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SPREADING SEAMLESS RADIO OVER IP SERVICES IN TACTICAL PUBLIC SAFETY COMMUNICATIONS USING PTP MICROWAVE IP RADIO NETWORKS

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ABSTRACT

In the event of natural disaster or emergency Tactical Public Safety Communications Infrastructure (TPSCI) has a vital importance. In order to have uninterrupted seamless Communication between the emergency services it is required to have easy unified integration between different VHF, UHF & HF Wireless Radio Technologies. Authors in this research has proposed the use of Services Integration Unit (SIU) which is equipped with RoIP Module for continuous connectivity between different VHF, UHF & HF Wireless Radio Technologies. Here in this study Authors have proposed Two-Tier Architecture for uninterrupted Tactical Public Safety communication. In the First Tier Device to Device Communication (D2DC) will be preferred in the same wireless technology. In the Second Tier Services Integration Unit (SIU) will be used to extend Radio voice traffic by converting it to IP Traffic via Radio over IP (RoIP) module. The Radio voice traffic will be converted into IP Traffic and extended to the remote location through back haul Point to Point Microwave Radio (PTPMR). At the remote location Second Services Integration Unit (SIU) will be deployed which will receive the Radio IP traffic through backhaul Point to Point Microwave Radio (PTPMR) and will be reconverted in to Radio voice traffic through inbuilt Radio over IP (RoIP) module present in the remote Services Integration Unit (SIU). Further Authors will suggest that how the Two-Tier Architecture can be professionally deployed in the Public Safety Communications for uninterrupted seamless communication between emergency services in the event of natural disaster or emergency.

Keywords: *Tactical Public Safety Communications Infrastructure (TPSCI), Device to Device Communication (D2DC), Trunk Mode of Operation (TMO), Services Integration Unit (SIU), Radio over IP (RoIP), Point to Point Microwave Radio (PTPMR), Receive Signal Strength Indicator (RSSI), Bit Error Rates (BER), Signal to Noise Ratio (SNR), Line of Sight (LOS)*

I. INTRODUCTION

In the event of Natural disasters similar to Flooding, Earth Quakes and Tornado, first entity which is severely affected is the damage of Roads, Highways, Bridges and Telecom & Cellular Communication infrastructure. Therefore, Core Communication infrastructure similar to backhaul media like Fiber Optics, PSTN Trunks and Cellular Towers are greatly affected or completely destroyed. This leads us with no alternative other than to deploy a Tactical Public Safety Communication Infrastructure (TPSCI), which is completely independent from the existing Communication Network infrastructure [1-6].

In the event of natural disaster or calamity mostly the existing core communication infrastructure is destroyed or damaged beyond level-1 repairs. Hence for immediately connectivity with disaster area a Tactical Public Safety Communication Infrastructure (PSCI) has to be deployed instantaneously. In the natural hit disaster region Tactical Public Safety Communication Infrastructure (PSCI) is the only source of connectivity between the First Emergency Rescue Responder teams in field to their Dispatcher in Central Headquarters [1-6].

II. 2-TIER APPROACH IN IMPLEMENTING TPSCI

Tactical Public Safety Communication Infrastructure (PSCI) has to be deployed in First and Second Tier Approach scenarios for interrupted connectivity between the VHF, UHF & HF Radio Terminals. Authors in this research works has proposed the scenarios for establishing uninterrupted communication in the event of Natural Disaster or Emergency in remote region, where approachability is challenging [1-6].

A. First Tier Approach Scenario

In the occurrence of Natural Disaster or calamity it is difficult to establish Public Safety Communication via existing wireless infrastructure as it could be damaged or destroyed. To overcome this challenge Public Safety Communication technologies operating in VHF, UHF & HF rely on Device to Device Communication (D2DC) in First Tier. In the First Tier Device to Device Communication (D2DC) can be establish directly in between the Radio Terminals, if the radio terminal are not in the coverage range or vicinity of local VHF, UHF & HF base station repeater [1-7].

Otherwise, if the Radio Terminals are present in the RF coverage range or vicinity of local VHF, UHF & HF base station repeater, then the connectivity can be established through the VHF, UHF & HF base station repeater. Here the VHF, UHF & HF base station repeater is not connected to the central network infrastructure, therefore it is operating in Direct Device to Device Communication (D2DC) mode of operation as shown in the Figure-1 [1-7].

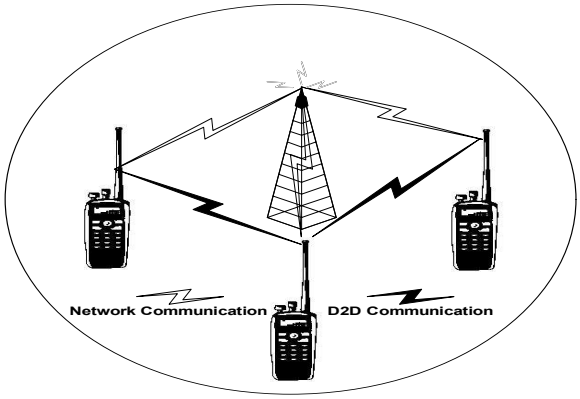

Fig-1 First Tier Device to Device Communication (D2DC)

B. Second Tier Approach Scenario

If the Natural Disaster or calamity is present in a vast region like County or District, then it will be difficult to deploy a Tactical Public Safety Communication Infrastructure (TPSCI) using First Tier approach. To overcome this phenomenon Second Tier approach will be used. Here two remote VHF, UHF & HF Radio terminals will be interconnected via establishing a Short-term private Tactical Public Safety Communication Infrastructure (TPSCI). In this private infrastructure VHF, UHF & HF near and far end base station repeater will be interconnected via back haul Point to Point Microwave Radio (PTPMR) [1-8]. By adopting Second Tier approach Communication range between the VHF, UHF & HF near and far end base station repeaters present at hop length of 45 Km apart from each other can be easily interconnected as shown in the Figure-2. Once a connectivity is established between the near and far end base station repeaters. Then VHF, UHF & HF Terminals present in the RF coverage range of the respective near and far end base station repeaters can easily communicate with each other seamlessly in Direct Device to Device Communication (D2DC) mode without any interruptions or delays [1-8].

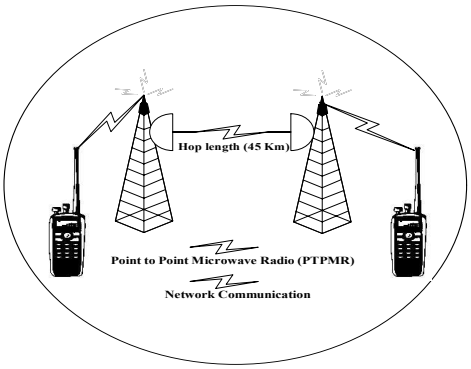

Fig-2 Second Tier Point to Point Microwave Radio (PTPMR)

II. D2DC For Public Safety Uses

In mission critical Tactical applications reliable and seamless communication is required between the rescue teams and Central Headquarters. In the event of Natural Disaster or calamity it is difficult for the Rescue teams to communicate with each other in absence of communication infrastructure. Therefore Device to Device Communication (D2DC) plays a vital role in the connectivity between the local and remote Rescue Teams. Rescue Teams like Law enforcement agencies, paramedics and fire fighters often need to be interconnected with each other [1-8].

For local connectivity within range of 1.5 Km Device to Device Communication (D2DC) can be implemented directly between the VHF, UHF & HF Radio Terminals. Whereas for interconnection between the Rescue teams like Law enforcement agencies, paramedics and fire fighters which are present far apart Tactical Public Safety Communication Infrastructure (TPSCI) can be used. In this private infrastructure VHF, UHF & HF near and far end base station repeaters will be interconnected via back haul Point to Point Microwave Radio (PTPMR) as shown in the Figure-3 [1-8].

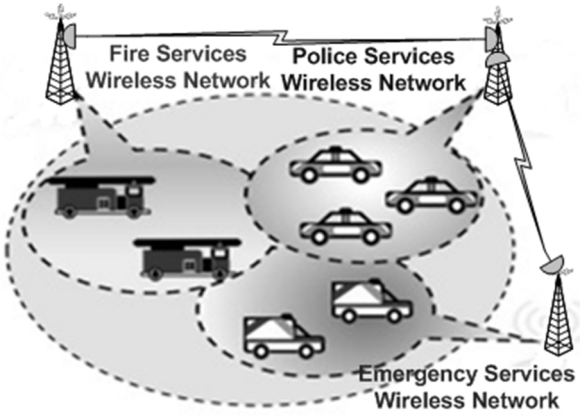

Fig-3 D2DC Public Safety Network

III. Disadvantages of TMO

Trunk Mode of Operation (TMO) has some drawbacks which the Authors have discussed in this research work. In the Trunk Mode of Operation (TMO) fixed connectivity is required between the Wireless Base stations and the core Switching System. Therefore in the event of natural disaster or calamity, fixed connectivity between the Wireless Base stations and the core switching system can be damaged or completely wiped out [1-8].

In the absence of backhaul connectivity infrastructure VHF, UHF & HF Terminals present in the RF coverage range of the respective near and far end base station repeaters cannot easily communicate with each other seamlessly.

Further in Trunk Mode is of Operation (TMO), Direct Device to Device Communication (D2DC) mode not present. Thus this makes this technology of Trunk Mode of Operation (TMO) incompatible to be adopt for Public Safety Applications in Disaster recovery and Emergency Services [1-8].

IV. Problem Statement

The major drawbacks of Trunk Mode of Operation (TMO) is the fixed Site to Site connectivity of Wireless Base stations to the core Switching System. Thus this does not enable TMO network to operate with central Switching system in the absence of backhaul connectivity between the Wireless Base stations and core Switching System. The backhaul media connectivity is often damaged or destroyed during the occurrence of natural disaster or calamity. This result in complete outage of the VHF, UHF & HF Wireless Network Infrastructure. Due to this network outage interconnection between the Rescue teams like Law enforcement agencies, paramedics and fire fighters which are present geographically apart from each other locations is not possible. Another drawback of Trunk Mode of Operation (TMO), is the absence of Direct Device to Device Communication (D2DC) mode. Thus under these circumstances Trunk Mode of Operation (TMO) is not viable to be adopted for Public Safety Applications in the event of Natural Disaster recovery or calamity [1-7].

V. Proposed Solution

In this research work Authors have proposed the use of Services Integration Unit (SIU) which is equipped with RoIP Module for continuous connectivity between different VHF, UHF & HF Wireless Radio Technologies. Here in this study Authors have proposed Two-Tier Architecture for uninterrupted Public Safety communication. In the First Tier Device to Device Communication (D2DC) will be preferred in the same wireless technology.

In the Second Tier Services Integration Unit (SIU) will be used to extend Radio voice traffic by converting it to IP Traffic via Radio over IP (RoIP) module. The Radio voice traffic will be converted into IP Traffic and extended to the remote location through back haul Point to Point Microwave Radio (PTPMR). At the remote location Second Services Integration Unit (SIU) will be deployed which will receive the Radio IP traffic through backhaul Point to Point Microwave Radio (PTPMR) and will be reconverted in to Radio voice traffic through inbuilt Radio over IP (RoIP) module present in the remote Services Integration Unit (SIU).

VI. Use of Service Integration Unit (SIU)

For providing uninterruptible voice and data communication in Second Tier of Tactical Public Safety Communication Infrastructure (TPSCI) between the local and remote VHF, UHF & HF Wireless Network Infrastructure Services Integration Unit (SIU) will be used. The Services Integration Unit (SIU) equipped with Radio over IP (RoIP) module will be present on the both near and far end locations for converting radio voice traffic into IP traffic and IP traffic into radio voice traffic. Further this IP traffic will be transported through backhaul Point to Point Microwave Radio (PTPMR) between near to far end Services Integration Units (SIU). The Services Integration Units (SIU) as shown in the Figure-4 has following Key Features as mentioned in Table-1.

Fig-4 Services Integration Unit (SIU) Case

Table-1 Services Integration Unit (SIU) Technical Parameters

Key Features	No of Ports
RoIP Traffic Interface	01
E1Traffic	01
Engineering Order Wire (EOW)	01
Microwave PoE	01
Video Phone PoE	01
GE Interface	02
Power Out Put for Radio Antenna Alignment System (RAAS) 28 VDC	01
DC Power In Put 12 to 34 VDC	01
AC Power In Put 90 to 265 VAC	01

VII. SIU Field Trails

In first phase of field trials Tactical Public Safety Communication Infrastructure (TPSCI) VHF, UHF & HF Wireless Network Hand Held Radio at location-A present in field at 1.5 Km apart is wirelessly connected to the Gateway vehicular mobile radio at the base which is further connected to the Services Integration Unit (SIU) through Cable. Radio over IP (RoIP) module present in Services Integration Unit (SIU) convert radio voice traffic into IP traffic. Then in second phase of field trials this IP traffic is then transported to the Location-B Services Integration Unit (SIU) 45Km apart through IP based backhaul Point to Point Microwave Radio (PTPMR) Link. In the field trials we have use Tactical Telescopic Antenna Masts for the installation of Microwave Radio Links at both locations-A & B.

Once the IP traffic is received at the Services Integration Unit (SIU), it is reconverted into Radio voice traffic by Radio over IP (RoIP) module. This radio voice traffic is then induced to VHF, UHF & HF Wireless Network Gateway vehicular mobile radio through cable at Location-B. Further this Gateway vehicular mobile radio present at the base in location-B wirelessly broadcast the radio voice traffic to Hand Held Radio present in his network as shown in the Figure-5. Hence by using Services Integration Unit (SIU) in Second Tier we can implement seamless Radio over IP Services in Tactical Public Safety Communication Infrastructure (TPSCI).

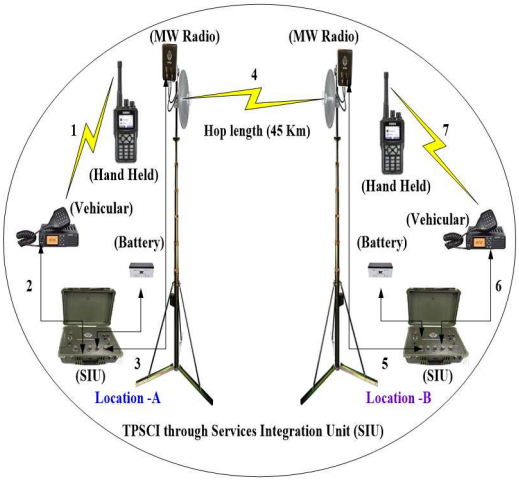

Fig-5 Tactical Public Safety Communication Infrastructure

VIII. Point to Point Microwave Radio

In this project for end to end connectivity between the locations-A & B the Authors have used Point to Point Microwave Radio (PTPMR) operating in Band VI (6.000 to 6.425 GHz). The Pont to Point Band VI Microwave Radio as shown in the Figure-6 has following Key Features as mentioned in Table-2 [9].

Fig-6 Point to Point Microwave Radio

Table-2 MW Radio Technical Parameters [9]

NO	Key Features
1.	Channel Bandwidth Sizes from (3.5, 5, 7, 10, 14, 15, 20, 28, 30, 40, 50 & 56 MHz)
2.	Dynamic Frequency Scanning (DFS)
3.	Automatic Transmit Power Control
4.	MIMO-2x2
5.	Modulation from QPSK 1/4 to QAM 256 7/8
6.	Net throughput up to 650 Mbps
7.	Transmit Power up to 27 dBm
8.	Receiver Sensitivity up to -101 dBm
9.	Operating temperature range -40 +60
10.	IP66/IP67 compliant water and dust Protection
11.	Web-based graphical user interface
12.	Command line interface
13.	SNMP v1/2c/3 support (MIB-II & proprietary MIBs)
14.	Centralized monitoring using NMS
15.	Built-in antenna alignment tool
16.	Built-in Spectrum Analyzer
17.	Built-in- full-fledged L2 switch
18.	100-240 VAC~@50/60 Hz or ±43 ±56 VDC, 802.3 at compliant
19.	Power consumption up to 15 W

IX. SIU RoIP Module

Both the Services Integration Unit (SIU) unit at near and far end locations are fitted with Vocality RoIP modules. These RoIP modules basic functionality is to translate near end VHF, UHF& HF Radio Voice traffic to IP traffic and retranslate the IP traffic received at far end to Radio voice traffic. The Vocality RoIP module is equipped with four RoIP ports and two Ethernet data ports as shown in the Figure-7 [10].

For end to end connectivity between the near and far end Vocality RoIP modules a basic connectivity route from source to destination is define in both the devices. For end to end connection establishment both the RoIP modules are configured with each other IP addresses. Both the User Datagram Protocol (UDP) port numbers at both the near and far end RoIP modules should be configured same in the Vocality GUI as shown in Figure-8 & 9. Further in Vocality module Routing tab GUI name of each other Vocality module node is given to establish a static routing path as shown in Figure-10 & 11 [10].

Fig-7 Vocality RoIP Module

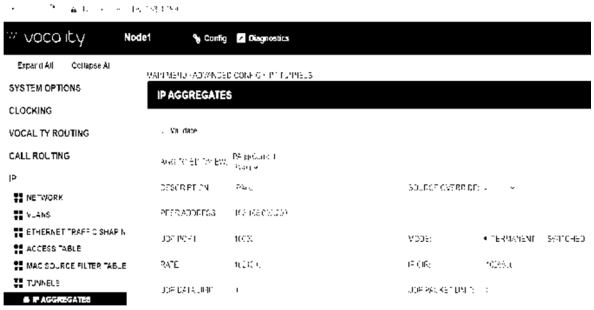

Fig-8 Local end Node-1 GUI Parameters

Fig-9 Far end Node-2 GUI Parameters

Fig-10 Local end Node-1 Routing Tab Parameters

Fig-11 Far end Node-2 Routing Tab Parameters

X. CONCLUSIONS

In this study Authors have suggested the use of Two-Tier Architecture for uninterrupted Tactical Public Safety communication. In the First Tier Device to Device Communication (D2DC) will be preferred amongst the neighboring radio devices present up to 1.5 Km. In the Second Tier Services Integration Unit (SIU) along with back haul Point to Point Microwave Radio (PTPMR) will be used to extend radio communication between two separate wireless networks which are 45 Km apart or more. Here Services Integration Unit (SIU) will be installed at both local and far end for Radio voice to IP traffic conversion and reconversion.

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