Loon Data Center

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***Abstract*—In today's world data centers can be found on land and water, which can easily be attacked or damaged by natural disasters caused on earth. Our idea is to have a data center up in the sky (stratosphere layer), so that it is saved from natural disasters on earth and is difficult to attack as the data center will be in constant motion and moving from one place to another. This idea of ours is not only secure from human interaction but is also cost efficient as it is powered and cooled using natural resources. Loon data centers can be a placed anywhere around the world with the same infrastructure and provide this facility where maintaining a data center would be expensive and difficult to have. Loon data center solves major issues faced by the providers today.**

Keywords — Loon data center, flying data center, balloon carrying data center, portable data center.

I. INTRODUCTION

Data centers are playing crucial roles in the modern world. The companies like Amazon, Microsoft, IBM, Google are the leading ones as the cloud providers. Google and Microsoft are working on innovative ideas of placing a data center. Microsoft is planning their data centers to be placed underwater, while Google is building their data center on water. As there are many data centers on the land its bit tough to handle their security issues. Considering the security and power management they are using the water sources for data center.

The loon data center is placed in the sky i.e., 25km away from the earth's surface in the stratosphere, where it uses 100% natural resources to work. The data center will be using solar energy for power and it has a free cooling system, as the temperatures in the sky is always below zero and negative, which makes it one of the best place for having the data center in such location gives solution for many issues. Comparing the loon data center with the data centers on earth, the chances of happening a natural disaster in the sky are negligible. The geo-location of the data center made it more secure due to no direct human interaction with it which will be the innovation for our proposed model. Loon data center has many advantages that solve most of the current issues faced by the data centers on earth.

II. STATE OF THE ART.

A. Loon Data Center

The loon data centre is an evident data centre which is out of the usual data centres that are in land and water. This loon data center will be distant version of a normal data centre that is situated somewhere far away from the land and water by this way it lets you to access the data via internet services. The Project loon data centre levitates in the stratosphere which is 25 km above the ground. The loon data centre utilizes high-altitude loons that is in the stratosphere in a height of 25 km above the ground level. After examining the speed and the direction of the wind data from the National Oceanic and Atmospheric Administration (NOAA) in the wind layer, the position of the loon Data centre can be altered by modifying the altitude in the stratosphere to travel along the layer. The main aim of the loon data centre is to connect or to have a backup of data when there is a disaster in the land and water.

The whole infrastructure is based on loon edge data centre will be carried by the balloon. The edge data centre is like a legacy data centre that indicates to a nano server hardware on the loon to supply and acquire data via native network communication with the data center. The advantage of stratosphere layer is that the speed of the wind is comparably low, and the rate of the turbulence is minimum. However, this model will have a reasonable accuracy, the seasonal, longitudinal, and latitudinal variations in wind speeds within the stratospheric layer.

B. Balloon Specifications.

Figure 2: - Balloon Picture.

The loon material is composed of the rubber material mixed with graphene with around 0.090 mm in thickness, it is very flexible and stretchy and very strong. The size of the balloon will be around 20m that is 65 feet in width and 15m that is 49 feet tall when filled with gas or air. The balloon has a smaller balloon inside the main balloon, which will be connected with a device called "Croce"(a device which allows air to be pumped in and removed when needed.) and is filled with helium gas, as it is the lightest gas. The smaller balloon is installed to avoid mixing of helium gas in the main balloon with the air pumped in stratosphere. The main balloon is completely filled with helium gas only and can hold good amount of air pressure, because the temperatures in the sky can compress the air and gas in the balloon and the Croce device helps the balloon to maintain its pressure to stay as long as possible in the sky. The average balloons can stay from 150 to 200 days up in the sky without any physical maintenance needed.

C. *Loon Navigation in Stratosphere.*

The distance between the ground and loon is nearly 20kms. That is the balloon lies in the stratosphere. The wind layers in the stratosphere vary in speed and has different direction. The algorithms of the program we write helps us to control which direction the balloon needs to move. NOAA (National oceanic and atmospheric administration) provides us the details of the current wind directions and speeds in the sky. Since the wind layers vary in the stratosphere, we need to change the altitude of the balloons for each layer in the program so that the balloon moves in the right direction.

Figure 3: - Loon with wind directions.

There are three way to control the altitudes of the balloons. There is a high-pressure storage chamber present in the loon, the gas present in the balloon is pumped out to this chamber when we need to reduce the altitude. To rise the altitude, we should pump in the gas using the croce device connected with the smaller balloon inside the main balloon. Another way to change the direction of loon is the reverse hydrogen gas fuel cell. The hydrogen gas produced by this fuel cell produces hydrogen which can help to increase the up thrust and altitude. This hydrogen gas can also help in producing power by the hydrogen oxygen chemical reaction to produce H2O. We can also heat the gas in the balloon to change its direction. Some portion of the balloon envelope can be painted black. We know black can easily absorb heat, thus the air in the envelope also gets warm. We constantly need to change the altitudes and directions of the loon so that it stays with in the communicable range to control the equipment's on the loon. Network Connectivity with the loon: - Radio communication is most reliable and secure means for long range communication. The loon will have radio communication system on it, so that it can be controlled from the ground base station to change its course and directions up in the sky.

D. *Data Center Platform.*

Figure 4: - Data center Platform.

There will be an edge data center which is compact and small in size and light in weight so that it can be carried by the balloon up into the sky. The data center will be constructed with some innovative ideas and specifications. This data center will work completely using natural resources and will have no specific cooling requirement. The loon data center will have data backup of the data center on land, which can be destroyed by natural disasters caused on earth. Loon data center will always be safe from these problems. This data center can also be useful for the companies to have their own data center, this type of data center can also be easily placed in places where electricity and cooling is one of the major issues.

E. *Powering loon data center.*

To power the data center, we will use solar energy which is in abundance up in the sky. The loon has solar panels placed between the balloon and data center box as shown in the image 2. Solar panels are proved to be much efficient and reliable source to convert solar energy into electrical energy. The loon's electronic equipment's are powered by solar panels that is between the envelope and the hardware. In full sun, the panels produce more than 100 watts of power, which is enough to keep the unit running and charging a battery for use at night. The solar panels used in the loon data centre is Gallium Arsenide which is almost three times more efficient than the current products in the industry.

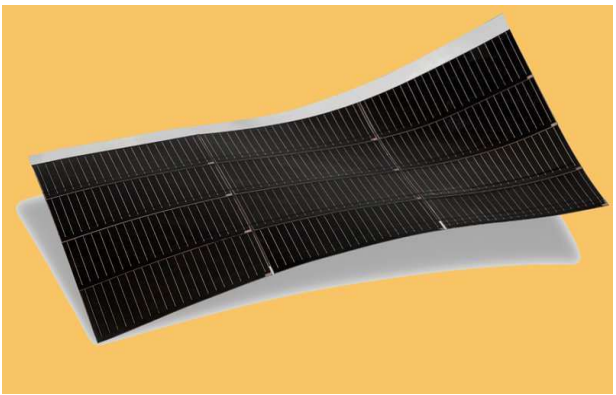

Figure 5: - Solar Panels used in loon.

They are defined as the triple junction cells because they optimize the sunlight in a chemically altered manner. The solar panel has a built-in battery that is 20% more useful and 25% cheaper than anything in the industry now a days. The most important point why this design is more effective is that the rechargeable battery is built with solar panel itself instead of accessing two standalone systems.

The data center runs with electricity produced by the solar panels and simultaneously the batteries are also charged, so that during night when there is no sunlight the data center can work using power from the batteries.

As the temperature in stratosphere layer is always around -60 Celsius, and lithium ion batteries may not work at those temperature, so the idea is to cover the battery containers in a "space blanket". This space blanket is used by NASA for their space equipment's, it does not allow the heat and cold to get inside the battery and freeze the battery liquid. It also saves the battery from the radiations from the sun which may cause battery malfunction.

Figure 6: - Space Blanket used to cover Batteries.

The battery used to power the loon data center is RELiON's lithium iron phosphate batteries rather than the lead-acid batteries because can easily power the nano data centre and it can provide better storage facilities for solar power system. They have a very good life span and are lighter in weight. The capacity of the batterie is also high. The maintenance cost is nearly zero and the battery has no effect to its mounting direction. They can run even without being fully charged. It can be charged very fast and has very good performance even at cold temperature. The battery can be discharged from –20°C to 60°C. At low temperatures like 0°C, the capacity of the lead-acid batteries is only detected by 50%, while in the case of the lithium iron phosphate battery the loss is only a 10%. The power of RELiON's low-temperature series is nearly same as that of other battery, so is its performance. They can be used as a backup for the RELiON batteries applications because it has the same charging time, configuration, connectivity and shape. All the low-temperature application which uses lead-acid batteries can be changed to the RELiON's lithium iron phosphate battery.

*F. **Network Connectivity with the data center.***

Network Connectivity is one of the most important aspects to consider while building/placing a data center in stratosphere and high up in the sky. The loon data center will have a direct connectivity using laser and radio communication. Laser communication has been known to provide high data transfer rates and excellent connectivity, laser is also used to communicate with space satellites and explore our universe with this technology as it has a very high range and consistency.

The optical communication uses light to transfer and receive data and information over huge distance objects. Optical spectrum uses lasers communication to communicate and exchange data instead of the standard radio communication. The frequency range is shown in the picture below:

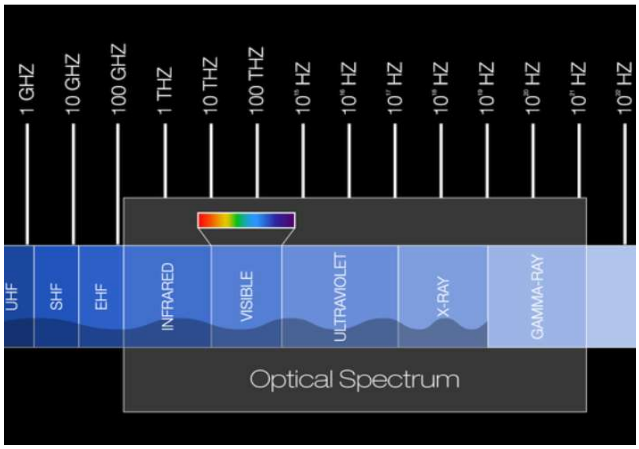

Figure 7: - Frequency range used by laser devices.

The frequency range depends on how far the communication must be placed, the higher the frequency the more the data transfer rate will be achieved.

In 2013 a German company Mynaric used their laser terminal to transmit data at a speed of 1Gbit/s over distance of around 60km and the object was moving at a flight speed of 800km/h. Our loon would also have a similar connectivity but with less moving speed and distance, so obviously it would provide a better connection from the ground to the loon data center. In 2014 also EDRS (European data relay system) carried out the first ever gigabit laser communication in which data from the sentinel-1A satellite was transferred to ESA-Inmarsat in geo using an optical link between them. This system could offer data transfer speeds of up to 7.2Gbit/s. By 2025 we can expect a stable and secure means of laser communication with astonishing speeds and data transfer rates.

Figure 8: - Laser Communication Device.

The loon data center will always be moving from one place to another following the wind direction and it must be controlled from the ground base control center. But the lasers work by sending a straight beam light and it cannot connect if it moves away from its range, so we need to have multiple laser transmitter and receiver. When one laser beam is about to lose its connection with the loon, the other laser device which will be at some other location and in range with the loon will automatically get connected with the loon data center and the connection between the loon and the station will never be disconnected.

*G. **Cooling and Heating**.*

One of the main advantages of having a data center with loon in stratosphere is not having to worry about the cooling of the data center. Most of the data center on earth requires 40% of power to cool them down. As the loon data center is in stratosphere which has temperatures ranging from -50 to 0 degrees Celsius. Considering the temperatures at 25km to 30km away from earth which ranges between -20 to -10 degrees it is not required to spend that amount power to cool the data center. However, we will be having cooling system to the container in order to remove the hot air inside produced by servers and data racks.

The cooling system uses free cooling process which is air side process that removes the hot air from top of the container. The bottom of the data center will be equipped with air inhaler fan which will send in the cool air and top will have minimal openings to push the hot air out with the help of exhaust fan. The inner part of the data center will have flooring of about 3 inches high with small openings, so that the air doesn't hit the data racks directly. In the same way the ceiling will be designed in a way that it passes the hot air through it. To ensure that the racks are at certain temperature we will be using some monitoring tools. The exhaust fans needn't be continuously kept on due to the climate over there and can be turned on when the temperature is raised.

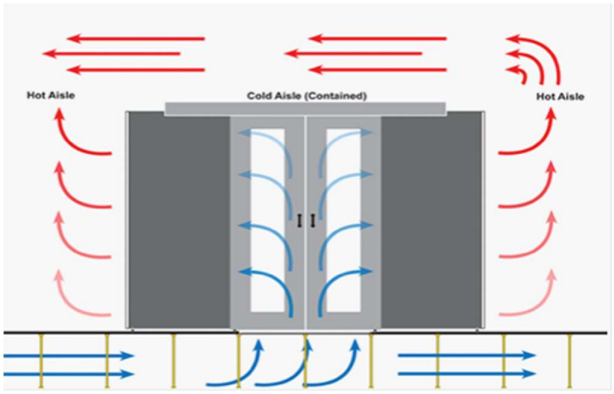

Figure 9: - Air flow in data center cabinet.

The hot air can be used for heating up the battery. As the liquid present in the battery may get frozen at the temperatures over there, it should be kept warm for not getting the battery liquid frozen. In order to do so, the hot air will used to keep the battery warm. Also, the battery performance as well as the capacity can be raised using this process. The cooling system does not require much electricity to work, there a few fans which needs minimal power and only must work for a few times in a day and only for few minutes or seconds.

III. Novelty of our Innovation.

*A. **Geo-location.***

Now a days the location of the data center is the major issue faced by the data center owners. Some places are having the data center where they use lots of power for cooling itself. Some of the companies are trying to build their data center in cool regions so that the maintenance of the data center consuming low power consumption. While speed of usage from data center depends on the distance of the data center location.

Figure 10: - Loon placed in stratosphere.

1. Natural and climatic Risks.

   Having a data center in the sky has many pros than cons, one of them is, it is saved from the natural disasters caused on earth and is also portable as it is flying with the wind directions. If the location of the data center must be changed, they just have to change the course of the loon and place the loon to the direction of the wind where they want to move, without any physical work and hassle it can be moved.

2. Natural energy resources.

   A data center requires massive amount of power to run it, we are using the renewable energy recourse and batteries to make it work during the nights. Solar energy is the only energy source that is being emitted every day, so it makes the data center run for the daytime and during nights batteries are used which are charged during day itself.

3. Natural cooling.

   There are many reasons for locating the data center in the air as loon data center. Climatic change is the prominent thing that should be considered for building a data center. Cooling system is also free out there, because the

temperature in stratosphere is always negative/ around -50 Celsius, so we use fans to inhale cold and send out hot air.

4. Physical Risks and security.

The data center which is always moving and has no human interaction is already more secure than the data centers on land. It is also safe from breeches and attacks from terrorists, as its moving and the location of the loon is confidential.

B. Power Efficiency and Batteries.

As we know data centers alone in the world consume will 1/5th of the earth's electrical energy by the year 2025 and this is only expected to increase in number in the upcoming years. Having a data center which works 100% on natural resources and is efficient and reliable is gemmed to have. The loon data center is a perfect example of this, as it uses solar energy to power the data center and other electronics equipment on the loon. During day the data center runs using solar energy and simultaneously the batteries are also charged, so that during night when there is no electricity the batteries would come into action and power the data center.

The battery used to power the data center is RELiON's lithium iron phosphate batteries, which is much better than standard lithium ion battery in terms of performance and life span and does not require any maintenance to keep them running. Relion's iron phosphate battery is also known to work well in cold temperatures, which is perfect to use in loon data center in stratosphere. The new battery products in the LT Series are RB20-LT, RB35-LT and RB100-LT. RB20-LT, RB35-LT are mostly used in cold weather applications like remote sensing monitors, traffic control cameras, small solar energy systems and LED lights. While the RB100-LT should be used in applications which needs to be charged at cooler temperatures.

C. Data Center Construction.

The loon must carry the edge data center with it along the skies, so the data center should be light in weight and strong because it must hold the components together. To reduce the weight of the data center we use allite super magnesium which is 56% stronger than titanium and 75 % lighter than traditional steel and metal. The exterior compartment, racks and cabinets will be of this lightest and strongest metal, which is allite super magnesium, this would make the data center way lighter and stronger than the edge data center currently being used.

Figure 11: - SSD

One more important detail must be considered to make the data center light weight is using M.2 SSD instead of hard drives. As we all know hard drives are not light weight and takes a lot of space and produce a lot of heat, using M.2 SSD would reduce the overall server weight, save space and does not get heated much and is faster than hard drives.

IV. COMMERCIAL VIABILITY.

Data centers around the world are facing similar issues and challenges, to overcome those problems loon data center will be great choice. As the market for data center is only known to grow in the upcoming years, having this kind of secure and cost-efficient data center would be a reliable decision. Availability of a data center services plays a crucial role for a company. The data centers with high availability goes into public quickly while the loon data center is the one which will be more compatible for governance because of its security. The main customers or users of this loon data center would the companies who are planning to have their own data center or to a cloud provider for delivering services to a particular region or company. The companies want their data center to be secure and easily accessible, laser communication helps them to achieve this goal.

A. Security.

The loon data center is more secure than other data centers on land as this has no human interaction with the data center. The exact location of the data center is not known to anyone except the operation controlling the loon from ground base station. In terms of network connectivity, laser communication is one the secure ways of communicating with the data center.

B. Cost Efficient.

The loon data center uses only natural resources to power with solar energy and cooling is done using cold air in the stratosphere, these two aspect covers the cost used to maintain a traditional data center on land as cooling and power is one of the main concerns while building a data center.

C. Environment friendly.

The stratosphere layer is not polluted and will not be having a dust or particles in that layer, our data center will be safe there. As the loon data center uses all-natural resources to work, there is no harm to the environment as it does not use any toxic or frameable objects with it. The hardware on the data center will also work at its full capabilities as the temperature does not reach high at all, thanks to the cooling system installed in loon data center.

D. Portability.

As the loon data center is placed in the sky and is constantly moving from one to another, it is very easy for the company to change the location of their data center. They would only have to redirect the loon to the wind direction they want their loon to move and provide services to different region in no time and without any physical work and hassle.

V. IMPLEMENTATION.

The loon data center model is divided into three parts, firstly the balloon, solar panels and data center cabinet.

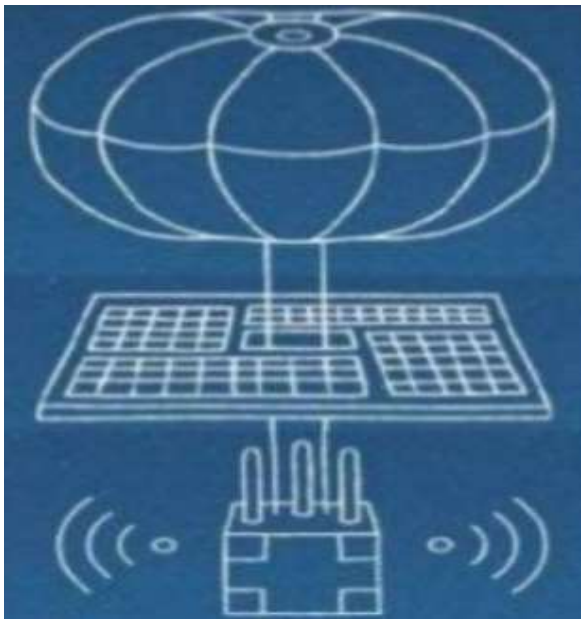

Figure 1: - Loon Data Center Prototype.

A. Balloon.

The balloon is at the top which is filled with helium gas and has a secondary balloon inside the main balloon. It also has 2 parachutes which could be deployed, if there would arise any problem with the balloon to safely bring down the data center.

B. Launching the balloon.

There is machine particularly built to launch these balloons into the atmosphere. Launching each balloon would take only 30 minutes, if all the equipment's are attached properly.

Figure 12: - Balloon launching machine.

This machine has foldable walls around them to block the winds while the balloon is being filled with gas and while launching the balloon. It hold the balloon till the process is completed and then it automatically unplugs the balloon to fly into the atmosphere.

C. Solar panels.

The solar panels are placed below the balloon and above the data center. The solar panels are thin and light weight and is placed in way that, it absorbs sunlight as much as possible and stores the energy into the batteries which is in the data center cabinet.

D. Data center cabinet.

This will be at the bottom, this will be an edge data center with a couple of racks and few servers in it. It must be built in specifically for the loon, to be lightweight and has enough space for the batteries and to withstand harsh cold temperatures up there. It would have fans for cooling/inhaler and exhaust cool/hot air from the data center.

E. Landing and recovery.

The loon has 2 parachutes, which would open if there is a problem with the balloon. Each balloon can last for around 200 days and must be brought down and is guided to an easily reachable location to change or for refilling the gas inside the balloon. The data center would have air bags at he bottom of the cabinet to ensure soft landing.

F. Ground base station.

Base station is the place from where the loon will be constantly monitored and controlled by an operator. The communication system will also be placed at the base station to not have delays while connecting to the data center.

VI. EXISTING AND NEW TECHNOLOGIES.

A. Existing Technologies.

- Loon currently is being used to deliver 4G network coverage in remote areas by google.
- The balloon of the loon currently used is only made of flexible rubber and latex, which makes it heavy.
- The solar panels and batteries used are not exactly light weight.

B. New Technologies.

- Our idea is to use loon to attach data center to overcome some challenges faced by current traditional data centers.
- The balloon will be mixed with graphene and rubber, which is flexible and super strong material and it would also reduce the balloon overall weight.
- The solar panels we use are light weight and 3 times more efficient and the relion's lithium iron phosphate batteries are also better than standard lithium ion batteries.
- We use laser system to communicate with the data center and loon, which delivers super-fast network connectivity and have radio communication as backup.
- We use natural cooling technique, the temperature in stratosphere is naturally colder. Using only fans to cool the data center would me more than enough.

VII. Conclusion and findings.

Loon data center plays an important role in solving few of the challenges faced by the data center providers today. It provides security in ways which no other data center on land and water can provide, it has no human interaction with the data center. The companies want their data center to be untouchable by other authorities, this data center helps them to achieve this as the loon data center is always in constant motion and the exact location of the data center is not known to anyone other than the operator in the ground base station. Once the loon is launched it is safe in the atmosphere without anything to worry about collision, as the stratosphere layer has nothing but empty sky.

As the loon data center uses all naturally available resources to work, it solves the issues of electricity and cooling methods faced by data centers today. This reduces the cost of maintaining a loon data center by a huge margin than the costs involved to maintain the data centers on land and water. The hardware used in this data center would also work to its full capacities, as the hardware temperature would never reach high, thanks to its cooling technique. This also increases the lifespan of the hardware used.

The connectivity with the data center is achieved using laser communication and radio communication systems. Laser communications is considered to the faster means to connect with the objects at long distances and it is only expected to improve in the upcoming years.

The loon data center does have some limitations and scope for improvement in its technique. But the pros of having this data center is much more than the cons. The loon data center needs to be monitored by an operator constantly and there are risks involved, which could overcome in the near future.

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