

# Telecommunication Networks in Disaster Management: A Review

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**Abstract**—This paper aims to provide a comprehensive review on the roles of telecommunication and computer networks in disaster management. In this regard, a variety of networks have been proposed, investigated and successfully implemented in various part of the world, especially in developed countries. The undergoing work not only enlist the telecommunication networks being used for disaster management, but their limitations, pros and cons have also been discussed. Moreover, all types of telecommunication networks are summarized in the end of paper.

**Index Terms**—Information and Communication Technologies (ICT), Disaster Management, Backup and Recovery, Telecommunication networks

## I. INTRODUCTION

There are many ordinary disasters, but the Earthquake is the most precarious disaster due to its uncountable sufferings such as lives or foundation. This is impossible to get the information related to earthquakes before they occur. Though, when this disaster happened in any area of the world then it depends on their managements how they can save the lives and communication or transportation system. How can they find the missed people above or subversive? Several organizations provide their services professionally and deal with disaster circumstances [1]–[6]. All subsequent parts of this article are having the knowledge about most recent projected systems, tentative studies and execution of the results of these studies in developed regions.

At the last part, this article keeps their power forces and constraints also.

Rest of the paper is arranged just as following parts. Part 2 is keeping related work about disaster management systems and 3 comprise the summarization of ICT networks which used in disaster management. Part 4 related about the article discussion.

## II. REVIEW ON DISASTER MANAGEMENT SYSTEMS

### A. ICT based Networks in Large Scale Disasters

From historic studies it is apparent that that severe natural disasters like earthquakes, hurricanes, Tsunamis, floods and typhoons etc., may appear in the suspected areas around the world. This happens mostly without warning, cause huge losses in terms of lives and infrastructure. Because of the observation of such massive natural disasters related damages, researchers suggest systems and functions that help reducing the impact of future large-scale disasters. They proposed a resilient disaster network called Never Die Network, NDN, designed for Japan island due to the nature of the area of which 70% is comprised of mountain and is surrounded by large oceans. The main architecture of NDN system, shown by schematic in fig-1 [7], consists of three networks: fixed NDN, mobile NDN and air NDN self-power supplied fixed cognitive wireless network, mobile cloud computing nodes and self-power supplied wireless balloon stations. The main purpose of NDN is to provide emergency support to both the disaster victims and the crewmembers helping the victims. This purpose is accomplished at the disaster affected area by providing a communication infrastructure and other disaster relief operations that involve searching for and locating the survivors, and then rescuing them.

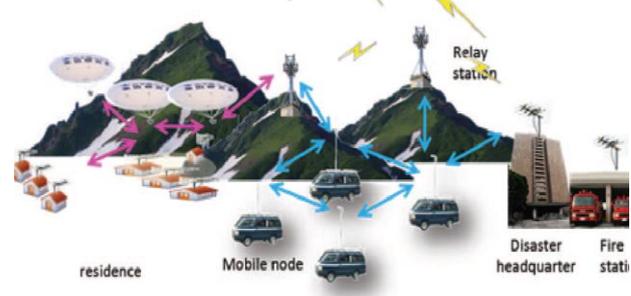


Fig. 1. Never Die Network (NDN) [7].

However, the search operation in NDN is manual and thus considered to be time consuming and inefficient for locating and rescuing survivors. To overcome the problem of manual search and locating operations, researchers introduced a novel network architecture

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called the Portable Disaster Recovery Network, PDRN, that supports automating search and locating operations by enabling survivors in a disaster area or a non-disaster to report their locations to a Command Center which in turn enables quick respond and rescue. A study in [8] provides an analysis for the performance of random walk models of the movement of survivors in PDRN. The study shows that the main important factors affecting the performance include battery life, number of phones, number of survivors, and distribution patterns of the phones and the survivors.

Moreover, in most earthquake events, it takes few seconds to strike and influence several miles causing major destruction as well as haunting people by its aftershocks and tsunami threats. To reduce the impact of these events, researchers in [9] provided a study on implementing ICT and Wireless Sensor Networks both together to support and help in disseminating earthquake alerts as an Early Warning Systems based on Earthquake prediction methods and disaster management strategies. The study shows how Wireless Sensor Networks is used to design earthquake detection mechanisms and how ICT does enable broadcasting earthquake precautionary measures and safety information and thus avoiding overwhelming situations during quakes and safeguard people from heavy losses.

Earthquake Early Warning Systems (EEWs), use a combination of seismometers, accelerometers, communication network, and alarms tools designed to alert devices and people for the coming substantial earthquake before shaking begins. The research and developments in earthquake science and monitoring systems technologies enable EEWs increasing the feasibility of short time warning about the arrival of the earthquake while it is in progress. The difference in speed between the faster wave captured by seismic sensors and the slower surface wave that causes the actual damage gives a few seconds to minutes of advance-warning to reduce the risk from earthquake hazards. A study given in [10] provided an analysis on earthquake early warnings on the U.S. West Coast based on surveys of residents and statistical models. The results show that most of all respondents agreed that EEW systems are effective however, the results show a need for an integrated pre- and post-event data collection and analysis strategy to enable better understanding of people's expectations and experiences which in turn prepare them for hazards [10].

Considering the observed significant role of both ICT and mass media taken place after the Great East Japan Earthquake, a study in [11] provided a two model case study of the Great East Japan Earthquake to explore and examine the effects of ICT and mass media in post-disaster recovery based on data collected from the three areas that were directly hit by the disaster. The results out of the study demonstrate a consistent pattern on the positive effects of ICT and mass media in post-disaster recovery. Due to their important implications on the

social capital and civic participation in the society, they lead to better recovery work and policy making in post-disaster recovery. Unlike the previous studies, this study provided a demonstration on how media can affect people's perception and behavior toward a positive participation in post-disaster related activities. Moreover, the two proposed models can serve as the foundation for future studies on the underlying mechanisms of the media's effect and role in post-disaster recovery [11].

### B. Geographical Information System (GIS)

The importance of networks be a very essential part of lifelines due to these networks, these lines are active and purposeful. Most of the natural disasters cannot obliterate these lifelines e.g., earthquakes. The fundamental needs of these lifelines are the investigation of dimensional structure according to the specified risky portion of the map with a very good consistency part. The author introduced GIS base software for the dimensional structure examination and this software operate with the help of Geo Tools. The major signification of risky tectonic part of the progressive software is to build up a network frame with its layers. At last, this software operation is to compute the dimensional structure of an algorithm which includes the upper and lower parts of lifeline underneath any type of risk. According to this software, end user can envision the consistency within the graphs and confined lifeline consistency map along colors. These operations show each level with link and entire network perspective. In the form of file system, study outcomes are saving according to the calculation of the given functions. For verification and approving of software, an application about allotment of water system of Bursa in Turkey is a part of literature. This GIS based software specifications are very constructive in the form of alteration and some extra features along structural mapping are also there such as user responsive, completing time of a job is quick and descriptive according to this literature [12]. Fig. 2 describes it better.



Fig. 2. The lifeline layer drawn by software over a satellite image [12].

According to ecological regions with multi criterion susceptibility evaluation methods, effect of the earthquake disaster enumerates on extreme level on road networks. In these networks, USGS Shaken Maps method is very useful. The researchers examine weak portions by using USGS approach. When earthquake Vulnerability Surface (VS) is created then belongs to this part in which it covers as on the whole pointer of weakness. Through

VS process, a straightforward and applicable process comes in front for incarcerate the most crucial effects of earthquake disaster. This process is also helpful for designers who planned the providing process of services and to evaluate the sturdiness of other different, in which toward make sure to cities which are place in the strict parts of the disaster region is fully prepared for the sudden happens. This process chances try on two US cities, Los Angeles and San Francisco, these cities are at risk of brutal tectonic movements [13].

More than last two decades, controlling process of revolution related to different urban areas has been established by application illustration. This process is having benefits from remote sensing (RS), in order systems of geological part and the actual annotations. In general, relief stage is focal point for the researchers as a substitute of succeeding stage which has initial stage improvement, recovery and expansion steps. The basic purpose of assessment is to check the amount of incorporation of accessible tools, approaches and material. This amount of incorporation is useful for the monitoring process of recovery. In 2009 earthquake of Italian city of L'Aquila, this had observed by Earth observation data. The reason behind this earthquake was modifications in buildings of that city and the identifiable data used as a pointer of development in recovery step. These modifications assess by (1) investigation of visualization, (2) discovery of automated alteration along a decision rules set, and all this happened within investigation structure and (3) a grouping of illustration and semi-automated judgments were based for substantiation step. Evaluation of the automated investigation is having two types of accuracy results; 81% accuracy for producer and 55% accuracy for end user along error of omission 19% and 45% respectively. RS responses give a major theme about modifications and improve the types which used in index recovery. Along this advantage of RS, it provides progressive information related wide area field work of recovery step in the reduction form [14].

Dhaka is a city, in which the earthquake and fire tragedies are most common. An aged portion of this city elected for the evaluation of both disasters as defenselessness. In current years, the social aspect of these two disasters with their weaknesses becomes an important problem in the evaluation part. The foundation of tactic depends upon three diverse susceptibility estimations and the amalgamation of the outcomes provides the compound susceptibility achieve value while the investigation of the learning has been characterized. In earthquake disaster, an illustration about screening process FEMA-RVS used for analysis of 350 building samples. To handle these types of situations, a tactic given by ADPC in favor of fire tragedy and World Bank present a framework for social issues. Fire disaster is more dangerous than earthquake through different studies [15]. EAGA (Earthquake Averter and Guidance App) is a Smartphone app, this app used for searching both tragedies losses. Throughout the earthquake and its

aftershocks, geo collective knowledge in sequence gathered by taking decisions based on probabilistic processes. This app has four different types of operational functions. Firstly, standby function accumulates information which is related to the users with their frequently seen places and societal relations. The second alert function work as a alarming bell, with the help of this function mechanism, a warning of future or upcoming earthquake send to the relevant management. On the spot, this function also gives the preliminary instructions about the disaster to the users [16]. For ordinary tragedies, such places e.g., city parks, play grounds, ground buildings etc play a vital role. These places used as a refugee's campus in which management provides basic support for their survival. The combination of an open space system with urban described the strength of the management through spatial situation of two Chilean cities and these are pretentious via earthquakes. Interviews were the basic control process of data collection from victims in crisis circumstances through Projecting Mapping approach while inflicted to satisfaction. GIS systems used for earthquake recuperation according to the analysis of classifying the category, efficacy and allocation [17].

Landslide division of spatial and contour maps main focused is its mass, area wise fraction and attrition width. These main points assembled the spatial division trends for co-tectonic landslides. Regarding statistics, the division volume and morphometric parameters play an important role in the form of carrier and contrast along further earthquake events occurred in the whole world. Four major agents of co-tectonic landslide load such as landslides centroid number density (LCND), landslide top number density (LTND), landslide area percentage (LAP) and landslide erosion thickness (LET) used as an association with a number of ecological limits [18].

GIS based design presents utensils distribution and placement in any disaster. This design is based on three sub-systems and these sub-systems become useful facilitator in information collection and conclusion process. Mobile devices run an application for scheduled field source demand which is developed in first sub-system. A resource storage area combined with a geo spatial database implementation in which spatial reservation permits along a graphical interface. Adding up in this, a GIS presents its functionality with some key rules just like corresponding process of resources, search out a better direction for allocation of resources etc. Assimilation of decision processes which used for support of multifarious decisions for the allocation of equipment performed prototyped [19].

### C. Wireless Ad-hoc Network

Nepal is a country where the outcomes from multiple earthquakes are, in the form of lives failure as well as the rescue resources convey concentration towards drastically increasing management systems. Most probably, on large scale tragedies as in the form of earthquake and Tsunami

needs attention from the managements. Now researcher's main focus is how they can get more benefits from the management systems in the field of wireless communication such as mobile technologies and other devices with their protocols. A brief study about the usage of new production technologies with telecommunications e.g., 5G, Device-to-Device, 4G/LTE, software can bring the impending in networks of management systems [20]. Network framework damaged in ordinary disasters while the people required a diverse network. Victims want to correspond to each other during any disaster through several wireless technologies such as Bluetooth, Wi-Fi etc. The network main function is to be capable, to modify the admittance of any type of technology that makes sure QoS for currently used applications. Furthermore, energy storage is as large as possible in any network. SDN method is used as a prototype [21].

Communication is a major problem in between the relief operation of any disaster. So, the wireless systems used for communication with their limited resources because of saving lives in miserable situations. There are so many disasters in past which is not describable such as 2011-tsunami, attacks of 11-September, Katrina Hurricane. These disasters give us a proof of solemn loop hole in communication systems which we used currently. Now researchers provide more accurate solutions for these types of disasters with better wireless networks. Several common obligations for relief operation performance evaluated with maximum wireless applications e.g., SPWC which have self-supporting and quick movable network for relief operation in any disaster.

With the help of Low Altitude Platform (LAP) flying objects, the process of communication on the ground level provide better results. Time is the main parameter in any disaster because when lives are at stake so at that time power back up is important for quick response. SPWC might be the most economical solution [22]. In any type of crisis or tragedy, the Intelligent Transportation Systems and Services (ITSS) participates an important part. The system assessment done by micro simulation design is called S-Paramics ITS system. This system calculated the efficiency with mass departure traits. Additionally, driver quick reply is measured and assessed. According to this system, outcomes present the major enhancement in rescue activities (to save human lives and vehicles). Now researchers focus is on supplementary developments in the part of investigation and substantiation of the systems [23].

In common relevance just like supervision, observation or management systems used networks in which micro aerial vehicles (MAVs) along sensors may enlarge their capability. Researchers try to examine the communication needs and proposed a new system that used for depiction of multiple demands and these demands belongs to concerning applications. Consequently, mining of main operations of the MAV network is the next step of the

researchers. They take out focal predictable operations then plot these operations on structural blocks and differentiate the predictable communication supplies. Based on experimental research, researchers explain the potential of obtainable communication technologies with their constraints and in the direction of execution, the trial product used for structural blocks [24].

Further work is based on the progression of human life recognition system. According to this system, information about the victims or survival has been provided automatically so that's why this system known as auto info-provider. The system keeps a special receiver circuit that is useful in any natural tragedy just like earthquake etc. the working of this system on the part of detection side for human lives as an exemplary system, to checks alive class individually then screamed the siren and showed the outcomes on LCD. While information about any individual received by PIR (Passive Infrared Rays) sensory trail system with 2DC motors, receiver circuit working will be start because process of display this information is the major task of this receiver. Therefore, robotic type organize access through devices such as mobile is necessary from distant positions and avoid the accidents [25].

In this research, the structure based on vehicle support flexible in sequence with network system used for administration process regardless of the internet un-accessibility after big tragedies. This structure consist of three parts following as 1) smartphone apps which present operations of SOS in which description, existence, medication, stipulation and secure road finding directions considered; 2) mobile base stations worked on the trade part of the data exchange in between the apps and servers and 3) a type of geo distributed servers while the working of these servers consider the main operations related to the collection of user information, analyzed the distributed data and decision making about management system [26].

Japan is a country which considers as a king of earthquake a great earthquake disaster in Japan was to become a main cause of ICT sources failure, break optical fiber links and so many others fully or to some extent half damages. All these damages occur due to the consequential Tsunami on March 11, 2011. Therefore, overcrowding of traffic arise as a severe issue. All ICT networks might be not able to solve this problem efficiently. Natural mishaps somehow come to the occurrence portion slowly but become a reason of big disasters and no one can stop these disasters. There is only one way to save the human lives, which is the idea of awareness. The awareness perception about natural misfortunes is to become strong rescue operations and other accessories. Prior approaches used tiny robots for this purpose; these robots keep PIR built-in sensors towards identification of the human being there under the surface of the earth. But due to the machine (robot), there is a disadvantage such as robot can be jammed anywhere. To solve this issue, there is an idea in which robots

substitute through an Infrared Ray (IR). With the help of this approach, the victims can be sense and release in a very short period [27]. The idea presents a network structure in which the affecting and deploying operations are focus where we submit to as MDRUs.

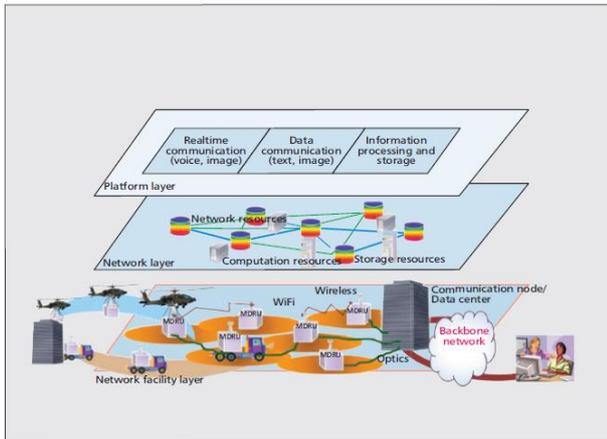


Fig. 3. Considered system overview (MDRU) [28]

The capability of the MDRU system is near to contain the communication with reasonable knowledge. This knowledge can be transferred towards the tragedy area vastly. This system takes a very short period for organization of the network as well as launch ICT services. In this research, the idea and arrangement about structural design of the network with its prominent characteristics are illustrated by the researcher. Several early stage recreation outcomes also provided for the assessment of the performance parameter of the researcher presented network [28]. All this process with structural design of network is shown in Fig. 3.

#### D. Social Networks

Due to the literature, extensive term investments on any natural tragedy flexibility required good plans. Plans included the power of the social societies and these societies make plans, attractive systems, to answer and recuperate the disaster damages. This is an important aspect of the investment in the direction of continuity. So, a theoretical design presented for the explanation of the resilience for continuity in supply chain networks. For this continuity, two type of data used as an unstructured and structured form. In unstructured form, big data based upon 36,422 items collected through many types (tweets, news, Facebook, WordPress, Instagram, google and YouTube) while on the other hand, structured data based on 205 managers which occupied during aid operations in 2015 Nepal earthquake [29]. Social Networks (SNs) is growing fast and a large number of users whom communicated to each other with the help of SN turn out to be a famous and flourishing area now days. Several probabilities, amount and different type of assortments tender through SNs. SN grow to be an important tool for daily life operations and in social links. The main characteristic of SN is, to permit end users as a form of groups, arrange these groups in an order and their social

links divided into sub-form of groups or circles through classification process. An innovative algorithm based on Ant Colony Optimization (ACO) has been presented for searching and examining operations on these circles. This algorithm performed on every social network, but the prediction is true on Facebook, twitter and google+. Based on investigational operations, this algorithm applies on the various forms of benchmark databases and shows what the working style is [30]. With the passage of time, online social networks (OSNs) usage is budding fast more than 1 billion end users. Such examples of OSNs are twitter and Facebook in which the growth crosses the limit and flourishing with intelligent ability. In badly hinted areas, the searching activities are more dangerous rather than transport the necessary items such as food, clean water, medication, shelter. Therefore, internet facilities and cellular communication structure perform vital role because when somewhere any tragedy can happen, most important part is communication to each other. In natural disaster circumstances, communication sources ruined first, in the form of disturbance, excessive their end users and provided information about their siblings, relatives, family friends and so on. When tragedies happened in any part of the world, structural design destroys first while due to this harm, network traffic overloaded on other accessible routes. This becomes the main reason of blocking and so-called delays on network routes. When end users required a good connection of internet facility at that time they required flawless extra ordinary communication path with open access yet with high demand of usage in tremendous conditions. DTN is a type of direction-finding scheme which have the capability toward about distributing process of data on alternating network. Besides this, a major defy for DTN is achieving performance in real world. Consideration of the DTNs consistency along their capability feature for social networks support program is very crucial due to some reasons that make sure DTN is appraised use-cases. These cases are replicable, analogous and offered to everyone [31]. Internet accomplishment is beyond the limit during any disaster still with the majority of positive anticipations. It depends on all portions of the accessible civilization and its financial system. Communication is a focal factor for the internet. The success rate of internet is directly proportional to the dependency of communication. According to the success rate, several processes reinforcement and provide a powerful base for any up to date civilization rather than crushed it and due to this reason communication would not be available sometimes. Although, the world bad luck is that the recent security and accessibility measures are not enough for providing a good facility of the internet. First, internet structure has not been able to do its job on high ranked tasks previously. But now days, some enhancements in internet security systems provide good infrastructure of its structural design with constraints. To address these problems, SCION (Scalability, Control and Isolation on

Next generation networks) mentioned as an inter-domain structural design of a network [32].

The SNs power shows its potency along with weaknesses in an effectual way. Its authority maintains the capability of different communities to handle the situation of any disaster. SNs present the study for such multifarious networks with high extent in tragedy strike areas; this process is called Social Network Analysis (SNA). SNA is a type of application in which researchers explain the tragedy strike areas with networks along their changing trends throughout in any disaster. Any disaster is somehow become an event and this event concept consists of four stages such as ‘extreme event’, ‘immediate community response’, ‘relief’, and ‘rehabilitation’. In addition, these four stages names given by different group discussions along community decision. Early stage with post stage considers providing the comparison between the communities SN [33]. Management of any disaster is a very big problem for any part of the world and now it become a recent issue for research. Due to this, Emergency Communication Networks (ECNs) present the basic operations. In general, communication facility is not vacant during any smash up and restraints. Researcher provides a complete review on baseline ECNs and big data for satisfied material with their spatial circumstances. While satisfied material part depends upon the review about data mining with its analysis approaches. On the other hand, the second part is spatial circumstances, related to the applications, mutual probabilities and enhances ECNs [34]. All description is shown in Fig. 4.

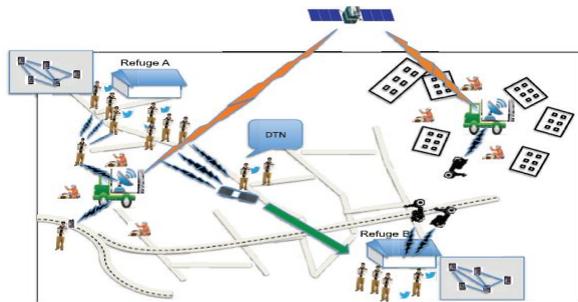


Fig. 4. Example of usage of hybrid ECNs [34].

Lately, tragedies on social media such as 20 million tweets regarding ‘Sandy storm’ and sending/receiving pictures on Instagram with 10/sec ratio is keeping the statistics about indulgent as well as management events. Several agencies in which control process apply on the law and order situation and some civil aviation gets successful benefits as of social media with their flexible processes. The research about social media usage discussed on different forms, researcher’s discussion related to the wide range of extended versions of social media such as promotion, structural point of view and some type of financial issues increase day by day. But still they cannot find a better, simple, valuable and normalized method to control the versions of social media rivulets. EU FP7 is a project SUPER (Social

sensors for security assessments and Proactive Emergencies management), basic purpose of this project is to handle this type of technology problem, started in 2014 [35].

Twitter is very famous now days in which important attribute is real time nature. Therefore, most of the researchers determine the relationship in between the events and the Twitter. Based on interaction relationship, researchers propose an algorithm and this algorithm used for monitoring process of tweets. According to the monitoring tweets, they identify a target event and plan a classifier for learning process of these tweets e.g., focal reserved words, count frequency along context. Consequently, researchers work on target event and construct a probabilistic spatiotemporal model and this model can discover the central position of the event also. Japan is the country who develops an application of reporting system for earthquake disaster. Due to various disasters regarding earthquakes, Twitter users overall the country can perceive an event of earthquake along elevated ratio of tectonic power through monitoring tweets data. Japan Meteorological Agency (JMA) provides 93% of tectonic intensity results on till level 3. The presented system is faster than JMA broadcast announcements [36]. Governments try to set before time warning systems for any upcoming disasters. Co-production assumption of citizen with flexible knowledge about communication framework create impact factor sketch. So, the researchers used government network that is Twitter Tsunami Early Warning Civic and try to provide the useful information before time to the citizens. The government of Indonesia deploys this type of early warning tweet and this tweet spread by its own followers without any delay. This tweet generated by itself such as “re-tweeted” and travelling time is only 15 minutes and reach about 4 million twitter users in 2012 earthquake. If government and citizens work together than they get fully control power on network and based on this article selected case study, Twitter information work stream and communication between different networks give a way to researchers for searching speedy and better solutions for early warning systems by governments. This contribution provides good results on the citizens co-production such as citizens confidence or know how about the government steps is increase and then the government work efficiently with the time [37].

#### E. Wireless Sensor Networks

In ordinary disasters, researchers endow with an innovative method in favor of recognition of aliveness feature of people. This method is having some important components such as PIR, ATMEGA16 Microcontroller with baseline GSM expertise and Power Line Communication systems. While the detection process is performed based on heat, pulsation, IR, ultra-sonic detector which provide full substantiation with necessary information concerning attendance of breathing people under the surface of the earth. GSM is the best control technology, through which, send some apprehension

messages to the base service room which can make when any disaster happens in any region by power line communication system. With the help of this communication system, management can save the victims at proper time [38]. Several Radar systems can also design for the detection process of alive human. As a result, time is varying silently and returns the useful information related to alive human pass to the base stations at some stage in action. These radar systems provide the information about presence and categorize the human movements. Most recent advancements contain permitted some dimensions regarding pointed rate of affecting people individually. On the other side, inactive systems contained an offering policy about balanced exposure form in which finding an alive human with their categorization activities performed [39]. Keen knowledge related to the compound, corporeal parts with some organic systems of earth used in Earth Observation (EO) through the distant sensing methods. Among the amalgamation of satellites, EO have been triggered in several fields just like monitoring process, organization of resources, prediction about weather, calculation related to the part of the land and so on. Researchers found another issue in EO that demands active topology power while this topology used for satellite cluster networks (SCNs) rather than inter satellite links (ISLs) used for constancy [40]. Ultra-Wide Band (UWB) is one of the most famous types of radar in which sensors work is more important because sensors used for intelligence beyond the walls also. In any case of crisis just like earthquake is a cause of fall down the buildings, houses etc. So, in these types of circumstances, UWB radar used for detection of alive individuals. Two major operations such as search and save are under consideration when responders supply well. A Standard Deviation (STD) based method is proposed by researchers for individual recognition process. It is an easy task in accomplishment phase with the limitation on accurateness. This method gets the excellent result of recognition without any fault [41]. Another pioneer research shows the structure with experimental results along low down budget release robot system in which light mass PIR used for the recognition process in any tragedy [42]. A wireless body sensor network (WBSN) is another fruitful research in which incorporation take part a lot with several physiological sensors. These sensors attached with radio line for safety of the human life and broadcast their information to a distant healthcare center by a useful device just like smartphone. All the information and outcomes based on wireless broadcasting as well as emulation are explained [43].

Robot system used for human recognition process even in garbage on time is a big achievement that sense help reached there where victims need it. Robot structure consist of a PIR sensor which handle the recognition, an automatic support that get rid of the obstructions and a camera for pictures and after that these pictures propel to the control room. Microcontroller SST89E516RD is considering the heart of the robot because due to this,

robot will be under control. Next step of robot is about its movement, with the help of three wheels geared along DC motors, robot can move forward as well as overturn [44]. Robotic structure is exposed in Fig. 5.

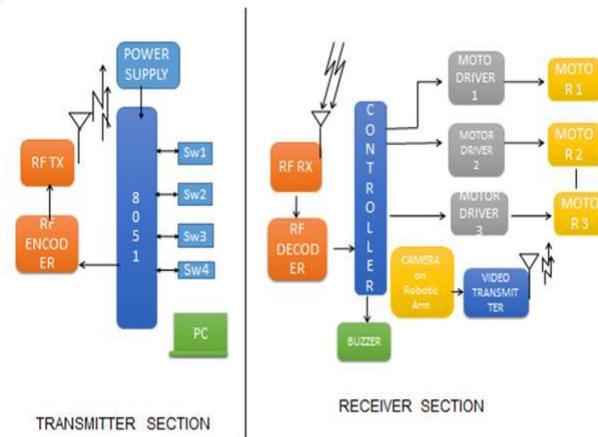


Fig. 5. Human detection robot block diagram [44].

Further research based on the validation and evaluation process. An innovative idea about detection process named as arrayed laser image contrast evaluation (Alice), consider visual assets of individual skin. According to this system, an NIR dot array laser work for the lighting operation while a camera used for detecting the region which is irradiated. Properties of the human skin are unique and classifying by a laser distinction which can be computed as of power division form along reflects of laser light. Alice system can work on even a small piece of skin and distinguish completely concealed individual [45]. The PANDORA Robotics Team belongs to Aristotle University of Thessaloniki (AUTH), try to work on the structural design of the empirical robots and later, these robots used for investigation with classification of the injured party. This PANDORA Team initially originated in 2005 and contributed in RoboCup-Rescue 2008, 2009, 2011 in addition to 2013 antagonisms [46].

#### F. HAP (High Altitude Platforms)

This is the world of high altitudes that's why it seems very hard on behalf of helicopters on the way to go for short height. There are several reasons behind it e.g., hilly or island, weather stipulation, muscular wind speed etc. Therefore, choice of helium gas balloons structure named high altitude platform (HAP) is a good option while the major functions of this scheme are based on the speed, exact, squat budget and more secure. According to the functions, this system formulates fruitful operations such as sending correct information about disasters toward the supportive station [47]. There are several examples of HAP which used for stationary objects with its surveillance as well as communication overhauls, high altitude balloon (HAB) used for this purpose. For sustained the location in front of stratus globular airstream, electro hydrodynamic (EHD) offered by researchers [48]. Next step of research belongs to the systems in which the authentic time active and

understanding against responsibility are the most significant qualities keep keen observation part about natural tragedies. Conditionally, participation of the broadcasting about admonition signals or alarms become a good part of the aid operation in which researchers achieve their goals of territory Unmanned Ground Vehicle [49]. Journey of the research continue the struggle about wireless networks and they reached to a system that consist of an Omni directional camera with elevated declaration, wireless LAN and capturing images as of the sky and drive these images directly convey base station. Consequently, extensive region images are the foundation of the decisions; main center of operations make their decisions on it [50]. A new idea arrived about Location Oriented Directional Medium Access Control (LODMAC) etiquette in which national area (neighbor) recognition and broadcasting the information are working equivalent; these operations performed by the directional antennas. In addition, ability of this etiquette is very high; on this behalf researchers consider, this is a good substitute of HAP [51]. A brief review about baselines HAP with their functional applications presents by the scholars. In the prospect, applications and networks have precise intrinsic leverages adjacent to HAPs. Technical problems of the HAPs may provide a new line of research within these systems be capable of association with other networks such as satellites or global world [52]. Technical point of view, the entire scenario prescribed in Fig. 6 [96] and some related work in [97]-[100].

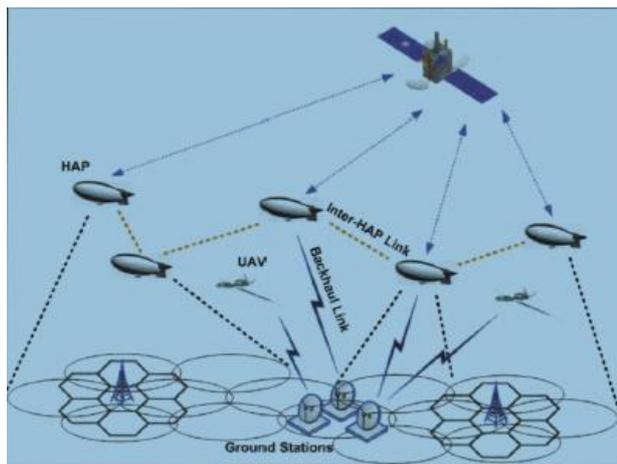


Fig. 6. High amplitude platform system architecture [52].

### G. FANET (Flying Ad-hoc Network)

In seek and save task, airborne ad-hoc networks participate significant position in the result and these solutions are, for several applications. Though, a few networks solved only explicit problems about communication. Several models which have the quality function of mobility offer direction for indulgent about flying ad-hoc networks. Dependency of the network along approved systems is a memorable trick which remains pros and cons with their understanding factor [53]. Contrast of two well-known algorithms presented in

this critique such as optimized link state routing (OLSR) as well as predictive OLSR (POLSR). OLSR new version draws for structure of the FANETs while these have benefit over Global Positioning System (GPS) for admittance of useful information. On the other hand, POLSR is only stuck with FANET work such as Linux. Tentative results provide the assessment regarding array of messages, performance factor of association and direction-finding [54]. During topical era, Unmanned Aerial Vehicles (UAVs) growth increase speedily with their competences and responsibilities within the martial and public societies because of the enhancements according to the expertise such as robot systems. Scholars find out the solution of the practical plan in favor of multi UAV structures which have two parts of the operations such as support and group effort. FANET used for this technical issue. The scholars have a formation for these problems as well as disputes [55]. An informational comparison among FANET and classical FANET is presented in this research. FANET used accessible map-reading procedures and divided these procedures into six diverse classes. In these classes, examination and comparison are operational factor on performance metric. These relative studies provide some advantages to engineers who built networks like buildings and select suitable procedures for FANET exploitation [56]. There is a survey about FANETs association with UAVs in which comparison presented about flying ad-hoc networks (FANETs), Mobile ad-hoc networks (MANETs), vehicle ad-hoc networks (VANETs) along explanation and introduction. Some open challenge problems about FANET protocols are argued in this article also [57]. This depicted in Fig. 7.

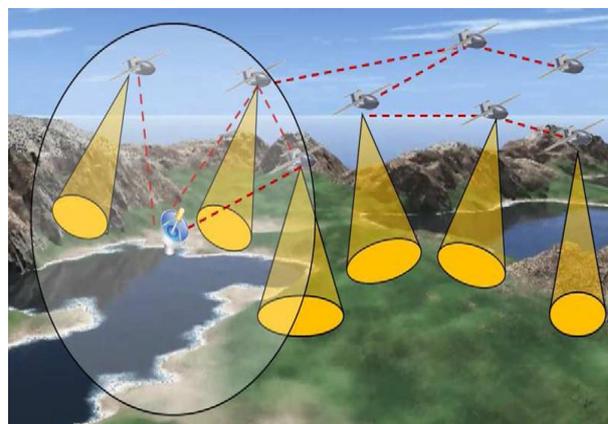


Fig. 7. FANET systems [57].

### H. UAV (Unmanned Aerial Vehicle)

For the survival of the capability, rescue teams with their manager's efforts about work speedily due to the elevated demands of the excellent work and high pledge on geo spatial informational data where UAV used for equally such as surface of the earth and in the sky air [58]. UAVs gain forever green fame in societies publicly with volunteers and service providers whereas LTE 4/5 G

networks along mobile edge computing also used for it. The next research gives the idea about UAVs interlinked with IoT and its deliverance process with all the services of IoT. Overview of the incorporation of UAV and IoT next to taken orchestrator provides a brief explanation about introductory session. At the same time, visualization process used in a crowd with the help of UAV for detection of the faces. In this scenario, estimation about use-cases divided into two parts offloading and onboard; examination of data dealing out in the form of video is belongs to the first function and local processing of data is about onboard [59]. Communication is a main point in any civic operation due to the several reasons such as relationship with network, breakdown of supportive positions, wicked assaults etc. this is not possible to provide communication publicly during any natural tragedy. Lately, on the place of UAVS, public safety communications (PSCs) used for deploying rules and regulations with collaboration of heterogeneous network (HETNET) planning. After this, Genetic Algorithm (GA) introduced as an optimization of UAV base stations position as well as the recreation outcomes demonstrate some scenarios when a network disastrous then the UAV base stations get better their own output and network output with 5<sup>th</sup> percentile [60]. FANETs provide their links with other networks and the noteworthy problems about design with open available research challenges [61]. According to the analysis and their applications, UAS connection with shipping and its performing objective is; for proper ground setting. In shipping and traffic manufacturing, UAS accomplishment and consideration include several important activities regarding integration. In the light of different studies, shipping structure divided into many fields. Supplementary prominent operations or functions can be merged for achieving the capable challenges. In conclusion, intangible as well as practical problems are exposed in rising concept [62]. UAV format collaborate with IoT services for preliminary part of the systems and achieved to handle main problematic portion which presented in [63]. The forwarding step in UAV is management and it can combine with neural network for cognitive and topology maps. Two filters named indirect and Bayesian Kalmar may utilize in support of evaluation. The field research recovered focal design that is suitable for searching operation with the help of UAV multiple maps and pursues superfluous way of searching such as user nodes and geographical areas; with categorizing process. With the help of recreation, results show in the manner of efficiency [64]. Another expertise RIFD used to be appropriate the functions on controlling process. The exemplary design focused on RFID tags while allocation of the lands and user fitting process of UAV development perform very well. UAV used in the process of collecting information from scattered area through RFID sensors. The scheme style established for reaching to destination, go after in the air process and compute the data. The execution of an autonomous network along

RFID sensors provides a better result by covering large area or in very hazardous situations [65].

In this research, the researcher presents an architecture for closed circuit monitoring of such sites, which may consist of multiple indoor and outdoor vantage points by using the legacy 4G LTE wireless network cellular infrastructure in and around the buildings consisting of several outdoor macro cells and indoor. Researchers investigate the technical performance of such a video streaming system using the metrics of throughputs, loss rates and delay in relation to the physical aspects of wireless propagation; multipath propagation loss, shadowing and fading models [66]. This research presents a realistic mobility model designed for UAV ad hoc networks. Since evaluating the performances of ad hoc protocols is an important step to predict possible problems that can affect the system in the real environment. This mobility model behavior is compared to the well-known mobility model behavior Random-Way Point. It is also compared to real movements' traces using several metrics [67]. In this research, a new multi UAV task planning heuristic is prototype for FANETs to visit all target points in a minimum time, while preserving all time network connectivity. Effectiveness in the mission execution and cost efficiency in the task allocation have been presented by conducting a bunch of experiments performed on 2D terrains. Performance results validated the usage of our algorithms for the connected multi UAV task planning problem for FANET [68]. It is depicted in Fig. 8.

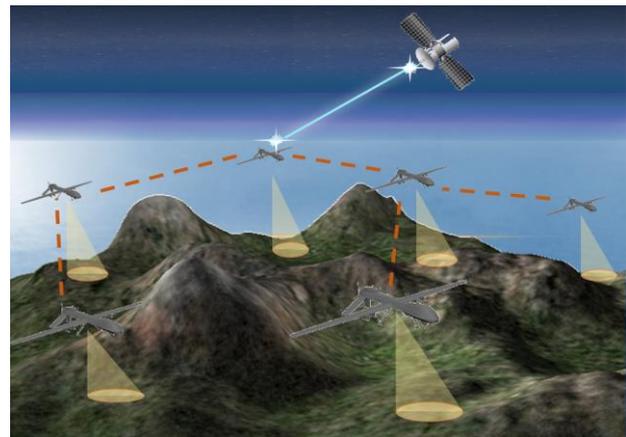


Fig. 8. UAV systems [68].

Live aerial observations from field to control and operations centers, in form of photos and video for visual situational awareness, are valuable in several mission-critical operations, such as disaster management, search and rescue, border control, police operations, security and safety. The use of small UAVs to obtain these observations is attractive, but often challenged by lack of suitable solutions to get live images back to decision makers. In mission-critical operations, detailed observations may be required in real-time, shared beyond the location of a pilot and payload operator. For UAV flights anytime/anywhere, potentially beyond radio line-

of-sight, one cannot depend on terrestrial communications alone. Satellite communications is required either in the UAV itself or as a relay via ground to secure the observations can be shared. High definition photos and video have given high costs and long delay, often needing more capacity than available. Scholars present a novel concept for obtaining live mission-critical visual information from UAVs that combats these traditional barriers for operations [69]. Acknowledging the need for bolstering disaster resilience, here the researcher describes a vision for leveraging the latest advances in wireless sensor network (WSN) technology and unmanned aerial vehicles (UAVs) to enhance the ability of network-assisted disaster prediction, assessment, and response. When a disaster occurs, the most important issue is preserving human lives. In this context, the first 72 hours after the disaster hits are the most critical, which means that search and rescue (SAR) operations must be conducted quickly and efficiently.

In precise, researchers present an approach for classifying disasters, and they outline suitable network architectures for effective disaster management based on these classifications [70].

#### I. Drones Technology

Search and rescue (SAR) operations continue where they required while these operations are very heavy loaded for government and citizens due to the far-off areas. Currently used approaches for SAR operations are not automatic or semi-automatic because of this, these approaches are not suitable for modern technology. Advancements can be made to improve the SAR process by integrating self-directed drones according to the human systems. In SAR system, drones take place important role while these drones have bad impact such as they used just only for rough country applications. The problem is never tapped due to high cost of promotion and no novel resolution achieved. In this situation, accessible SAR drones are not enough. With the help of group of sensors, drones become powerful source for advancements in SAR steps and reduce the chances of failure of earlier products. The objective of the new framework for drone with group of sensors is more efficient than previous work. Integration of drones with sensors give more power to the source and searching process for victims can be easier, speedily and securely. Drones check the position of the victim and provide that location to the base stations. So, the process of sending rescue team or services will be easier. Therefore, according to the new emerging technology of drones can be improve the current SAR conditions. The expected results of this scheme is effectual on SAR approaches regarding wilderness [71]. The drone4u project has developed functional building blocks supporting such an autonomous operation and can be implemented as: (1) autonomous navigation based on the 3D reconstruction of the drone environment in order to detect obstacles and (2) victim detection and tracking. [72]. Countries such as

Indonesia and Japan are badly affected by disasters. Telecommunication infrastructure is often damaged because of disasters, while reliable communication link is vital in search and rescue operation following a disaster. To overcome this problem, swarm quad rotor robots expanded by the scholars; it may be competent of self-deployment and broaden the reporting of accessible Wi-Fi network. Several devices connected with Wi-Fi which quad rotors designed. The structure of robot depends upon the Parrot AR Drone along the facility of internet adapter and GPS [73].

Upcoming advancement in networks are including internet facility, visualization scheme for discovering the hit region, to assist the rescue groups, search out the partially or fully hidden individuals etc. summarized the maintenance of connection. Without any doubt, many self-directed drones discover the part of the lands where the tragedy happened and help with rescue groups side by side [74]. Another design approach used multimodal scheme that make sure about an individual worker communication by the side of co-positional drones within the relief operations. Usually, human multi drones communicate in distinct conditions. The case is unique for operation implementation due to this, the worker main concern is not only to operate the robots as well as they riveted in rescue missions also. With the help of volunteers and workers, rescue activities increase their speed with high regard. Every design needs a better support from the modal and the schemes which they used for the communication. Most effective and turning point of the interaction is the relationship in between worker and robots. Hence, the description about the main stream line related to the format or architecture of multimodal interaction along network is in [75]. There is an Italian National Fire Corps management which is responsible of quick reaction in any disaster and rescue individuals with rehabilitation of the nation. This management manage all the damages by their own but in June 2012 very first time they want to demand for help such as clear the historical buildings, artistic manufactured articles etc. from EU-funded project NIFTi. After this demand, NIFTi collaborate with this management among their Human and robotic force mutually in red area [76]. The work about human and drones with UAVs quite good. This becomes a good combination for plan and implementation rescue operations. This provides one worker as a supervisor who led the team or group and coordinate along multiple operational functions of the system.

Specifically, searching mission about the individuals is a real time activity in any condition. According to this perspective, assumption will be more powerful about worker who operation the functions directly consider a member of the rescue team. Therefore, it is necessary that the worker concentration point is not only the robot but also its operational functions. In these types of circumstances, the design of the plan carries self-efficiency and alters this as of unambiguous operations.

The scholars give a best demonstration about the main area and entire design of a system as in the form of a case study [77]. A rotor wing drone depict in Fig. 9 with its parts.



Fig. 9. Rotor wing drone

1) *Survivals finding technologies used in drones*

At the present major importance of drones might be human security. On the other hand, drones extraordinary work is to find out the victims through different types of cameras or thermal images by using sensors then provide urgent situation supplies just as clean water, lifesaving jackets, medical accessories etc. Drones helps in monitoring system and save victims during any type of disaster such as fire, earthquake etc. operations during disasters for searching people even where human resource cannot go for search, drone helps there and search out victims quickly as compare to human resource. Approximately, 59 victims rescue through drones within 18 tragedies and average ratio of drones saving lives are almost one life proportional to one week. Drones used for sending the ropes, life jackets, medications, food and other useful accessories for human safety. There are some more examples, when drones become helpful hand of rescue missions such as 19 missing victims successful search operation, 9 lives saved from flood etc. [78].

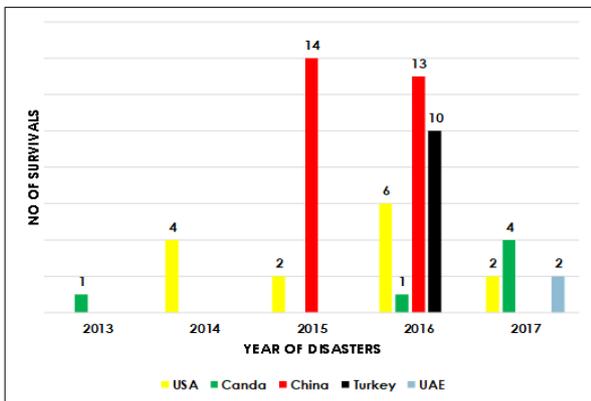


Fig. 10. Survivals rescued worldwide by the years (2013-2017)

In Table I, significant characteristics with their drawbacks of a drone mentioned. Above mentioned examples are the reported samples of using of drones and how drones save lives in different incidents? Fig. 10

shows the resultant factors in the form of counting disasters and victims.

TABLE I: FEATURES AND LIMITATIONS OF TECHNOLOGIES USED IN DRONE

Country	Features	Technology limitations
Canada	1: Infrared Camera and Camera technology	In Canada in three disasters the simple drones were used with Infrared camera and with normal camera embedded to save six lives.
USA	1: Camera/GPRS 2: Heat Sensing Camera and Hook embedded with camera	In USA four types of the technology embedded drones were such as camera/GPRS, Heat Sensing camera, simple camera and hock. Attached used in eight disasters to save fourteen peoples.
China	Hook embedded with camera	In china, drones were used with very simple technology just camera with hock embedded to save twenty-seven survivals in five different disasters.
UAE	High Resolution Camera technology	In UAE two persons were saved with simple camera embedded drone technology
Turkey	Camera Technology	In Turkey ten lives were saved by the single technology-based drone

2) *Emergency responders*

The participation of the drones during rescue operations is more valuable than anything. Workers safety is also a prior task for drones in any case of emergency. Drones help according to the operation layout such as present vision, approachable path, and safe incoming and outgoing turns in very bad situation. Drones consider as an open eye with all its benefits. Drones gather detailed information and send these to the base stations; hence they have good planning based on the drone’s information and perform actions without any hazard. Now days, drones used everywhere in the world so on this base, countries discussion show the importance of drones during crisis. A practical example of drone rescue operation is in the Canadian province where a person is injured, and drone locate that injured person and rescue team send emergency accessories through drone in time and save a precious life of a common man. This is first time when a small helicopter drone used for rescue operation [79]. Here a more complex example of drone help about a person who disappeared, drone found this person in a very short time period [80]. Another drone with infrared rays performs a successful searching mission in dusk, this is about 4 lives, life enjoying with the game of skiing hills [81]. A drone drags a line over the river and save a teenage boy with video also [82]. There is a drone engineer who used his one drone in two different tragedies such as saving 4 lives during flood [83]. A Sheriff Officer locates a missing teacher with the help of drone alive [84]. On the behalf of drone, rescue team found 2 missing persons within 3 minutes [85]. With the help of drone, in Anoka, an old hunter found with his dog safely [86]. Again heavy rains become the cause of flood in Guangxi province, a number of citizens

ambushed in this flood, out of these, 6 persons saved by drone with thermal imaging technology [87]. Fig. 11 depict the full scene with drone thermal imaging expertise.



Fig. 11. [87] (Georgetown County Emergency Management)

Another successful achievement of drone was toward finding 36 victims during flood in Weihe River [88]. Under construction building in Wutong Town, 14 labors ensnared but the drone found these labors within hours [89]. During rock climbing, a woman trapped in landscape and rescue team found this woman with the help of drone [90]. In UAE Ajman beach, drones help two victims they lost in the sea and drone SAR operation result was present the best option of search [91]. A film

making team disappeared during the shooting of the film in a remote area. This tragedy happened in Turkey, but the fact is that the drone search detects this crew also and save their lives [92].

Conversely, drones can be attached with different categories of vehicles, helicopters, some ground stations etc. in SAR operations and this suggestion ultimately the best part of the SAR process. A positive effect of drone is implementing in the SAR process. According to the drone’s operations, these can be uncomplicated to arrange the position, less cost factor for functions and nearer to those people who become victims in any disaster. Though, it does not mean that drones can do the whole thing. A camera is a practical device that not only used for saving people but also used to warn about any disaster before time. A camera which fixed in the drone is relatively narrow part of the view as compared to human observer. But the comparison between human eye and drone camera scanning operation is very difficult. Several families not found in a severe tragedy in India 2015 then drone used with the rescue teams and saved up to 200 people [93].

A virtual clinic based remote healthcare system has been proposed by [94]-[96]. Where the system helps the rural areas in terms of life saving and other healthcare facilities. Similar type of researches conducts in [97-102].

TABLE II: SUMMARY OF LITERATURE REVIEW

Year	Title of Publication	Technologies	Limitations
2017	Help from the Sky: Leveraging UAVs for Disaster Management	Drones	<ul style="list-style-type: none"> <li>The existing drone technology don't have integration of advance technologies</li> <li>It only detects the over surface disaster survivals</li> <li>Unable to detection the survivals location as well racking</li> </ul>
2017	UAV-Based IoT Platform: A Crowd Surveillance Use Case	UAV Networks	<ul style="list-style-type: none"> <li>The exiting UAV don't detect the survival respiration</li> <li>The proposed UAV only used for surveillance</li> <li>It is only used for upper surface survivals detection in disaster</li> </ul>
2017	The role of Big Data in explaining disaster resilience in supply chains for sustainability	Social Networks	<ul style="list-style-type: none"> <li>Social networks have only provision SMS about disasters</li> <li>These networks cannot detect the survivals under and upper surface of disaster</li> <li>Don't have provision of survivals tracking and detection location</li> </ul>
2017	Characteristic ground motions of the 25th April 2015 Nepal earthquake (Mw 7.9) and its implications for the structural design codes for the border areas of India to Nepal	Wireless Sensors	<ul style="list-style-type: none"> <li>lack of integration of advance technologies</li> <li>cannot detect over surface under surface/behind the wall detection approach</li> </ul>
2017	The SCION Internet Architecture An Internet Architecture for the 21st Century	Internet	<ul style="list-style-type: none"> <li>Only transfer the disaster information</li> <li>The proposed system does not have mechanism to detect tracks survivals and do not measured the respiration movement detection methods</li> </ul>
2016	Station-keeping of a high-altitude balloon with electric propulsion and wireless power transmission: A concept study	HAP Networks	<ul style="list-style-type: none"> <li>Only used to monitor the disaster area</li> <li>The technology is only used to provide the aids on limited biases to survivals</li> <li>Cannot send any SMS data to the base station about survivals</li> </ul>
2016	Software Defined Mobile Sensor Network for Micro UAV Swarm	MAV Networks	<ul style="list-style-type: none"> <li>Lacks integration of advance technologies to provide redundant network connectivity</li> <li>Only provision of SMS services to transfer the information from the remote places.</li> <li>Cannot detect any movement of survivals in disaster areas</li> </ul>
2016	A Detail Review on Unmanned Aeronautical Ad-hoc Networks	Ad Hoc Networks UAV	<ul style="list-style-type: none"> <li>The proposed systems are only used to develop a short-term communication between disaster zone and base station.</li> <li>The system does not have provision to detect the survivals from over surface under surface/Behind the wall</li> </ul>
2016	Social Networks in Crisis Response: Trust is Vital	Social networks	<ul style="list-style-type: none"> <li>Social networks are only used to separate the information on other social and electronic communication medium</li> <li>cannot tracks of survivals respiration movement</li> </ul>
2016	Using tweets to support disaster planning, warning and response	Social Networks	<ul style="list-style-type: none"> <li>Used to separate the disaster area information to different</li> <li>Through SMS services indicates the disaster locations</li> </ul>
2016	A dynamic decision support system based on geographical information and mobile social networks: A model for tsunami risk mitigation in Padang, Indonesia	Mobile Social Networks and GIS	<ul style="list-style-type: none"> <li>Integration of advance Technologies to transfer the disaster information</li> <li>Only provision have Over surface survival detection</li> </ul>
2016	A Resilient Network and Information Management System for Large Scale Disaster	LAN, WAN, Internet and Radio systems	<ul style="list-style-type: none"> <li>Integration of multiple Technologies</li> <li>don't detection and tracking mechanism for survivals</li> <li>Unable to detect respiration rate of survivals</li> </ul>
2016	A geographical and multi-criteria vulnerability assessment of transportation networks against extreme earthquakes	GIS	<ul style="list-style-type: none"> <li>Provision of location detection of disaster zones</li> <li>Provision of disaster mapping system for rescue teams</li> </ul>
2015	A Cooperative Network Framework for Multi-UAV Guided Ground Ad Hoc Networks	Ad Hoc Networks	<ul style="list-style-type: none"> <li>Integration of advance Technologies to provide the assistance for survivals but do not facility to measure the respiration information of survivals</li> <li>Only detect survivals on upper surface level</li> </ul>
2015	Autonomous Drones for Disasters Management: Safety and Security Verifications	Drones	<ul style="list-style-type: none"> <li>Only captured the images of disaster area</li> <li>Detect survivals from the upper surface of disaster</li> <li>Limited flying capabilities</li> </ul>
2014	Drones	Flying Technology	<ul style="list-style-type: none"> <li>Limited flying capabilities to capture the images of disaster zones</li> <li>Usage of single based drone technology and cannot provide redundant communication links.</li> </ul>
2013	On the performance of Flying Ad Hoc Networks (FANETs) Utilizing Near Space High Altitude Platforms (HAPs)	FANET Networks	<ul style="list-style-type: none"> <li>Don't have facility to detect the location lack of survivals tracking mechanism</li> <li>cannot measured the respiration rates of survivals</li> <li>don't have Call and SMS services communication facility to invoke the quick services for disaster area</li> </ul>
2013 [94]	Virtual Clinic: A Telemedicine Proposal for Remote Areas of Pakistan	ICT/GSM/Wi-Fi	<ul style="list-style-type: none"> <li>Works for normal day to day life not equipped with emergency handling</li> </ul>

### III. SUMMARY OF THE EXISTING ICT NETWORKS USED IN LITERATURE

The summing up process of a very large number of ICT networks with their applications has been explained in Table II with all its sequential arrangements. This table consist of four different attributes where the first is having periodical time, next to this is based on periodical name, very next is the category of networks and the last attribute is keeping explanation with all its limitations.

### IV. CONCLUSION

This research article comprehensively presents the literature about variety of telecommunication networks proposed, investigated and implemented all over the world for sake disaster management. These networks are presented through several well-known researchers internationally. Many categories discuss with explanation e.g., Geographic Information System, Wireless ad-hoc networks and other type of networks like social, sensor, mobile, flying, HAP, UAV plus drone-based network. The comparisons between multiple existing wireless technologies and their drawbacks or loop-holes are also listed in it.

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