Mitigating the Effect of COVID Lockdown Period on Channel and Bandwidth Utilization in Mobile Communication Network in North Western Rajasthan (India)

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Abstract

The COVID-19 lockdown has led all the citizens (mobile subscribers) of India to stay at home and rather work from home. The people have started consuming more channel utilization (in mobile communication) through a continuous long duration conversations and more internet data through more streaming content as well as logging on to work from home. It was also reflected in how data demand from residential areas rose as compared to commercial areas. Consequently the bandwidth and channel saturation has evolved out to be a severe problem thereby affecting the work performance of all online offices and multi-national companies. This research paper proposes the simulation based experimental study of DITMC technique for mitigating this effect with a special concern in North Western Rajasthan part of India. The simulation results show that significant enhancement of 60.52% in channel utilization and bandwidth optimization is possible with negligible overhead of 0.23%. This technique also enables the telecom operators to ponder research in this field that will promisingly lead to manage augmented number of mobile subscribers (independent of any lockdown period) in limited bandwidth thereby using the spectrum efficiently.

Keywords COVID-19 lockdown · COAI · Bandwidth · Channel utilization · Interleaving

Abbreviations

COAI Cellular Operators Association of India

DITMC Data Interleaving Technique in Mobile Communication

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DOT	Department of Telecommunication
BTS	Base Transceiver Station
OTT	Over-the-top
COVID	Corona Virus Disease
GSM	Global System for Mobile Communications
DSI	Digital Speech Interpolation

1 Introduction

The information from the Department of Telecommunications (DOT, India) demonstrated that between March 22 and March 28, Indians expended a normal of 307,963 TB or 307 petabytes (PB) of information. This was a climb of 9% from the 282,282 TB or 282 PB of information utilized on March 21, the day when the "Lockdown" was declared, and a climb of 13% from March 19, when the utilization was 270 PB [1]. The telecommunication industries claimed that there is sudden raise in the demand of the wireless network of over 10% in the lockdown amid CoVID-19. Due to increase in the usage of Internet for Work from Home activity, more of entertainment and health care videos due to increased restrictions of movement of people, education purposes like online class etc. surge the pressure on the telecommunication industries. The escalated demands of data usage have resulted in crawling mobile traffic involving voice and data transmission. A surge in the Internet data consumption has caused increased latency and packet loss resulting in network congestion and bandwidth saturation. According to the economic times report on the impact of corona virus, the worse affected part of the society from the low internet speed was urban areas. It was analyzed that there would be increase in the data consumption of up to 30% thereby decreasing the speed to 20%. Cellular Operators Association of India (COAI), have requested users for efficient network usage in peak hours of works (9 a.m. to 11 a.m. and 4 p.m.–9 p.m.) to avoid clogging. The Ookla analytics depicts the downfall in the speed of Wi-Fi and Internet in March comparatively to February as shown in the Fig. 1. In this pandemic, people have been relying on digitalization even for the simplest tasks. But we can't judge a book by its cover, with increasing usage of digital platforms we would be entering into the state of war for efficient bandwidth utilization. A mediocre solution is suggested by COAI to manage the plethora of data and reduce the burden of telecommunication industries [2].

Fig. 1 Wi-Fi and internet speed (Mbps) [2, 3]

COAI has requested 11 streaming video companies to reduce the data bit rates to efficiently use the bandwidth without stepping into the saturation. COAI has asked the Over –the –top media services to back pedal to the standard definition videos instead of high definition and avoid pop ups of advertisement. The Spokesperson of Hotstar, one of the biggest market covering OTT has said "We are careful about the remarkable and intently observing it". They assured the COAI to reduce the bit rate of the HD streams when the need arise and the HD videos is available only for the subscribers among the 300 million users. The video streaming is based on the adaptive bit rate streaming technique and content complexity to ensure the inclined internet consumption graph. Other OTTs like Zee5 and Viacom 18 and its Voot brand have agreed to the COAI's logic and started working closely to reduce bit rate according the Indian audience's data consumption pattern without overstretching the existing bandwidth. To manage this multitude flow of voice and data traffic, an efficient model is required to avoid the poor communication services. The world is moving towards more novel applications of smart space development and edge centric technology of IoT called fog computing, which involves the plethora of data from edge and intermediate devices. All around, the all out number of Internet clients is anticipated to develop from 3.9 billion out of 2018 to 5.3 billion by 2023 at a CAGR of 6%. Regarding populace, this speaks to 51% of the worldwide populace in 2018 and 66% of worldwide populace infiltration by 2023 [2]. India's web utilization rose by 13% since the across the country lockdown was set up to check the spread of Covid-19, as indicated by telecom service information that demonstrated Indians expended 307 petabytes (PB) or 307,963 terabytes (TB) of information every day on a normal for the week starting March 22. According to the division of telecom, which ordered reports from specialist co-ops, the day by day normal utilization in this period was 9% higher than 282 PB information utilized on March 21 (the day the Lockdown was declared) and 13% more than March 19, when utilization was 270 PB. Web entrance rate in India has increased to 50% (approximately) in 2020 [3], from only 4% in 2007. In spite of the fact that these figures appear to be generally low, it implied that around half of the number of inhabitants in 1.37 billion individuals approached web that year. This additionally positioned the nation second on the planet regarding dynamic web clients [4]. The lockdown period has, undoubtedly, played a significant role in digitalizing the rural areas of India but on the contrary side it has left the following challenges to work upon:

- (a) Optimum utilization of channel and bandwidth in mobile communication.
- (b) Ensuring computer literacy in rural areas of India.
- (c) Optimizing mobile and BTS's radiations to avoid any harmful effects on crops and human beings.
- (d) Resisting the installation of BTS's in urban as well as rural areas.

In order to avoid adopting any mediocre solutions at the eleventh hour, proper funded and monitored research in the field of Data Interleaving (at byte level) must be adopted to meet the foreseen challenges in the field of mobile communication as mentioned above. Data Interleaving Technique introduces an efficient and economical way to deal with the problem of bandwidth saturation and congestion conundrum in various networks. Data Interleaving Technique roots from the fact that there is lot of difference in the information and bit rate requirement in encoding the speech signal. The channel space occupied by the redundant and silence bytes in the speech signal can be used for interleaving the data.

2 Related Work

The foundation brick in the journey of analyzing redundancy in channel utilization was proposed by Brady [5] in the year 1965 for wired communication. In early 2000's Dr. K L Sharma endeavor a new idea called Data Interleaving Technique and found significant enhancement of 43.253% in the usage of channel [5, 6]. The conventional theoretical channel utilization was 36% leading to total 79.253% ($36 + 43.253$) betterment in channel consumption. H. Purohit et al. further in his research work discussed about the Data Interleaving Technique in Mobile Communication (DITMC) and simulated the model exhibiting significant results in the field of mobile communication in India as well as some parts of East Africa regions, especially Kampala, Uganda [4–8]. The research work carried out in India showed 47.32% of increase in channel usage leading to overall utilization of 83.32% ($36 + 47.32$) in mobile networks [7]. In East African region (Kampala, Uganda) the work demonstrated an increase in channel utilization up to 54.22% leading to overall 90.22% involving various East African languages in the speech samples and inevitably bandwidth optimization can be done.

Various models based on Markov Theory, adaptive bandwidth binning, flexibility in bandwidth management, Channel Reservation and Channel Aggregation [7–14] with their specific constraints have already been proposed for better and optimized spectrum management in mobile communication. Gongbing Hong et al. have discussed Adaptive Bandwidth Binning (ABB) in their research work [9] based on WFQ's weighted max–min fair allocation that is capable of providing sharing of downstream bandwidth for a DOCSIS cable network. Amuthan Arjanam et al. have also recommended the possibility of multiple channels in Mobile Ad hoc NETworks (MANET). The research work opens up/suggested the several alternatives for utilizing channel efficiently to obtain better system performance with regard to throughput and overhead parameters impacting the spectral efficiency [15]. The improvement of 23% and 19% in terms of packet delivery ratio and throughput respectively was shown by the Hyper Erlang Channel Allocation Factor-based QoS Enhancement Mechanism (HECAFQEM) compared with the existing QoS adaptation mechanisms. Hyung Rai Oh and Hwangjun Song probe caching algorithm [16] in video streaming traffic and examined the dependency of decreased channel bandwidth and client's connection on relative frame position in the time axis and remaining buffer size in cache. Similarly Feng-Ming Yang et al. have discussed about the throughput improvement and provisioning of QoS for multiple users with limited bandwidth resources [14]. Various other techniques using speech interpolation were also introduced in early 1990's. The work exhibited by Langenbucher GG regarding the basic principles as well as performance characterization of speech interpolation and coding paved the strong base for the adoption of ADPCM and DSI together to provide a 4:1 compression ratio compared to standard PCM (data rate 16 kbits/s) without any audible distortions [17]. Chen Liang et al. also showed in their work that it is feasible to transmit colossal volume of video and audio data over VoIP (Voice over Internet Protocol) communication continuously (enabling it to be potentially available for stealth message transfer). He propounded a “hole in the corner” channel technique that communicates the packets after rearranging its transmitting sequences while maintaining the un-detectibility and robustness [18]. Massimo D'Apuzzo, Mauro D'Arco discussed about original high-speed digitizer (proposed by them) that make the most use of frequency conversion and time interleaving techniques. They exploited 4 time interleaved channels thereby achieving significant noise reduction as compared to traditional time interleaved architectures [19]. Suganya and Jayashree showed in their research paper that the

improvement of multi channel accessibility is based on using channel efficiently and consequently improving system functionality based throughput, point-to-point delay and overhead [20]. Senthilkumar S. and Geetha Priya C truly proposed the significance of spectrum sensing techniques that spot/sense the idle channels for allocating them to ancillary users. They also explained the importance of CRN (Cognitive Radio Networks) and their proposed work exhibited better energy consumption, through-put, bandwidth-power product, lower running time and average end-to-end delay when compared to the existing schemes [21]. Various bandwidth utilization techniques in the areas of multimedia communications in next generation Mobile Communication Networks and Mobile Ad Hoc networks have been proposed [22, 23] that also boosted the research interest in enhanced channel utilization. All these research works have some advantages but on the contrary these were having some constraints and disadvantages also. These all work led to the development of DITMC technique and its advantages over the all previous works have been shown in this research work.

3 Data Interleaving Technique in Mobile Communication (DITMC)

3.1 Data Interleaving Technique in Mobile Communication (DITMC)

COVID 19 lockdown period has metaphorically exhibited the silent pauses, the quiet stops and repetition (in a noteworthy way) during the significant discussions utilizing discourse channels of the mobile communication networks (GSM). This captivates the issue of "transmission capacity wastage" and in this way draws the consideration for productive use of the discourse channels. It was genuinely said that in mid 2000's the discourse traffic commanded the information traffic in versatile correspondence. Unexpectedly, in 2019 the web versatile information traffic is ruling the voice traffic. During the COVID-19 lockdown period both discourse and information traffic is by all accounts used to fullest contingent on the circumstance. In the event that the discourse channel and transmission capacity usage isn't explored in a compelling and improved manner then very soon the issue of data transfer capacity immersion may happen.

It has just been confirmed that the direct usage in voice correspondence was in the request for just 36% [24], the staying 64% being squandered in a duplex channel. Numerous strategies for upgrading channel use with streamlining of exorbitant transmission capacity were proposed and endeavored during the most recent four decades. These strategies included bit rate reduction procedures, signal compression methods and speech interpolation strategies. As none of these techniques independently could improve the channel use up-to 100%, endeavors were made to utilize them related, which improved the usage fundamentally in spite of the fact that not arriving at 100%. The idea of Data Interleaving Technique in portable correspondence focuses on evacuating the excess saw in voice bytes and the quiet time frame bytes and is portrayed in Fig. 2 followed by a state transition diagram at Mobile Station shown in Fig. 3.

3.2 Advantages of Data Interleaving Technique

This strategy for data interleaving [11] has the basic qualities like delay in speech of just 2 samples ($125 \mu\text{s} * 2 = 250 \mu\text{s}$), improved channel usage upgrade, no handover, concealment of the excess (monotonous) message codes transmission, encouraging channel space

Fig. 2 Concept of data interleaving. Symbols: S1, S2 = repetitive speech bytes, * = speech byte (S), D = data byte (S)

Fig. 3 State transition diagram for DITMC at mobile station [7]

accessible for extra information transmission (as shown in Fig. 4), no requirement of any speech detectors like in most of the speech interpolation processes, detection of much smaller duration speech pauses (generally more frequent), an imperceptible inbuilt delay in the system for real time applications, the signal delay takes place at the originating node only and it is also independent of the network distances. Radiation hazards and size of battery is expected to be reduced as the required energy integration will be reduced.

3.3 Assumptions and Simulation Methodology

The Data Interleaving Technique was simulated using a JAVA code to put a figure on the total bytes in the file, proportion per centum of bytes that can be interleaved and following the required overhead bytes. The simulation program aims at reading the input. wav files and then its configured contents are interpreted. The one way communication

Channel Allotted to Voice & Data	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Number of data channels (due to interleaving)
Channel available for S1	V	V	V	D	D	D	V	V	V	D	D	D	D	D	V	D	9
Channel available for S2	V	V	I	D	D	D	I	V	V	D	D	D	D	D	V	D	11
Channel available for S3	V	I	I	D	D	D	V	I	I	D	D	D	D	D	V	D	13
Channel available for S4	V	I	V	D	D	D	I	I	V	D	D	D	D	D	V	D	12
Channel available for S5	V	V	V	D	D	D	V	V	V	D	D	D	D	D	V	D	09
Channel available for S6	I	I	I	D	D	D	I	I	I	D	D	D	D	D	I	D	15
Channel available for S7	V	I	I	D	D	D	I	V	I	D	D	D	D	D	I	D	14
Channel available for S8	V	V	V	D	D	D	V	V	I	D	D	D	D	D	V	D	10

Fig. 4 Increased channels for data due to the data interleaving concept. V: voice channel, I: interleaved channel available for data traffic, D: data channel [8]

with random noisy environment was tape through sound recorder of mobile handset and thereafter converted into .wav extension files using “audio.online-convert.com” with following assumptions:

- The voice samples were recorded (one way) in multimedia mobile handsets using GSM network.
- Sampling Rate = 8 Kbps (audio.online-convert.com).
- Bit resolution of 8-bit (audio.online-convert.com).
- The Mobile Communication Network endowed with the Data Interleaving process is experimented on WAVE file format which is standard linear PCM format.
- Once the Data Interleaving process is implemented on the .WAV files these can also be converted into the relevant format (depending upon the mobile network i.e. either .amr for GSM or .evrc for CDMA or any other system) so as to enhance the channel utilization.
- It will not affect the process as the time between two consecutive samples (125 microseconds) is sufficient to incorporate the digital conversion of the files.
- Sufficient amount of digital data is available at the initiating and intermediate nodes for the interleaving process.
- A delay of 2 Bytes transmission period is incorporated at the initiating node and no existence of further deliberate delay of any kind in the system up to the final terminative node.
- The Data Interleaving process is implemented on non-real time (data messages) as well as real time (speech) data.
- A Battery OFF code exhibits the redundant transmission and a Battery ON code exhibits the useful speech information transmission in any interleaving interval. (At the Mobile Station side).

- (k) At second level interleaving in data, the DATA REPETITION CODE followed by number of repetitions (in data) shortens the length of data file and hence further increases the channel utilization.

After acceptable configuration of input file, the evaluation regarding the total bytes in the specific input file and part of bytes per frame (in “t” time period) is done. Further the procedure for the computation of mean square value of all the bytes in a frame of set time duration is performed. In the first instance, threshold is marked to be a non-integer value (take on 100) and it is stretch adaptively with a step size of 0.5%. Following it, the juxtaposition between the calculated mean square value and threshold is analyzed to dig out whether the bytes indicate the speech signal or silence period. The decision making regarding the per centum of bytes that can be interleaved per frame and required overhead bytes is resolved. The simulation was effectuated over 46 speech samples of different durations, speakers and diverse languages of North Western Rajasthan area including Marwari, Hindi, English, Punjabi and Sanskrit. The final review on the total sample size, percentage interleaving and incurred with the DITMC is accomplished.

4 Simulation Results (Before Covid-19 Lockdown and During Covid-19 Lockdown)

The results show that a considerable amount of time (channel or bandwidth indeed) is wasted during the conversation in silence period as well as in the repetition of speech/voice bytes. The simulation program demonstrates the channel utilization by considering both of the above-said factors. The experimental results obtained from our simulation experiments for GSM network settings are shown in Table 1 and Fig. 5. The results provide the strong basis for expected channel utilization enhancement. The channel utilization enhancement is 58.39% leading to overall channel utilization (voice/speech channel) of 94.39%. (36 + 58.39) with negligible overhead (0.1844%) in terms of bytes. The total number of bytes in the random 46 speech samples is 0.4964 GB. The total number of interleaved bytes is 0.2898 GB. Data interleaved in Voice is 94.39%. The overhead involved in the interleaving process is 0.0342%. The channel utilization without interleaving is 36%. Therefore, channel utilization with interleaving is $36 + 58.39 = 94.39\%$.

The simulation results shows a significant improvement of 7.07% ($94.39 - 87.32 = 7.07$) in channel utilization during the “lockdown period”. An enhancement of 7.07% ($94.39 - 87.32 = 7.07$) is observed (Fig. 6).

As shown in the Table 2

Overall Sample bytes = 533,088,316 (0.4964 GB).

Interleaving bytes = 311,273,252 (0.2898 GB).

Overhead Bytes incurred in the collected samples = 983,072.

Overall Interleaving in the collected samples = 58.39%

Overall Overhead in the collected samples = 0.1844%

Channel Utilization (without Interleaving) = 36%

Enhanced Channel Utilization (with Interleaving) = $36\% + 58.39\% = 94.39\%$ During lockdown (March 2020–May 2020).

Enhanced Channel Utilization (with Interleaving) = $36\% + 47.32\% = 83.32\%$ (Before lockdown in 2015).

Table 1 Simulation Results for various samples with possible interleaving and overhead occurred (March 2020–May 2020)

Sample no.	Total bytes	Interleaving bytes	Overhead bytes	% Interleaving
1.	32,408,494	19,624,342	60,092	60.55
2.	26,302,598	15,118,509	50,274	57.47
3.	1,304,250	788,780	1560	60.48
4.	40,436,046	20,206,451	6526	49.97
5.	7,270,966	4,180,550	13,340	57.49
6.	6,701,358	4,299,258	7428	64.15
7.	8,203,990	4,757,486	15,596	57.98
8.	14,740,314	9,548,331	19,886	64.77
9.	2,560,398	1,212,256	10,656	47.34
10.	1,311,652	706,042	4132	53.82
11.	1,924,494	1,037,049	5914	53.88
12.	11,781,006	5,770,479	42,934	48.98
13.	5,272,782	2,550,791	21,286	48.37
14.	1,173,390	646,738	4948	55.11
15.	29,839,182	14,784,157	46,402	49.54
16.	54,160,974	31,924,566	19,996	58.94
17.	2,713,678	1,226,719	11,414	45.20
18.	1,961,038	1,232,679	6214	62.86
19.	9,859,186	5,934,415	20,790	60.19
20.	8,202,318	5,231,476	20,136	63.78
21.	4,601,626	3,035,898	6468	65.97
22.	4,300,878	2,221,216	20,096	51.65
23.	4,450,418	1,939,265	17,770	43.57
24.	3,476,936	2,039,771	10,286	58.66
25.	3,069,780	1,454,863	6038	47.39
26.	11,512,398	7,236,930	32,500	62.86
27.	11,645,726	6,616,889	33,274	56.81
28.	13,033,892	8,381,635	19,550	64.30
29.	9,048,826	5,985,543	17,318	66.14
30.	16,542,116	10,782,293	33,778	65.18
31.	3,826,084	2,521,882	6052	65.91
32.	9,282,638	6,037,228	22,648	65.03
33.	6,225,694	4,240,175	11,830	68.10
34.	6,306,590	2,741,751	21,766	43.47
35.	6,322,478	4,253,085	6850	67.26
36.	5,799,262	3,198,495	10,710	55.15
37.	37,918,798	25,954,518	71,228	68.44
38.	22,210,638	14,456,631	49,126	65.08
39.	9,989,198	6,267,662	24,812	62.74
40.	7,845,730	4,465,297	13,802	56.91
41.	7,830,302	2,828,200	27,280	36.11
42.	10,231,584	6,243,437	28,282	61.02
43.	4,873,970	3,103,465	6810	63.67
44.	22,367,006	13,801,546	44,516	61.70

Table 1 (continued)

Sample no.	Total bytes	Interleaving bytes	Overhead bytes	% Interleaving
45.	11,090,696	6,143,348	17,608	55.39
46.	11,156,938	4,541,155	33,150	40.70
Total samples size	533,088,316	311,273,252	983,072	58.39

Fig. 5 Interleaving and overhead bytes versus samples**Fig. 6** Interleaving, overhead and overall samples (in %)

5 Conclusion

It can be concluded that the proposed methodology of DITMC for mitigating the impact of COVID-19 “Lockdown period” seems to be promising solution and it’s capable of enhancing channel utilization ensuring the accommodation of swarm of subscribers in GSM networks with allotted bandwidth and spectrum in North Western Rajasthan, India (as

Table 2 Comparison of Channel Utilization enhancement (Before and after lockdown period)

Parameters	Before COVID 19 Lockdown (2015)	During COVID 19 Lockdown (March 2020–May 2020)
No. of samples	120	46
Sample Size (Total)	2,723,319,872 (2.536 GB)	533,088,316 (0.4964 GB)
Interleaving Bytes	1,288,768,358 (1.2 GB)	311,273,252 (0.2898 GB)
Overhead Bytes	936,668	983,072
Interleaving	47.32%	58.39%
Overhead	0.034394%	0.1844%
Enhancement in channel utilization	83.32%	94.39%

samples were taken in India only). It further avoids the adoption of Spectrum Re-farming and thereby facilitating the COAI and telecommunication companies to deliver quality of service during any pandemic situation. The overall channel utilization of 94.39% is far better than it would be before “lockdown period” (83.32%). Further second order DITMC extends the horizon for research exhibiting the utilization of redundancy in interleaved data that may lead to more enhanced utilization. The same analysis can be achieved globally by collecting the samples of different native speakers of various countries and the generalized model can be authenticated universally. It has already successfully been experimented in East African languages.

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Code Availability Yes.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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