An Integrated RoIP Communication Network for Effective Collaboration During Emergency and Disaster Management

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Abstract. Disaster and emergencies are sometimes difficult to manage in terrains where there are limited communications. Some geographical areas can prove to be difficult during disaster areas to reach. During disasters, lack of communications infrastructure can hinder operations involving coordination, effective reporting and communications of events on the grounds for delivery of services such as food, medicine, etc. In this paper we proposed and developed an integrated radio over Internet Protocol Network for easy integration into other networks for effective communications, deployment and management of information. We integrated the system over satellite, phone and other alert voice systems for effective disaster management. Results showed ease of usage was effective and it is suitable for easy deployment and management of disaster and emergencies.

Keywords: Disaster management · Communications network · Radio over internet protocol · Satellite communications

1 Introduction

The success of personal mobile communication technologies has led the emergence of mobile telephony and communication technologies involving identity calling and unicasting capabilities with privacy enhancement technologies. These technologies have made communications easier across geographical locations in real-time. An emerging expansion of the telecommunication infrastructure led explosion of mobile broadband data traffic as more and more people completely rely on their mobile devices, either for work or entertainment etc. [1]. With massive telecommunications infrastructure and wide range network, communications involving, text, voice, image and video becomes a daily part of one's digital life. The widespread of the internet has made access to information more open and easier. Integrating devices over the internet and the developments in internet of things are creating endless intercommunications and monitory systems ranging from home automation, sensor networks [2] etc.

T.F. Bissyande and O. Sie (Eds.): AFRICOMM 2016, LNICST 208, pp. 174–185, 2018.
https://doi.org/10.1007/978-3-319-66742-3_17

During disaster and emergency, communications have to be broadcasted to teams on the grounds over radio communications systems for an effective collaboration. This is where several teams of intervention need to be coordinated with different teams. Integration of different radio networks such as fire fighters, police, ambulance services radio communications etc. can be better used in coordination in the presence of interoperable communications system. This will make situational awareness of events for effective. In this paper, we proposed and developed an integrated radio over Internet Protocol Network for easy integration into other networks and an effective interoperable communications to aid coordination and management of disaster events.

2 Radio Communications and the Internet Protocol

A radio communications uses a radio wave which is a signal with characteristics such as phase, amplitude and frequency [3]. It may be simplex which a one-way communication is where there is no reply channel provided; e.g. radio and television broadcasting. There is also a Half-duplex which is a two-way service with transmission over a circuit capable of transmitting in either direction but with only one direction at a time. The other one of a half-duplex is Full duplex or just duplex defines simultaneous two-way independent transmission on a circuit in both directions [4] (Fig. 1).

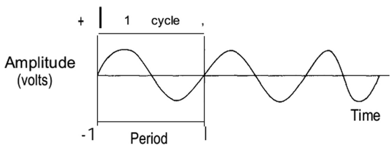

Fig. 1. A graph of amplitude, period and cycle of a pure radio wave in time

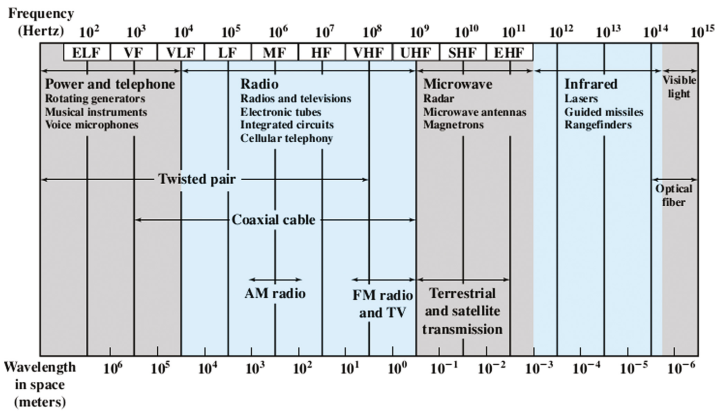

Fig. 2. Electromagnetic Spectrum for Telecommunications LF Extremely low frequency VF Voice frequency, VLF Very low frequency, LF Low frequency, MF Medium frequency, HF High frequency, VHF Very high frequency, UHF Ultra high frequency, SHF Super high frequency, EHF Extremely high frequency [4]

We have several part of the electromagnetic spectrum engaged in communications at different levels of communications. Above in the Fig. 2 is the ranges used in telecommunications. In our work, we considered the devices in the VHF and UHF frequency range used for a two-way half duplex radio communications system. Below in Fig. 3 is a block diagram and example of the radio in Fig. 4.

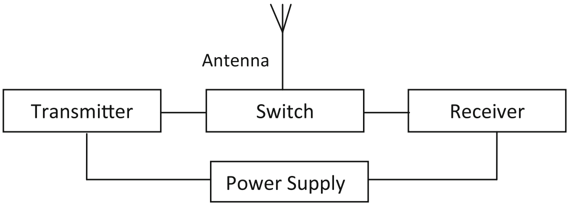

Fig. 3. An amateur radio block diagram

Fig. 4. An example of a radio UHV/VHF Dual band

Tabsombat et al. presented a Linux-based Radio over IP system and were able to achieve IP interoperability. They integrated their developed system with other mobile communication devices and also with a telephone network. They used hardware-software coordination on asterisk SIP IP-PBX running under Linux OS. Below is the block diagram of their system [5] (Fig. 5).

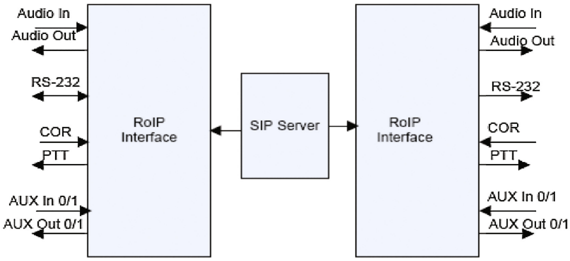

Fig. 5. Block diagram of radio over IP system

The system can enable the interconnection between many different kinds of equipment such as cell-phones, 2-way radio, PSTN, Internet phones, VoIP phones, etc. and it can be readily deployed to use as a backup communication system in both urban and remote area.

There have been other integrated approaches where integration of other systems have been successful such as remote microwave observation systems over optical IP networks using a Digitized Radio-over-Fiber technique by Shoji et al. [6] based on the concept in Fig. 6.

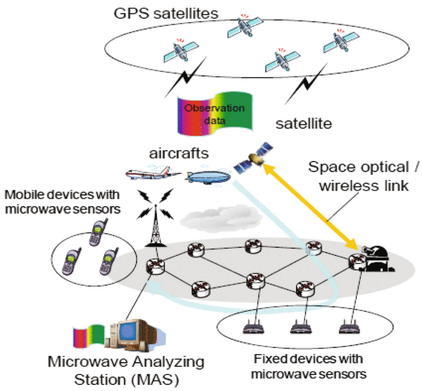

Fig. 6. A basic concept of remote microwave observation systems

They have considered a concept where aircrafts, mobile devices, satellites and other stationary devices that have microwave sensors and network interfaces can be connected to IP-based networks as shown in the figure above. Their approach was effective in analyzing remote microwave conditions at multiple places.

There have been some works in push to talk mobile communications over IP such as with JAIN SIP Object Architecture [7] as shown in Fig. 7 below, Voice Communication Systems with Session Initiation Protocol [8] as shown in Fig. 8 and Push-To-Talk in IP Multimedia Subsystem Mobile Environment [9] as in Fig. 10 and with PTT components as specified by OMA as shown in Fig. 9.

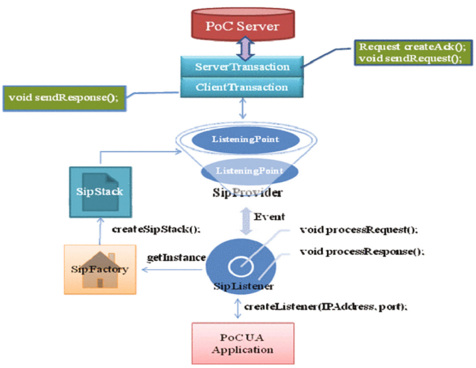

Fig. 7. JAIN SIP Object Architecture

In Fig. 7, JAIN Session Initiation Protocol Application Programming Interfaces were to used to create services using high-level methods that were not independent of the underlying network technology. This made it possible to manage multiple tasks. This can support RTP and RTCP, SIP-based Push to talk over Cellular PoC service. The SIP-based Voice Communication System (VCS) in Fig. 8 can provide phone and radio services different communication standards which may consists of multi-feature operator positions as well as standard IP-phones, which were connected peer to peer in the LAN. In Fig. 10, the Push To Talk service has a relation of one-to-one and one-to-many voice communication system. This was based on half-duplex communications mode based on Voice over IP (VoIP) technology with OMA [10] specifications. This made interoperability between other PoC services on different network operators more possible. There have been some patent works in radio over IP over the years [12–15].

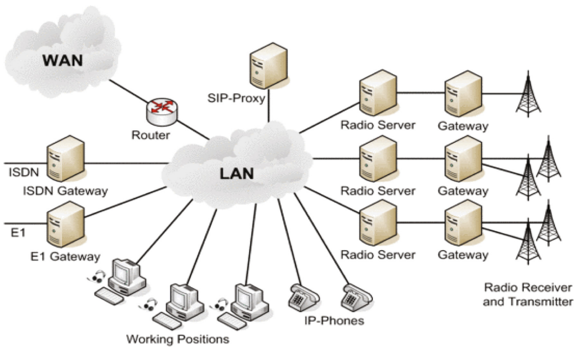

Fig. 8. SIP-based Voice Communication System

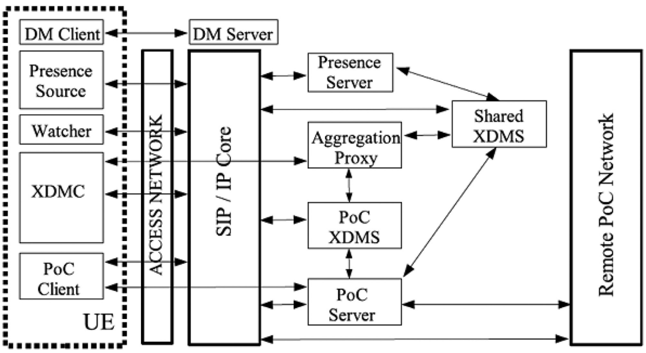

Fig. 9. PTT components as specified by OMA [10].

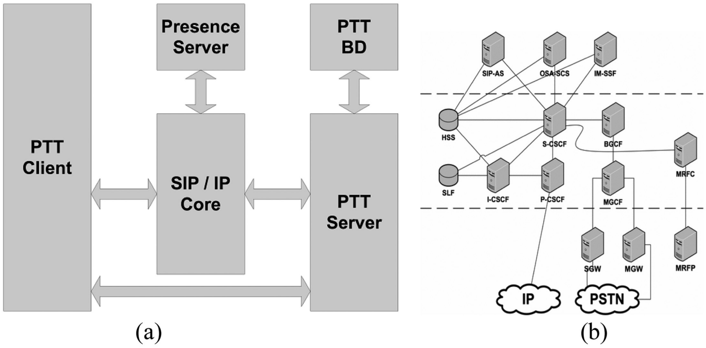

Fig. 10. PTT on IMS solution (a) and Simplified IMS architecture (b)

3 The Approach

The proposed approach was based on VoIP in accomplishing the sending and receiving audio data over TCP/IP protocol. The radio 1, 2, 3…n can communicate among themselves and radio 3 is connected to the server A which then relay the voice communication via IP to Node A and Node B. Mobile A can also tap into the same system and listen to communications over the radio network. Node A, node B and Mobile A can also communicate over back to the radio 1, 2, 3…n via the server. This made it effective for interoperability to be possible with disparate communication devices over the network making integration more easy and deployment more possible over satellite communications and the internet (Fig. 11).

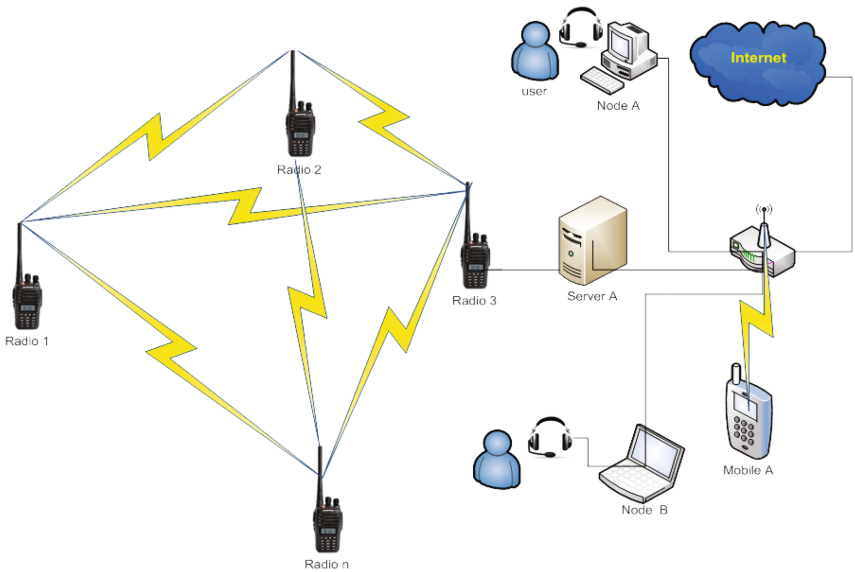

Fig. 11. The proposed system network

The proposed system network is cost effective for implementation and easy to deploy. New Networks can easily be added and different frequency communicating radios can easily be integrated into the platform.

4 Implementation, Results and Discussions

The streaming of the audio data was streamed over the Transmission Control Protocol. The RoIP systems voice quality was improved by using an adaptive jitter buffer to compensate for late, misarranged, or loss packets and the diagram of VOIP with an adaptive jitter is shown below. Jitter adapts to the packet transmission characteristic observed in a given transmission link (Figs. 12 and 13).

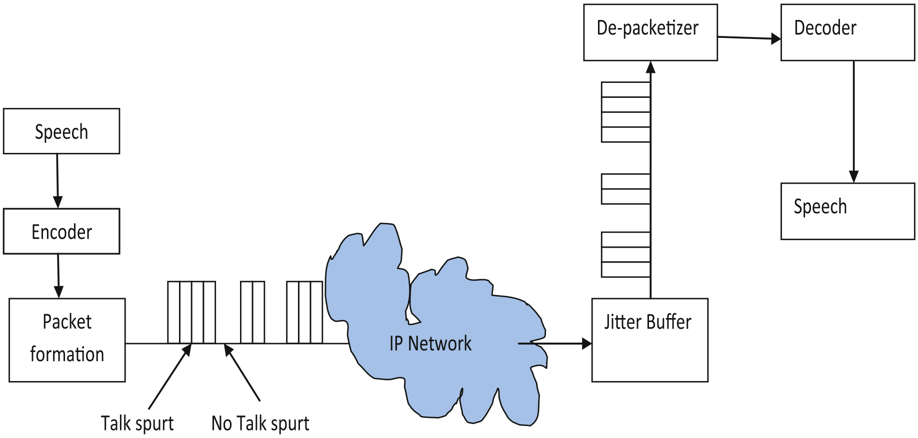

Fig. 12. VOIP with an adaptive jitter

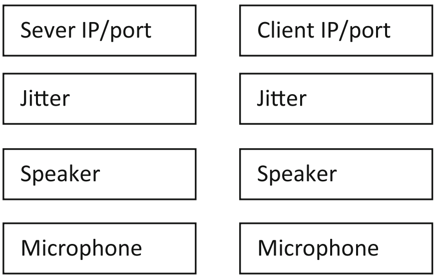

Fig. 13. Server-Client settings

Below are code snippets that are used to start the server and also connect the client. The client and server configuration involves the setting of the IP, choosing of jitter value and communication port. The microphones and speakers are also enabled for communications (Figs. 14, 15 and 16).

```
    Server_connect(object sender, EventArgs e)
              {try
                    {FormToConfig();
                         if (IsServerRunning)
                         {StopServer();
              StopRecordingFromSounddevice_Server();
                               StopTimerMixed();
                         }else {
                               StartServer();
    if m_Config.ServerNoSpeakAll == false)
              {StartRecordingFromSounddevice_Server();
              }StartTimerMixed();
                         }}catch (Exception ex){
        ShowError(LabelServer, ex.Message);
                    }
              }
```

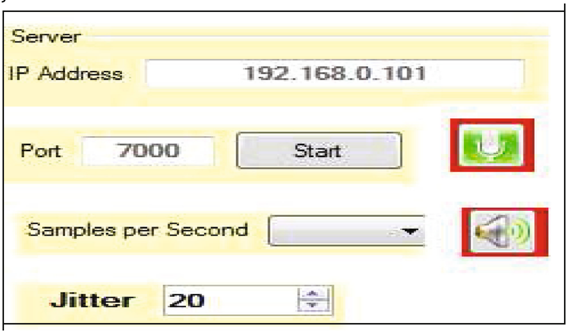

Fig. 14. Server interface settings

The radio used was UV-B5 Dual Band UHF VHF Two way radio with its specifications below and the setup was done as shown in Fig. 17 and performance analysis was done on the TCP IPV4 protocol as shown in the graph above in Fig. 18. The drop in graph shows no communications and the measure in high peaks showed commu-

```
Client_Connect (object sender, EventArgs e)
          {try{ FormToConfig();
                      if (IsClientConnected)
                      {DisconnectClient();
                 StopRecordingFromSounddevice_Client();
                      }else{
                           ConnectClient();
                      }
    System.Threading.Thread.Sleep(100);
                 }
                 catch (Exception ex)
                 {
 ShowError(LabelClient, ex.Message);
                 }
          }
```

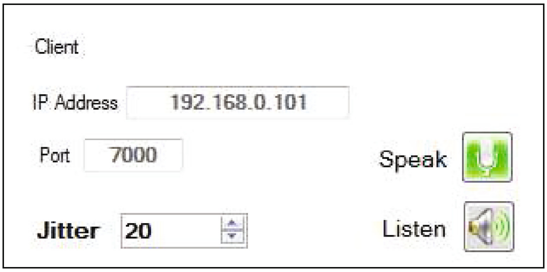

Fig. 15. Client interface settings

Fig. 16. BAOFENG UV-B5 Dual Band UHF VHF two way walkie radio

nications. The tested system performed effectively over the designed network and it was effective. Different radio frequency channels were able to interoperate on the system (Table 1).

Fig. 17. System setup of the communication system

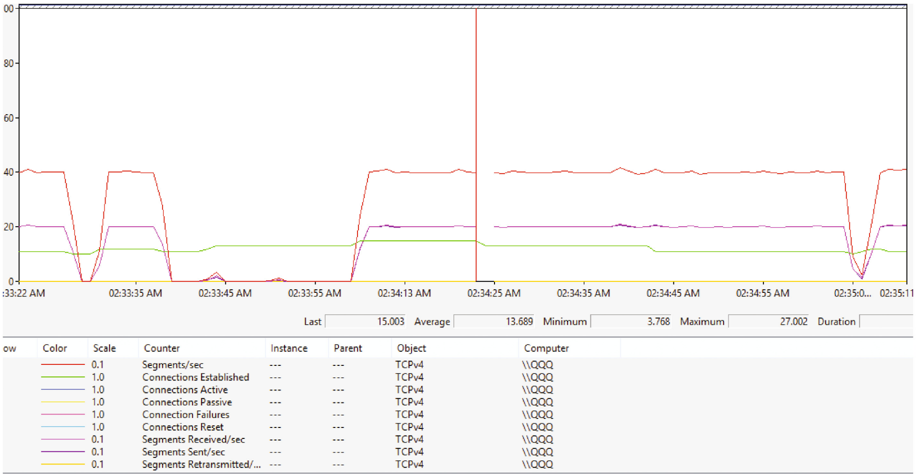

Fig. 18. System setup of the communication system

Table 1. Specifications of the BAOFENG UV-B5 dual band UHF VHF two way walkie radio

Specification	Description
Brand	Baofeng/Pofung
Model	UV-B5
Features	Built-in VOX Function, 50 CTCSS, 104 CDCSS, 1750 Hz Brust Tone, LED Flashlight, Large LCD Display, Hight/Low RF Power Switchable, Emergency Alert, Low Battery Alert, Battery Saver
Number of channels	128
Type	Portable/Handheld
Frequency range (FM)	65–108 MHz (FM Receive only)
Frequency range	VHF136–174 MHz UHF 400–520 MHz

5 Conclusions

With different teams on the grounds during disaster and emergency situations, commutations can be interoperated irrespective of the frequencies of communications and coordination of activities can be done in a more efficient way. With the proposed system, one can stream communications over the internet and also record communications easily. The system is easy to deploy and manage, making it more easy to carry and operate. The system can also be deployed over Virtual private networks, as well as over satellite communications switches supporting TCP protocols.

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