Mission-Critical Management Using Media Independent Handover

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***Abstract*—Natural disasters are an unexpected fact of life that may occur during unpredictable times and in unpredictable ways. Ability to mitigate and adapt to natural disasters after many devastating events is becoming a greater challenge to the emergency response operators. Inefficiencies in the technology during rescue operations made the communiction between the rescuers problematic. There is a need to switch between different access networks for an effective mission critical communication. The emerging role of GPR and GSM remote cameras makes it possible to capture and process the mission-critical data, and provides a smooth communication for the use of first responders. Due to its low power and affordable cost, it is feasible to integrate them into environment monitoring tasks in critical care regions. Effective standards are required for providing seamless handover between heterogeneous access networks and for facilitating multiple mobility management mechanisms. IEEE 802.21 standard provides a media independent framework that enables seamless handover between heterogeneous access technologies. We proposed a life detection framework that assists the rescue operators in detecting alive humans and uses media independent handover mechanism for providing effective communication.**

***Keywords*—Media Independent Handover(MIH), unmanned aerial vehicles(UAVs), disaster detection, handover.**

I. Introduction

Disasters in various places of the planet have caused an extensive loss of lives, severe damages to properties and the environment, as well as a tremendous shock to the survivors. For relief and mitigation operations, rescue operators are immediately dispatched to the disaster areas. Agencies that are the first to arrive on the scene of a natural disaster or emergency are known as first responders. This group includes local police and military departments, fire departments, and emergency-medical teams. Their role is to secure the area for safety, rescue those who may be trapped under rubble or other debris, deliver medical attention to those injured in the disaster and to keep the peace through policing efforts. First responders are in constant contact with local emergency management officials to keep them informed of exactly which kind of help is needed most and where.

Local emergency management officials are specially designated to act on behalf of citizens during a natural dissater and are responsible for planning local governments response to such disasters. Relief efforts, evacuation routes, shelters, supplies and interim governing laws are all components of their plans of action. During natural disasters like earthquakes and tsunami a large number of people are buried under debris. Thus it is vital that the rescue effort knows where exactly the victims are buried so that assistance can be provided at the earliest. From the past reports it was made clear that after many devastating events, the current technologies used, failed to support the mission critical communications, which inturn causes further loss of lives. Various inefficiencies of the current communications used for emergency response include lack of technology inter-operability between different jurisdictions, and high vulnerability due to their centralized infrastructure. For that we propose a flexible network architecture that provides a common networking platform for heterogeneous multi-operator networks, for interoperation in case of emergencies. Development of a media independent platform that will enable the cooperation of unmanned aerial vehicles (UAVs) with ground wireless sensor networks for disaster detection is the main focus of this article.

Device manufacturers are now integrating more and more network interfaces into their devices. Providing the users of such multi interface devices with a seamless roaming and inter-technology handover is a key element that help operators manage and thrive from this heterogeneity. Service providers who have the ability to switch a user's session from one access technology to another can better manage their networks and accommodate the service requirements of their users. IEEE 802.21 standard defines a media independent handover (MIH) mechanism that can significantly improve handover between heterogeneous networks. This standard defines the tools that are needed to exchange events, information, and commands to facilitate handover preparation and handover initiation. We utilize two system layers of abstraction specialized for specific tasks:dynamic networking under mobility conditions and distributed services for disaster management. Among them, the main concern is dynamic networking under mobility conditions.

In disaster areas, UAVs can be effectively used for search and detection of victims. An Unmanned Aerial Vehicle (UAV) is a pilotless aerial vehicle that can be monitored by radio signal remote or fly autonomously based on flight path programmed or more complicated autonomous systems. UAVs are equipped with many sensors, gps and services. UAVs have the advantage that they can be easily reconfigured, retasked and upgraded to take advantage of different payloads. UAV is beneficial mainly because of two reasons. First is, it can transfer the data collected to ground station units for further analysis. Second is that the situational awareness is achieved directly during the flight. In this paper, we discuss about the design and development of a life detection framework for searching and detecting the victims in a disaster hit area that uses the MIH services. Rescue operators should identify the victims should by processing the acquired data on the spot.

II. RELATED WORK

In [1], an automatic vehicle detection framework for aerial surveillance is used. The vehicle detection framework can be divided into the training phase and the detection phase. Training phase extract multiple features including local edge and corner features, as well as vehicle colors to train a dynamic Bayesian network (DBN). Detection phase perform background color removal. The extracted features serve as the evidence to infer the unknown state of the trained DBN, which indicates whether a pixel belongs to a vehicle or not.

The disaster detection framework designed in [2] can collect sensor data and image data by using UAV with payload sensor platform. Data that is collected must be viewable by operator at ground station unit as well as central agencies which can access from Internet through Sensor Service Grid (SSG). Sensor network is used to monitor physical or environmental conditions. It consists of two main services:Sensor Observation Service(SOS) and Sensor Service Grid(SSG). SOS can handle the data collection in the field and runs on sensor stations. SSG can be accessed from the internet.

In a disaster affected area it may not be a possible thing to install a new sensor station, when the stations already installed might be affected by the disaster. We can eliminate this problem by extending SOS and SSG to unmanned UAVs based sensor station. A UAV loaded with sensors and camera can fly by remote control in to a disaster affected area and can sense humidity and temperature while capturing images on its flight. Mobile features can be added to the existing software for SOS station that was initially designed to operate on fixed posiition node and it cannot apply for using with the sensor node which always changes its position such as helicopter. When it flies the position of the sensor is changed in accordance with the helicopter position. GPS sensor provides the position of the sensor.

The effects of inter-cell and intra-cell handoff hysteresis margins and log-normal shadowing based on the residence time in different quality zones in mobile cellular systems with link adaptation are evaluated in [3]. Intra-cell handoff margin refers to a difference of Signal-to-Interference ratios, which is used to determine whenever intra-cell handoff is required, on contrary the inter-cell handoff margin refers to a difference of received signal strengths.

In [4], a middleware implementation of the MIH services has been developed in Linux platform. Authors have designed a high quality VoIP system that integrates Stream Control Transmission Protocol (SCTP), MIH-IS based user motion detection services and an adaptive QoS playout algorithm on the basis of MIH software. The multi-homing capability and Dynamic address configuration extension of SCTP are applied in the VoIP system for performing seamless handoffs.

Various reports indicated that after many natural disasters, the current disaster detection framework failed to support the mission critical communications which inturn results in further loss of lives and property. Drawbacks of the current communication used for emergency response includes lack of technology interoperability between different jurisdictions and high vulnerability. Mobile communication technologies have evolved into cellular and wireless networks that are offered with super abundance of devices,each having its own intrinsic capabilities and characteristics. However, the next big challenge is the combination of all these technologies into a single mean of access provision, allowing user devices equipped with several interfaces to be connected through the best access possible, with the best throughput and the least cost. It should satisfy the users requirement of Always Best Connected. These considerations amplifies the motivation for introducing an enabler that aims to smooth the effort that brings these concepts together. That enabler is the IEEE 802.21 standard or Media Independent Handover.

III. SYSTEM DESIGN

In this paper, a new life detection framework for disaster areas is designed which uses Media Independent Handover technology. The proposed system framework consists of the following three modules as illustrated in Fig. 1. A search and detection system that aims at searching and detecting the victims of a disaster, an MIH function service that facilitates a smooth communication platform and a post processing section that helps the rescue agencies for carrying out the rescue operations.

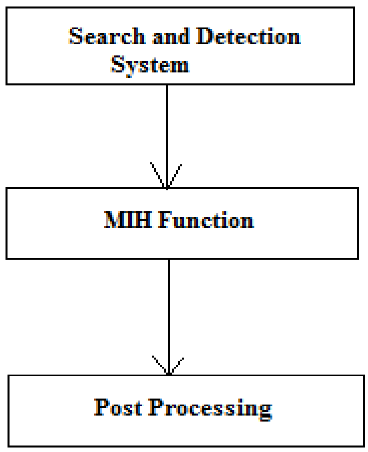

Fig 1.Life Detection Framework

A. Search and Detection System

Search and detection module gives the ability to measure and analyze physical phenomena. When disaster strikes and people are buried alive, search and rescue teams need to be readily deployed with simple-to-use search techniques. Earlier disaster techniques commonly uses trained sniffer dogs, and audible detection of victims cries for help. If a rescue dog finds a scent, the smell may have travelled dozens of meters from the actual victim, who may not even be alive. For that a better framework for identifying the exact location of alive human victims is needed. The main components of a search and detection consists of a UAV platform and a sensor system. Flight path for the UAVs and other mission requirements are programmed by the ground station engineers into the mission planning softwares that helps the auto pilot in controlling and directing the aircraft during the mission. The sensor system may includes GPR and a GSM Remote Camera. GPR and GSM Remote Cameras are the emerging remote sensing technologies, together they can be used for detecting alive victims. The rescue operators are equipped with GPR and GSM Remote Cameras for detecting the buried victims and for identifying their exact location.

1). GPR: Search and rescue at a disaster site requires quick location and recovery of buried victims. Site conditions are usually chaotic and access to support is limited. Seeing into the material overlying victims is challenging. Common burial materials are collapsed building debris, mudflows and avalanche snow. Each environment presents unique challenges with all being opaque to human vision. While using advanced technology can help, caution must be exercised since failure to detect a response can result in victims not being found. On the other hand, false alarms result in a waste of valuable resources and false hopes.

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. Unique properties of GPR make it an effective tool in the rescuer's arsenal looking for living victims as well. GPR does not get tired, it does not need silence, and it does not rely on line-of-site detection. A GPR locator looks specifically for life, via breathing or motion, and then reports the depth to the victim within seconds for teams to start the rescue. GPR can be used in a variety of media, including rock, soil, ice, fresh water, pavements and structures.

2). GSM Remote Camera: GSM Remote Camera is one of the simple image capture device supports with GSM network, transmits and receives data via SMS and transmits image data through GPRS. It is wireless terminal, easy to install. GSM Remote Camera supports motion detection and PIR body detector, it can detect any movement or any uninvited people within monitoring area and make alarm via sending MMS (Multimedia Message Service) or calling to pre-set mobile phone or E-mail. GSM Remote Cameras allow connecting up to 15 sensors to monitor several areas at the same time. It can act as a mobile phone, wireless alarm, camera or as a sensor The backup lithium battery ensures constantly operation when external power failure.

GSM Remote Camera provides dual-detection technology, including PIR (Passive Infrared) Body Detector and camera motion detection, make it more reliable. PIRs are basically made of a pyroelectric sensor which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. Infrared radiation emitted by an alive human is different from a died one. Normal body temperature of a human being is 37*C. Every alive human body emits radiation in the infrared region in the electromagnetic spectrum. After death, body temperature decreases by 1.5*C. In PIR sensor a threshold temperature is set to differentiate between alive and dead. Therefore by using the PIR sensor in GSM Remote Camera, the presence of alive human in a particular area can be detected.

Rescue operator can identify the presence of an alive humanbeing with the help of PIR sensor present inside the GSM Remote Camera. But the exact position cannot be obtained from the PIR sensor. So a GPR will help the rescue operator in detecting the exact location where the humanbeing is lying. For a GPR, deployment consisted of placing the sensor on the debris pile where a response is to be obtained. The rescue operator stands at a distance greater than the expected victim burial depth. A wireless link from the operator control unit to the sensor allows the operator to monitor detection progress. Generally, GPR will reveal the horizontal positioning of targets in their exact locations, however, there are a number of factors which can affect the accuracy of the depth measurements. The depth to a target is calculated based on the amount of time it takes for the radar signal to be reflected back to the antenna.

After getting the exact location, the rescue operator can move to that location for rescuing the identified victim. He can check the condition of that person and pass this information to the rescue agency and to other rescue operators with the help of GSM Remote Camera. That is, the rescue operator can take the images of the victims and can attach some image icons and send these informations along with the location. Along with the icon we can send details about the disaster as text messages also. Image icons are used to indicate the current condition of the victim. For example, if a fire occurs we can pass a message with fire icon.

When a disaster occurs, either all the communication lines become busy or communication line is cut off. So it becomes difficult to provide communication. We suggest vertical handoff among existing networks to provide seamless communication. Soon after a disaster happens, it is proposed that Access Points (AP) can be deployed in the disaster area. As emergency vehicles like UAVs generally already contain a base station they can be used as the APs.

The proposed system provides an adaptive network for media independent handover through multiple networks such as cellular network, Wi-Fi, bluetooth etc. MIH allows vertical
handover i.e. handoff from a GSM to Wi-Fi network or Wi-Fi
to Bluetooth network. Figure 2 illustrates the system architecture. The rescue operators equipment should be equipped with the 802.21 service. So whenever the GSM coverage goes off , it can search for the remaining networks that are available. If WiFi coverage is available, the mobile device can switch to the WiFi network and viceversa. After the internal routing inside the disaster area, the information can be routed to the outside world like rescue agencies using the UAV communication.

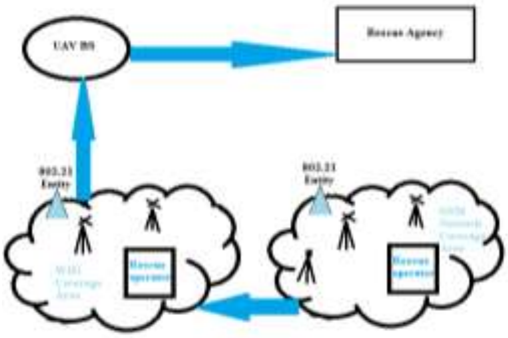

Fig 3. System Architecture

B . Media Independent Handover Function

Natural disasters like the tsunami, Hurricane Katrina in US etc have shown that the need for communications and network connectivity is of vital importance for saving lives and property. After a disaster, we need the immediate services and cooperation of rescue agencies, control and commander centres, police, fire stations, army etc for saving the lives. The problem is that the rescuers equipment that belongs to different jurisdictions (police,army,fire department etc)are not compatible to each other. The reason behind the problem is that there is a lack of inter-operability between different jurisdictions and high vulnerability due to their centralized infrastructure.

A media-independent framework is an efficient and scalable method to ensure handover interoperability across multiple access technologies. The Media Independent Handover Function (MIHF) is a logical layer in the mobility management protocol stack, both in the mobile node and the network elements. The main purpose is to aid and facilitate handover decision making through the supply of inputs and context to the upper layers, for handover decision and link selection. Handover can be classified into two types: horizontal and vertical. Horizontal handover refers to the handover occurred in the same technology networks. Vertical handover involves handover between different types of networks. MIH allows vertical handover i.e. handoff from a GSM to Wi-Fi network or Wi-Fi to Bluetooth network. Figure 3 illustrates MIH fuction and services.

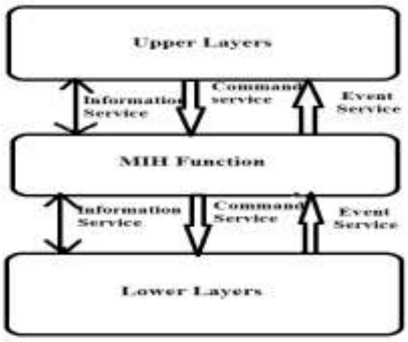

Fig .3. MIH Function and services

Abstracted services to higher layers can be provided using MIHF. It offers a single unified interface to higher layers through technology independent primitives. It also obtains information from the lower layers through media specific interfaces.

MIH services includes:

1). Media Independent Event Service:

It defines events that represents changes in dynamic link characteristics such as link quality and link status. There are two main categories of events: link events that originate from the lower layers and propagate upward and MIH events that originate from the MIHF. Events can be further classified as local or remote. Local events are contained within a single node and are subscribed to by the local MIHF. Remote events are delivered over a network and are subscribed to by a remote node.

2). Media Independent Command Service:

It provides commands to control the link state. Invokation of commands can done either locally or remotely by MIH users or by MIHF itself. Local commands propagate from the MIH users to the MIHF and then from the MIHF to the lower layers. Remote commands can propagate from the MIHF in the local protocol stack to the MIHF in a peer
protocol stack.

3). Media Independent Information Service:

It provides a set of information elements, their structure, representation, and a query response based mechanism for information transfer. A framework is provided for MIIS entities to discover information useful for making handover decisions. If the information required for handover decisions is not available locally, the MIH protocol can be used to access remote information sources.

We are creating a temporary network using Wi-Fi or Bluetooth connection in the disaster area and communication is handed over to nearby congestion free networks. Since it is possible to perform handoff among heterogeneous networks using MIH, the whole communication load is distributed among various networks.

Figure 4 explains the transition diagram of a mobile node. Mobile node is initially in the OFF state. When a mobile node becomes on, it goes to standby state to save power or requests for 3G connection if communication is needed. It searches for available connection if 3G connection is not available. If a mobile node loses its 3G connectivity, it searches for available connection and switches to it. When a mobile node does handoff from 3G to WLAN, it is called vertical handoff and within the 3G network itself, it is called horizontal handoff.

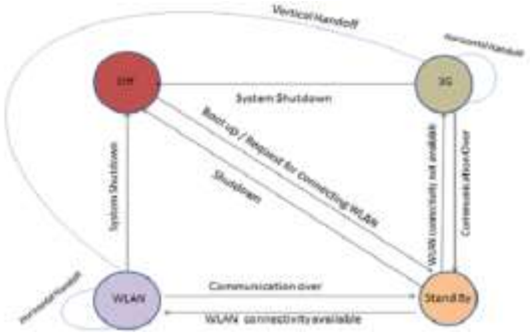

Fig. 4.State Transition Diagram to show communication among mobile nodes

Figure 5 explains the basic MIH handoff. Three steps are used to perform handoff in MIH i.e. handoff detection, handoff decision and handoff performance. Handoff decision can be done from network side. An appropriate network satisfying the given objectives has to be selected from the available networks. Factors like location, data rate, speed and user preference have to be considered.

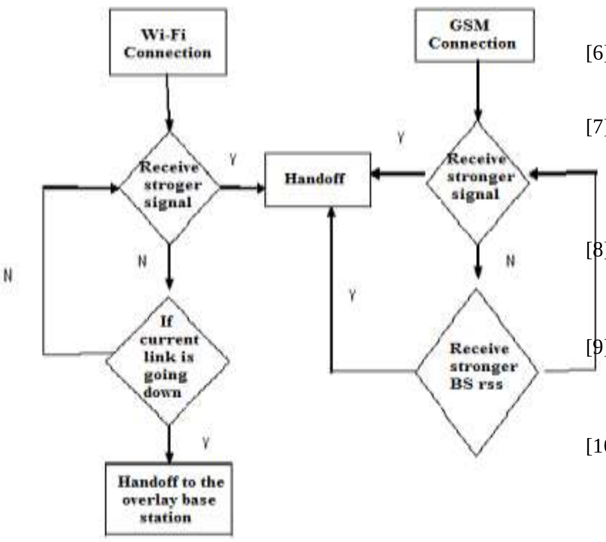

Fig .5. MIH handoff

C . Post Processing

A central controlling mobile phone is used for receiving the information from the rescue operators at the disaster site. It helps the rescue agency at the ground station for visual inspection of the detected objects and their real world location. Commands can be given to the rescue operators through the central controlling mobile phone. It would be convenient for the rescue commander to determine where to send the rescue teams for providing medical aids by surfing through the processed image.

IV. CONCLUSIONS

In this paper we have tried to introduce some technologies to provide efficient and effective communication for disaster management. For mission critical operations, first responders often need to share vital information. In today's world we can see that lot of lives are lost during disasters mainly because of inefficient first response systems. This paper discusses on applying MIH for efficient communication during disaster which can make use of any existing network for communication. We propose a flexible design that provides a common networking platform for heterogeneous muilti-operator networks, for interoperation in the case of emergencies.

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