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# Anywhere at Anytime Internet: Google Loon Balloons

**Sheba Jiju George*, K. R. Remesh Babu****

**Abstract**

"Loon Balloons", the network of balloons which provides Internet for people in rural and remote area, is a recent project undertaken by Google. Though Internet is a global network, large number of people does not have access to it. Loon technology is also helpful in disaster management, e.g.: during floods in Kashmir, where a reliable communication system was not available, Google Loon Balloons could be one of the solutions. These balloons with the help of Wi-Fi technology, help to attain unlimited connectivity to the global community of internet. The Loon Balloons provide connectivity to a ground area of about 40 km in diameter using LTE. Using LTE enabled devices and also through their phones, people can directly access the Internet. Google implemented Loon project in New Zealand in June 2013 as a pilot experiment and now improvements are being made in Loon technology based on the pilot test results.

**Keywords:** Loon Balloon, Envelope, Solar Panels, Enodes, Sensor Database, Seismic Waves

## Introduction

Communication is one of the elementary needs of a human being to survive. It gains more importance especially during a life threatening situation like flood, landslide or any other natural disaster. But in most of these cases, first damage happens to this communication infrastructure itself. In this paper we suggest a corrective means for those disaster management communications through a network of balloons. Loon technology is the most reliable and efficient technology which can be achieved with a network of balloons.

Disasters are the severe calamities that happen to a specific zone and these have negative impact on human lives. Disasters may be natural or synthetic, but consequences of both are same. Most of the rescue operations during a disaster become very difficult due to unreliable communication network. So that the communication failure will make lives miserable in those times. If there is a reliable communication system then the rescue activities will be much more efficient, which in turn will in turn help in saving more lives. The need for good communication technology points to the Loon Balloons.

Loon technology is an excellent and appreciable project introduced by Google[X] laboratory. Loon Balloons are network of balloons with Wi-Fi accessibility; a single balloon can provide connectivity to a ground area of 40km diameter. This is based on a wireless communication technology i.e.; Long Term Evolution (LTE). LTE is to enhance high-speed data for mobile phones and data terminals. To use LTE, project Loon partners with telecommunications companies to share cellular spectrum so that people will be able to access the Internet everywhere directly from their phones & other LTE enabled devices. Loon was first introduced in New Zealand in June 2013, with an aim to provide Internet to everyone and make aware of the unlimited as well as the galaxy of Internet services among the common people. In this paper we limit our discussion to the extent to which Loon will help to manage disasters.

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## DISASTER

Disaster is a sudden accident that breaks up the steadiness of services on a particular region or society. The services may include communication, transportation and accommodation. Among them communication plays a much important role more than other services, as without communication, success in rescue activities would be limited.

Hazards have a negative effect on humans. It is also a great threat to all lives. Geological hazard is a natural hazard that mainly occurs when earthquake, volcanic eruptions, tsunami, landslides, etc. takes place. Atmospheric hazards are natural calamities caused by tropical cyclones, droughts, thunderstorm, and lightening. Catastrophic hazards are those with devastating consequences to large numbers of people or have a worldwide effect, such as impacts with large space objects, huge volcanic eruptions, disease epidemics. Rapid onset hazards are due to volcanic eruptions, earthquakes, flash floods, etc. Slow onset hazards will take time to affect the environment, they occur when drought, disease epidemics etc. takes place.

All the above hazards commonly affect sustainability of ecosystem and the basic infrastructure. The basic infrastructure includes food, medicine, shelter and communication. Among these, communication has an important role, because when we become isolated, the need to communicate with the world becomes a necessity. For the rescue activities and rehabilitation the communication is fundamental. Communication service provides people a means to contact with the officials, family members, and friends to seek for the safety of their lives. So communication has a great influence on the occasion of disasters.

## Disaster Management and Communication

On emergency situations communication is a key element, which will enhance the ability to manage these emergencies as efficiently as possible. Reliable communication is an inevitable factor to provide smooth rescue operations. Some of the scientists and observers found out some important judgments based on which, Auf der Hiede observes that "one of the most consistent observations about disasters is that communication is inadequate". From his studies he concluded with that insufficient communication technology during disaster is the main dilemma. From the recent disaster case studies we can see the relevance and the influence of reliable communication.

Liebenau points out, "the destruction of World Trade Center… brought to public attention the many critical roles that communications play when disaster strikes" [2]. In each and every disaster management, communication is an imminent thing for survival. there were some mitigation efforts are suggested which has four phases. First being helping disaster personnel and agencies develop communication networks, increase the flow of relevant information and share ideas. The second phase identifies a number of communication related reasons for public and governmental apathy which point at a lack of awareness, underestimation of risk, social pressure, opposing special interest groups, difficulty sub staining the benefits of preparedness, and ambiguity of responsibility.

The third phase is the response phase. During emergencies, there will be a tremendous increase in the volume and speed of data in the upward and downward communication, so the need to coordinate these without any delay is an important aspect.

The fourth and final phase is the recovery phase, without the three phases we cannot go for this phase. In all of these phases communication is necessary and it has great relevance. Here we take two case studies to analysis the influence of communication during disasters. The following two case studies will easily demonstrate the essence of communication during disasters.

### Case Study 1: Katrina

Communication breakdown will occur during any natural disaster, especially one as devastating to an infrastructure as Hurricane Katrina. Most of the communications failed and this made a big boundary to get key response from the official. The coordination of rescue activities was limited on that time due to this unreliable communication. This unreliable communication ceased the functioning of rescue, police, military etc.

In New Orleans hundreds of police officials were left trying to communicate with the radio channels, but it was failed because of delay in the communication. So many cell phones were experienced interruptions and are being

out of service along the Gulf Coast. Those situations made a vulnerable situation in the communication field and in the rescue activities. Many of the residents trapped in home were isolated because of the failure in communication such that they can't contact the friends, family members, police etc. during disaster. This case study leads to the conclusion that, communication failure is the worst situation during a disaster.

**Fig. 1: Katrina Cyclone Disaster Effects Image**

**Case study 2: Uttarakhand Flood and Cloud Burst**

After 2004 Tsunami, Uttarakhand flood and cloud burst were disasters that affected the majority of India. Most of the ground based towers were collapsed so that the communication became vulnerable. The basic infrastructure was destroyed and the people were stranded. The transportation through road ways was wiped out in the flood leaving many isolated and trapped. Due to the problems in communication system the rescue officials could not take an immediate as well as effective action. From this case study also, we can conclude that with a communication system free from ground based towers, we can effectively handle the emergency situations.

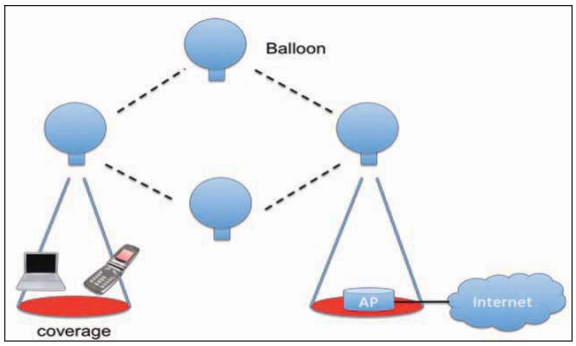
**Fig. 2: Uttarakhand Cloud Burst Image**

## Balloon Based Networking

The balloon based networking was first used by the Chinese rulers, for military purpose, where small hot air balloons were used to communicate with allies. Since 220-280 AD the balloon networking technology ideas were flourished in the minds and now this technology has transformed into anywhere at any time network system. Over the years technology has leaped forward and now Google has finally come up with Loon technology which also uses balloons to provide network for everyone.

In disaster management this balloon based network technology was proposed to provide a reliable communication. In Japan, Yosgutaka Shibata *et al*. (2009) proposed a new ballooned wireless mesh network system for disaster. Balloons with wireless network devices, floats around 40-100 m in the sky. These balloons have two wireless network devices such as (1) the vertical network and (2) the mesh network. The vertical network communicates with the network device in the balloon with the ground station devices and systems. The mesh network is to provide communication within the network of balloons. Loon can also be implemented in this way for disaster management communication.

**Fig. 3: Balloon Networking for Disasters**



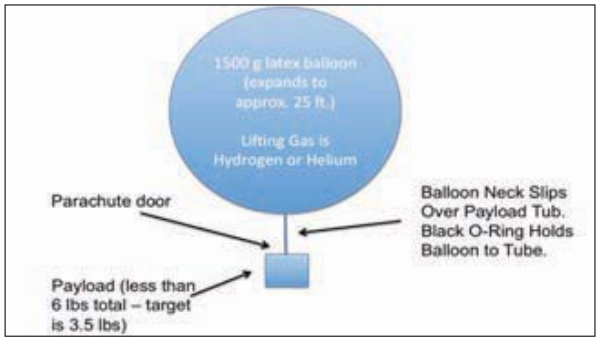

This mesh network provides a wireless auto configuration functions, achieved by electromagnetic field power density. In this network of balloons they will try to find out the neighboring balloon node with strongest power density. If any balloon is moved or falls down the neighboring nodes will tries to find another one. This will maintain the network stable.

If a disaster occurs a network of balloons will launch and then provide internet access to these balloons from

the nearby access point so that the people whom where lost the communication will get a stable internet access. People will get Internet access through their phones, PCs, laptops etc. This is shown in Fig. 3. This will help to get a good and proper communication while disaster occurs. Here the data packets from the mobile phones or PCs were passed to the balloons in the mesh network and from the mesh network the balloon with connection to the nearest AP sends the data packet.

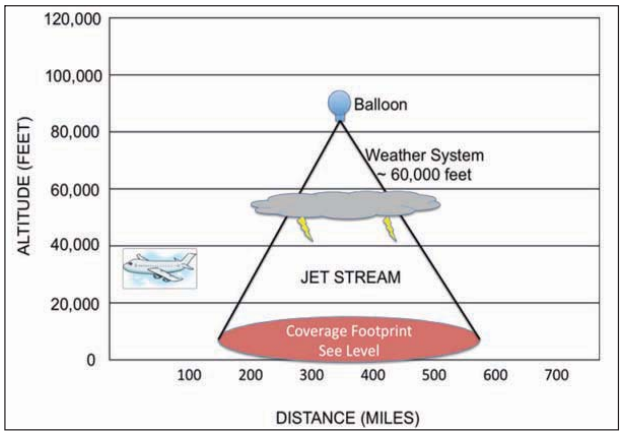
In 2001, Jerry Knoblach, the founder and chairman of Space Data Inc. suggested an idea to establish a wireless balloon technology to people those who were sparsely populated and did not have an Internet access. Each balloon consists of a latex parachute which expands approximately up to 25 feet. Each balloon with a weight of 1.5 kg, a size of 7.6 m will cover an area of 670 km diameter. These balloons can remain up to 24 hrs. The model of balloon is shown in Fig. 4.

**Fig. 4: Sky Site Balloon**




These all are the previous balloon based networking technologies. On the above two data speed rates are about 4.9 GHz transmission frequency, 250mW power density and 54Mbps network bandwidth in the case of Shibata et al. Sky Site uses the standard wireless protocol of Motorola 2-way packet data and its own narrow band PCS spectrum of 1.7 MHz of nationwide spectrum in 901-940 MHz band. Fig. 5 shows the Sky Site Platform for network.

**Fig. 5: Sky Site Platform**




## Google Loon Balloon

Google Loon is the recent project undertaken by Google[x] labs. The main architect of this project is Rich De Vaul and the head of this Google lab is Astro Teller who helped a lot to present this seminar with the project leader Mr. Mike Cassidy. Google Loon aims to bring network among everyone. A balloon with unlimited Wi-Fi is the main technology behind this project Loon. Loon balloons were network of balloons floating in the stratosphere to provide internet access to all.

Only one-third of the world population still has internet access, the remaining two-third does not yet have access to Internet. That reality made Google to think about a project to bring everyone online. The main reason for this is the sparsely populated areas in the world, high data charges and the geographical problems. Google Loon will overcome all these problems with its floating technology. The network of balloons floats in the stratosphere with the help of wind, and they have wireless devices in them which will communicate with the neighboring balloons and with the ground station also.

This is a crazy project commenced by Google to ensure wide range Internet facility. This was first implemented in New Zealand, in June 2013 and this is a pilot experiment launched around 30 balloons with the help of civil aviation from Tekapo. Long term evolution (LTE), the rapid development in wireless telecommunication is another revolution in the telecommunication is using in this Loon balloons. Loon Balloons are free from the territorial boundaries, so that there is an unlimited connectivity to the world through this. This paper focuses on the Loon Balloon to manage emergency communication during disasters. The key of disaster management is the reliable communication, without a proper communication disaster management become impossible. That's why we focus on this after examining some case studies we can conclude Google Loon as a prime solution.

## Loon Technology

The network of balloons floating in the stratosphere with the help of winds, are different from ordinary balloons. Each balloon with wireless device provides connectivity to each other and also with the ground station. The stratosphere environment differs from the normal conditions were a great challenge, but the steady winds within the stratosphere is helpful to control the balloons floating directions. Some of the challenges within the stratosphere are the varying temperature, air pressure etc. were overcome by the Loon technology.

Loon balloons consist of an envelope, Linux based computer, Wi-Fi radios, GPS, and several sensors used to record air temperature, altitude, and speed of movements. The movement of these balloons controlled through some certain algorithms. Each balloon is launched in the altitude of 20 Km, is 15 m in wide and provides a connectivity of about 40 km in diameter. The main components of this balloon were:

### Envelope

The inflated part of the Loon balloon is known as envelope. This is filled with Helium gas that takes the responsibility to keep the balloon in its proper place. The balloons are made up of polyethylene film, those are three times thicker than the ordinary supermarket carrier bag, but they are enough to withstand the air pressure without exploding. These balloons will stay in the atmosphere for 100 days. These balloons are steerable from the ground, so that there is no need to tie up the balloons. According to the need of network these balloons will move from one place to another. These balloons are 12 meters tall and 15 meters wide when the balloon is fully inflated. When the balloon will meet its lifetime to give up, it will release the gas filled in the envelope and bring the balloon back to the earth. If the balloon drops too quickly then the parachute attached to that will deployed.

### Solar Panels

The electronics in this balloon is powered with the help of solar panels. This solar panel is made up of an array of flexible plastic laminate supported by a lightweight aluminum frame and uses high efficiency mono crystalline solar panels. Solar panel is placed at a steep angle so that the solar energy from the sun can be captured in the windy days also. The sufficient energy to operate the Loon balloon can be stored within 4-5 hours, but it will store the energy for the night with the help of Lithium battery.

### Electronics

A small box with 10 kg weight is hangs underneath of the inflated balloon. This small box contains a Linux based computer, GPS, sensors and radio antennas to communicate with other balloons and with the Internet antennas on the ground.

### How Does Loon Connect

The network of balloons connects with the ground station with wireless devices in it. The balloons communicate one another and sends data to the neighboring balloons and finally to the ground station. The special antennas placed in the home will help to connect with the PCs, laptop, and mobile phones. The LTE technology is enhanced with the loon balloons support the connectivity of data, with a speed rate of ISM 5:8 GHz band.

**Fig. 6: Structure of Loon**

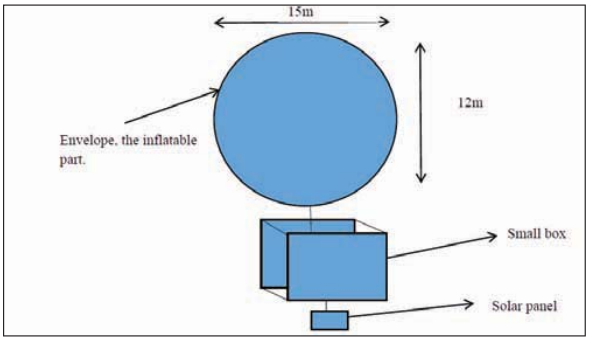



**Fig. 7: Loon Balloon**

## Disaster Management System Architecture

Disaster detection is a prominent way to save many lives before any disaster might have been happens. Disasters can be detected with the help of environmental sensors. Environment sensors are the sensors which were using to sense the environmental conditions. Here we mainly consider the disasters such as earthquake, tsunami, drought, flood, and cyclones. To detect whether any probability of the occurrence of these disasters we uses sensors nodes named as *enodes*. The enodes sense the environmental conditions and pass this information to the sensor database, where the further processing and the analysis of the data that have been collected by the sensors.

The enodes are placed inside the earth surface and senses the seismic waves those are the main reason for the earthquake, volcanic explosion, tsunami etc. The propagation velocity of the waves is sensed by the sensors and determines the probability for earthquakes. The propagation velocity depends on the density or elasticity of the medium, it is at rate of 2 to 8 km/s in the earth's crust and in deep mantle is about 13 km/s. And according to certain threshold values we can determine the probability of an earthquake or tsunami. Velocity can be calculated as follows;

$$V = \sqrt{(k + 4/3u)/d}$$

$$V = \sqrt{(\lambda + 2u)/d}$$

k : bulk modulus
u : shear modulus
λ lame parameter
d : density

### Algorithm:

input : velocity sensed from eqnode
output : probability.

Step 1: sensed velocity value as the input, sv

Step 2: calculate the velocity; $V = \sqrt{(k + 4/3u)/d}$

Step 3: calculate the probability: p = sv / v

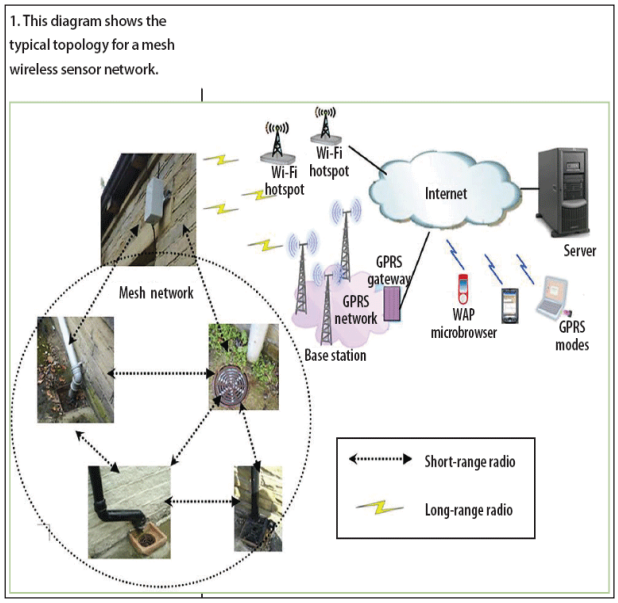
Step 4: if the probability p>1 then set alert.

Step 5: else normal condition.

Step 6: send data to the loon balloons and then finally to destination nodes such as the emergency alert centers.

Step 7: stop.

**Fig. 8: Sensor Nodes Placed in Various Locations to Sense the Environment to Detect Anomalies**




Similar to the earthquake detection sensor the tsunami sensors can also be placed beneath the oceanic surface. Thereby we can find out the probability for the occurrence of any tsunami waves or not so that the evacuation of the region before the disaster can be done. The sensed data are passed to the database and finally after the analysis the data will pass if any variation in the data has been sensed. The data need to be passed in a reliable channel, that is why we adopted the Loon Balloons for the communication. The data reliably passes to the emergency centers by this network of balloons. And also the evacuated area rescue also can be done through these balloons. We can apply this balloon along with the idea of SENDROM which has been developed for the disaster relief operation so that the rescue activities become more effective.

In the case of drought detection also we can use the sensor nodes (enodes) which will detect the humidity of the atmosphere. Humidity calculation will help us to find out the probability for drought. The main reason for drought is the deficiency of the water content in the environment. Humidity refers to the water content and so that this parameter will help us to find out the probability for the

drought in a particular region. Here the relative humidity can be calculated as following;

*Relativehumidity = Airvapourpressure / saturatedvapourpressure*

Same as the algorithm for earthquake, here probability for drought can be calculated as probability is equal to the sensed humidity divides the calculated humidity. Then according to the probability we can find out the traces for drought in a particular region.

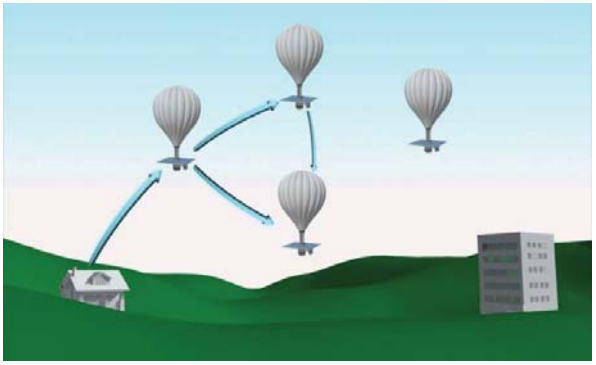
Flood can be detected and warning can be sensed by the sensor nodes placed in the water resources if they exceed the normal water level then the sensed data in the database will send to emergency centers via the balloons. In that condition, the probability can be calculated based on the prehistoric knowledge about the water level rise and the normal level. In the cities the sensors can be placed in the pathways if the rainfall is heavier and the water deposited or sediment in the roadways can also be detected using the sensors.

Cyclones can be sensed by measuring the speed of wind blows. The warm oceans in the tropical regions are the main reason for the cyclones. The meteorological department has the values of normal wind blows of particular regions and we have the data regarding the sensors. So that we can calculate the probability by the estimated value from the meteorological data versus the data sensed so that the easy calculation of the data can be done. We can detect the chances of the cyclone by this method.

These are the various disaster detections can be done with the help of sensors. The sensed data will be transmitted to the database and from there based on the algorithms on the probability value will determine the chances for the disaster. According to the analysis the information will be passed through the Google Loon Balloons to the emergency centers without any delay. Since there is no time to waste, we use this communication technique which can be easily accessed by anyone from anywhere at anytime. This is the system proposed for the disaster detection and for the relief operation we can use SENDROM along with the Google Loon balloons.

The balloons in this communication network are controlled by a master balloon and in the conventional method the base transmission centresare there. But here we use specialised antennas for transmission of data through the balloons. We also specify the master balloon to route the destination balloon and finally to the emergency centre. This is the method we follow in this disaster management scheme so that a reliable as well as portable communication can be provided. The master balloon will check whether the network of balloons is properly working or not. Then set proxy from the nearby place. If anything happens to the master balloon then the base station detects it and immediately takes necessary action to create a proxy and repair the original one. It is illustrated in Fig. 8.

**Fig, 8: Three Balloons are Connected to Each Other and a Master Balloon in it Checks the Working**



## Loon Implementation

In June 2013, Google began a pilot experiment in New Zealand where 30 balloons were launched in coordination with the civil aviation from Tekapo area in the South Island. About 50 local users in and around Christ Church and the Centerburg region tested the connections of Loon using the special antennas. After this initial trial they plan on sending more balloons around the world. This Loon technology has also been implanted in Brazil, and they also plan to extend the technology in the southern hemisphere.

Bringing the world online is a great challenge, but they took that challenge. The researcher now focuses on the disaster management communication via Loon balloons. Those were able to connect everyone in the world residing anywhere and at any time in the network connectivity. During disaster management, communication is necessary. Loon provides a reliable communication throughout the entire world. The researcher proposes an idea to inform the common people and officials about disaster through an alarm system, if any variance in the reading occurs. This will help the people to survive on the earth, without getting affected by the disaster hazards.

The next implementation of Loon they were planning is to bring the southern hemisphere online.This is named as project 'GHOST'. This project is an initial step to bring the world online. This is the dream to get a stable Internet access without any boundary.

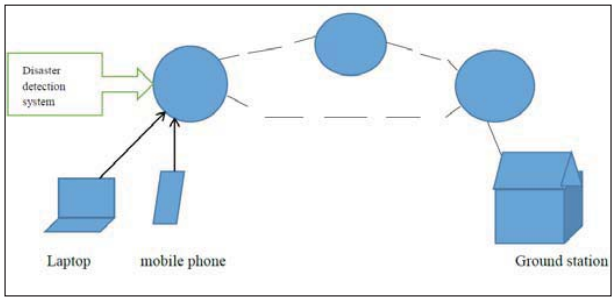
## Future Enhancements

The life time of a balloon is 100 days, after which it will return to the earth. Here the researcher proposes a secondary balloon along with the same balloon which can be deployed while the first one meets some conditions. Within the lifetime of secondary balloon the first will be repaired and reused. For the reuse and repairing activities some artificial intelligence based algorithms are needed.

Self-recovery from any accidents, is the another future enhancement. It will cure itself from the immediate accident that happens to it. This will help extend the lifetime of the balloons and reduce the maintenance cost. In our ordinary situation if any small error occurs in telecommunication we want to replace the entire optical fiber cable, which is so expensive. Here we can introduce a mechanism to reduce interference.

Next is a disaster detection and alarm system within the Loon balloons, so that the disaster can be easily detected. It will also be helpful in taking rescue activities quickly. The framework of this system is shown in Fig. 9.

**Fig. 9: Framework of Disaster Detection System**



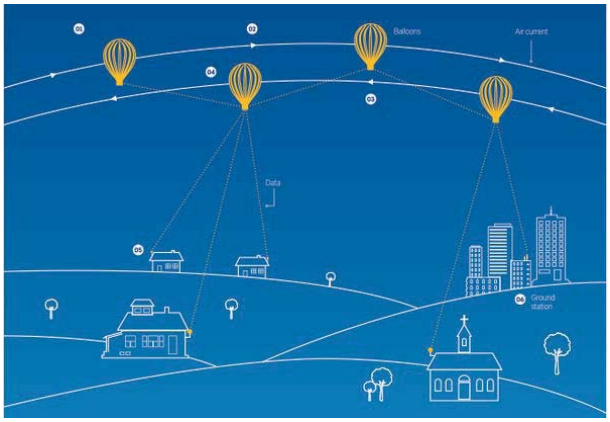

Interference avoidance is an important thing in emergency communication systems. Sicne the need of interference reduction is important, in this case we can suggest the interference avoidance scheme of VANETs in Google Loon technology. But here the movements were not similar to that of vehicles, because the vehicles have a forward or backward movement. Hence in case of Loon Balloons we want to consider a 3D motion, whereas in case of vehicles only 1D motion was introduced.

In VANETs to reduce the interference, an IEEE transaction suggested by Dmitry Zelikman and Michael Segal (2014) is a good idea to enhance communication in vehicles. Here in this paper we can use the same idea for communication in a 3D view. In the above transaction they suggested a scheme with media access control protocol and a clustering algorithm. In the usual cases carrier sense multiple access with collision avoidance is mostly used, but it is not sufficient. So here time division multiple access is used.

This idea proposed for Google Loon Balloons is based on reducing interference in VANETs. Here we usea detailed approach of this concept. When the data from Network A are transmitted to E, there is a network of balloons to transmit it. In that case we use a slotted ALOHA for transmission. Two channels are implemented in it, one for forwarding the message and the other for reverse direction of forwarding. But here is a need of upward and downward motion due to the balloon positioning after the wind effects.

Consider Fig. 10: in which the message from the terminal consisting of special antenna is sentto balloon A. From there, after analysing the path it will be sent to balloon B. It will continue in a network of balloons and finally to balloon E which is the nearest one to the ground station. In that forwarding, A uses the channel to avoid interference and channel B for the reverse process, finally retrieving the message from the network of balloons with the specialized antenna.

**Fig. 10: Forwarding Messages in Google Loon**



## Conclusion

An accurate and reliable communication has a great influence in disaster management. The key to disaster management is a stable communication which will coordinate the rescue activities. Reliable communication without any territorial boundary is only possible through the Loon technology. With the Loon we can provide a complete connectivity through the balloons.

During disaster this new technology will help to find out people those who are isolated and trapped in a house or in a particular area. With the help of this, the management of disaster can be handled easily. Also the connectivity helps to maintain contact with family members, friends and police. This will ensure that the chances for survival of disaster victims can be increased.

The disaster detection and warning system is an effective way to minimise the impact of disaster. After detecting the variations in the environment/climate, the balloon will generate alarm or warning messages to the people connected in that region and also to the authorities. This will help them to recover and survive from the disaster. Precaution is better than cure, is the main idea to prepare this paper.

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