Effect of Attenuation Exponent on the Channel Capacity of Spectrum Allocated by India's National Frequency Allocation Plan (NFAP)

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ABSTRACT
In this paper, the relation between Bit rate and Bandwidth depending upon various factors are considered. In those factors, attenuation exponent is mainly considered. This paper analyzes the effect of change in attenuation exponent on the bit rate of frequency bands allocated to various types of radio services in India as per National Frequency Allocation Plan. In order to obtain better performance in data communication, it is necessary to obtain such relations.

Keywords
NFAP, SNR.

1. INTRODUCTION
High data rate is the main requirement of any communication network weather it is wired network or wireless network. But the data rate is affected by time and the attenuation of the signal. Signal strength can be obtained by the Signal to Noise ratio (SNR) which is usually expressed in decibel or dB and defined by relation [1].

$$\text{SNR (dB)} = 10\log_{10}(\text{Signal Energy}/\text{Noise Energy}) \quad (1)$$

As the signal strength increases signal to noise ratio increases. In the same way, as the strength of noise signal increases the signal to noise ratio decreases.

Let us temporarily assume that the bit-rate of links is given by

$$Bit\ Rate = BW \log_2(1 + SNR) \quad (2)$$

where BW *is* the bandwidth and SNR is the ratio of the signal noise. We further assume that a single channel is used, nodes are synchronized and nodes follow a common TDM schedule. Specifically, we assume that each node transmits once per *T* time slots and that when a node receives a packet in one time-slot, it transmits it in the next time-slot. The result of this scheme is that transmitting nodes upstream and downstream of a receiving node will interfere with the reception. For ease of discussion, assume that the nodes are uniformly spaced *d* meters apart, and that the propagation environment is such that the received signal power strength is KPT/d^{α}, where *K* is a constant, α is the attenuation exponent and *PT* is the transmission power, which, we assume, is common to all transmitters.
Under these assumptions, the average received bit-rate by any node is

$$\mathrm{BR(T)} = \frac{\mathrm{BW}}{\mathrm{T}}\log 2\left(1 + \frac{\frac{\mathrm{KPT}}{\mathrm{d}^{\alpha}}}{\mathrm{N} + \sum_{\mathrm{j=1}}^{\infty}\frac{\mathrm{KPT}}{\mathrm{d(jT-1)}^{\alpha}} + \sum_{\mathrm{j=1}}^{\infty}\frac{\mathrm{KPT}}{\mathrm{d(jT+1)}^{\alpha}}}\right) \quad (3)$$

where N is the variance of noise and the $\sum_{j=1}^{\infty}\frac{\mathrm{KPT}}{\mathrm{d(jT-1)}^{\alpha}}$ and $\sum_{j=1}^{\infty}\frac{\mathrm{KPT}}{\mathrm{d(jT+1)}^{\alpha}}$ terms account for interferencefrom the downstream and upstream transmission,respectively. Furthermore, since the node only transmits once out of every *T* time-slots, the average bit-rate is the bit rate achieved during reception divided by *T*. For ease we focus only on the most significant source of interference, which is from the node that is $T - 1$ hops upstream. If we assume that the transmission power is large enough so that the noise is substantially smaller than the interference, and can be neglected, we obtain [1-3]

$$BR(T) \le \frac{BW}{T} log2\left(1 + \frac{\frac{KPT}{d^{\alpha}}}{\frac{KPT}{(d(T-1))^{\alpha}}}\right) \quad (4)$$

$$BR(T) = \frac{BW}{T} log2(1 + (T-1)^{\alpha})^{[2]} \quad (5)$$

2. NATIONAL FREQUENCY ALLOCATION PLAN
International telecommunication union (ITU) set the parameters on the basis of frequency band with the help of national frequency allocation table (NFAT). NFAT term derived to frequency band allocation and the allocation identity from the table of frequency allocation using ground and space radio communication technologies. All frequency band with different allocation are specified for different conditions. So we can use different services at different frequency bands. Different countries or geographical areas allotted designated frequency under fixed plans excepted by competent conferences. To implement ground and space radio communication. Number of assignment comes under the allocation of frequency band governed by administration for radio station to use the channels of radio frequency. [4-5]

Radio frequency Spectrum is limited but having infinite applications as a national precious resource. It covers the all range of electromagnetic radio frequencies that are used in transmission of voice, data and images. RF spectrum is a resource of considerable and important for growing economic.

Consumer and business benefits derived from it. One of the important criteria of spectrum allocation in many countries varied from initial minimum allocation to enable starting of the service with subsequent increments based on increase of subscribers, and charges. Also conceding the factor interference free operation for each radio services. [6-7] Types of allocations

- No one may transmit: no frequency can interfere with frequencies reserved for radio astronomy.
- Anyone may transmit, as long as they respect certain transmission power and other limits: unlicensed ISM band of open spectrum bands and the unlicensed ultra-wideband band allocated and the somewhat more regulated part -time or unpaired radio frequency allocations.

- Only the licensed user of that band may transmit: only the licensing RF spectrum band gives the same frequency to several users as a figure of frequency reuse if they cannot interfere due to without overlapping of converging areas. [8]

During the time of planning of allocation of frequency spectrum involves international agreements, technical characteristics and potential of radio spectrum and more important national policies and priorities. Also RF spectrum expressed as way to distribute the frequency band for different radio services. [9] Standard bodies for spectrum allocation

- *ITU (international telecommunication union*
- *Regional telecommunication organization (like- CITEL, CEPT etc.) [10, 11].*

3. Effect of Attenuation Exponent on spectrum allocated by NFAP

The range of path loss (Attenuation) exponent is from 4 to 6 [4,12]. The effect of attenuation exponent on the bit rate of spectrum allocated by NFAP is given in the table 1.

Table 1. Change in bit rate by changing the attenuation exponent and keeping time period constant (T=5sec)

S.No.	Frequency band Allocated(MHz)	Bandwidth (MHz)	Bit Rate when α = 4 (Mbps)	Bit Rate when α = 5 (Mbps)	Bit Rate when α = 6 (Mbps)
1	0-87.5	87.5	140	175	210
2	87.5-108	20.5	32.8	41	49.2
3	109-173	64	102.4	128	153.6
4	174-230	56	89.6	179.2	134.4
5	230-450	220	352	440	528
6	450-585	135	216	270	324
7	585-698	113	180.8	226	271.2
8	698-806	108	172.8	216	259.2
9	806-960	154	246.4	308	369.6
10	960-1710	750	1200	1500	1800
11	1710-1930	220	352	440	528
12	1930-2010	80	128	160	192
13	2010-2025	15	24	30	36
14	2025-2110	85	136	170	204
15	2110-2170	60	96	120	144
16	2170-2300	130	208	260	312
17	2300-2400	100	160	200	240
18	2400-2483.5	83.5	133.8	167	200.4
19	2483.5-3300	816.5	1306.4	163.3	1959.6
20	3300-3600	300	480	600	720
21	3600-10000	6400	10,240	12,800	15,360

Generally bit rate has very small effect of change in time but bit rate is highly affected by change in attenuation exponent.

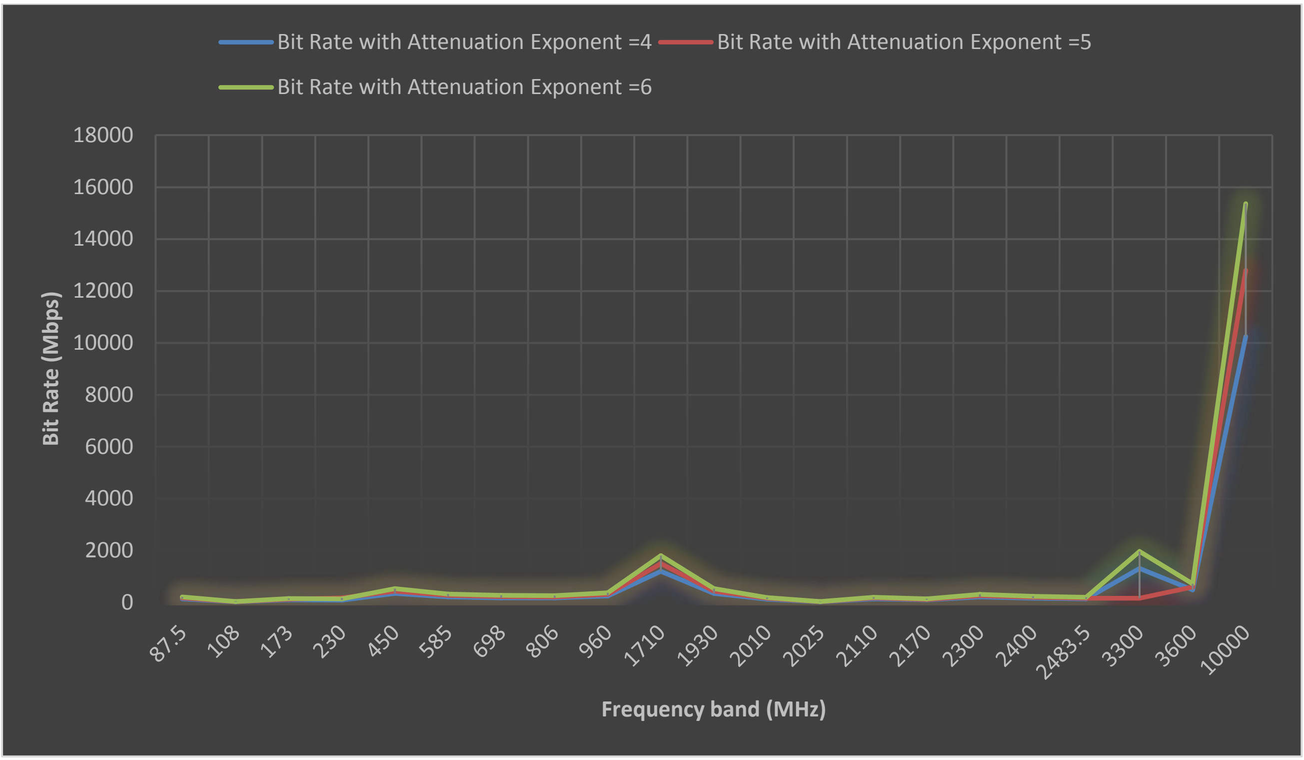

Fig. 1: Change in bit rate by changing the attenuation (t=5sec)

Now let us analyze the effect of change in time period on the bit rate keeping attenuation exponent (α) constant using the equation (5). Keeping the attenuation exponent constant, we get the table 2.

Table 2. Change in bit rate with the change in time constant

S.No.	Time period (sec)	Attenuation exponent	Bit rate
1	5	6	2.4 B.W
2	10	6	1.9 B.W
3	15	6	1.5 B.W
4	5	5	2 B.W
5	10	5	1.5 B.W
6	15	5	1.27 B.W
7	5	4	1.6 B.W
8	10	4	1.27 B.W
9	15	4	1 B.W

From the table shown above it is clear that bit rate decreases with the increase in time period even if attenuation exponent is constant.

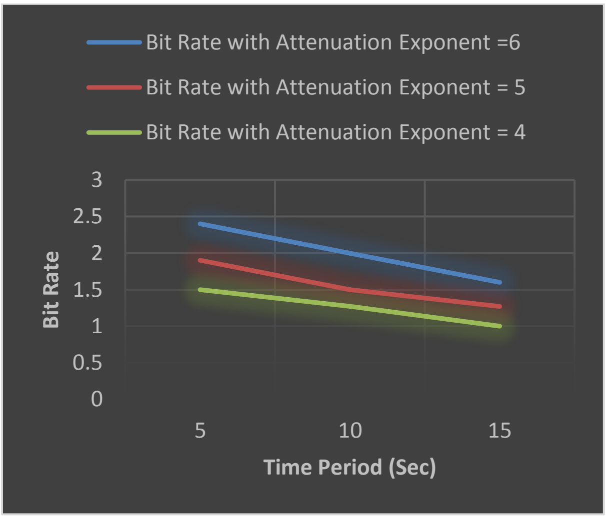

Fig. 2: Change in bit rate with the change in time constant

4. CONCLUSION

As channel capacity or bit rate as per equation (5), depends upon Attenuation exponent and time period. So, from Table I and Table 2 we can conclude that attenuation exponent must be high so that data rate will be high in the communication system because with the passage of time bit rate is going to decrease. This problem can be solved by decreasing the distance between transmitter and receiver.

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