security within the convergence layer thru authentication headers could protect against replay attacks but requires a key management infrastructure.[7] Existing public key infrastructures are insufficient in IPN because they may not be accessible due to high network latency or disruption in the IPN. PKI's also require a high amount of bandwidth and processor power required to perform public key cryptography, both of which are in short supply in the IPN.[8] Therefore both processing efficiency for both data transmission and processing should be a critical component of any proposal we fund.

Our company is poised to take invest in a technology that will undoubtedly become more important as exploration into space continues throughout the 21st century and into the future. If we a fund a proposal that ultimately becomes the standard for IPN, we could stand to benefit from this (financially or by name).

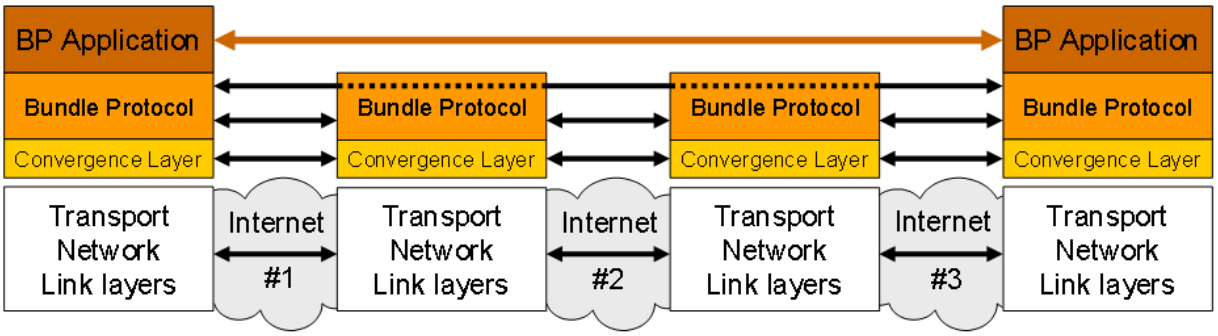
Sincerely,

Michael Chung

[5] Licklider Transmission Protocol – Motivation, http://www.rfc-editor.org/rfc/rfc5325.txt
[6] *Ibid.*
[7] *Ibid.*
[8] Interplanetary Internet (IPN): Architectural Definition, http://www.ipnsig.org/reports/memo-ipnrg-arch-00.pdf

Figure A

Bundle Protocol & Convergence Layer are placed on top of Transport/Network/Link layers; Bundle protocol handles end-to-end communication between interplanetary nodes. Convergence layer provides mapping to lower layers.



http://www.netlab.tkk.fi/u/jo/dtn/index.html