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LET's GO Through: Interplanetary Internet

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ABSTRACT
Growth of information technology in the field of space is increasing day by day . one of the major one is IPN (InterPlanetary Network).The main objective of this paper is to motivate the researchers around the world to tackle these challenging problems and help to realize the InterPlanetary Internet.

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I. INTRODUCTION

The InterPlanetary internet is being designed to be a network that connects a series of internets , these internets would be located on planets and moons , or abroad spacecraft .It is the means whereby Earth's nervous system expands outwards ,across the solar system . InterPlaNetary (IPN) Internet is expected to be the next step in the design and development of deep space networks as the Internet of the deep space planetary networks. However, there exist significant challenges to be addressed for the realization of this objective .In this paper ,the current status of the research efforts to realize the InterPlanetary Internet objective is captured.The architecture is presented and the challenges of IPN are introduced . The existing algorithm and protocols developed for each layer and their shortcomes are pointed out along with the open research issues for the realization of the InterPlanetary Internet.

Interplanetary Internet

The interplanetary Internet is a conceived computer network in space, consisting of a set of network nodes that can communicate with each other.

Interplanetary communication is greatly delayed by interplanetary distances, so a new set of protocols and technology that are tolerant to large delays and errors are required. The interplanetary Internet is a store and forward network of internets that is often disconnected, has a wireless backbone fraught with error-prone links and delays ranging from tens of minutes to even hours, even when there is a connection.

The Interplanetary Internet study at NASA's Jet Propulsion Laboratory (JPL) was started by a team of scientists at JPL led by Vinton Cerf and the late Adrian Hooke . Cerf is one of the pioneers of the Internet on Earth, and currently holds the position of distinguished visiting scientist at JPL. Hooke was one of the founders and directors of CCSDS .

While IP-like SCPS protocols are feasible for short hops, such as ground station to orbiter, rover to lander , lander to orbiter, probe to flyby, and so on, delay-tolerant networking is needed to get information from one region of the Solar System to another. It becomes apparent that the concept of a region is a natural architectural factoring of the Interplanetary Internet.

A region is an area where the characteristics of communication are the same. Region characteristics include communications, security, the maintenance of resources, perhaps ownership, and other factors. The Interplanetary Internet is a "network of regional internets".

What is needed then, is a standard way to achieve end-to-end communication through multiple regions in a disconnected, variable-delay environment using a generalized suite of protocols. Examples of regions might include the terrestrial Internet as a region, a region on the surface of the Moon or Mars, or a ground-to-orbit region.

The recognition of this requirement led to the concept of a "bundle" as a high- level way to address the generalized Store-and-Forward problem. Bundles are an area of new protocol development in the upper layers of the OSI model, above the Transport Layer with the goal of addressing the issue of bundling store-andforward information so that it can reliably traverse radically dissimilar environments constituting a "network of regional internets".

Delay-tolerant networking (DTN) was designed to enable standardized communications over long distances and through time delays. At its core is something called the Bundle Protocol (BP), which is similar to the Internet Protocol, or IP, that serves as the heart of the Internet here on Earth. The big difference between the regular Internet Protocol (IP) and the Bundle Protocol is that IP assumes a seamless end-to-end data path, while

BP is built to account for errors and disconnections — glitches that commonly plague deep-space communications.

First generation IPN

IPN generally deals with space exploration . communication within our planet is happening in lightning speed . But it's not the case outside our planet . Communication outside our planet is an irony .

If I say a "Hi" to you and you hear it after 2 hours!! This is the problem of communication outside the planet . Space mission failure become a familiar term associated with space exploration . Mass amount of resources go waste . Billions of economy vanishes into air like cracker . One of the failed mission is Mars polar lander . Failure happens when communication with satellite breaks . only the solution is the INTERplaNET (IPN)

Introduction to IPN

On the freezing surface of mars a sensor takes readings of the thin atmosphere and transmits the data to an automated rover . which relays the information to an orbiting satellite from there the data packet's are sent to an approaching research ship , where astronauts study the reading and their findings back to earth via e-mail.

Obstacles in spacecommunication

Communication in space moves as a snail when compared to communication in earth. Main reasons are:

- Distance –On earth we are only a fraction of a light second apart making earth communication nearly instantaneous over the internet . As you move farther out into space , however there is a delay of minutes or hours because a light has to travel million of miles , between transmitter and receiver our nearest planet mars is 200 million km away.

- Line of sight obstruction – Anything that blocks the space between the signal transmitter and receiver , celestial blocking can interrupt communication .Landed vehicles on remote planetary surfaces will move out of sight of earth as the body rotates and may have to communicate through local relay satellites that only provide data transmission contacts for a few minutes at a time . weight –high powered antennas that would improve communication with deep space probes are often too heavy to send on a space mission , because the payload must be light and efficiently used . NASA currently communicates with interplanetary and earth – orbiting missions using deep space network . The network consists of dishes in California , spain , and Australia which are manually set to receive transmission from a given spacecraft . Each facility is equipped with one 111-foot (34 meter) diameter height efficiency antenna , one 111-foot beam waveguide antenna (three in California) one 85-foot (26 meter) antenna , one 230-foot (70 meter) antenna and one 36-foot (11 meter) antenna . The antennas are place 120degree apart to cover the whole 360 degree .

up until now , sending command to a lonely ship was simply a matter of shooting off a radio signal when it's antenna came within range . A simple matter that is after telecommunications software written precisely for that are specific mission has been painstakingly fashioned afterward , that software was usually discarded . for the next mission , unique software was crafted all over again . The main drawback of the Deep Space Network is that it relies on line-of –sight transmission that means rovers or astronauts on the far side of mars must wait until they are back in the line of sight with earth before sending a message home to receive the message the deep space network dishes must be pointed in the right direction at the right time or the signal will be lost forever . However recent space mission have lost communication with the DSN , including the mars climate orbit and the mars polar lander mission in 1999 .

Architecture

Even though the theoretical architecture of IPN is similar to that of the normal internet system the components such as gateways and transmission channels are different due to the long distance to be covered. By the signal here are three basic components of the proposed interplanetary

- NASA's Deep Space Network(DSN).
- A six satellite constellation around mars.
- A new protocol for transferring data.

1. Deep space network

The DSN is the international network of antennas used by NASA to track data and control navigation of interplanetary spacecraft it is designed to allow for continuous radio communication with the spacecraft .DSN will work as earth is gateway in the proposed system . In an interplanetary internet the DSN will be the earth's gateway or portal to that internet in a paper published by the MITRE Corp , a company that is financing the interplanetary internet study , researchers suggest that the DSN's antennas could be pointed at mars to connect earth and mars for at least 12 hours each day satellites orbiting mars should provide a full time connection between the twoplanets.

A martian rover probe or human colony will provide a mars portal to the interplanetary internet.

2. Satellite Constellation

Under the mars network plan , the DSN will interact with a constellation of six microsatellites and one large Marsat satellite places in low mars orbit . the six microsat are relay satellites for spacecraft on or near the surface of the planet , they will allow more data to come back from the mars mission. The marsat will collect data from each of the smaller satellites and beam it to earth . It will also keep earth and distance spacecraft connected continuously and allow for high bandwidth data ,and video of the planet.

3. Protocol used

Programmers are developing an internet file transfer protocol to transmit the messages and overcome delay , and interruptions this protocol will get as the backbone of the entire system much as the internet protocol (IP) and transmission control protocol (TCP) operate on earth . Vint Cerf is part of the team of scientists who are developing a new protocol to enable reliable file transfer over the long distances between planets and spacecraft . this new space protocol must keep the internet running even if some packets of data or lost during transmission . it must also block out noise picked up while crossing millions of miles . An initial test of DTN in space last October was successful .The code was loaded on a comet-studying space craft called deep impact ,as that probe headed out for a flyby of comet Hartley 2 . During the test about 300 images where transmitted over distances that stretched upto 24 million km . The software even survived the unintentional reboot of one of the earth based antennas . A key to DTN is a technique called "store and forward" .Basically every node hangs on to the data it receives until it can safely pass it on . On earth , the data would simply get dumped if there was a problem and be retransmitted by the source . A 'region' is an area where the characteristics of communication are the same . region characteristics include communications , security , the maintenance of resources , perhaps ownership , and other factors . The interplanetary internet is a "network of regional internets"

The bundling protocol operates in two ways:

It operates in a " store and forward "mode , very similar to e-mail , where bundles are held at routers along the way until such time as a forward path is established .It avoids the need for a sender to store data until an acknowledgement is received from the other end by operating in a "custodial" mode . In this mode , intermediate nodes in the network can assume responsibly for ensuring that bundles reach their destinations , allowing senders (and previous custodians) to reassign resources to new observations . In the presence of high error rate links , the hop-by-hop store-and-forward bundling model with per-hop error control increase the probability of successful end-to-end transmission.

One idea for the space protocol is called the Parcel Transfer Protocol (PTP) , which will store and forward data at the gateway of each planet . The IPN would work more like e-mail , where information would be stored and forwarded to any hub on the system . This "delay-tolerant "network would provide an always –on connection between spacecraft , planet and the terrestrial internet . In the case of mars these hubs could be installed on a series of satellites circling the planet . Astronauts could sent messages from the far side of mars , and those messages would be relayed to the nearest hub for routing back to earth . The "store and forward" methodology of the IPN helps minimize problems that crop up due to the vast distance involved , such as high error rates and latency rates that are minutes or even hours long (versus fraction of a second on earth) .

A routing function will direct bundles (messages) through a concatenated series of internets , just as the earth's current Internet Protocol(IP) routes data through a series of independent networks on earth .To guarantee reliability of the end-to-end transfer , the bundles will also contain retransmission mechanism functionally similar to those provided by the terrestrials internets Transmission Control Protocol(TCP).

IMPLEMENTATION

The InterPlanetary Internet Special Interest Group of the Internet Society has worked on defining protocols and standards that would make the IPN possibleThe Delay-Tolerant Networking Research Group (DTNRG) is the primary group researching Delay-tolerant networking (DTN). Additional research efforts focus on various uses of the new technology.

The canceled Mars Telecommunications Orbiter had been planned to establish an Interplanetary Internet link between Earth and Mars, in order to support other Mars missions. Rather than using RF, it would have used optical communications using laser beams for their higher data rates. "Lasercom sends information using beams of light and optical elements, such as telescopes and optical amplifiers, rather than RF signals, amplifiers, and antennas"

NASA JPL continued to test the DTN protocol with their Deep Impact Networking (DINET) experiment on board the Deep Impact/EPOXI spacecraft in October, 2008. In May 2009, DTN was deployed to a payload on board the ISS. NASA and BioServe Space Technologies, a research group at the University of Colorado, have been continuously testing DTN on two Commercial Generic Bioprocessing Apparatus (CGBA) payloads. CGBA-4 and CGBA-5 serve as computational and communications platforms which are remotely controlled from BioServe's Payload Operations Control Center (POCC) in Boulder, CO.[17][18] In October 2012 ISS Station commander Sunita Williams remotely operated Mocup (Meteron Operations and Communications Prototype), a "cat-sized" Lego Mindstorms robot fitted with a BeagleBoard computer and webcam, located in the European Space Operations Centre in Germany in an experiment using DTN.These initial experiments provide insight into future missions where DTN will enable the extension of networks into deep space to explore other planets and solar system points of interest. Seen as necessary for space exploration, DTN enables timeliness of data return from operating assets which results in reduced risk and cost, increased crew safety, and improved operational awareness and science return for NASA and additional space agencies.

DTN has several major arenas of application, in addition to the Interplanetary Internet, which include sensor networks, military and tactical communications, disaster recovery, hostile environments, mobile devices and remote outposts . As an example of a remote outpost, imagine an isolated Arctic village, or a faraway island, with electricity, one or more computers, but no communication connectivity. With the addition of a simple wireless hotspot in the village, plus DTN-enabled devices on, say, dog sleds or fishing boats, a resident would be able to check their e-mail or click on a Wikipedia article, and have their requests forwarded to the nearest networked location on the sled's or boat's next visit, and get the replies on its return.

Challenges to Interplanetary Internet(disadvantages)

An interplanetary internet will make data move drastically faster between earth and the probes and other spacecraft that are millions of miles away .

Engineers need to overcome several challenges before we plan our virtual journey to mars through cyberspace . challenges are :

1. The speed –of-light delay

On , earth two computers connected to the internet are only a few thousand miles away at the most . Because light travels 3 lakh km per hour . It takes only a few fractions of a second to send a packet of data from one computer to another . In contrast , distances between a station on earth and one on mars can be between 38 million miles (56 million km) and 248 million miles (400 million km) . At these distances , it can take several minutes or hours for a radio signal to reach a receiving station . An interplanetary internet will not be able to duplicate the real time immediacy of the internet . that we use The "store and forward method" will allow information to be sent in bundles and overcome the concern of data being lost due to delays .

2. Power supply

A major problem faced by the interplanetary internet is with power consumption by the various nodes in the system . The fact that the solar flux on mars is half that on earth , and that the use of nuclear power sources is still somewhat forbidden , and it becomes clear that both power sources and power usage need to place a strong emphasis on efficiency and economy . Current photovoltaic –powered satellites start to become impractical beyond the orbit of mars necessitating more efficient hardware and different power supplies .

3. Satellite maintenance

The satellites of the mars network will be tens or hundreds of millions of miles from earth and that means that it will be hard to get up there to fix things when they go wrong . The components of these satellites would have to be much more reliable than those circling earth.

4. Hackers

Hackers pose the biggest threat to an interplanetary internet . Break –ins and corruption of navigation or communication systems could be disastrous for space missions and even cause deaths in manned- spacecraft missions . Developers are taking every precaution to design a system that will be able to control access the protocol selected will have to be impenetrable to hackers , something that has not been possible on earth .Developers may look at the Secure Sockets Layer (SSL) Protocol used for financial transaction as model for securing the interplanetary internet .

5. Noise Interference

Even if noise interference problem can be solved to a particular extend with the help of the new protocol , it is going to be a serious threat for the scientists . Since the distances to be covered by the signals are so large , the interference of noise in the IPN will be very high

Applications & Future Developments

The interplanetary internet will possibly wire us to mars within the decade and to other planets in the decade to follow . It will no longer be necessary to go into space to experience space travel . Instead , space will be brought right to your desktop with enhancements made to boost data rate transfers , you and I might soon be able to take a virtual space trip to the mountains of mars

, the rings of Saturn or the giant spot on Jupiter . The main fields of application of IPN are:

- Astronomical Research

IPN actually helps scientists to study various events happening in the universe easily with the help of more and more data which will be available from IPN they can make more effective study .

- Public Viewing

High between satellites can sent videos for public viewing on the earth . now we are only seeing events on other planets with the help of animation or if original videos , they will be blurred due to the lower data rate , which will be solved to a particular extend with the help of IPN . Delay-tolerant networking which has several major areas of application in addition to the interplanetary internet , including stressed tactical communications , sensor webs , disaster recovery , hostile environment and remote outposts.

- Virtual World

Can be implemented with the help of virtual reality and can be used for scientific and entertainment purposes . This will make an economical way for ordinary people to experience various environments in other planet .

- Space tourism

Space tourism is human space travel for recreational purposes .

II. CONCLUSION

The space exploration field needs computers that are capable to process huge amount of information and then render them into a simple form so that scientist can use them for their own purposes. And there is no alternative way to gain success in space research and related space technology.

Interplanetary internet is going to change the way of study of astronomers and the way we think about other planets. IPN will truly reach us to the corners of universe .with this kind of networks in place , the communications problem resulting from having very little communication infrastructure in place at mars that played the 'rescue ' efforts after the mars polar lander disappeared would be greatly simplified The potential application of a interplanetary internet extend well beyond the management of space mission . people who surf the internet today and tap websites in extreme locations such as Antartica may some day be able to communicate to web or ftp servers in martian microsatellites to request data directly from mars and that just the beginning . eventually there will be web servers on the International Space Station , on (or above) the moon and other planets and other regions of the solar system. Internet and Information Technology plays a vital role in space technology and bring various enhancements in space exploration .

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