Relaying of 4G Signal over 5G Suitable for Disaster Management following 3GPP Release 18 Standard

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Abstract

Technologies for disaster management are highly sought areas for research and commercial deployment. Landslides, Flood, cyclones, earthquakes, forest fires and road/train accidents are some causes of disasters. Capturing video and accessing data in real time from the disaster site can help first responders make split second decisions which may save human lives and valuable resource destructions. In this context the communication technologies performing the task should have high bandwidth and low latency which only 5G can deliver. But unfortunately in India, deployment of the 5G mobile communication systems is yet to give a shape and again in remote areas unavailability of 4G signals is still severe. In this situation the authors have proposed, simulated and experimented a 4G-5G communication scheme where from the disaster site the signals will be transmitted by a 5G terminal to a nearby 4G-5G gateway installed in a mobile vehicle. The received 5G signal will be further relayed by the 4G-5G gateway to the fixed 4G base station for onward transmission towards the disaster management station for decision making, deployment and relief monitoring. The 4G-5G gateway acts as a relay and converter of 5G signal to 4G signal and vice versa. This relayed system can be further mounted on a vehicle mounted relay (VMR) as proposed by 3GPP in Release 18. The scheme is also in the same line of context with Verizon's, "Tactical Humanitarian Operations Response" (THOR) vehicle concept. The performance of the link is studied in different channel conditions, the throughput achieved is superb. The authors

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have implemented the above mentioned system towards smart campus networking and monitoring landslides activities which are common in their regions.

Keywords: VMR, MCPTT, THOR, SWIPT, CPE

1. Introduction

3GPP [1] is dedicated towards developing technical specifications and standards for communication and its use case services. One of the key focused areas is Mission Critical services as required from various sectors present in the critical communication industry. In Release 14, the Mission Critical services include Mission Critical Push to Talk (MCPTT), Mission Critical Data (MCData), Mission Critical Video (MCVideo) and a framework in which Mission Critical (MC) services are standardized. In Release 15, there was an evolution for various MC Services such as Connectivity among 3GPP defined MC systems along with their functionalities and requirements from various industries etc. 3GPP also evolved standards in phase 2 with Release 16 and 17 [2], where 5G URLLC is included for ensuring reliability in MC applications. The above 5G Phase 1 & 2 research and development activities are proliferated as deployment of 5G core and 5G user equipment (UE) worldwide.

5G second wave activities have started in the later part of the year 2021 and 3GPP is also progressing in formulating the standard with Release 18. The 5G use cases in the form of a triangle are getting updated by encircling the triangle with an outer circle as shown in the figure 1 [3]. The four quality of service (QoS) namely Experience, Extension, Expansion and Excellence as mentioned in **Fig. 1** are the four major directions of the second wave of 5G evolution.

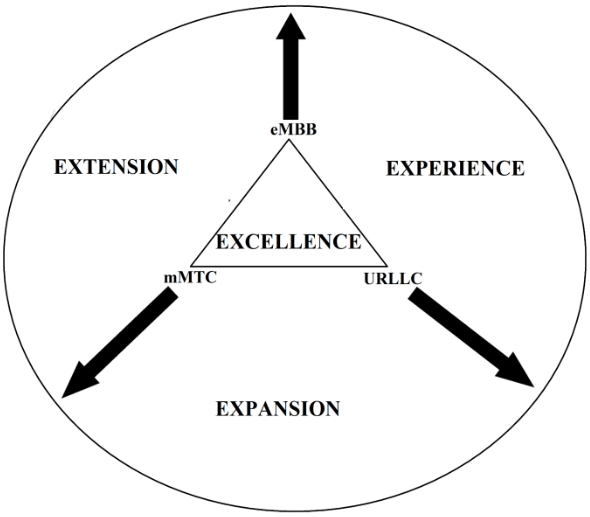

Fig. 1. Upgradation of 5G Phase 1 Triangular Use Cases towards 5G second wave

The 5G Extension program as in Release 18, depicted in **Fig. 2** is dedicated to fulfill the gap in realizing the campaign, '5G should be everywhere'. This challenging problem is being solved by introducing the Repeaters, Relays/ VMR, integrated access and backhaul (IAB) Nodes and Non Terrestrial Networks (NTN) like Drone and Satellite. The 5G gNBs are split into two subsections i) Central Unit (CU) : 5G gNB-CU ii) Distributed Unit (DU) : 5G gNB DU and the above four different approaches of Relays can be deployed at the Distributed Unit as depicted in figure 2 [4]. The different 5G gNB DU will address different slices like road vehicle based Relays, Repeaters, NTN Relays whereas 5G gNB CU will handle the Mobile IAB. In this way, 5G NR RAN will be split into 5G gNB splitted with CU and DU units and using different types of relays ensuring reliability. The split gNB with CU and DU add on is, however, complements the power split receiver technology used in SWIPT (simultaneous wireless information and power transfer) for 5G NOMA [5].

The above 5G System capabilities will be improved in near future by connecting the system/subsystems via a 5G Residential Gateway (5G-RG) or simply a Gateway [6]. THOR is a private 5G Ultra-Wideband (UWB) mobile vehicle unit [7], equipped with a mobile edge compute (MEC) based rapid-response command center capable of being deployed in any situation. THOR was developed by Verizon, to act as a crisis response vehicle able to operate in any environment, under any network conditions. THOR is capable of providing mission-critical capabilities to first responders and military members in most hostile environments, as a communications provider using Vehicle as gateway.

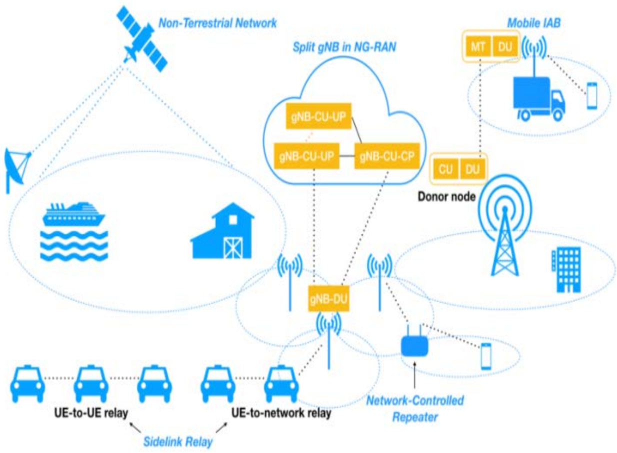

Fig. 2. 5G extension program of the Release 18 (Courtesy : ERICSSON[4])

In line with release 18 evolution by 3GPP and others, the authors have proposed and presented their contributions in this paper. A novel scheme of establishing a communication link between a disaster management control room and a disaster site for information exchange has been proposed which is shown in **Fig. 3**. The authors have simulated the model of the above mentioned scheme based on 5G NR with the concept of VMR. Hardware realization partly of the scheme is established. ***Effectively, the contribution claims for the second wave of 5G realization with two distinct success stories and their Integration as depicted in Fig. 2.***

The paper is organized as follows:

In article 1, the authors have presented the evolution of 3GPP releases particularly from 14 to 18 in context to MC use cases and the corresponding technologies.

Article 2 discusses the proposed scheme, remote monitoring of a Disaster Site as shown in **Fig. 3**, its Link Budget and related formulation.

In article 3, two simulation models of 4G LTE [7] and 5G NR [8] links are described which are the parts of the proposed scheme as shown in **Fig. 3**. The models are simulated by Keysight Technologies simulation software, “Systemvue”. The first model is a 4G LTE link between the 4G BS and 4G-5G Gateway. The second model is a 5G NR link between the gateway and 5G user equipment.

Article 4 will describe the hardware realization of two developments. The authors have realized the 5G hardware with two distinct success stories. The first development is a link setup for the relay of 4G signals to a distant region where 4G signal is unavailable by a 5G link. The second development is the relay of FM signals over 5G signal to serve a campus. Finally the two systems are integrated to achieve a smart campus with disaster monitoring.

The much awaited reception of Siliguri FM radio station within the author's Sikkim Manipal Institute of Technology(SMIT) campus (90 km away from Siliguri) is now a reality and SMITians are enjoying it. The disaster event from landslides from nearby hills is now monitored online using a 5G/4G system combination and the same is displayed on SMITians 4G mobile.

Finally, article 5 discusses the summary of results with conclusions.

2. Proposed Scheme for Remote Monitoring of a Disaster Site

A novel scheme for remote monitoring of a disaster site is proposed as shown in **Fig. 3**. In a disaster situation like flood, cyclone, earthquake, landslide, fire, war and train accident etc., existing infrastructure is ruined. There is a huge loss of life, property and other resources. It is very important to save life and take timely measures to minimize the damage. Moreover sometimes the disaster site could not be reached by vehicles to find out the magnitude of the devastation. So it is very important to establish a communication link to take an account of the magnitude of the toll from the disaster site and convey the same to appropriate authorities for providing relief and help. In this scheme we propose a communication link between a control room set up for disaster management & monitoring and the disaster site using the existing 4G base station (BS). This BS is far away from the disaster site and not affected by the disaster. The control room for disaster management is linked to the 4G base station through optical fiber connectivity. This 4G BS is linked to a 4G-5G Gateway installed in a mobile van. The mobile 4G-5G[9] Gateway in turn could reach to the maximum possible spot close to the disaster site and can establish a link to a 5G mobile handset (user equipment) possessed by a user who is in the disaster site capturing live videos for onward transmission towards the control room. The gateway and the 5G UE are to be supplied by the disaster management team.

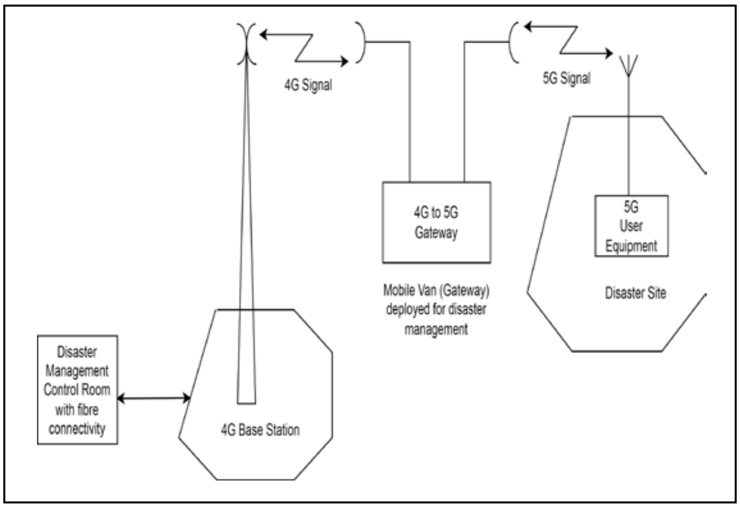

Fig. 3. Relay of 4G signal over 5G, ensuring safety for the disaster site

The 4G-5G mobile gateway is placed in between the 4G tower and the disaster site in such a fashion that it can receive the 4G signal directly from the tower and transponds it to an equivalent 5G signal towards the 5G UE in the disaster site. Effectively it is a two-hop communication between 4G tower and the 5G UE where the gateway is acting as a relay center. This technology is getting standardized by 3GPP in release 18 as mobile integrated access backhaul (IAB)[10] and vehicle mounted relay (VMR) [11], [12], [13].

2.1 Link Budget and related formulation

The received power for an 4G/5G communication link is given by

$$P_{Rx} = P_{Tx} + G_{Tx} - P_L + G_{Rx} \quad (1)$$

Where P_{Tx} is the transmitted power, G_{Tx} is the transmitter antenna gain, P_L is the path loss and G_{Rx} is the receiving antenna gain [14]. The receiver sensitivity is expressed as

$$S_{Rx} = N_f + N_T + SINR \quad (2)$$

Where N_f is the noise figure, N_T is the thermal noise and SINR is the signal to interference and noise ratio. The thermal noise N_T is defined as

$$N_T = -174 + 10\log(B) \quad (3)$$

Where B is the transmission bandwidth.

The schematic diagram of 4G base station to gateway LTE link in AWGN environment is shown in **Fig. 4** and the parameters for the 4G LTE link budget are shown in **Table 1**. The two dimensional (2D) distance between the 4G BS and the gateway is considered 4 km. The carrier frequency is 2 GHz. The downlink environment is considered with 5 MHz bandwidth. The transmitted power from the 4G BS is 40 dBm. The transmitter antenna gain is 30 dB and the antenna height is 20 meters. The effective intrinsic radiated power (EIRP) is 70 dBm. The receiver antenna height at the gateway is 3 meters, the receiver sensitivity is -90.47 dBm and the receiver antenna gain is 30 dB. The pathloss is 152.68 dB considering the rural macro propagation channel with line of sight (LOS) communication. Finally the received signal power at the receiver i.e. link budget is -52.68 dBm.

Table 1. Link budget of the 4G LTE link

Parameters	Values
2D distance	4 km
Carrier frequency	2 GHz
Link environment	Downlink LOS
Bandwidth	5 MHz
Transmitted power (P_{Tx})	40 dBm
Transmitter antenna gain (G_{Tx})	30 dB
EIRP	70 dBm
Transmitter antenna height	20 meter
Receiver antenna height	3 meter
Receiver antenna gain	30 dB
Receiver sensitivity	-90.47 dBm
Path loss	152.68 dB
Received Power i) at the antenna terminal ii) at the input of the Demodulator	-52.68 dBm -30dBm

The link budget parameters for the 5G NR from the gateway to the disaster site are shown in **Table 2**. The two dimensional (2D) distance between the 4G-5G gateway and the UE of the disaster site is considered 400 m. The carrier frequency is 28 GHz. The downlink environment is considered with 10 MHz bandwidth. The transmitted power from the 5G transmitter of the gateway is 40 dBm. The transmitter antenna gain is 30 dB and the antenna height is 3 meters. The effective intrinsic radiated power (EIRP) then 70 dBm. The receiver antenna height at the gateway is 1.5 meters, the receiver sensitivity is -80.13 dBm and the receiver antenna gain is 30 dB. The pathloss is 162.57 dB considering the rural macro propagation channel with line of sight (LOS) communication. Finally the received signal power at the receiver i.e. link budget is -62.58 dBm.

Table 2. Link budget of the 5G NR link

Parameters	Values
2D distance	400 m
Carrier frequency	28 GHz
Link environment	Downlink LOS
Bandwidth	60 MHz
Transmitted power (P_{Tx})	40 dBm
Transmitter antenna gain (G_{Tx})	30 dB
EIRP	70 dBm
Transmitter antenna height	3 meter
Receiver antenna height	1.5 meter
Receiver antenna gain	30 dB
Receiver sensitivity	-80.13 dBm
Path loss	162.57 dB
Received Power i) at the antenna terminal ii) at the input of the Demodulator	-62.58 dBm -40dBm

3. Simulation and Results of the proposed scheme

Three mission critical (MC) services are suggested by 3GPP, namely i) MC based audio service ii) MC video based Video service iii) MC data based data services. The proposed scheme of 4G signal relay over 5G is implemented in Keysight SystemVue software platform where audio, video and any kind of sensor data can be sent and tested. Clearly, this work is two slices based, namely 1) Voice Over Internet Protocol (VOIP) Audio and Sensor Data, 2) 5G eMBB for Mission Critical Video.

3.1 Simulation of Audio/Video Signal over 4G

The link between the 4G base station and the gateway is established in a downlink environment with LTE (long term evolution) signal. The system details are shown in **Fig. 4**. A sine wave generator is considered as an audio signal and a pattern generator is considered as a video signal source. This audio/video signal is used to generate a 4G LTE signal as per 3GPP LTE downlink standard. The 4G LTE signal is then carrier modulated at 2GHz and transmitted. An AWGN channel model is used here for performance evaluation of the 4G link to the gateway. The demodulator shifts the received signal spectrum and hence the LTE downlink baseband receiver detects the baseband audio/video signal. The detected audio/video signal is stored in the data sink. The received audio signal is shown in **Fig. 5** and **Fig. 6** shows the received video signal collected at the data sink.

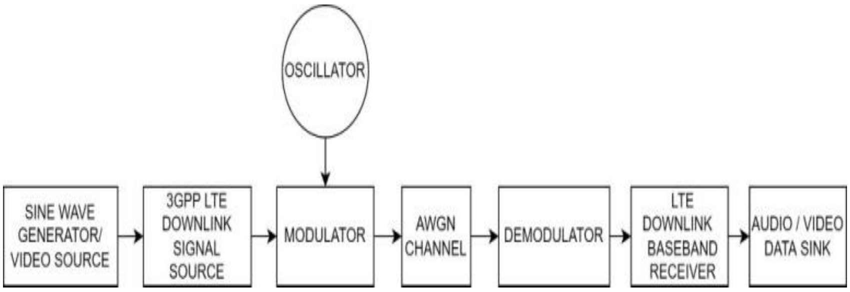

Fig. 4. Schematic diagram of 4G base station to gateway LTE link in AWGN environment.

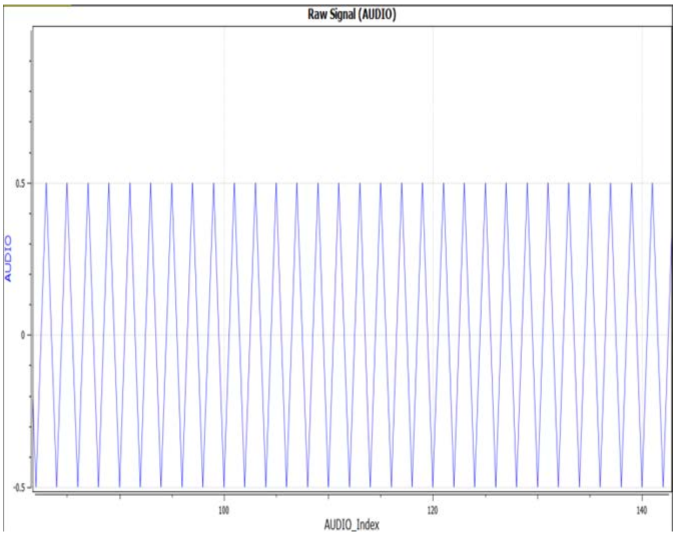

Fig. 5. Output of the Audio signal at Data Sink

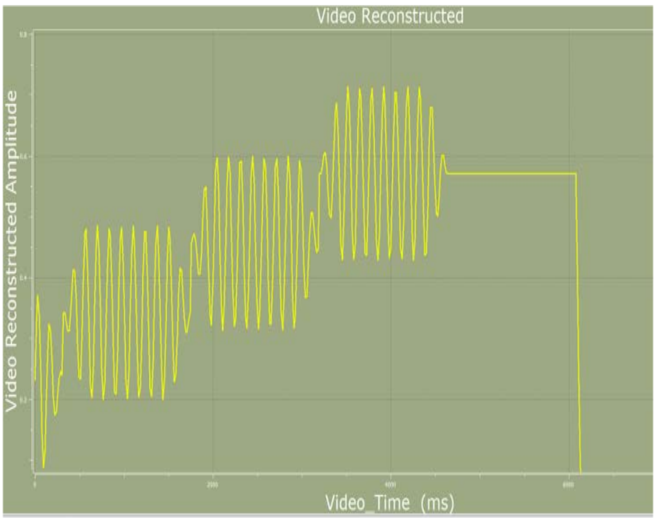

Fig. 6. Output of the Video signal at Data Sink

3.2 Simulation of 4G to 5G Gateway

The gateway as mentioned in **Fig. 3** is used to change the 4G LTE signal to 5G New Radio (NR) signal for the 5G connectivity of the next hop from gateway to the UE at the disaster site. The gateway here is acting like an ethernet switch and it bridges the gap between the 4G signal and 5G NR signal proposed in **Fig. 3**. The detailed simulated design is shown in **Fig. 7**. The LTE downlink baseband receiver and the audio/video sink of **Fig. 4** are actually the parts of the gateway. The LTE receiver generates the baseband signal from the received signal and it is stored in a text file via the audio/video data sink. Hence the 5G NR downlink signal source recognizes the baseband signal as the input through the read file functional block of the simulation platform. Finally it transmits the 5G NR signal for the disaster site. It is the entrance point to the 5G network.

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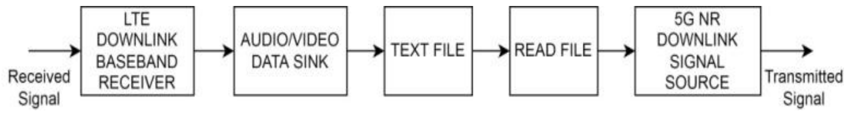

Fig. 7. Gateway Junction

3.3 Simulation of 5G URLLC Link

Ultra-Reliable and Low Latency communications (URLLC) [15] is a new service category in 5G to accommodate emerging services and applications having stringent latency and reliability requirements [16]. The link between the gateway and the disaster site is simulated with a 5G NR signal as shown in **Fig. 8**. As already stated that the read file functional block and the 5G NR downlink source are parts of the gateway. The 5G NR source takes the input data stored in a text file through the read file functional block. The technique of polarization diversity and maximum ratio combining is adopted to increase the reliability of the system [17], [18]. Two RF (radio frequency) chains are taken out from the 5G NR source for two polarizations. The upper branch indicated in green shaded box represents the RF data for polarization 1 and the lower branch indicated in pink shaded box represents the RF data for polarization 2. Both the RF signal branch is carrier modulated at 28 GHz and a suitable narrow beam is formed using the beamformer blocks. These RF signals are fed to beam signals with two polarizations with dual polarized antenna elements of the 3D channel model which is used to study the performance of the 5G link. There are two receiver branches for two polarizations with two beamformers and demodulators i.e. signals of two polarizations [19] are received with two beams. The 5G NR downlink receiver works with the maximum ratio combiner (MRC). The MRC combines signals from the two receiving beams of two polarizations with necessary signal processing to a single line. Then the 5G NR receiver generates the baseband signal and it is collected in the audio/video data sink. The audio signal received is shown in **Fig. 9** and the video pattern signal collected is shown in **Fig. 10**.

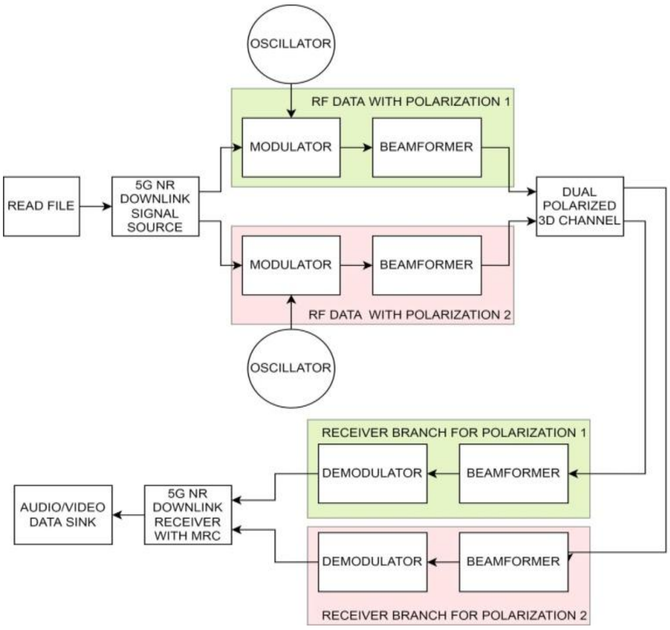

Fig. 8. 5G URLLC Link between the gateway and the disaster site

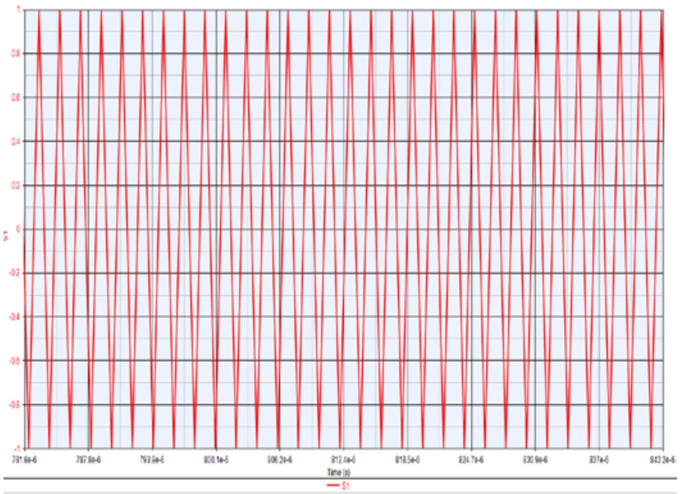

Fig. 9. Output of the audio signal at the 5G Baseband Receiver

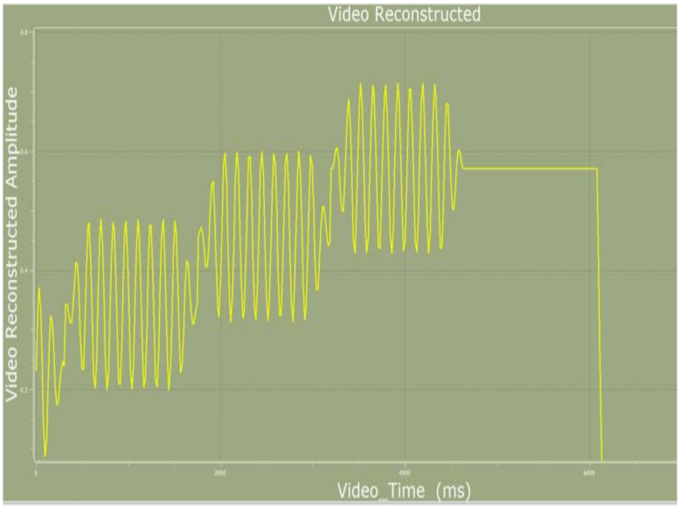

Fig. 10. Output at the sink of the 5G NR receiver

The bit error rate (BER) versus SNR performance is shown in **Fig. 11** and the throughput versus SNR performance is shown in **Fig. 12**. Both the BER and the throughput performances are evaluated for 10 MHz, 15 MHz, 20 MHz, 25 MHz and 30 MHz transmission bandwidth considering different kinds of data transmission between the gateway and the disaster site. BER achieves the level of 10^{-4} almost at the SNR level of 30 dB and the throughput achieves the value of 2.5 MBPS at the same SNR level in all the cases.

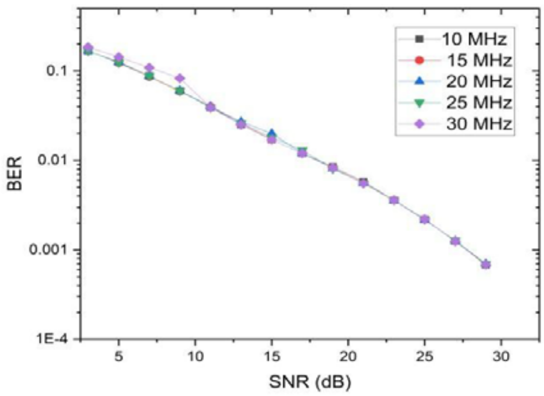

Fig. 11. BER vs SNR performance of the 5G URLLC link

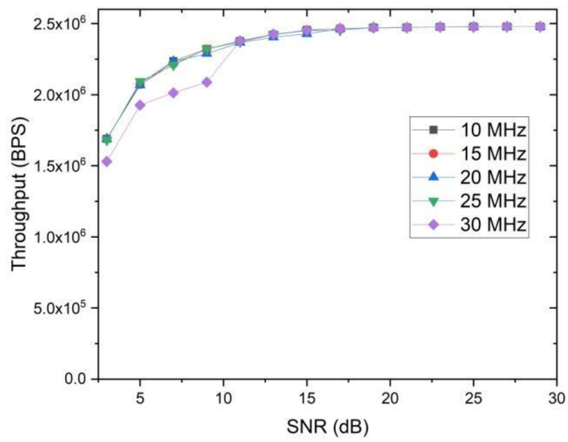

Fig. 12. Throughput vs SNR performance of the 5G URLLC link

4. Hardware Realization of 4G Signal Transmitted over 5G System

4.1. 4G relayed over 5G: Success story 1

The block diagram of the 4G signal relayed over the 5G system is shown in **Fig. 13**. The above system block diagram is composed of i) 4G LTE base station ii) Smartphone iii) WiFi Router iv) 5G Hotspot Terminal at 28 GHz and v) 5G UE CPE Terminal at 28 GHz. The disaster site is located in a no-coverage zone of LTE signal. A 5G Relay station is placed at the good LTE mobile coverage zone to solve the problem of non reception at disaster sites. The LTE mobile coverage is divided into 3 zones. First zone is declared as a good 4G coverage zone which is 1 Km apart from the existing LTE Base station. 1 to 3 Km range is considered as medium signal strength coverage zone, and 3-5 Km or more than that is considered as no-coverage zone.

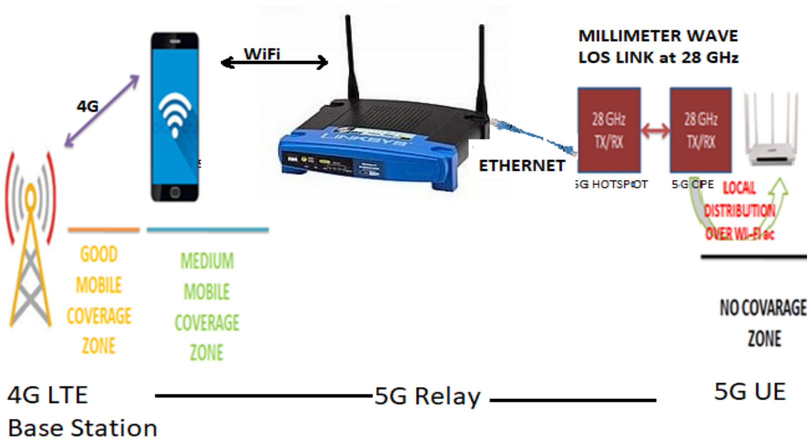

Fig. 13. 4G relayed over 5G architecture realized by the authors

The Internet data transmitted over 4G LTE base station (data rate considered to be 30 Mbps typical) is received by placing a smartphone in the good/medium coverage zone. The same data from the smartphone is shared to a WiFi Router by invoking the smartphone's ‘ Portable Wi Fi hotspot’ mode. One Ethernet cable is used further to connect between the Wifi router and the 5G Hotspot terminal and data is relayed over a 28 GHz 5G radio point to point link. The 5G CPE Terminal is located near the disaster site. *Thus the 4G signal is relayed over 5G link and the authors are able to connect the disaster site located at no coverage zone of* 4G LTE base station *successfully.*

4.2 FM relayed over 5G: Success story 2

4.2.1 Problem of FM signal reception at Cell edge

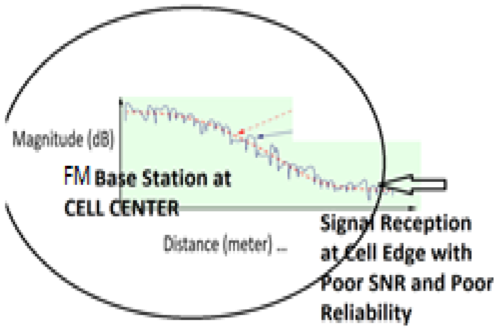

Fig. 14(a). Received signal fading at Cell edge

In general, signal reception is poor at Cell edge due to Large Scale Fading faced by received signal. Also, huge fluctuation in received signal is noticed due to small scale fading and small changes in distance as depicted in **Fig. 14(a)**.

In comparison, small scale fading has a severe impact on received signal which is mainly due to multipath reception and is manifested as large fluctuation of signal reception with small changes in distance. **Fig. 14(b)** depicts such reception where received signal undergoes from peak to null magnitude excursion.

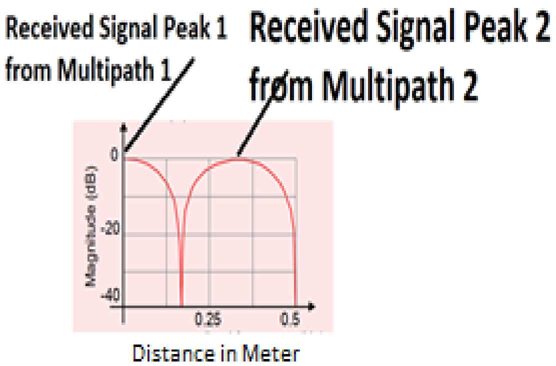

Fig. 14(b). Manifestation of small scale fading at Cell edge

Such is the condition of FM signal reception within Author’s SMIT Campus which is located at the cell edge of the Siliguri Radio Misti FM station. The distance between Siliguri popular Radio Misti FM Broadcast station to SMIT is 90 Km.

4.2.2 Solution toward poor Siliguri Radio Misti FM signal reception at SMIT Cell edge

Received signal Peaking and Nulling are clearly visible over small distances and marked in **Fig. 14(b)**. Also two received signal Peak 1 and received signal peak 2 are marked which the solution to this problem is. The authors have experimented this at SMIT rooftop by tuning the Siliguri Radio Misti Station on their mobile phone with good clear radio reception at the Peak position only. **Fig. 15(a)** depicts such experimental block diagram with four major items namely i) Siliguri FM Radio Misti Station (90 km away from SMIT CAMPUS) ii) Relay station at SMIT rooftop iii) FM re-transmission at SMIT Rooftop Lab with 'Radio Talk Show' iv) Radio reception within SMIT campus by SMITians at their Mobile phone.

The relay mobile is placed at the Peak reception location on the rooftop of SMIT Campus as shown in **Fig. 15(b)** whose analog speaker output signal is connected to a PC. The converted digital Ethernet output signal from the PC is connected to the 5G Hotspot Terminal. 5G CPE terminal which is used for the reception of the FM signal and is placed near the Laboratory where the FM re-transmission system is operational. The Fading problem in audio reception is solved successfully. Photographs of the said experimental set up are shown in **Fig. 15(b)**. Effectively, three radio hops are implemented in this Experimental set up for FM over 5G as shown in **Fig. 15(a)** with marking of the three hop with three different color lines.

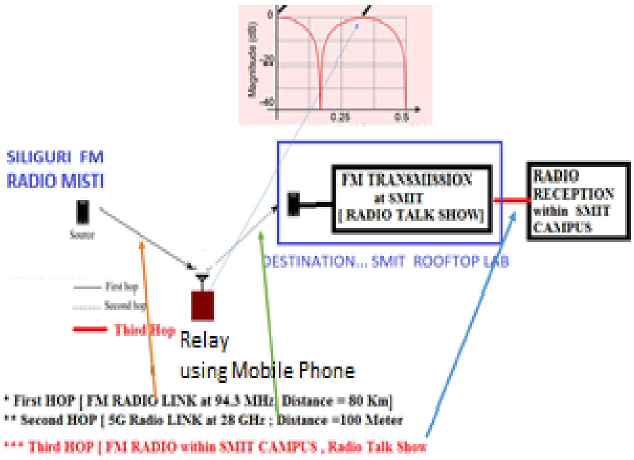

Fig. 15(a). SILIGURI FM radio Misti reception at SMIT rooftop with an outdoor relay, FM Redistribution within SMIT Campus and Radio Talk Show.

Fig. 15(b). Photograph of SILIGURI FM radio Misti reception at SMIT rooftop with an outdoor relay, FM Redistribution within SMIT Campus and Radio Talk Show.

Result

- We are able to listen the Transmitted music from SILIGURI ' RADIO MISTI' FM STATION using LOCAL 5G Based Relay station at 28 GHz
- Earlier we are not able to listen the transmitted Music
- The entire SMIT is now listening to the said FM Radio station with ultra-reliability in reception and further FM transmission within SMIT campus.

Thus Relaying of SILIGURI RADIO MISTI FM RADIO over SMIT CAMPUS is successfully operational.

4.3 Integration of both the FM and 4G signals relayed over 5G to have a 'SMART CAMPUS NETWORK'

The Needs:

Need 1 towards Disaster monitoring and Control :- Author's University premises SMIT is situated at the hilly terrain of Himalaya in the state of Sikkim surrounded by hills as shown in the photo of **Fig. 16**. Landslides are very common in the rainy season.

Fig. 16. Author's SMIT campus, implementation site of Campus Network

During rain, there are often landslides in the nearest hills creating a disaster situation for the residents of SMITians. So, the landslide events need to be broadcasted using 4G tower over the SMIT campus for the preventive measure against landslide disaster.

Need 2 towards listening to Siliguri FM radio station over SMIT campus:- Siliguri FM radio station is too popular amongst the SMITians but it is far apart with an air distance of more than 90 Km. The reception within SMIT campus is full of Noise or No reception at different corners of SMIT campus. The authors are also engaged in relaying the said FM radio over SMITians and successfully completed this project. The above two needs and their solution is illustrated in the figure.

Need 3 (Future Needs) towards 5G ENTV reception on mobiles over SMIT campus: Recently, Rai successfully tested the transmission of a high quality video stream towards mobile devices in 5G broadcast mode according to the most recent implementation of the 3GPP enTV Rel-16 standard [20]. The demonstration showcased the potential of 5G for the TV reception in terms of video and audio quality enhancements as it will be on the next generation mobile phones and tablets implementing this technology. The Authors at SMIT are also working on the same demonstration that showcased the potential of 5G for the TV reception on 5G mobile phone.

Power SPLIT receiver and its realization

Earlier the author's have realized in hardware,60 GHz Line of Sight Communication Link [21] used for voice, video and data transmission and reception. There, all the three signals voice, video and data are received through a common radio channel from the antenna upto IF section of the receiver,which can be treated as Central Unit (CU) [22] after that the common unit is split into three Distributed Units (DU) [22] having different demodulators for each unit and used for retrieval of individual information. Thus one CU is chained with three DU at the 60 GHz split receiver.

SPLIT Base Station and its realization

The same concept is repeated in this work as split base station at the transmitter side instead of receiver side and results in split base station realization which will be discussed subsequently.


5G Terminal 1
using 28 GHz RADIO
Mobile as FM Relay of
SILIGURI RADIO STATION
VOICE SIGNAL OUT
from FM RELAY
USB CAMERA
for Motoring of
LANDSLIDES of
Nearby HILLs
at SMIT
PC GATEWAY
for combining
FM radio signal
with Camera signal


5G TERMINAL 2
Using 28 GHz Radio
** Signal Output using ETHERNET CABLE
from 28 GHz 5G Terminal 2
*** To be interfaced with
CAMPUS Radio Distribution System (CRDS)

Fig. 17(a), (b) and (c) Photograph of CRDS at Author's SMIT CAMPUS

<u>The Detailed Architecture for CRDS (Campus Radio Distribution System) at Author's SMIT CAMPUS</u>

Fig. 17(a) is the 5G Radio terminal 1 placed near to DISASTER SITE using 28 Radio having major items as

i) USB camera for monitoring of landslides of nearby Hills at SMIT at the disaster site

ii) Mobile as FM Relay of Siliguri FM radio station having air distance over 90 Km

iii) PC gateway for Combining Radio signal with Camera Signal

iv) Complete 5G Radio Terminal 1 at 28 GHz with input from the ethernet port of PC Gateway.

Fig. 17(b) is the 5G Radio terminal 2 having 28 Radio as major items.

Fig. 17(c) is the CRDS having SPLIT Base station functionality with major items as
i) Vector Signal generator VSG N5182A as the Transmitting unit with SPLIT functionality having one CU and Three DU. CU is a common Central Unit using the Baseband FPGA section of VSG and coming out as an I Q signal. The Common I Q signal is SPLIT into three DU and each DU is interfaced with its Own Radio units and Antennas. One RF DU unit is the built-in Radio unit within the VSG and other external radio units are interfaced within the VSG as shown in **Fig. 17(c)**.

RF Output with Built in LTE waveform and transmitted over Horn antenna at 2 GHz which will be received by nearby LTE Commercial Base station so as to reach SMITians as a video signal displayed at their mobile. The landslide event at the nearby SMIT Campus will be live streamed as HD video and will be visible at their 4G Mobile.

IQ Output from the same VSG with FM retransmission over Yagi Uda antenna at 107 MHz so as to reach SMITians as Voice signal at their mobile. They have to tune FM radio at 107 MHz at their Mobile. The landslide event at the nearby SMIT Campus will be audible at their Mobile FM radio.

The authors are working further in extending the IQ Output from the same VSG with 5G NOMA transmission so as to reach SMITians as Video signals at their 5G mobile. The landslide event at the nearby SMIT Campus will be live streamed as HD video and will be visible at their 5G Mobile. 5G ENTV in this way will be distributed within SMITians at their 5G Mobile.

5. Conclusion

The design and use of 4G/5G communication systems towards disaster monitoring and control are recent technical trends and the standards are also formulated by 3GPP in release 14 and subsequent releases like release 18. The use of fixed Relay, Vehicle Mounted Relay(mobile relay) which acts as Repeaters are more useful in extending the network and fulfill the gap in realizing the campaign, ‘5G should be everywhere’. Further, to serve vertical industries by 5G , 5G slices depicting the different services are also useful which is also getting standardized by 3GPP in release 18 and is being realized by SPLIT gNB operation.

One of the author's SMIT campus is situated in a harsh environment where landslides in the rainy season are very common and in this paper the details are highlighted which will be useful for disaster monitoring and data distribution for smart campus residences. This realization is the primary service in the CU part of their development. Additional service from Siliguri FM radio service is also integrated into the above system as DU and realized at Authors Campus. In future 5G ENTV as a ‘need 3’ of the authors will be realized as second DU. Thus authors are motivated with two success stories with the realization of the smart SMIT Campus Networks with both Normal communication service as well as Mission Critical Service for disaster monitoring and control.
This relayed system can be further mounted on a vehicle mounted relay (VMR) as proposed by 3GPP in Release 18.

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