ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 5, Issue 5, May 2016

Study on Google's Loon Project

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***Abstract*-Loon Project is a research and development project being developed by Google with the mission of providing Internet access to rural and remote area. This paper describes an overview of a Balloon-Powered Internet for everyone. The project use high-altitude balloon placed in the stratosphere at an altitude of about 20 miles (32km over of 40 km) create an aerial wireless network with up to 3G-like speeds. For balloon to balloon and balloon to ground communication, the infrastructure use antennas equipped with specialization radio frequency technology. As per of 2013 test navigate in new Zealand, project loon used ISM bands (specifically 2.4 and 5.8 GHZ bands) that are available for anyone to use. This type of service can be use for making connection with the remote and rural areas, and disaster affected people.**

Google may initially partner with BSNL for testing this technology by use broadband spectrum in 2.6 GHZ band. When contract, a Google spokesperson refused to comment. The technology used for 4G service, has potential to replace mobile towers as it can directly transmit signals on 4G mobile phones.

Keywords-Google Project Loon, Stratosphere, Equipment, solar plate.

I. INTRODUCTION

This massive project may include a setup of around 2, 00,000 towers in India alone Even though India has excelled in different sectors, it still hasn't been able to provide Internet facilities to all. Tech giants like Facebook and Google are continuously working on its pilot mission of providing Internet to all corners of the earth, thus helping the world connect to each other. Recent reports state that the Project Loon introduced by Google in 2013 may also be introduced in India soon. A report in Wall Street Journal states that Google is in talks with telecommunications companies in India to enable balloon-based Internet in rural and developing areas as well.

A research conducted by the Google X research lab revealed that around 4.5 billion people don't have access to the Internet in the technology-driven world. The Project Loon by Google floats 60,000 feet in one of the Earth's layers. And impressing, the Wi-Fi friendly balloon provides Internet using the same technology used by cellular devices at any latitude and can last in the sky for 100 days.

This massive project may include a set up of around 2,00,000 towers in India alone, which in turn hints at a huge investment in the telecommunication infrastructure. On the arrival of the Project Loon in India in 2016, the Project Loon balloon can prove to be a boon to rural areas in India.

II. Google Loon Project: Definition, Terminology

Google's an attempt to build a network of stratospheric balloons to provide Internet access to anyone, anywhere in the world. Loon balloons travel twice as high as commercial airlines—20 kilometers above the earth—and function like a network of floating cell towers. Right now, your phone uses a stationary tower on the ground, and switches to new cell towers as you move around. Loon balloons are just cell towers that move, following the wind currents, and your phone would switch to the nearest one just like it does with stationary towers.

III. Overview on Loon

We want to help the Internet reach its maximum potential to make people's lives better. Internet access has a positive impact in areas like education, healthcare, and democratic participation. But over four billion people have unreliable, unaffordable, or slow connections or even no access at all. That's why Google has always invested in a variety of projects that help the Internet grow, from Chrome to Google Fiber, and why we continue to develop new technologies, like Loon, that have the potential to bring hundreds of millions more people online in the coming years.

3.1 Existing Loon Technologies

We've come quite a ways since our first tests in New Zealand in 2013, where our goal was to connect to real users for the first time. Our balloons are lasting longer—our record so far is 187days aloft!—and our navigation is getting more accurate as we improve our ability to predict wind patterns. We recently successfully navigated a group of our balloons a total distance of10,000 kilometers, and came within one kilometer of our target destination. Given that, we think we may only need two launch sites in the Southern Hemisphere to be able to navigate our balloons to any point in that hemisphere. We've also made the actual connection technology more efficient—we used to have to install antennas to carry the signal from the balloon to people's phones, but now people can just connect directly from an LTE enabled mobile phone The main challenge we're focused on now is scaling. In order to make this work for everyone, anywhere, we need to launch and navigate thousands of balloons to ensure there's always one overhead. We're working with several Telco's around the world to test integrating Loon into their existing networks and operations.

In Japan, 2009 proposed a new ballooned wireless mesh network system for disaster. It consists of normal rubber balloons and wireless network devices. The balloon typically floats around 40-100 m (130-300 ft) in the sky. Each balloon

has two wireless network devices for (1) the vertical network and (2) the mesh network.
(1) The vertical network is for communications between the wireless network node attached to the balloon and mobile PCs or devices on ground. It uses the access method, IEEE 802.11b,g with the maximum distance around 600 m (2000 ft). That is a standard Wireless Local area network (WLAN) protocol also known as Wi-Fi. It uses a hexahedral antenna because it can cover a ground area of around 100m (328 ft) diameters from 40 m (131 ft) above the area. (2) The mesh network is for between balloons. It works over Wi-Fi IEEE 802.11j with 4.9 GHz transmission frequency, 250mW power density, and 54Mbps network bandwidth, which is now incorporated into the IEEE 802.11-2007 standard. More information is shown in Table 1.

Table 1. Specifications of mesh and vertical network

	Mess Network	**Virtual network**
Standard	**IEE802.11j**	**IEEE802.11b,g**
Frequency	2.4 GHz	4.9 GHz
Signal Power	250mW	10mW
Trans. Speed	54 Mbps	54 Mbps
Max. Distance	600 m	100 m
Antenna	octagonal plains	co-linear

The wireless mesh network is made up of the balloons by auto configuration functions. This is achieved by electro-magnetic field power density. For example, a balloon tries to find one of its neighbor balloons which has the strongest power density and establish a connection with it. Then, the mesh network eventually has a minimums panning tree network. If a balloon moves by wind or falls down, the connection between balloons is closed. The neighbor node immediately notices the failure, and tries to find another neighbor node automatically as the same way. This makes the mesh network stable.

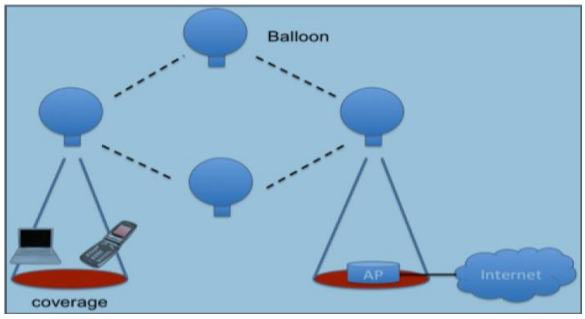

Fig. 3.2.1balloon networking for disasters

If a disaster occurs, some balloons would be launched. One of them, which is the closest to the area which has Internet access, establishes a connection over IEEE 802.11b,g. Other balloons organize a mesh network in the sky through the procedures above. Mobile devices on ground can join the closest balloon network in the sky over Wi-Fi, and communicate with the balloon as shown in Figure 1. The balloon forwards the received data packets from the mobile device to its neighbor balloon through the mesh network. If a balloon, which has an Internet connection, receives the packet, it sends the packet to the AP on ground.

3.2.1 Balloon Collecting data

The only data we collect is what we need to help us accurately track, maneuver, and monitor the health of our balloons—so, wind speed and direction, plus the temperature and GPS location of each balloon. We actually share our data on wind speed and temperatures with the scientific community—no other system is able to collect and share as much information on conditions in the stratosphere.


3.2.2 A Loon balloon floats above New Zealand's Southern Alps

How big are the balloons? Do they pose any danger to planes or birds?
They're about the size of a tennis court when fully inflated, although they're almost impossible to see from the ground. And because they are so high up (twice as high as commercial airliners),they avoid planes, wildlife, and even bad weather.

What happens if a balloon malfunctions and drops from the sky?
All Loon balloons are equipped with a parachute, which deploys automatically if the balloon makes an unexpected landing (which is unlikely). The balloon will also send us an immediate notification, so we can use the built-in GPS to determine its exact location and remain inconstant contact with local aviation authorities throughout the descent to ensure a safe landing. The balloons also carry transponders so they show up on air traffic control radars just like airplanes do.
But we try hard to avoid an unexpected landing in the first place. We monitor the health of each balloon and when it looks like one is getting close to the end of its life, we

navigate it down safely, away from people. We're also setting up designated landing zones where we can more easily recover the balloons . It's important to get them back to our lab so we can understand what went well and what didn't—a lot happens in the stratosphere that we can't replicate on the ground. By examining the balloon itself, we can learn things like where the fabric is getting stressed as it's expanding, or, if it got a hole, we can try and figure out what caused it.

Is it true that Loon is going to provide Internet coverage to Sri Lanka next year?

We've signed an MOU and begun discussions with the Sri Lankan government about bringing Internet to the country. It's still early in the process, so the timetable for when service will be available isn't finalized yet, but we hope to begin some testing in the coming months. If you want to keep up with the latest announcements, you can follow our G+ page.

IV. Project Loon

Google's internet-beaming balloons, known as Project Loon, are currently being tested in Indonesia and Sri Lanka, where high-speed Internet signals are transmitted from balloon clusters floating 60,000 feet above the Earth.

But the project, aimed at countries with limited internet coverage, may face regulatory issues in one of its biggest target markets - India. Indian newspaper, the Economic Times, reported that India's Department of Telecommunications has pointed out several technical issues with the project, which may prevent it from going ahead."The proposed frequency band to be used in the Loon Project of Google is being used for cellular operations in India and it will lead to interference with cellular transmissions," Union communications and IT minister Ravi Shankar Prasad wrote in a memo to the Indian upper house of Parliament, the RajyaSabha.

According to the Economic Times, the Home Ministry, Aviation and Defense Ministry were also concerned about the security of the project, with fears about surveillance, and interference with chartered flight routes or military aircraft.

Google's new CEO, SundarPichai will be visiting India next month to meet with government representatives. The Indian Prime Minister NarendraModi and MrPichai reportedly discussed the Loon project on MrModi's recent trip to Silicon Valley in September, so the Loon pilot is thought to be a major point of discussion.

According to technology news site Recode, a spokesperson for the Loon project said in a statement:"We've had several positive meetings with the Indian Government about Project Loon...We have already successfully tested integrating the Loon system into the infrastructure of several major telco's."We believe that we can operate a balloon network on shared spectrum in a way that will enhance coverage without impacting existing operations, just like a telco can roll out new towers to expand coverage without causing interference."

Fig:4.1Facebook is trialing an internet-beaming drone called Aquila

Several other technology companies are involved in the effort to connect the unconnected - Facebook is testing out its WiFi-beaming Aquila drones in an unknown location, while Microsoft is trialing a pilot project utilizing unused television spectrum to deliver low cost Internet connectivity to the Indian state of Andhra Pradesh.

4.1 How Loon moves?

Project Loon balloons positioned in the stratosphere winds at an altitude of about 20 km, twice as high as airplane flights and the weather changes . In the stratosphere, there are many layers of wind, and each layer of wind varies in direction and speed. Why the stratosphere means? It is situated on the edge of space, between 10 km and 60 km in altitude having steady winds below 20 mph. This spherical layer is great for solar panels because there are no clouds to block the sun. Loon balloons are directed by rising or descending into a layer of wind blowing in the desired direction of travel by using wind data from NOAA. By moving with the wind, the balloons can be arranged to form one large communication network. Each balloon is equipped with a GPS for tracking its location. Project Loon has complex algorithms to determine where its balloons need to go, then moves each one into a layer of wind blowing in the right direction.

People connect to the network using a special internet antenna attached to their building. The signal bounces form balloon to balloon the global internet back on earth. Each balloon can provide connectivity to a ground about 40km in diameter at speeds comparable to 3G. For balloon to balloon-to-ground communications, the balloons use antennas equipped with specialized radio frequency technology. Project loon currently uses ISM band (specifically 2.4 and 5.8 GHz bands) that are available for anyone to use.

4.3 Loon design

Loon balloons are also unique in that they are steerable and entirely solar powered. The balloons and equipment can be reused, and each loon has an approximately 2 years of life time.

In loon design there are three main components (see Fig.):

1. Envelope
2. Solar Panels
3. Electronics

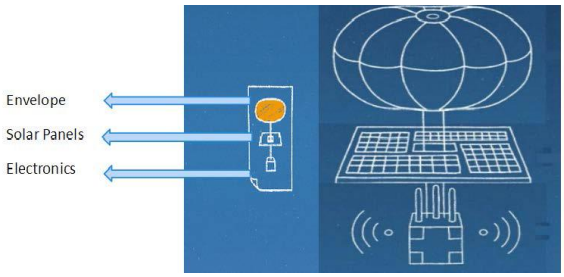

Fig:- Loon Design .

Envelope: The inflatable part of the balloon is called envelope. Each super-pressure balloon is made of polyethylene plastic material and filled with helium. When fully inflated, the balloon height is 12 m and its width is 15 m. The envelope is designed to resistant exposure to UV rays and is capable to function at dramatic temperature swings as low as -80oC. A well-made polyethylene plastic balloon envelope is critical for allowing a balloon to last around 100 days in the stratosphere. A parachute is attached to the top of the envelope, which is used for bringing down the balloon safely.

Solar panels: Each balloon's solar panel provides power to its own electronics. The solar array is made of flexible plastic laminate supported by a light-weight aluminum frame. It uses high efficiency monocrystalline solar cells. The solar panels are mounted at a steep angle to effectively capture sunlight. The panels produce approximately 100 Watts of power in full sun (that power is sufficient to keep Loon's electronics running 24 hrs a day), and the additional power is stored in a rechargeable battery.

Electronics: A small electronics box (payload) hangs underneath the inflated envelope. This box contains circuit boards, Linux-based computer, radio antenna, GPS, sensors, and batteries. They have specific functions: circuit boards to control the system, radio antenna for communication, GPS for tracking location, sensors to monitor and record weather conditions, and lithium ion batteries to store solar power.

4.4 How Loon connects?

Each balloon has a radio antenna that provides constant connectivity to the ground and connects each balloon to other balloon. There is a special ground antenna that is installed on the home or workplace to access the internet from balloon. Google™ claims that each balloon can provide signal connectivity to a ground area about 40 km in diameter and able to deliver 3G comparable speeds (up to 10 Mbps). These antennas use ISM bands of spectrum 2.4 GHz & 5.8 GHz. ISM radio bands (portions of the radio spectrum) reserved internationally for industrial, scientific, and medical purposes other than telecommunications.

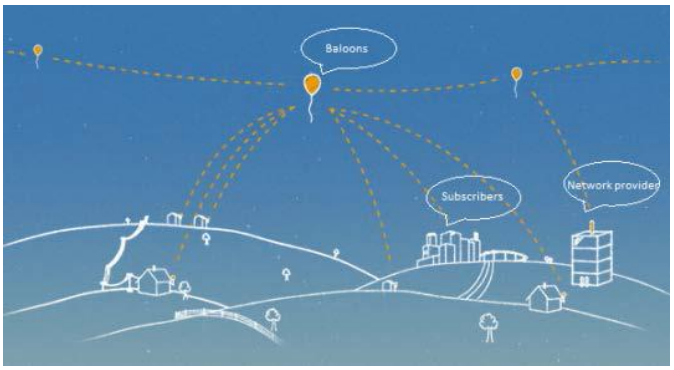

Fig: Transmitting signals

Google™ balloons are connected in the mesh topology to ensure reliability. The IEEE802.11s standard defines how wireless devices form the mesh network. Loon's protocol stack is not disclosed yet.

There are two types of communications:

1. Balloon-to-balloon communication
2. Balloon-to-ground communication.

Subscriber-to-ISP: First, the specialized internet antenna on the ground sends signals to a balloon. Then signal hops forward from the balloon to neighboring balloons. Finally, signals from the balloon reach a ground station which is connected to a local internet provider, or pre-existing internet infrastructure which provides service via the network of balloons.

Fig :Ground antenna

ISP-to-Subscriber: The Internet Service Provider or pre-existing internet infrastructure sends response back to the Balloon network; then data travels through the balloon network. Finally, the closest balloon to the subscriber receives data and sends it back to the subscriber .

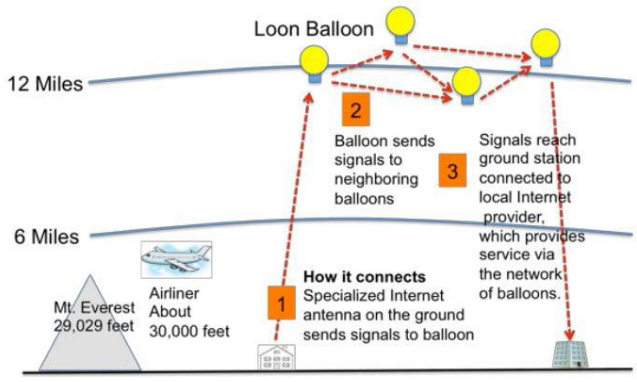

Fig .How it connects in Project Loon.

Maintenance :
If a balloon fails or needs maintenance, Google™ staff brings the balloon down. A trigger mechanism on the top of the balloon would deflate it by releasing gas from the envelope, and it releases a parachute that brings the balloon down to the Earth in a controlled descent. GPS equipment tracks where the balloon is landing. Google™ needs the dedicated staff across the globe for balloon maintenance.

V. Balloon-Specific Problems

A number of technical challenges arise for Project Loon, not because it is a HAP but specifically because it is a balloon-based system. Indeed, most skeptics have focused their concerns on this area. In September 2013, hot air balloonist and aeronautical engineer Per Lind strand went so far as to say that Google would be unable to keep a helium balloon afloat for more than three days—a rather strange claim, given that Google was already claiming 100+ day journeys at that time .

The question of steering balloons using stratospheric winds is a tricky one, though. Google has admitted that their tests flights have been around the same latitude because winds there are favorable; the successes it has had steering balloons around New Zealand and South America may not be repeatable closer to the equator. Lind strand's other persistent claim about the futility of using balloons as a High-Altitude Platform is that balloons inevitably end up at either the North Pole or the South Pole; they can't be kept in a predetermined latitude indefinitely.
However, Google is not planning to launch balloons indefinitely. It plans to keep each envelope up for a few months at a time before landing it, recycling the balloon, and sending the payload back up on anew balloon.
Others have questioned the number of balloons needed, which could number in the millions; Google's counterargument is that only a few tens of thousands are needed as long as they are steerable. They currently only have the infrastructure to keep about 2000 aloft at a time, but that infrastructure will presumably grow in the next few years.
A more serious concern is Google's reliance for helium for this platform. In 2013 the world faced a significant helium shortage, with prices soaring to double what they had been a few years earlier. Some experts expect there to be cyclical helium shortages in the foreseeable future , which would make a helium balloon–based HAP untenable. However, Google has an answer for this, too: it is researching ways to use hydrogen balloons in a safer way than the famed Hindenburg did . Whether it will find away to make this transition is, however, yet to be seen. A final concern about Google basing its Internet universalization plan on balloons is simply that other technologies may ultimately prove more tractable. Project Loon will probably be competing with Facebook/Internet. org's drone-based HAP, as well as expanding satellite-based Internet from O3b, among other planned ventures. Google doesn't seem very threatened by alternate technologies, though; it is investing heavily in O3b, and has even acquired two competing technologies itself — a satellite system called Skybox Imaging, and an unpiloted drone called Titan .

5.1Logistical Issues

More mundanely, there are a number of logistics Google will need to work out to bring Project Loon online. Because the balloons will fly over many governments' airspace, Google will need to secure flyover rights from each country at a given latitude in order to service countries in that latitude. If a single country refuses to grant flyover rights or work with it to build base stations, that country would effectively veto many other countries' access to Project Loon. When asked about this, project manager Cassidy said only that such negotiations were going better than one might expect, and that many countries—even ones known for Internet censorship—were very welcoming of Project Loon. However, it seems entirely unrealistic to expect that every country on Earth will be eager to partner with Google.

Google has solved radio frequency rights, another common concern, by partnering with local telecoms. However, this in itself raises other logistical issues. Will Google provide censored Internet connections in countries where the government requires telecoms to restrict Internet access? How will it deal with corrupt telecom systems? This may prove to be a thorny issue as Project Loon rolls out.

5.2Does Project Loon Address the Right Issues?

A final critique of Project Loon is that providing expanded LTE coverage may not be the best approach to ensuring universal Internet access. Project Loon addresses two of McKinsey & Company's four major barriers to Internet access: infrastructure and affordability. By providing Internet using cheaper infrastructure than terrestrial platforms, Loon promises to make the Internet available in locations that currently lack it, as well as in locations where it is currently too expensive for many consumers. However ,it does nothing to increase *electrical* infrastructure, which as a significant barrier to Internet in much of Africa. The high costs of charging a device in the absence of grid electricity will probably keep many low-income Africans offline even if Internet access itself becomes much more ubiquitous and affordable. And, of course, consumers will need to buy Internet-capable devices, which are still out of reach of those who live on a dollar a day.

Providing expanded LTE coverage also does nothing to ameliorate the other two problems, namely incentives and user capability. The 28 percent of offline individuals who are illiterate will be no more able to read a web page after getting Loon access than they are now. As Zuckerberg says, non-terrestrial network platforms

"will eventually be necessary to connect everyone since some people live in remote areas where there is just no infrastructure to connect them. But this isn't the problem most people have. In fact, almost 90% of the world's population already lives within range of an existing cellular network. For everyone in those areas, we don't need to build completely new kinds of infrastructure to help them connect. We just need to show why it's valuable and make it affordable".

However, while Zuckerberg is right that 90% of people live in cellular range, we have already shown that Ericsson's statistics support the idea that insufficient cellular network speed is a significant impediment to Internet access for 1.2 to 2.8 billion people. Upgrading service to 4G speeds for those people would be no small feat.

V Conclusions

Internet connectivity and communication become one of the basic needs in modern human daily life. An innovative and scalable idea like the Google™ Project Loon would aid and benefit remote areas of the world as well as population to reap the benefits of modern communications. It would also provide backbone communications during and after natural disasters when ground infrastructure is scarce or destroyed.

Acknowledgement

We thank our colleagues from IMCOST who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper.

We thank Mrs.Trupti Mam for assistance us by providing proper IEEE formats and all faculties for guiding us.

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