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Airborne Internet - A Step towards Technological Inclusion

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Abstract - In the era where we take internet access for granted, it is a setback to know that two out of three persons on the globe do not have access to internet connectivity. It is said that when internet penetration of a country increases by 10 percent, the GDP of the country can increase by 1.4 percent. Hence it becomes a quintessential task to have internet connectivity to cover as much as geographical area as possible. In this paper discusses technologies which help in providing internet access to places, where it is considered difficult to provide. Such places can be said to be when in transit in an aircraft or geographically tougher terrain where is difficult to lay optical fibres or cables. Airborne internet, Google's project LOON is a few of the things explained here. We can see how these technologies are implemented and discuss how various researches have contributed their ideas for improving connectivity. We see the applications and advantages of "network in the sky" here.

Keywords - Airborne Internet, LOON, ANP, AANET, AODV

I. INTRODUCTION

The necessity of the day is being able to access the internet wherever we are present. But there are still a lot of areas like rural areas, remote places, aircraft transits where it is still a very challenging task to have uninterrupted connectivity to the internet. Some of the places where internet is already accessible, there is an issue of speed persistent while uploading or downloading of information like video, audio so on. Most of these places will be having internet access through satellites, which again is restricted in the speed and cost of procurement of this facility is high. Hence there raises a necessity to find a technology where people from remote places can have accessibility to the internet and people who already have access, to be able to access it economically with higher speeds.

It's now the fact that internet access is very well established in airports where people complete the chores for which they would require internet access. But it is also pressing concern that once people aboard the flight they are almost like disconnected from the world of the internet as there is very less or almost no internet access while in transit in aircraft. Also, remote places like rural areas have very limited access to the internet, especially in India where almost 70 percent of the population resides in rural areas. One more situation where we get the necessity having the internet connectivity is when there is a natural calamity like earthquakes or Tsunamis where generally the conventional communication elements like towers are destroyed and it becomes difficult to communicate in such scenarios. In such situations having a way to communicate and locate people in distress becomes a very important task. With the help of airborne internet and devices like cell phones, such areas can be covered.

Airborne internet refers to providing internet access between aircraft to aircraft, aircraft to ground and within the aircraft. This is made possible by making the aircraft an "essential wireless router". The idea of "Airborne Internet" came to light in 1999 at NASA Langley Research Center's Small Aircraft Transportation System(SATS) Planning Conference[9]. Three different methods were proposed for creating the communication nodes in the air they were manned aircraft, unmanned aerial vehicles(UAV) and the third one was to use blimps. The betterment here compared to conventional ways of communication was that data rates would be better as the distance from the ground compared to satellite communication would be much lesser, also the cost of enablement would be much economical.

Different researchers have proposed different methodologies to implement this. Some have directly dived into this area; some have used the basic idea of this to be implemented across different areas. Though there have been attempts to have internet access within aircraft mostly they have been based on satellite communication. In proposed airborne internet its mostly about using aircraft itself as routers/nodes of communication without having to use satellite communication. As the aircraft are mobile objects, the use of the MANET routing protocol is significant.

The recent technology development on the same lines as "router in the air" is adapted by Google's LOON project. Its main aim is providing internet access to remote and rural areas, and during natural calamities where a single messaging capability would save thousands of lives. It uses balloons placed in stratosphere as router in air to provide internet access over a certain area, especially where it is difficult to provide conventional ways of communication.

Users of the internet connection via a special antenna fixed at their end. This paper aims at giving an overview of airborne internet, related technologies and giving an overview of different researches based on same. Here will be a fair description of working of airborne internet, applications and advantages of this technology over the conventional ones. Project Loon which is Google's ambitious program is seen here through a bird's eye view and the advantages of same are elaborated.

Rest of this paper explains about airborne internet in sections. In Section II we come across related works of different scholars on Airborne Internet. In Section III we see the working principles of airborne internet technology and project Loon. Section IV we see the advantages of airborne internet and Project Loon. Section V concludes and provides future aim of the technology.

II. Related Works

A. The Global In-flight Internet:

In the paper "The Global In-flight Internet" [1] the authors have highlighted the concept called AANET which stands for Aeronautical Ad-hoc Network. In AANET the conventional architecture of the network is extended to include multi-hop ad-hoc networking(MANET). This is in addition to conventional communication with ground stations which is directly established and with satellite communication capability. In this AANET an aircraft can download the data initially either through ground station connection or through satellite connection and then happen to share the cached data with other aircraft as and when requested. This is possible by establishing a single or multi-hop connection between the serving aircraft and requesting aircraft by making use of ad hoc network principles. This comes with its demands say the need for enough aircraft to be present in the sky at a given point of time to establish an Adhoc network route within the aircraft. Second routing will be a challenge here as the aircraft would be moving at high speed thus the routing needs to cluster-based as it cannot be a flat hierarchical scheme and routing should consider the stability of link duration. Here they also have proposed a concept wherein a Mobile IP layer is separated from the AANET layer. This Mobile IP layer carries out the functioning of establishing a connection with the ground station and downloading the necessary information. This is then cached in AANET layer of one aircraft. This aircraft shares the information with other aircraft as and when requested.

B. Architecture and Routing Protocols for Airborne Internet Access:

In the paper [2] the authors have proposed architecture of airborne internet access inspired by land mobile radio cellular networks. They have considered end-to-end packet delay as for analyzing the performance of the airborne internet access(AIA). The studies and proposals carried out by different scholars have been stated. In their analysis, an architecture for Airborne Internet Access(AIA) is provided by getting inspiration from long term evolution(LTE) based architecture for mobile networks. End to end delay is considered a measure of performance in various scenarios like impact when the network size is increased, impact when network load is varied, impact when nodes are highly mobile. For analyzing they have made use of two different routing protocols i.e., Ad-hoc On-demand Distance Vector (AODV) and Greedy Perimeter Stateless Routing Protocol(GPSR). The architecture proposed here consists of equipment like User Equipment(like mobile user), Air Stations(AS- similar functionality as BS) which is equipped with an antenna, Air Station Access Points(ASAP) which is connected to a Wi-Fi router which provides service to users present within the plane. It also contains Airborne Internet Ground Station(AIGS) which is equipped with an antenna, Airborne Internet Base Station Subsystem(AIBSS) and Airborne Internet Service Provider(AISP). The AS and AIGS will have highly directional antennas attached to them so that reliable transmission can be done in the intended direction. In all the scenarios, analysis results show that AODV is favourable when compared to GPSR for Airborne Internet Architecture proposed here when the end to end delay is considered as a parameter for measuring the performance.

C. Airborne Internet Access Through Submarine Optical Fiber Cables:

In this paper [3] the authors propose a methodology wherein the optical cables which run under the oceans are used to provide internet capability to flights which cross over the oceans instead of using the conventional satellite communication. Here they say that satellite communication has the disadvantages of high cost and long delay when compared to optical fibre communication. The ships stationed in between the oceans which are connected to submarine optical cables are used as base stations here hence reducing the need for having dedicated base station facilities built in between the oceans for this purpose. These ships which are base stations are connected to the optical fibre cable using "Injector/Extractor" which stabilize/maintain the capacity of the optical cable without disturbing the existing traffic. Also, infrastructure installed on islands in remote areas can be used as base stations. This again reduces the overall cost. Here they are concerned with Ground-to-Air(G2A) connectivity. This

method is an improvement over the previous technology which mainly make use of satellite communication links.

D. Project LOON: Innovating the Connectivity Worldwide:

In this paper [4] the author aims at giving an overview of Google's ambitious project "Project Loon". It aims at connecting the chuck of mass who are deprived of internet connection and providing internet during calamities like earthquake, Tsunamis wherein the conventional connection may be disrupted due to obvious reasons. According to Google, the two reasons why people are deprived of internet connectivity is the cost of procurement and lack of infrastructure needed for the same. Its main motto behind this ambitious project is to provide internet inclusion in rural, remote places and to provide internet in crucial times like natural disasters in a very affordable manner. Google is overwhelmed with the idea of how much can nearly 4.5 billion people, who are currently not having internet access can contribute to the world of knowledge and improve their lives as well. Balloons filled with air and helium are used as routers in this technology. The balloons are placed in stratosphere much above where the planes fly and disturbances due to atmospheric phenomenon are not present in this layer. The direction, speed and altitude of these balloons are controlled using knowledge of wind mechanisms of the stratosphere. A dedicated antenna sends a signal to the balloons from the ground and this balloon sends a signal to neighbouring balloon and this continues. The connection is established once the balloon finally sends a signal to a ground station in turn connected to an internet service provider. ISP responds back and hence a network is established. This again has its challenges and trade-offs which have been described in this paper.

III. Working Of The Technology

A. Airborne Internet:

There can be three different objects which can be used as an air-based node. It can be either a manned plane, unmanned aerial vehicle or blimps which can be used as an airborne network platform. These will help in providing air to air, air to surface and surface to air internet accessibility. The aeroplane will be provided with a packet switching circuitry and some fast-digital network functions. The antenna for communication and miscellaneous other elements required for technical operations are suspended below the aircraft. The airborne internet technology would not be entirely wireless. The user premises will be connected to an antenna which is used to collect the signals from aircraft. There will be a beam to beam handoff as the aircraft is mobile. The user will have to install an antenna on their premises or corporate space to take the benefit of the airborne internet. This system will also work with Internet Service Providers(ISP). They will be responsible for providing seamless connectivity by lending their terminals to be used by this technology. The ISPs will already have a fibre point established with them. Airborne internet gives us hope to provide internet to areas which are lacking the availability of broadband cables or wires. The block diagram of airborne internet architecture is shown in figure 1. When concerned with air to air communication, aeroplanes act like ANP i.e., Airborne Network Platform. Many aircraft from these ANPs and are in communication with each other. When the fighter planes say for example move across various ANPs they will be switching from one ANPs coverage area to another and thus will be having continuous internet access.

The plan was to keep three dedicated aeroplanes to circle at high altitudes for an extended period which will serve as a dedicated way of getting access to the internet. These aeroplanes will be performing duties over an area for eight hours each, combining which will provide a 24/7 accessibility. A dedicated plane which is in figure 2 is called a proteus aircraft. These are High Altitude Long Operation (HALO) planes. In figure 3 we can see that the payload of the airplane takes the role of a becoming a hub of a star topology network. It performs routing of packets between two subscribers who having necessary premise equipment which is present within the network coverage area of this aircraft. The CPE (Consumer Premise Equipment), HG (Airborne Internet Gateway) and BPE (Business Premise Equipment) all these perform same functions of enabling communication by catching the signals from the aircraft, modulate, convert the signals to digital format and provide standard connectivity. HG is the airborne network gateway which is a critical network element in connecting to the local ISP and PSTN networks.

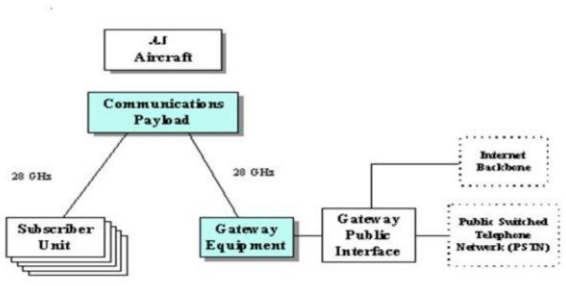

Fig. 1. Block Diagram of Airborne Internet Architecture

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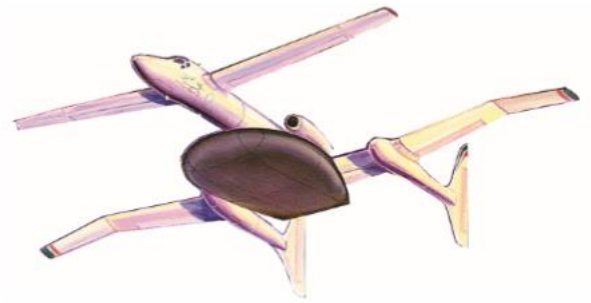

Fig. 2. Proteus Aircraft

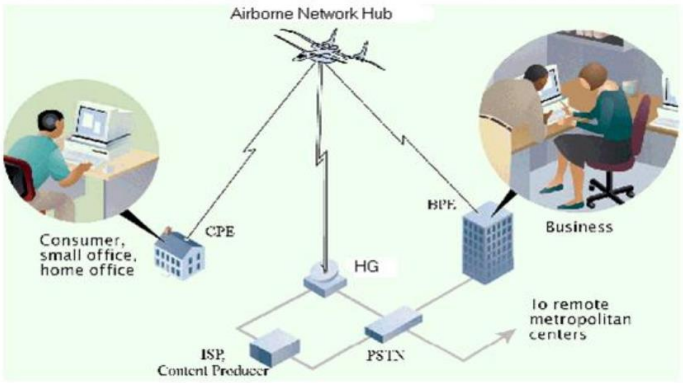

Fig. 3. Airborne internet stakeholders

B. Project LOON:

If we are looking for a more economical way of internet accessibility when compared to the airborne internet we can go for Google' Project LOON which makes use of balloons as "routers in the sky" for providing affordable, reliable and efficient internet access to remote places and in case of natural disasters. As shown in figure 4, basic components of the loon are the envelope, solar panels and equipment. The envelope consists of a balloon which is made up of polyethene plastic material, there will be two balloons one inside another. The exterior balloon is filled with helium gas and the inner balloons with normal air. The altitude of the balloons can be changed by changing the volume of the air present. Additionally, the wind data received from the meteorological departments will be used. As this balloon will be present above 99 percent of the earth's atmosphere the advantage of not getting affected by the atmospheric changes is present here. The second component is the Solar panel mainly used for providing power to the electronics. The third component is the equipment section which will be housing the essential electronics, GPS module, radio antenna, Linux based computer, sensors and Lithium-ion batteries to store the power.

In figure 5 it is shown how the loons connect. The antenna on the ground sends signals to the balloon, the balloons send signals to the neighbouring balloons, at the end the balloon sends a signal to the destined Internet Service Provider (ISP). The ISP sends a response back to the nearest balloon in the network and thus the data gets transmitted via the network. A single balloon can cover up to 40km diameter of ground area and provide speeds as that of 3G[4].

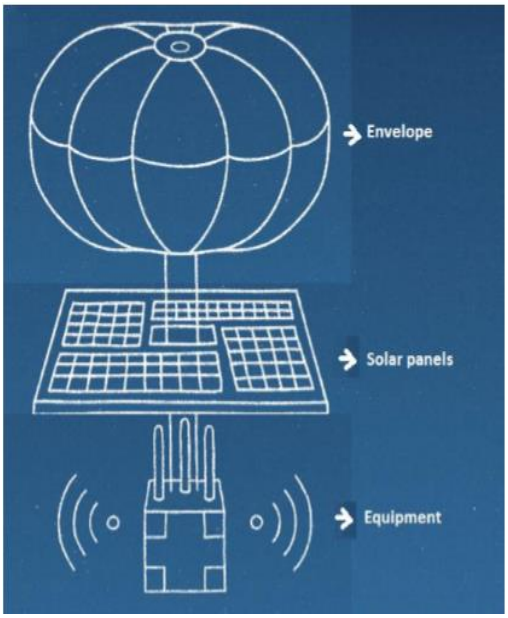

Fig. 4: Basic components of Loon

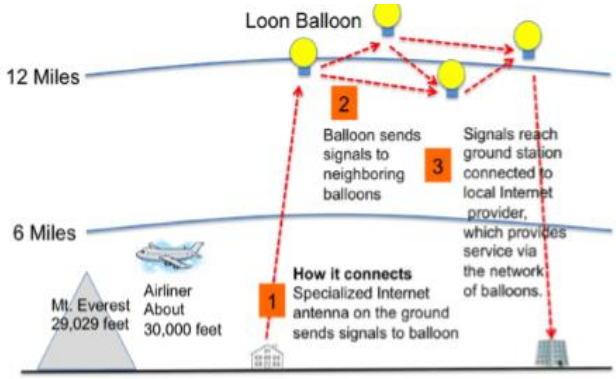

Fig. 5: Connection establishment in Loon

IV. ADVANTAGES

1. Providing internet access to millions of access deprived population.
2. As the altitude at which the balloons or aircraft is placed is much lower when compared to conventional satellite communication the delay is much lesser.

3. The cost of both, Airborne Internet using aircraft or blimps or UAVs and balloons in project Loon is economical when compared to internet access via satellite communication.
4. As and when there will be technological developments related to this field, it can assure more reliable, flexible and secure internet access.
5. It's possible to provide internet to people in transit in flights so that their time will be utilized efficiently.
6. In societal angle, it can upgrade the technological standard of living for millions of people who are in the shadow side of internet capabilities presently.

V. Conclusion And Future Work

In this paper, we have seen how the internet can be made available to normal areas, remote places and during disaster times using airborne internet technology. It's clear that airborne internet technology does not override the existing technology but will work in parallel to them. We have seen how different researchers and scholars have put forward their ideas to implement this technology in various situations and terrains. This has the potential of bringing internet deprived part of the world into the main frame internet world. The much-needed internet access to people who are in transit in aircraft can be provided using this technology. Thus, providing an opportunity for them to utilize their time efficiently. After the development of the airborne internet we can see that similar technologies like Project Loon have been developed whose purpose is the same. Thus, when implemented in large scale this technology will be a game-changer in the way people are connected through internet. Covering the maximum area with internet access will be the futuristic vision here.

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