Wireless Cellular Communications via Dronesandaerial Photography

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***Abstract*— There are approximately 432-450 million internet users in India which constitutes 60% of the urban areas while only 17% of the rural areas are internet users, which can be increased if they are reached out properly.During the floods in South India in 2015,over 1.1 million people were affected which left many people helpless due to no access for help or cellular connection. This huge growth in the number of connected wireless devices leads to an increasing demand for network connectivity.This paper gives a conceptual idea in which the UAVs assist the ground base stations to cellular networks by enhancing the coverage area by providing hotspot or acting as a mobile base station itself and usage of drone camera to give the immediate scenario of the location.**
These UAV's would fly over those region serving as a mini-BS's and provide a larger cellular reception along with camera feed (using the Gimbal technique) of the location while reducing the cost involved in such operations. The aim of this paper is to establish better communications between distraught people and the digital services to be provided, giving better understanding of the areas during scenarios such as natural disasters, war-struck areas,etc. by the usage of the unmanned aerial vehicles (usually drones)..

***Index Terms*— Base Stations(BS), Cellular connectivity, Drones, Gimbal, Unmanned Aerial Vehicles (UAV's), Wi-Fi.**

I. INTRODUCTION

Due to rapid technology improvements in the space of cellular networks and increase in number of cellular devices, only 34.8% of the population in India use the internet and around 3.2 billion people have access to it out of which 2 billion constitute the developing countries. This number can be increased if the 'least developed countries' as described by the UN which has 940 million potential users have a way to access them. While 69% of the world has 3G access, only 29% of the rural areas are served. From just 400 million internet users as surveyed in 2000,this shows there is a huge growth and need for access of the net across the world .As the installation and maintenance of a cell tower/base station in each of these areas would be expensive and would not happen anytime soon in rural areas or mainly disaster struck areas where the cell towers are damaged and cell reception/net is not accessible ,a UAV can be employed in such dire situations with a 3G(or)4G module or a mini base station fitted on top of it, with a camera attached to it.
The 2015 South India floods, which lasted between 8 November-14 December 2015,caused a lot of unrest and problems for the people residing there due to unplanned safety precautions/measurements and also not efficient drainage systems and was mainly amplified by the 2014-16 El-Nino event.

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As the rescue operations took place people without any communication access to these help were stuck behind in the shelters,home,etc.suffering from the consequences of the floods.The rescue operations would have been more efficient if there was a medium or channel of communications between the victims and the rescue personnel.
These kindof developments promote the use of drones for such specific purposes.The main parameters are:

- Optimal flight time.
- Constant availability.
- Safe navigation contact.
- Better picture of the area.
- In case of crashing of the drones,no human life is in danger.

An example of a part of the concept was tried out in the Aerohive BR100 Wi-Fi Router with a 4G module attached to a custom drone made by Aerohive.Using an AP-equipped drone to provide Wi-Fi over areas that don't, or cannot, have Wi-Fi coverage.The BR100 soared a few hundred feet and successfully beamed down Wi-Fi that was accessed by an iPhone. On the short list:

- Provide Wi-Fi to first responders to natural or man-made disasters,
- Provide Wi-Fi for events like outdoor concerts, company picnics, etc.
- Provide temporary bridge links between locations by bouncing off aircraft.
- Offer coverage for forward operations like oil exploration, expeditions, and remote camps.

The camera present in the UAV would detect any person or anything based on its thermal imaging and GPS location which is transmitted along with Wi-Fi connection established by the mini-base station/router on the Drone by using RF communications.
So we use a Drone, preferably DJI Phantom 4,which has a flight time of 25-30 minutes(max.) which comes with the camera and a self-balance system,which seems to be the best in the drone space.

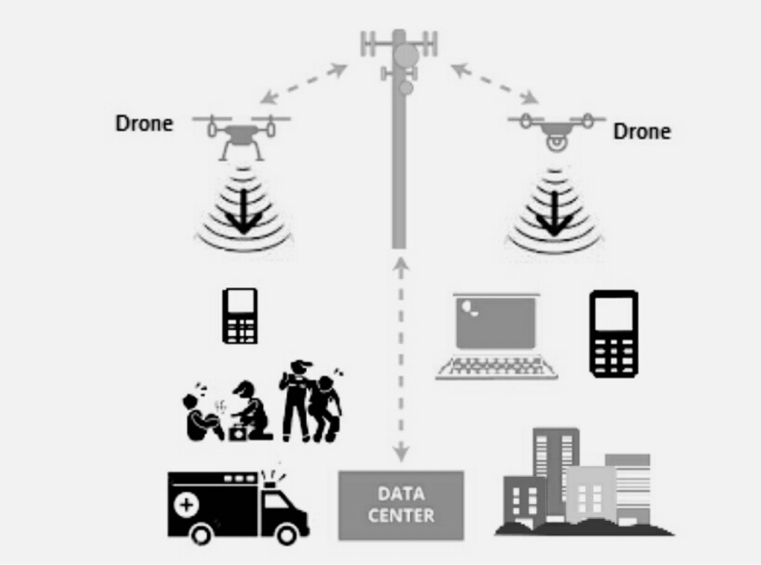

Fig 1. Concept Diagram of Drone-BSs used for aerial cellular communications

II. LITERATURE REVIEW

We know the research methodology for drones with hotspot, with base station and with camera using Gimbal technology. All the above applications are proven experimentally and verified. So, our paper includes all the above three applications of drones brought together on one platform to introduce a new concept of drones

with all the above three factors inbuilt, hence making it more efficient, cost effective and most importantly compact.

A. Air Borne Networks

In the telecommunication field, one of the most promising applications of UAV is to use them as support equipment, aimed at extending the capacity or coverage of wireless systems through the deployment of an aerial communication network.

Wi-Fi is so far the most widespread access network for providing connectivity to end users through wireless devices. An ultra-high bandwidth wireless network in the sky is of great help in the objective of this paper. An ultra – high bandwidth wireless network in the sky can be constructed which is capable of sending large amounts of data from 10 Gbpsupto80 Gbps between moving aircraft or between aircrafts and ground station 200km away.

Keeping the data flowing across a wireless communication link through a range of weather condition without suffering reduced performance or loss of signal will be another challenge .We can overcome this by combining two diverse wireless technologies such as optical and millimeter wave signals that can compensate for each other's short comings without interfering each other signals. In this setup, both signals need to be treated as equals, versus the alternative of treating one signal as a primary and other as a backup , thus allowing for the output data streams to be combined to yield the strongest possible receive signal. With this approach, the link can deliver fiber – like performance in terms of speed and reliability, even over fairly long distance.

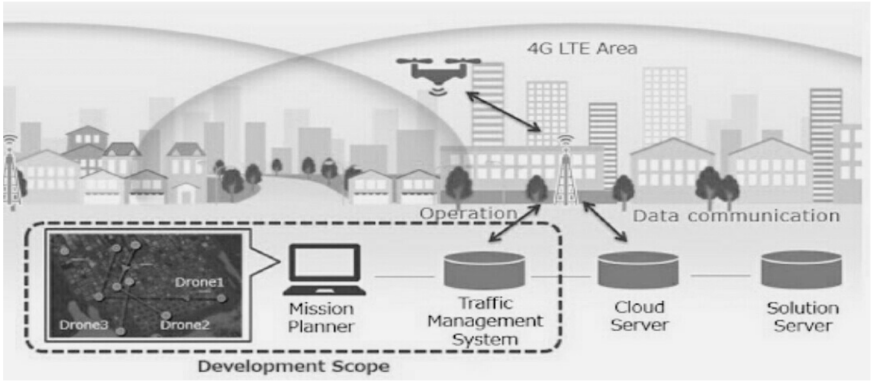

Fig 2. Visualization of the Drone-BS

B. Base-station

Drone base stations can help the ground network of base stations in providing high data rate coverage whenever there is an excessive need in space and time especially in situations when this excessive demand occurs in a rather difficult to predict manner. It can assist in both coverage and capacity enhancement.

Consider an area with specific number of users. The basic requirement is to find the minimum number of drone base-stations and to give service to the user in the region.We limit our analysis to downlink, so down base-stations are transmitting data. An important feature of a Drone-BS is its ability to move. Therefore we do not need to cover a region while there is no user. As users move, drone-BS might follow them if needed, so here we find the placement of the Drone-BSs by following the user from the camera feed.

C. Camera

Small Drones fly routes in an autonomous manner, carrying cameras for aerial photography. Modern camera drones orquad-copters, need to have control on multiple systems keeping the drone and the camera steady and under control, results in better smooth video and stunning photographs. At the heart of many camera drones is a magical device called a 3-axis brushless camera Gimbal and anti-vibration. The drone consists of the GPS system which is located at the top center hump of drone. This system gathers satellite data in order to determine the position of the drone-this data is also fed into the main flight controller. Underneath that is the flight computer along with main IMU (Internal Measurement Unit).The IMU contains:

- The barometer (measures the pressure in the air, which help the phantom know its altitude above the ground)
- Accelerometers inside the drone sense whether it is moving through the air.
- A gyroscope helps keep the drone body level during the flight.
- Radio receiver and transmitter which enables the user to communicate with the transmitter and smart devices back on the ground
- ESCs (Electronic Speed Controllers) which provide power to the drone motors and the externals features attached to the drone.

The Gimbal uses electric brushless motors to stabilize the position of the camera. 3-AXIS- The Gimbal describes and stabilizes the camera to adjusting all directions –up/down, left/right and forward/backward (also called yaw ,pitch and roll)(3 dimensions).The larger mechanical parts of Gimbal are-the camera holder and 3 motors which together to keep the assembly level and vibration free. This allows us to capture smooth footage that would otherwise only be possible with a counter weighted stabilizer like a glidecam.

The drone taken as an example(prototype) is DJI Phantom 4 which already employs this principle.The following is the method which employs our idea incorporated into the UAV.

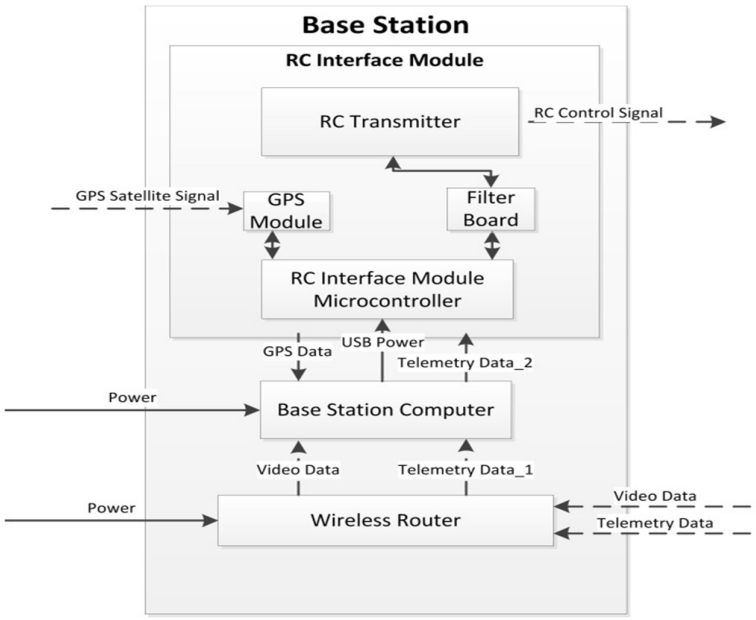

Fig 3. Block diagram of the base station

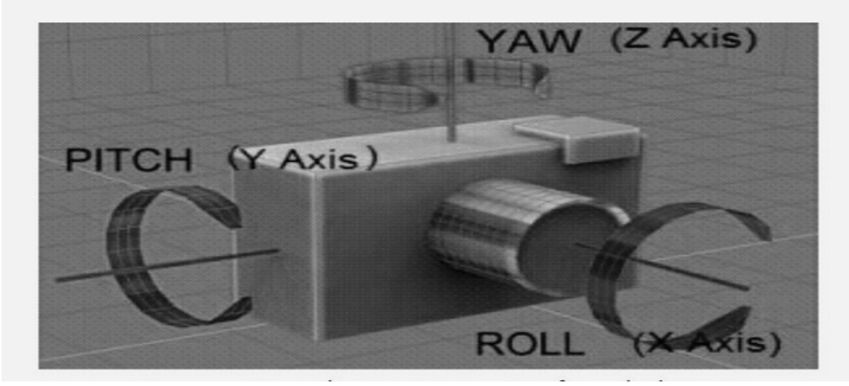

Fig. 4. Axial representation of Gimbal

III. METHODOLOGY

In the course of our research,we found out that on average $150,000-$250,000 are spent on cellular towers or base-stations which is quite expensive as compared to our Drone-BS's.Although the towers/stations are quite cheap in the long run,the maintenance as well as the overall expenditure of installing them in many areas causes them to be focused,rather concentrated in certain areas.This happens due to the total expenditure of the allocated funds given for installation of such equipments.Also not to forget the health risks it possesses due to radiation caused due to illegal levels of frequency range used and the non-function ability in case of bad weathers or natural disasters.Moreover this model is focused or rather conceivable in terms of rescue operation where communications between the rescue crew and the people can be established.

TABLE I. COMPARATIVE ANALYSIS OF DRONE BS

Comparison basis	Cell Tower (General)	Drone (DJI Phantom 4)
Price	$150,000-$250,000	$1500
Max. Flight time	Not Required	30 minutes
Communication distance(operating range)	35 km	6km
Range	2 Kilometers (microcell)	Approx. 2 km (long range)
Crew	4-5	1
Maintenance	$5,000-$10,000 p/m	Under $200 annually.

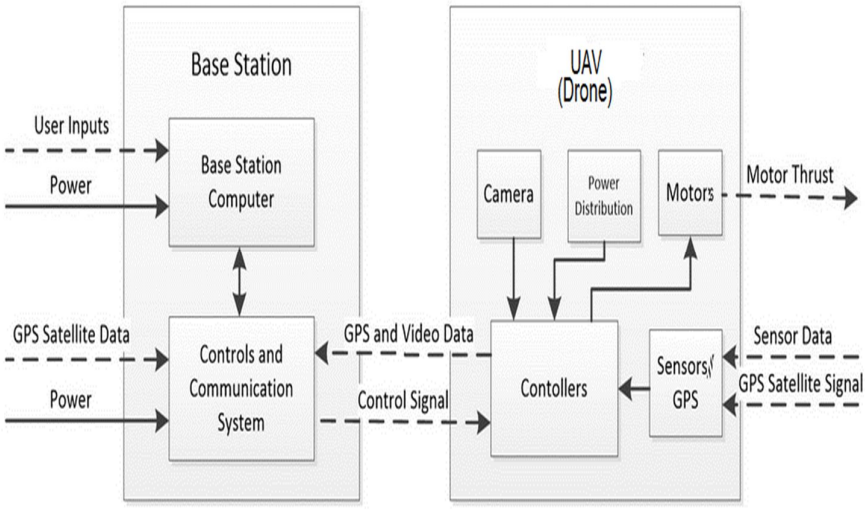

Fig.5. Block diagram of operation between BS and UAVs

The main advantage of Drone-BSs is that since they fly in a relatively lower altitude,they are not affected much by the weather and they don't possess any health risk.Due to this,the user has easy access to the hotspot and cell reception as the distance between the UAV and the user is drastically reduced.Also another advantage of it is that the UAV can be maneuvered as per the location of the user.As there are no users in the area, the UAVs need not be flying over.

So the UAVs(drones) are fitted with a mini base station consisting of small antennas and a mini-router on top of it,which is in access with the ground station.The UAV's is then flown over usually a few hundred feet even though they can reach high altitudes.As the UAV's fly over they broadcast the network with the hotspot through which people can access it. RF communications are recommended for the module. The devices,drones and the network operating frequencies should be different since if there was any overlap

between them, there would be interference and loss of communications and control of the operation of the drone.Also the drone which uses the Gimbal technique for the camera sends a feed of the location through the aerial network established.
The flight time of these drones would max reach up-to 25-30 minutes. So there is rotation of a numbers of drones thus maintaining a network. Along with this, multiple drones in air would form a network and thus increase their network range over the area. Depending on the need and the number of people as viewed by the UAV during situations when it is essential, only the required amount of drones would fly over thus not exhausting all the drones in stock.
An important aspect is that we do not want to replace the presence of cell towers but we would introduce drones as an assistance unit for better cell connectivity and encouraging smooth and constant net & cell reception. With the help of drones there are more possibilities in enhancing aerial networks.

IV. CONCLUSION

The paper describes and analyses one of the most promising applications of drones (UAVs) in the field of aerial communications and photography. Wireless users expect unlimited capacity everywhere and all the time, especially in dire situations. The most significant way to provide better high-rate coverage is to deploy a network of drone-BS's which would broadcast network and hotspot over the radius of coverage. Also provide us with an aerial feed of the location to get a better image, rather understanding of the area.
The main aspect of this paper is to make rescue operations more compatible and easier and also to complement the existing network system and make it more refined.
Hence our paper outstands with an excellent idea of bringing all the three applications (drones with hotspot, drones with base station and drones with camera using Gimbal technology) in a single unmanned aerial vehicle , making it more efficient, cost effective and compact.

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