GOOGLE™ PROJECT LOON

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Abstract

This paper describes an overview of a Balloon-powered Internet for everyone. Currently we are using the internet service through Internet Service Providers to connect globally. Loon purpose is to provide wireless network to remote areas through of a set of high altitude balloon equipped with advanced sophisticated wireless transceivers to connect people globally. This technology could allow developing countries to avoid the using of expensive underground infrastructure.

What is Project Loon?

In the evolution of the Internet nowadays, some population of the world enjoys the benefits of the Internet. According to Google™, two-thirds of people on the earth, reliable Internet connection is still out of reach. To solve this global problem, Google™ developed an innovative project called the "LOON", to provide broadband for free in rural and remote areas, as well as to improve communication during and after natural disasters or a humanitarian crisis. During a crisis, connectivity is really significant because information in itself is really lifesaving. Here the key concept is a set of high-altitude balloons ascends to the stratosphere and creates an aerial wireless network (see Fig. 1). The technology designed in the project could allow countries to avoid using expensive underground infrastructure. [1][2]

Figure 1. Balloon-based network [1].

History

The idea may sound a bit crazy, initially everyone thought it as a prank by Google™. The Project Loon unofficial development began in 2011 and officially announced as a Google™ project in 2013. A pilot experiment was happened in New Zealand's South Island where about 30 balloons were launched (see Fig. 2). [1] After this initial trial, Google™ plans on sending up 300 balloons around the world at the 40th parallel south that could provide coverage to New Zealand, Australia, Chile, and Argentina. Google™ hopes to eventually have thousands of balloon fly in the stratosphere. [3]

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Figure 2. Balloon launching in New Zealand [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 (see Fig. 3). 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. [9] 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. [1][2]

Figure 3. How Loon moves [1].

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. 4):

1. Envelope
2. Solar Panels
3. Electronics

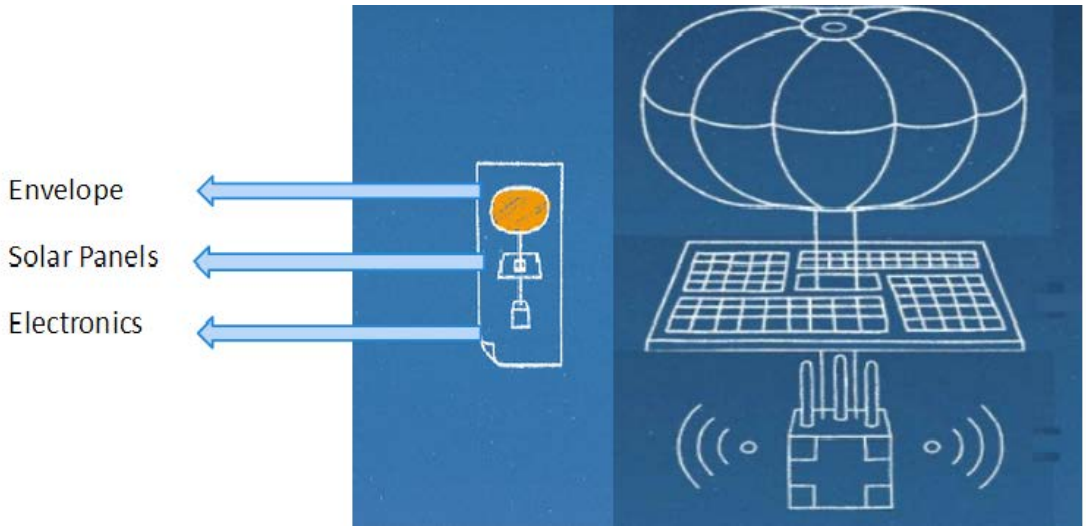

Figure 4. Loon Design [1].

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 [6]: 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. [1]

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). [1] 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. [4][7]

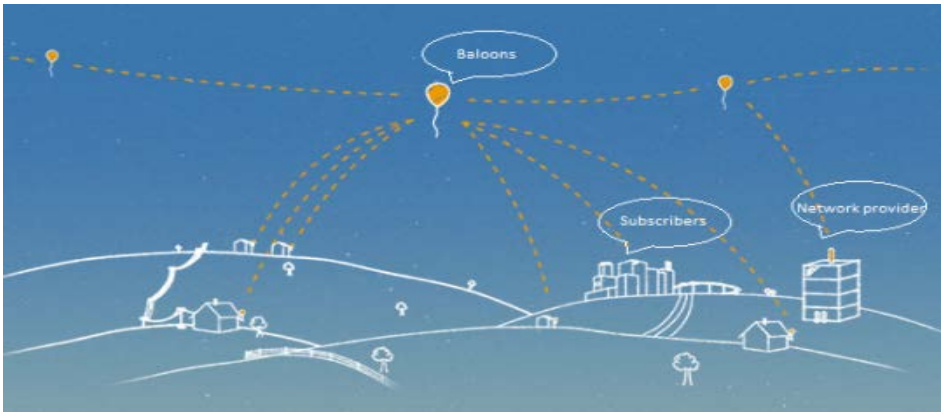

Figure 5. Transmitting signals [5].

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. [6]

There are two types of communications (see Fig. 5):

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

Subscriber-to-ISP: First, the specialized internet antenna (see Fig. 6) 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.

Figure 6. Ground antenna [6].

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 (see Fig. 7). [2][5]

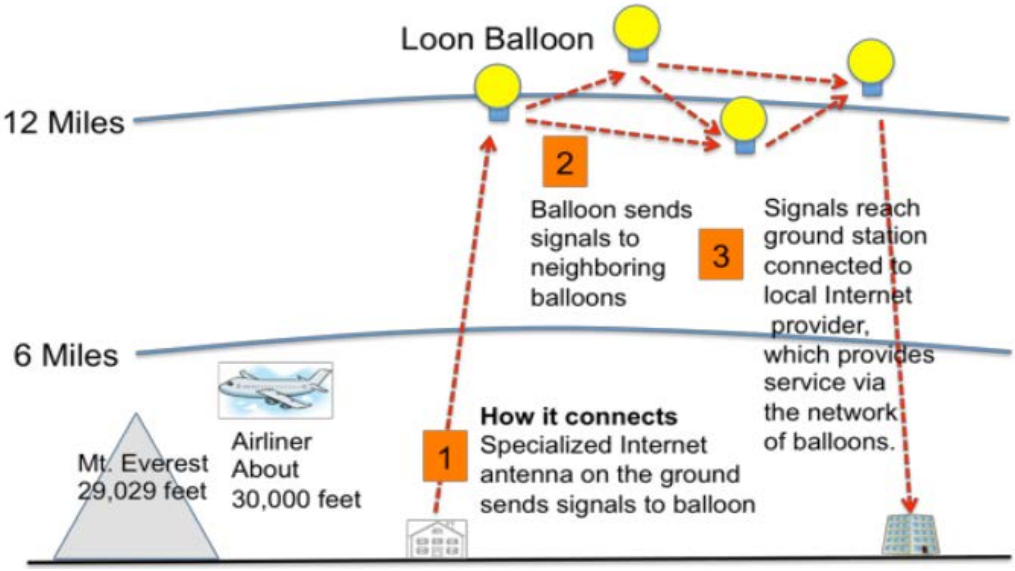

Figure 7. How it connects in Project Loon [5].

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. [1]

Challenges

Google™ wants to build a network with no borders. Its biggest obstacle is not technology. Some countries unwilling to give permission. In addition to permissions, Google™ should negotiate with countries to purchase or borrow specific radio frequencies. There might be spying and security threat over data. [8]

Pros:

The most obvious avails of the project is that Google™ will provide the Internet for free. This may increase the Internet usage throughout the world. Ground antennas are easy to use and install. No extra underground infrastructure is required; the equipment is relatively cheap.

Cons:

This project is labor intensive and provides the limited internet speed. Balloons can work 100 days only. The main problem is that the hardware failures cannot be reached at the intended location. If a Loon balloon fails, it can either remain up in the air floating or it might go down in unwanted areas like sea. These scenarios are a huge concern to the stability as well as the safety of people. [1]

Competing Ideas

Facebook™'s Drones is the competing idea for Google™ Loon. As compare to the balloons, drones provide more coverage area per drone, more internet speed, and can stay up in the air for years (~5 yrs.). But it

requires expensive equipment and could do a lot of damage if it fails and fell out of the sky, and security and privacy have other concerns accompanied the use of drones. [10]

Conclusion

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.

Abbreviations

NOAA - National Oceanic and Atmospheric Administration
GPS - Global Positioning System
UV rays - Ultraviolet rays
IEEE - Electronics and Electrical Engineering
ISP - Internet Service Provider

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