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Emergency Information System Architecture for Disaster Management: Metro City Perspective

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Abstract: During the disaster, communication is a tedious job through wired networks, so Wireless Sensor Network and Mobile Adhoc Network (MANET) has been chosen to make a novel design. WSNs are event-driven networks useful in emergency and at site where human cannot monitor properly. Within the range, proposed emergency Information System (IS) architecture will be able to communicate across the obstacle without help of any fixed infrastructure, as well as it will be able to communicate through the social media. This is a costly network due to the use of smartphones within it, but high cost of technology is a onetime investment. This paper investigates the technologies to help in disaster management, and showing the problem in different scenarios. Paper also presents this architecture with method of communication that will be helpful to understand its role in natural disaster management.

Keywords: Disaster management, Ad-hoc Networks, disaster management Network, Disaster Monitoring System, Alert system.

I. INTRODUCTION

Risk of every disaster can be minimized or stopped through proper monitoring and safety measures. Various agencies are involved to provide alert and monitoring of different disaster with the help of various software tools. These tools are based on diverse technologies, various software/hardware and protocol architecture according to their requirement. This paper presents a way to organize a new Information Architecture.

Rest of the paper is organized as the related work of paper presents the tools to help the victims and rescue team. These tools include information systems for post-disaster conditions and helpful to sense or inform about the disaster. This part involves a list of tools that is helpful for communication, victims and rescue team with its possible application. Third section discusses problem scenarios under section research problem while fourth section provides architecture to solve problem discussed in scenario. Section five provides conclusion and future work.

II. RELATED WORK

Various disaster management information systems are using different technologies to be a meaningful in typical disaster management.This section presents a light on different technologies discussed below:

MacEachren et al [6] have described a client-server based tool developed byGeodan that offers Real-time analysis components to help in disaster management at control centers. JW et al [7] described a GeoMAC developed by Geospatial Multi-Agency Coordination Group. GeoMAC is useful for fire managers to access maps of current locations and perimeters by which they can inform to save lives of victims, these feature makes Geo-mac more effective in fire related emergencies. Siegel et al [8] described Geo-Conference to provide geographic data. ESRI developed client-server based tool ArcPAD[9] for mobile devices to provide the ability to capture, analyze and display geographic information. Capata et al [3] presented a Geo based application with MANET devices to support rescue teams for outdoor environments. This application was designed to address the solution of problems faced by rescue team. Geographic information based application uses maps to provide information with GIS functionality. This application is conveneint to provide coordination through infrastructure or P2PMANET. Their system was applicable tohelp group members within a certain range. Fazardo et al [1] designed an application known as MyDisasterDroid,in which they found geographic location via SMS or app installation.

Luglio et al [4] presented a mechanism to work on MANET and satellite systems under Savion project. Point to Point Network (P2P net)[10] is designed to deploy by less number of workers easily. It comes in three flavors U1net, UKnet, and Cknet, in which, U1net is initial while CKnet is full flashed P2Pnet. Researchers designed a Rescue Information System for Earthquake Disaster (RAISED) [11] to improve disaster response operation. It'sprototype was implemented based on JXTA platform, which is a set of open protocols that is capable to enable any connected device on the network to communicate and collaborate in a P2P manner [12]. Other systems also were developed including walkie-talkie like communication system based on U1net and Uknet. It was implemented for the performance evaluation. Another is local cloud system given by Amro et al.2014 [13] envisions the idea of sharing information in a peer-to-peer fashion by creating MANETs and interconnecting them by means of devices moving from one MANET to another until eventually data can be shared with the online world. Hybrid cellular MANET also tried to use in a disaster scenario. To demonstrate its concept of utilization to

extend wireless coverage and evaluation of performance of its data forwarding mechanism, Zheng et al [21] build a microbloggingsystem based on Android and Weibo APIs to use in disaster affected area.

Researchers investigated wearable computers, sensors and smartphone devices [14] for complex applications but thesedevices having issues of mobile computing, intelligence, ubiquitous computing including power management and heat dissipation, software architectures, WPAN with the Insufficient bandwidth, Security standards, Power consumption, Transmission interferences, Potential health hazards and Human interface with the device.

Due to carrying sensors and high-speed Internet connection to sense traffic flow, identifying sources of environmental pollution, monitoring public health, and responding to natural disasters like hurricanes, floods, and earthquakes, researcher started to use Android and iOS devices for the disaster management in CSN project [15] since 2012. Table 1 enlisted useful tools in disaster:

Table 1: Summary of tools useful in disaster management

Tools	Application
OpenGarden [16]	Internet connection sharing tool.
Wi-FiDirect [17]	Ad-hoc Network creation.
Haggle [18]	Content exchange on Haggle.
Twilight [19]	Communication between the group.
Wifi-Opp [20]	To create Adhoc wifi network through Android API.
U1net over P2Pnet[10]	Initial P2P net.
UKnet over P2Pnet[10]	Advance features than U1net.
CKnet over P2Pnet[10]	Full P2Pnet.
RISE over P2P net [11]	To improve disaster management effectiveness.
GeoMAC[7]	To help fire managers.
HAZUS, ALOHA, SUMMIT [2]	GIS-based modeling tools.
ArcPAD[9]	Designed to provide geographic information.
MyDisasterDroid [1]	Find optimum route between two locations.
CSN project [15]	Application to use smartphone's sensor for disaster detection and data sharing.

III. RESEARCH PROBLEM

Disasters cannot be avoided but their impact can be minimized through effective Disaster Management that has four phases as (1) Planning (2) Mitigation (3) Preparedness (4) Response and Recovery. These four phases are supported by dynamic data integration of GIS with features of sensors, emergency call service, and video as per data used by tools discussed in table 1. In all these phases,from Planning wish to use software tools. Mitigation phase includes risk and hazard analysis, vulnerability assessment; Preparedness phase includes plan development, exercises, and situational awareness; response includes mobilization of resources, activation of war rooms and incident management supports while recovery phase includes assessing damage, prioritizing recovery efforts, obtaining funds and monitoring overall progress[5].These four phases are supported by dynamic data integration of GIS with features of sensors, emergency call service, and video. GIS is a technology that provides help in working environments in disaster scenario with the help of other tools. With the help of GIS, other technologies can play a vital role to perform the task to solve the problems under various phases. Due to importance of task, IS architecture has two kind of networks referred as MANET and WSN, in which a node of MANET has the capability to be connected to the Internet or Wi-Fi in infrastructure mode while other to sense and transmit hop by hop.

A. Possible Scenario

There are three scenarios to develop a model of Hybrid ad hoc network for Disaster management. These are:

Scenario 1: Within the zone,phone communicating to each otherthen not a serious problem. In this case, MANET will work to connect these phones with the devices from outside world, when it is under a certain range.

Scenario 2: In case when, Infrastructure damaged then WSN activated and this is activating to other MANET devices to flood the information to the monitoring device through powerful node like laptops (with infrastructure).

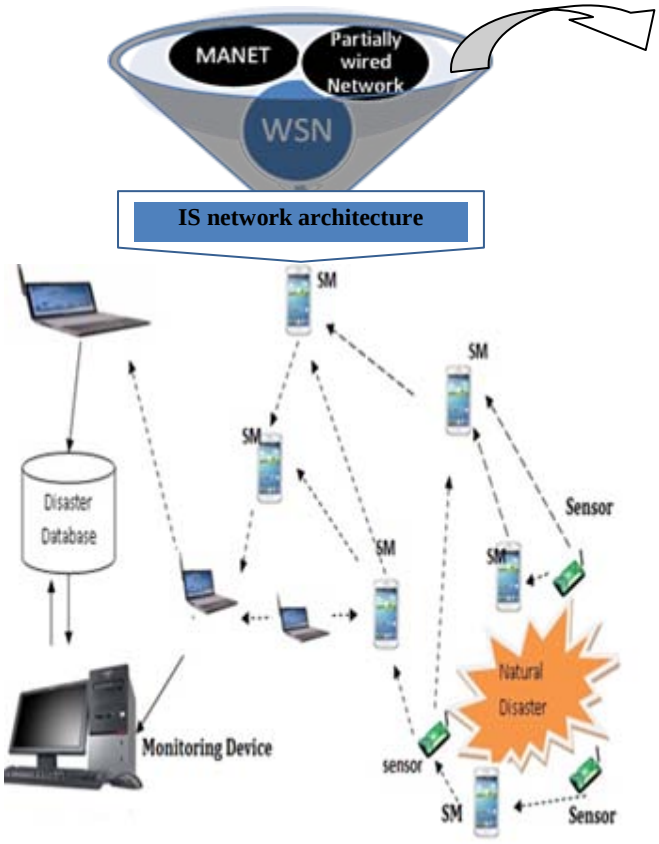
Scenario 3: Rescue team providing the facility but any node is not communicating with the rescue team, due to the power failure; finished lifetime (may be caused by irregular signal transmission). In this situation, themodel will have a provision to facilitate the power to the node through the wireless charging mechanism (even if the node is invisible). After this case, nodes will be able to be communicated.

IV. PROPOSED SOLUTION

To design a desired model, it is a need to investigate the feature of MANET and WSN that is useful to make it work together including devices, MAC layer, connectivity between nodes of both networks, connectivity with the infrastructure, location awareness, lifetime of MANET and WSN, working strategy, routing, security, and QoS. In this type of network, the delay and data aggregation may be a big issue with all other issue concerned. So, it has been tried over here to start our journey to design a great network to help in emergency. Thus, the Idea is trying to give a designed through combining MANET and WSN together. This design will be able to communicate with a monitoring station to transmit information from one end to other.

A. Architecture

The architecture of emergency ad hoc network may be a hybrid Adhoc network or might be different for natural disaster as per shown in figure 1. Without the help of any fixed infrastructure, the emergency Adhoc network will be able to communicate across the obstacle within range as well as it will be able to communicate through the social media sites. To minimize the losses of disaster, the plan is to develop an emergency network to provide prior/post or emergency information.



WSN platforms

Name	*Platform*	*Data rate*
MPR2400CB	MICA	38.4 / 250 Kbits/s
LPR2400	LOTUS	250Kbits/s
TPR2420	TelosB	250Kbits/s
XM2110CB	IRIS	250Kbits/s
MCS410CA	MICA	Fixed

All the enlisted nodes useingZigbee(IEEE 802.15.4) standard that is compatible with the other devices specially with Smartphones and Laptops. All these nodes are able to use 2.r GHz frequency band. The useful operating system for these nodes assumed here areTinyOS and Android.

MANET

MANET isbased on Smartphone devices, laptops and other devices able to connect in ad hoc environment.

Partially Wired Network

These are the sensing devices useful to sense humidity, temperature, acceleration.i.e. tilt sensor, displacement sensor.

Figure 1: Architecture of Ad hoc based Emergency Information System forNatural Disaster Management

Information System will provide prior information with the help of WSN and post information through MANET in absence of any infrastructure. There is an importance of information gathering systems for rescue operations from massively scaled terrorism or other unpredictable natural disasters. That will be possible through the proposed IS architecture.

B. Method of communication

About devices, figure 1 assumes that the devices are Bluetooth (802.15.1)/ Zigbee(802.15.4) enabled. So, in this architecture, a system consists of a transceiver, processor, and antenna. The system provides basic services to enable connection between devices and data exchange between them Here, transmitter consisting controller block, based on ARQ scheme, payload and FEC block, framing block, radio block while receiver having radio block based on basic rate, framing block, and controller block. Here, channel assumed full duplex (AWGN) with 802.11b to communicate.

C. Network Model

Offline Social Network (OffSN) model for this approach assumed to be used, which is another model then the Online Social Network(OnSN)[22]applied with internet facilities. OnSN model useful before the disaster and may be to form a good network model just to provide alert to the possible victims. But in case, where problem exists in communication, OffSN will work.

Data Rate in OffSN: There is a need to model intra-OffSN interference due to resource sharing between Adhoc and cellular communication. In this, few devices will be ready to communicate on same frequency as in downlink communication. In such case, where devices will use same downlink frequency they will experience an interference.In this case, power of link will be assumed according to discussed by Zhang et al [22] as:

$$P_{Li} = P_j \cdot d_{ji}^{-\eta} \cdot |h0|^2 \quad (1)$$

Where,

P_{Lj} = transmit power,

η = Path loss exponent (ranges from $2 \leq \eta \leq 5$),

dji = distance between d j and di

h0 = Complex Gaussian channel coefficient.

When a device i is working through cellular network, its data rate also assumed with the discussion of Zhang et al[22] :

$$R_i^d = W \log_2\left(1 + \frac{P_B|h_{Bi}|^2}{\sum_{j'} B_{j'i} P_{j'}|h_{j'i}|^2 + N_0}\right) (2)$$

Alternatively, when device i is working with device j through adhoc communication with co-channel interference, the data rate:

$$R_i^d = W \log_2\left(1 + \frac{P_j|h_{ji}|^2}{P_B|h_{Bi}|^2 + \sum_{j' \neq j} B_{j'i} P_{j'}|h_{j'i}|^2 + N_0}\right) (3)$$

Where,

P_B, = Transmitted powers of the Base station

$P_j, P_{j'}$ = Transmitted powers of device to device transmitter j and j'.

N_0 = Additive white Gaussian noise (AWGN) at the device receivers,

W = Channel bandwidth.

Here, we assume that W = 1. $B_{j'i}$in (2) indicates the presence of interference from device to device communication to cellular communication.

D. Security

To secure network discussed in figure 1, authors has assumed a multilayer security architecture that allows message transfer only to messages sent by authentic transmitter [23]. This architecture also allows us to secure sink node while security encryption algorithm can be change as per application and capacity of node, respectively.

E. Sensing

However, the architecture given is solely able to the sense few pre-situations of emergency but to increase the sensing capability of node, assumption is made to use WNSN also integrated within the network [24].

F. Geo-Informatics enabled devices

Various technologies also assumed to be use in smartphone including GIS and GPS related applications [25]. Smartphone used in this architecture also assumed to work with remote sensing data if applicable. In this, it is assumed that programmers can build application to convert a smartphone into a self-contained remote sensing device to use geographic data to map the conditions.

G. Charging Mechanism

Sometimes, in post disaster case, a chance of power failure is possible in device and no charging facility available to charge after a battery drain. To handle such kind of situations, few devices are assumed to be used as per discussed by Neeraj et al [26].

H. Limitation

All the known limitations of MANET and WSN also existing for proposed architecture of network i.e. limited lifetime, common topology and more. These Problems are due to:

- Lack of central entity for organization available;
- Limited range of wireless communication;
- Mobility of participants;
- Battery-operated entities.

V. CONCLUSION AND FUTURE WORK

The proposed network will be able to fulfill the requirements of rescuers as well as victims by which, proposed architecture can facilitate to help them in a systematic manner. All the improvement in technology will improve the network, so the performance of this network will depend on used devices in it; it means this will provide the scalability to the architecture. The performance of this new IS architecture of network will be depend on the nodes deployed in this network forsensing purpose including sensing node or Mote, and on a node of smartphone or other devices.

Parameters for future consideration are MAC layer, transmission delay, node selection criteria, data aggregation method, localization method, security mechanism, operating system selection, lifetime management, QoS, topology, coverage and connectivity, routing and finally the deployment. This work is going to focus on the implementation of the hybrid ad-hoc network that is not yet been implemented with the good features like wireless charging of network, minimum latency, common security scheme, compatible node selection and the communication in the simulation of a real disaster situation.

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