If spectrum availability becomes the crunch, ethical issues positing luxury against necessity will obviously arise. They will need to be debated, answered and a stand taken.

The word ‘natural resource’ brings to our mind environmental elements like water, land, minerals and petroleum products. One may stretch it to clean air. But no one so far even thought that an intangible and abstract entity called spectrum could be a natural resource. And that too with an adjective ‘scarce’, like any other resource.

Since the last four or five years a realization has come about the spectrum being scarce and insufficient for our ever expanding needs and hence precious. How else do you explain the windfall income of ₹ 67000 crore accruing from the ‘sale’ of a small portion of the spectrum; the government itself did not expect more than half that amount! It should look indeed curious that the entity is not perishable, nor consumable and yet it becomes scarce.

What is Spectrum?
Spectrum is a distribution of frequencies in a wave or a ray. The most popular example of a spectrum is the rainbow. The visible light from the sunrays is comprised of seven colours from violet to red in the famous sequence VIBGYOR. The same spectrum can be seen if the light is passed through a prism. Every colour in the sequence has its own wavelength increasing from violet to red. Our eyes have the capability to distinguish different wavelengths like 0.00042 mm (for violet) and 0.00066 mm (of red), and hence we recognize all colours differently.

Now look at the Fig 1. The visible spectrum here is a tiny part of the larger collection of waves called Electromagnetic spectrum (EM Spectrum, for short). Members of this spectrum are quite diverse in nature. Gamma rays, X-rays, infrared radiation, ultraviolet and radio waves including microwaves are all electromagnetic waves but have different properties. This comes from their frequencies that increase from the radio waves towards gamma rays as shown. Corresponding wavelengths are also shown in the figure. All these waves are showered on us from the outer space every minute, but humans learnt about that only in the 20th century because the mechanism of our eyes or any other organ in the body is not suitable to sense any of these waves.

Radio Waves
A significant part of the EM Spectrum is occupied by radio waves. They are a versatile tool and can perform very wide nature of duties for man. Different types of radio broadcasts - medium wave, short wave, FM and satellite radio, radars for traffic control and weather prediction, wireless communication for police and armed forces, conventional television, Cable TV, radio operated toys, robotics, microwave cooking and cordless phones are the traditional applications of these waves.

They are expanding but at a moderate rate. But applications like mobile phones, Global Positioning systems (GPS), satellite TV, bluetooth etc are newer applications and are expanding at a fast pace.
Which frequency is suitable for a particular application, depends upon the nature of application, its sensitivity to directionality, the distance between the instrument and the source etc. These waves have four different categories of penetration. Upto 2 Giga Hertz we have radio waves that can go through building structures/walls and trees. Apart from broadcast radio and television, which are to be used indoors, obvious contenders for a place in this segment are mobile phones.

The second category is semi-penetrating, which can manage some penetration but not through heavy structures or dense objects. They also do not need to have a direct line-of-sight access. Here a narrow band around 2.4 GHz is used for domestic services like cooking, cordless phones, bluetooth etc. DTH TV or police radars meant to detect speedsters can do with higher frequencies that need direct line of sight.

With such a wide nature of demand, frequencies need to be fixed for each application and for individual users in order to avoid interference across applications and disputes. Such allocations are done by the International Telecommunication Union (ITU) at the international level and by a Standing Committee in the Department of Telecommunications at the national level for our country. Once such allocation of frequency is done, the particular area of application feels the crunch if demand increases. The world that got increasingly wired during the first half of the last century, took a fancy to getting wireless in the latter half. This put the pressure on radio wave demand.

The first category of penetrating waves was already crowded due to favourable nature of the waves there; these frequencies get more and more ‘busy’ during wire-less culture. Among them mobile telephony is the fastest growing client. India has 70 crore mobiles ringing today because they do not need arduous cabling any more. That covers 59% of the population!

The landline density has grown only to 3% in these 20 years. This has its own problem. It is like having too many cars on a narrow road; traffic is sure to choke on the upstream side. It results in slow traffic flow and some cars may even stop. Similarly, more telephone traffic on a narrow width of frequency band results in our getting the line engaged or calls drop midway.

The radio frequency spectrum too has this issue though it is not a consumable item. Demand for the bandwidths for various applications is increasing and mobile telephony is the leading consumer.

**Shortage of Frequency**

Mobile telephony is allotted a nominally wide band of frequencies at two or three spots on the spectrum, viz at 400 MHz, 800 MHz and at 1900 MHz. Some countries have used 2100 MHz zone, which is not a slot of first choice. These bands were adequate, so far as we only wanted to talk. But the technology attracts more technology.

After voice, we needed to send written texts (as SMS); later, even more - photographs and songs too! Now this requires higher speed of data transfer, otherwise the song will stutter and pictures will appear in jerks. While 16 kbps (kilo bytes per second) speed is all right for voice content, songs need 128 kbps and data (like picture) may require even 1000kbps i.e. 1 Mbps. If you want to see a picture moving, the demand can be even higher.
Since the last four or five years a realization has come about the spectrum being scarce and insufficient for our ever expanding needs.

Faster data transfer needs a wider frequency band, that is, a broader slice on the spectrum line. Although many of the demands may be only for fashion or luxury and not basic need like voice telephone, no government that claims to be progressive can decline the demand for higher frequency bandwidth. The Indian government also did the very thing by ‘selling’ the spectrum in 2008 and 2010. (The more appropriate word though is ‘allocating’ as we shall see later.)

Unfortunately, this spectrum is not like currency notes that can be printed as done during deficit financing. It is like ‘atman’ of Bhagawad Geeta, eternal, invisible, non-destroyable (and hence not producible), which was always there and will be there! Thus, however much the government may want to share it with the public, there is a real shortage.

There are two solutions to this scarcity – administrative and technical. As part of the administrative solution the government has requested the defence ministry to vacate some frequencies that were earlier allotted to them. They can move over to other frequencies or change the technology itself – by using fibre optic cable networks. Such cables are delicate to handle in addition to the cost factor.

The technical solution to the shortage is found not by the government but by industry, not in India but abroad. That is, to use the spectrum more efficiently by sending more information using the same width of the frequency band. That is what 3G technology is all about.

In the first generation telephony we had analog exchanges. In the 2G or second generation the voice was transmitted in digital form. It is called duplex system because the line on which two persons are talking gets dedicated to that pair of talkers. To use the line more efficiently, more people should be able to use the same line simultaneously. Around the turn of this millennium, 3G technology came that permits this, among other things.

Compared to voice, the data comes in a more interrupted manner. It comes in bursts. There can be gaps between bursts. 3G uses this gap to push data from the other users. For this, the data is broken down into small packets and sent. At the destination these packets from respective users are joined appropriately to make a complete message (which can be a song, a picture or just a voice talk.)

Of course better results require better frequency bandwidth. Against a 2G line needing 30 to 200 kHz, a 3G requires 15 to 20 MHz of bandwidth. But it carries more traffic too. Some of the other issues like incompatibility between various techniques and standards in 2G technology are also addressed in 3G. Paradoxically, some companies are thinking of using spectrum obtained for 3G purposes for 2G applications because of the existing shortage in 2G itself. Some others are waiting for 4G technology to come, which is not far behind.

**Sale or Licensing?**

The spectrum may be a natural resource, but the waves required for telephony are produced by the respective telephone companies (telcos) and transmitted. They are received by the users' mobile equipments. The governments do not produce the waves required and really do not own the spectrum. Hence they do not sell it, but only give licence to use it.

This is unlike, for example, the road tax for which it has to prepare roads by spending money. Here the money comes without any investment. As the companies will recover licence fees of ‘67000 crore from the 70 crore mobile users, it works out to be ‘1000 per user. Some 25 years ago also we paid licence fee for playing radio sets in India. But back then the radio waves (and the programmes) were produced by the All India Radio, a government body, so it could be reconciled. Instead of such decentralized collection from radio owners, money now is collected in single bulk from the telcos. May be this is an efficient mode of earning revenue.

Worldwide there are five methods to allocate licence as described in the Encyclopedia of Electric and Electronic Engineering (Volume 13, page 349).

1. **Over the Counter.** This is same as the ‘first come, first served’. This method is fine if supply is more than the demand
2. **Comparative Assessment.** The regulator judges the social responsibility of the bidder and decides.
3. **Lottery.** This is a fair method provided there is no hoarding through proxy bidders.
4. **Tenders.** Good returns expected as rivals do not know bids of each other.
5. **Open tenders.** This method can fetch even better money than tender process. This was used in the latest 3G allotment.

The first ever licensing in our country was in 1996 when the tender method was adopted and fetched amount beyond expectation even in those days.

**Sustainability**

For all natural resources that are limited in supply, the issue of use within the sustainability boundaries always exists. The radio frequency spectrum too has this issue though it is not a consumable item. Demand for the bandwidths for various applications is increasing and mobile telephony is the leading consumer.

Can its demand be met if we allow ourselves to employ it for non-essential uses like viewing video or television while we are walking? Are such applications more deserving than social applications like telemedicine etc.? If spectrum availability becomes the crunch, ethical issues posing luxury against necessity will obviously arise. They will need to be debated, answered and a stand taken.

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