Response to Consultation Paper

IMT –Advanced Mobile Wireless Broadband Services

Introduction

With voice services achieving a good momentum in the country, there is a need to have focus on the data and Broadband services. The Data services targets have also been defined in the draft National Telecom Policy by the Government . The TRAI's consultation paper on IMT–Advanced Mobile Broadband Services is therefore a timely and welcome step.

As brought forward by TRAI in its consultation, there are two technologies which are a candidate for IMT – Advanced Mobile Broadband Services as defined by ITU. These are LTE advanced 3G PP release 10 and Wireless MAN advanced technology based on IEEE 802.16m. Since these standards are under development, the consultation is very important to represent the interests of our country in the International arena. Apart from these technical issues, the consultation paper has brought about regulatory issues which are unique to each country depending upon the availability of spectrum and in which bands and quantum of spectrum available for telecom purpose.

We recommend that user equipment and architecture for IMT Advanced Systems should be left to market forces. There can be allocation in multiple bands for an IMT-A operator depending on the availability of spectrum with at least 10 MHz in <1 GHz band and 20 MHz in the > 1 GHz band.

Spectrum in 900 MHz Band should be re-farmed for IMT-Advanced Broadband Services. We do not suggest any spectrum cap for allocation of spectrum for 3G or IMT-Advanced services. However it must be ensured that in any auction sufficient spectrum blocks are available for at least 6 operators including PSUs. The emphasis can be on FDD allocation for lower bandwidth blocks of 2x10 MHz so that they are compatible with legacy 2g/3G systems.

The reserve price should be reserve price as fixed for BWA spectrum on a per MHz basis. Alternately a consultation process may be followed involving various stakeholders at the time of auction. The rollout obligation for IMT-A services should be same as that for 3G services. VoIP may be permitted only under Unified license. VoIP should be subject to same conditions like emergency calls, interconnectivity with BSNL etc. Our detailed comments follow.

1. **Whether there is a need to define a particular user equipment or architecture to be used by the vendors or this may be left to the market forces?**

- User Equipment with poor estimation/adaptation capabilities may affect the performance of the network and impact existing subscribers if they enter the network without proper characterization. User Equipment functionality and specifications are defined in the international standards like ITU, 3GPP and IEEE to a great level of details. User terminals will be governed by underlying standards for LTE-A (i.e. 3GPP Release 10/11).

- We support open policy of permitting multiplicity of User Equipment vendors and leave it to market forces for deciding the user equipments for LTE. At the same time, we should emphasize on capability of devices to support the standards as will be defined by various bodies. Operator IOT should ensure compliance with LTE-A, legacy technologies and intra and inter network mobility.

- The architecture should support handling atleast two wide band channels each of 10 MHz and /or one channel of 20 MHz to really exploit the IMT-A envisaged services. **Architecture should also support a Triband RF transceiver with capability to support 700 / 800 / 900 MHz band as default support for LTE-A with** 3GPP release 10 /11. It is also desirable to have a 4^{th} band support in 2.5 GHz which is recognized as a globally harmonized spectrum band.

- The antennae architecture support in the User Equipment should **support MIMO of 4/4** as a default with capability to support higher order from 2015 onwards.

- The User Equipment should **support all IP architecture** in the protocols stack handling across up to the fourth layer for supporting call handling, routing, inter-networking functions, built-in test and auditing capabilities, security features across different layers as per 3GPP and QoS to support a minimum of six levels of assured service levels.

- The User Equipment architecture for smart phones, tablet and embedded devices should support **built-in power saving algorithms** to ensure longer periods of battery power availability before a recharge.

- User Equipment should meet basic performance characteristics such as **Inter operability, protocol conformance and emission tests**. Emphasis should be on **capability of handsets to fall back on legacy systems** for voice that is CDMA 1X or GSM 2G/3G. Currently most of the devices designed or deployed in LTE are data cards and dongles. Voice on LTE is still being developed.

LTE technology has the capability to fall back for voice on the legacy systems that is CDMA 1X or GSM 3G/2G. Therefore it is good to have LTE devices with the capability of fallback on existing networks, till the VOIP on LTE is established.

- The architecture to be used by vendors should also be left to market forces. Competition prevailing in the Telecom sector will automatically force the operators to deploy the most efficient architecture.

2. **Whether there is a minimal set of performance characteristics the UE has to meet before it is permitted to enter a network? These conformance and emission tests which presumably the UE has already passed.**

   The UE must meet the minimum 3GPP standards for LTE-A and legacy technologies. The overall performance characteristics will be decided by the service provider deploying the services. Factors and parameters which influence network capacity, should be defined and mandated. Individual UE performance which only impacts single user should be left to market force. **Features like support of interference cancellation, cell edge interference level for a 4/4/4 sector operation as per 3GPP on 4x4 MIMO should be considered as a minimal set of performance characteristic**. Features like maximum power, power control etc. should be defined.

   UE must support minimal antennae gain of atleast 9 dbi and a minimum of 22 dbm power output and -107 dbm of sensitivity for the receiver at 12 db SINAD. UE must support OFDMA Stack/ OS Algorithm to support a minimum of 8 concurrent IP sessions and voice at latency levels of less than 20 milli seconds.

   - Following are some of the capabilities/characteristics we can emphasize on:

     - Capability of handsets to switch to legacy networks (especially for voice)
     - Handsets should work effectively in the heterogeneous networks for higher data rates and capacity.
     - There should be no negative effect on networks by the device while doing channel condition adaption for data throughput (e.g., adaptive coding and modulation etc)

   In case user equipment is not following standard protocols or is not able to communicate to the transmitter effectively for channel condition adaptation, the performance of the network may go down considerably.

3. **In addition to what has been described above, what can be the other security issues in IMT-Advanced services? How can these security issues be addressed?**
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4. **What basic security frameworks should be mandated in all networks to protect customer?**

- IMT networks will provide huge **challenges in terms of security due to open architectures and IP based protocols**, these networks will be prone to security attacks similar to those of Internet. VOIP will bring in challenges of SPAM, eavesdropping etc. With M2M & M-commerce applications there will be lot many challenges as transactions would be done real-time. Though it makes sense for convergence with IMT but enterprises might be reluctant as the security applied in convergent system needs to be highly reliable.

- From air interface perspective defining same level of security as 3G & USIM mandate is enough in near to midterm. Overall measures need to be taken to ensure:

  - Re-use of UMTS Authentication and Key Agreement (AKA), Use of USIM required (GSM SIM excluded), Extended key hierarchy, Possibility for longer keys, Greater protection for backhaul, Integrated interworking security for legacy and non-3GPP networks. With IMT physical security of sites will be also important as lot of data will be available at eNodeB itself.
  - Separate authentication methodology will be required for relay and Femto. With Relays we will need to ensure that Control plane traffic integrity is protected, User plane traffic optionally integrity protected,
  - Relay Node and network connection confidentiality protected, Device integrity check & Secure environment for storing and processing sensitive data
  - The basic security aspects should be maintained as defined in 3GPP standards. Network level security protocols are covered exhaustively in the standards. Application level security will depend on the kind of applications involved. Some important aspects are that the security functions should not affect the transition from existing 3G services to IMT advanced and the USIM used for 3G services can still be used for the 4G networks.

5. **Which spectrum bands should be identified for the IMT – Advanced Services in India?**

<u>Requirement of existing 3G operators</u>

- The wireless internet access is not likely to grow but explode and therefore the spectrum requirement is immense. India needs as much of Broadband spectrum that can be made available to achieve the broadband penetration desired. The 3G would require more spectrum to meet the demand for higher throughput and quality of services. **This would require that**

more spectrum atleast equivalent amount in their existing spectrum in a contiguous manner for existing 3G operators which may be considered before any IMT-A allocations.

- The **preferred band for IMT-Advanced services in India should follow the globally harmonized spectrum bands** to be considered even in India for adoption by Telecom service providers to ensure international roaming for voice, data and video services including TV broadcast service delivery on IP to the mobile devices.

- **This mandates the consideration of 700 MHz band as the most preferred in association with 2.5 GHz band as a first preference in India**. This needs to be complemented by **the support of IMT-A services in the bands of 800 / 900 MHz** so as to conform and align to the evolution of networks in these bands being launched in Asia Pacific, Europe and North America.

- The lower frequency bands of **700 / 800/900 MHz bands have the benefit of increased coverage** and corresponding reduction in network deployment costs when compared to deployments at higher frequencies and therefore are preferred for Indian deployment which is highly dense in urban and sub urban areas with brick walls and concrete roof structures. These bands are considered most preferred for higher in-building penetration and therefore it is well suited to supporting those both dense urban and sub urban areas. Also these frequency bands offer much higher macro cellular coverage suiting vastly rural geography of India. Also India is a tropical country and these bands are considered the most useful bands for higher data rate applications in dense areas, high vegetation areas and prone for heavy rain in west coast especially.
- In addition, with the improved spectrum efficiency, **IMT Advanced deployment in the 900 MHz band would bring the highest capacity benefit and also provide operators the ability to deploy an LTE network** with greater coverage at a much reduced cost compared to higher frequency spectrum hence provide a good mobile broadband data countrywide layer. Based on recent development, many European countries have endorsed the refarming of GSM spectrum paving the way for potential deployments of LTE into 900MHz.

- **Technology Neutrality principle should be followed in the 700 / 800 /900 MHz bands**. This may require re-farming of spectrum without giving any undue advantage to incumbent operators.

<u>Need for Clear roadmap for spectrum allocation</u>

- **During 2012 to 2015 time frame it is essential to have access to a minimum of atleast 240 MHz of spectrum for IMT-Advanced services to cater to the needs of the society** to be served through a minimum of six PAN India operators.
- This mandates that the Regulator should make efforts to study the available spectrum bands in India and make available the **desired minimum spectrum as above in the bands of 700 MHz, 2.5 GHz, 900 MHz and 800 MHz in that order**.

- It is important for the Authority to provide a clear roadmap regarding availability of spectrum bands, current allocation/ usage and total amount of spectrum that can be made available in that particular spectrum band along with associated timelines. There will requirement of more spectrum for existing 3G operators to satisfy the anticipated demand for higher bandwidth services. Thus the foremost requirement is to meet the spectrum demand of existing 3G operators.

Bands for IMT-A Services

- Each bandwidth has benefits and drawbacks. Coverage for less dense areas require frequencies < 1GHz and for dense urban areas larger bandwidth channels are required which are at higher frequencies. The 700MHz band should be less expensive to implement and will provide wide-area and in-building coverage with a small amount of antennas and base stations, however, it is not optimal to achieve true 4G speed. In US deployment has been in 10MHz with LTE. 10 MHz block is giving a speed of ~ 70 Mbps with the present LTE version. The 2.6 GHz band, on the other hand, can provide optimum speeds with 20MHz of contiguous spectrum with high levels of data transmission capacity for a high number of users in dense (urban) environments. But it will also require building an adequate infrastructure, making it an expensive solution.

- In case of India, TRAI has already recommended 700 MHz band for 4G services. It is recommended that considering the economy of scale, support for international roaming, ease of availability of UEs, propagation characteristics and availability of spectrum bandwidth to provide the high speed data services through IMT Advanced technologies the 700 MHz band seems to be appropriate band for IMT-A Services in India.

- It needs to be noted that TRAI has already recommended that 700 MHz band be earmarked for IMT applications. The draft NTP'2011 also aims to make available globally harmonized bands for commercial mobile services, which will be a key driver for success of – IMT Advanced services in India

- Since the required spectrum requirement may not be entirely met through 700 MHz, Government may have to consider spectrum in at-least one more band. Another important band for deployment in India could be 2.3 GHz band or 2.5 – 2.69 MHz. While it does not have good propagation characteristics (as compared to 700 MHz), it is likely to have good global ecosystem which provides it an edge over other bands (except 700 MHz). In addition, 800 MHz and 900 MHz spectrum bands may be evolved towards for IMT– Advanced services

Therefore it is recommended that:

- **There can be for allocation in multiple bands for an LTE operator depending on the availability of spectrum with at least 10 MHz in <1 GHz band and 20 MHz in the > 1 GHz band i.e. 2.3 GHz band or 2.6 GHz band,**

- **Refarm 900 MHz spectrum band for IMT-A services.**

- **All spectrum auctions must have spectrum allocation roadmap for atleast next five years so that investors take informed decision before committing any investment.**

6. What should be the block size of spectrum to be put on auction? How many blocks of spectrum should be allocated/ auctioned per service area?

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7. What is the minimum spectrum block size for effective use of 4G technologies?

- While the technology allows combining multiple smaller blocks of spectrum, **larger the contiguous block of spectrum, better is the spectral efficiency** (using statistical multiplexing) and higher the cell throughput. Hence, it may not be advisable to divide the available spectrum up into smaller blocks that do not fulfil the licensed entity's requirements nor the end user's requirements or expectations of high speed/quality of broadband services. IMT-A achieves higher data rates and requires wider radio channels, such as 10 MHz wide channels. To deliver very high data rate, the system must minimize interference.

- It should be noted that moving towards more advanced standards, (e.g. LTE 3GPP rel 10) there is inherent support for larger bandwidth to gain larger throughput**. All IMT Advanced technologies would require wider contiguous channels** (10 MHz or more) to provide the desired services and level of performance required of IMT Advanced services which include enhanced data rates, value added services and various data centric applications.

- Spectral efficiencies of IMT Advanced technologies typically find synergy when larger bandwidths are available with the operator. **Internationally, 10-20 MHz of spectrum has been allocated to operators for rolling out IMT Advanced networks**.

- For example, in USA when FCC auctioned the 700 MHz spectrum, it divided the spectrum into 5 blocks as below:

Block	Description	Bandwidth (MHz)	Reserve price (Per MHz – USD Mn)	Highest Bid (Per MHz – USD Mn)
A	176 "economic area" licences for 2 × 6MHz	12	150.6	330.1
B	734 "cellular market area" licences for 2 × 6MHz	12	114.5	762
C	12 "regional economic area grouping" licences for 2 × 11MHz, with "open platform" conditions	22	210.8	215.8
D (unsold)	Single national licence for 2 × 5MHz, with conditions requiring a public/private partnership to create a public safety broadband network	10	133	47.2
E	176 economic area licences for 6MHz (unpaired)	6	150.6	211.1

- In the case of Germany, 360 MHz spectrum was auctioned across 4 different frequency bands viz., 800 MHz, 1.8 GHz, 2 GHz & 2.6 GHz. The spectrum was won by 4 players:

Player	Quantum of Spectrum
Telekom	95 MHz
Vodafone	95 MHz
E-Plus	70 MHz
Telefonica O2	99 MHz

- **Minimum block size for effective deployment of IMT Advanced networks should be 2 X 10MHz**. A 2x10 MHz bandwidth in FDD and 1x20 MHz in TDD per operator should be auctioned to achieve better efficiency and throughput. It is preferred to utilize more diversity gain considering high traffic demand.

- Ideally 6 blocks should be auctioned in every service area as this would protect consumer interest. These blocks may be identified across multiple bands. **The number of blocks auctioned should ideally be equal to the number of potential bidders minus 1** to ensure that the Government realizes the true value of the spectrum and at the same time **successful bidders do not face a "winners curse"**.

- **Recommendation: It is suggested that the block size of spectrum for**
- **deployment of IMT Advanced should be 2 X 10MHz in FDD and 1X20MHz in TDD mode. The number of blocks ideally to be auctioned could be 6 (Pan-India basis) to enable development of a fair market for end consumers in multiple band. These blocks could be identified across spectrum bands. This will allow fair amount of competition and would also provide for required bandwidth to deliver quality services to subscribers.**

8. **What should be the maximum amount of spectrum which a service provider can be allocated through auction?**

- The consultation also raises the possibility of imposing a spectrum cap on the total amount any individual bidder can acquire in the auction process. This is to address the specific potential competition problem of "spectrum hoarding", where an individual bidder attempts to block new entry through acquiring a large block of spectrum which provides a barrier to entry to new competition and innovation.

- The spectrum cap has limited role for introduction of the competition but it is not required for protection of the competition. The spectrum cap will only draw an arbitrary line in the name of competition. The spectrum cap may also prove to be one of the impediments for providing true broadband services in the country. **Therefore we do not suggest any spectrum cap for allocation of spectrum for IMT-Advanced services. However, in order to ensure that adequate competition exists in the market, Government may consider putting a cap of 1 block (of 2*10 MHz each for FDD) and 1*20MHz for TDD per operator for ensuring fair level of competition.**

- To serve the next 500 million potential subscribers on mobile broadband through six PAN India operators at the envisaged quality of service of 2 Mbps per user, network efficiencies for service

delivery and network economics of that service delivery play a significant role in the business case of the service providers.

- To ensure the QoS on a per user basis on a good sustainable growth of the industry, it is essential to have on a per operator basis, the spectrum as given below.

  - **At the initial auction during the time frame of 2012, the number of spectrum blocks may be capped at 1 (2 X 10 each for FDD) and 1X20 for TDD. However, there may not be any long-term capping on the maximum amount of spectrum which a service provider can be allocated.**

  - **During the period 2014 to 2017, the required spectrum cap on per operator basis should be atleast (6 x 10 or 3x20 for FDD and 2 x 20 for TDD).**

9. **Whether there is a need to specify the use of particular duplexing scheme based on the band in which spectrum allocation is done? If yes, in the case of TDD, is it required to specify further the frame duration, mandate frame synchronization using one of a specified set of timing sources, & a permissible set of Uplink/Downlink sub-frame schemes compatible with the IMT-A standards.**

   - **While TDD has more advantages, FDD is more widely deployed as the UL/DL is more backward compatible with the 2G/3G systems. Therefore FDD is a natural progression for operators on GSM/UMTS.**

   - No operator has so far commercially deployed TDD-LTE so far. Present LTE deployments in US are in FDD. LTE TDD commercial deployments may start happening by end of 2011. With bigger blocks like 20MHz, FDD can be an issue because the UL band will not be fully utilized. TDD can be more effective used in such scenarios. Biggest issue with TDD roll out is the lack of ecosystem specially the consumer devices.

   - Defining fixed duplexing scheme will ensure maximum spectrum efficiency and standardization. A subset of UL-DL ratios in the IMT-A standards that minimize overlap of UL and DL sub-frames needs to be defined. Timing also needs to be taken from a single source. In TDD system it is required to mandate frame synchronization & uplink downlink ratio to avoid inter operator interference.

   - Where TDD or FDD/TDD band plans are allocated or being contemplated, inter-system interference needs to be considered by the operators. Adjacent operators in such a scenario can:

- Choose to synchronize (sub-frame schemes) their networks and therefore negate the need for guard-bands, or
- Based on their network design and deployment choose to allow appropriate guard-bands from within their spectrum allocation

- **Based on the above discussions, it is suggested that emphasis should be on FDD to be able to utilize easy fallback on the existing networks.**

10. What should be the reserve price per MHz in different spectrum bands?

- While auction reserve price is an indication of the inherent value of the asset, competitive forces determine the real asset value in the market. Nominal reserve price may attract several players to the auction thereby extending the auction period and delaying the actual value realisation for the auctioner as market forces aim to reach the optimal value based on the underlying valuation factors. Alternatively, setting a reserve price closer to the real value quickens the value realisation which could be high enough to keep out weaker players while leaving enough room for value adjustment based on the estimates of the bidders.

- However, while reserve price may not have too high a bearing on the actual revenue realisation for the government, it is nevertheless a lever to control the auction behaviour in terms of number of bidders, auction duration etc. To this end, certain key parameters need to be borne into consideration while fixing the reserve price, some of which could be as given below:

  - Spectrum availability
  - Technological considerations
  - Market sentiments.
  - Reserve price of prior auction:

- In a market like US where purchasing power of consumers is high, potential for consumption mobile broadband services are high, device availability is high, device affordability is high and over all GDP being high, the base price was fixed at 6 to 8 cents per POP per MHz depending on the spectrum band i.e. 700 / 2500 MHz bands.

- Such references from Europe could also be taken. It is suggested to normalize those global references to the Indian society demographics, economic conditions and more importantly the availability of spectrum in the relevant bands.

- Summary: **Reserve price primarily serves to provide an indication of the inherent value of the asset being auctioned**, while the actual revenue realisation is market determined and conditioned by other aspects of the auction process such as sealed bid or increasing bid auction method, etc. As such it does not seem to have too high a bearing on the market valuation of the

spectrum. Nonetheless, to arrive at a reasonable estimate for the same, certain key factors such as spectrum availability, technological aspects of the spectrum band being auctioned and their cost implications, market sentiments, reserve price of prior auction of a similar asset etc., could be taken into consideration. **Thus, it is recommended that the Government may determine the appropriate reserve price based on the prevalent conditions at the time of auction and this may be done through a consultation process involving various stakeholders. Alternatively, the reserve price adopted for BWA auction may be taken as reserve price for IMT-A spectrum auction.**

11. What should be the eligibility conditions for bidding for spectrum?

- Eligibility criteria should aim to arrive at a balance between policy objectives, market realities and consumer benefit. While the government may aim at stimulating competition in the sector in the hope of providing meaningful services to the consumer at affordable prices, the same may not be viable from a market sustainability perspective as consolidation would eventually happen in an overly fragmented market.

- Policy objectives such as providing advanced communication services to all residents through the length and breadth of the country and promoting rollout of advanced communication network infrastructure to augment national productivity could be incorporated into the eligibility criteria through levers such as prior experience in providing such services and financial strength to implement projects of such scale. There could be other parameters as well that could have a bearing on more intricate issues of national interest and security and hence, could be incorporated into the eligibility conditions.

- The 2008, 700 MHz spectrum auctions in USA, also throws light on a hybrid model tried by the FCC which helped broader ecosystem players to participate in the auctions apart from established telecom operators. In an effort to encourage network neutrality, Google asked that the spectrum be free to lease wholesale and the devices operating under the spectrum be open. Google's specific requests were the adoption of certain policies such as open applications, open devices, open services and open networks. Currently many providers such as Verizon and AT&T use technological measures to block external applications. In return, Google guaranteed a minimum bid of $4.6 billion. However, this model of broader eco-system players playing a part in spectrum auctions has not seen significant success, with Google in this instance not winning any licenses. Even if regulator wants to keep the market open for non-telecom players, broader eco-system players can participate through M&As which are likely to be permitted under the new telecom policy.

- From coverage and 'provisioning of advanced communication services to all' perspective, and the viewpoint of continued delivery of the same to all consumers through the foreseeable future, certain key eligibility conditions could be mandated by the regulatory authority. These could include the following:

    - Financial strength:
    - Implementation capability:
    - Concrete rollout plans:

- Eligibility criteria could be:

    - The bidder should hold a UAS licence as per the current regime or
    - Unified license as per the envisaged future licensing regime

12. Should there be any roll out Obligations for spectrum given through auction?

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13. Whether there should be any specific roll out obligations in respect of rural areas?

- Though specific rollout may depend on the operator's service objectives and target markets, however **rollout obligation should be there up to some extent to encourage band use and prevent band hoarding.**

- **Ideally, since the spectrum is being acquired through market price discovery, there should not be any roll out obligations** since the acquirer pays for the spectrum based on its business case. The roll out obligations should normally be imposed only when the spectrum is made available below the market pricing.

- With the new NTP looking to delink spectrum from licenses and allow spectrum trading, it is critical to **impose rollout obligations to prevent speculators from bidding for the spectrum and trading them later**. Specific lock in provisions tied to the rollout obligations too is needed to prevent such speculation and trading activity and provide for the most efficient use of spectrum. Since the reserve price as well as the final price would take into account rollout obligations and the limitations of each band, rollout obligations need not differentiate between bands.

- **In order to ensure that the available scarce resource is put to most efficient use and also fulfils the service penetration targets of the licensor in line with the national objectives, spectrum roll out obligations for IMT-A services can be specified as applicable for 3G spectrum.**

14. What should be the spectrum usages charges? Should it be based on revenue share or be a fixed charge?

- Telecom subscribers pay a significant component of their bills as taxes and levies which include spectrum charges. To provide affordable services and to meet the projected penetration targets, spectrum usage charges should not be enforced.

- Once the spectrum is auctioned and the winning bidder has paid the stipulated market price, there should not be any extra charge levied on the service provider. For spectrum acquired through the auction process, the value of spectrum gets realized upfront; hence, there is no merit in levying any additional fees on the same resource. However, this is not relevant in case spectrum is administratively allocated.

15. Using a MIMO technology what can be the possible infrastructure sharing issues and what can be the probable solutions?

- MIMO will not have impact on RAN sharing because in case of several carriers, individual carriers can be assigned to different operators.

- However, if we go with extended use of MIMO in IMT-A like 8x8 configuration, then it will require a large number of radio elements and antennae elements at the site and UE which can put pressure on the physical infrastructure space. Practically 2x2 MIMO is being currently tested and deployed. 4x4 MIMO is not yet been tested or deployed. 4x4 and higher MIMO are difficult to be deployed on small devices and are more likely to be on bigger devices such as tablets.

- These kinds of issues will be relevant while providers negotiates tenancy rates with infrastructure providers. These can be discussed among service providers and no policy decisions needs to be mandated. Today also operators have chosen to put a wideband antenna and combine 2G and 3G instead of putting a separate 3 G antenna, these are site specific issues based on individual site limitations.

Recommendation:

- **Any issues in sharing of infrastructure can be resolved at the level of Infrastructure / Service providers.**

16. What Regulatory mechanisms are to be provided for delivery of voice services over IMT-A systems?

- Voice over LTE has not been fully established yet. In current deployment of LTE, for voice, fall back is on legacy system CDMA 1X or GSM 2G/3G. In 1X, one can have simultaneous voice and data session (data in LTE and voice in 1x). But with GSM simultaneous sessions of data and voice are not possible. Therefore switch down is to WCDMA for both voice and data.

- **For PSTN interconnected VoIP services there should be complete level playing field between operators.** The relevant conditions include:

    - license and spectrum fee;
    - Interconnection with BSNL at level 1, Level 2 or SDCA as being mandated for UASL/CMTS licensees;
    - Emergency services;
    - Monitoring and interception services;
    - Numbering scheme etc

17. Should the interoperability of services to legacy 2G/3G systems be left to market forces?

- LTE is both backward compatible with CDMA and GSM network. LTE and LTE-A standards provide the mechanisms for Voice and Data interoperability with legacy technologies, including GSM/WCDMA and CDMA/EVDO. Due to the fragmentation of global LTE frequencies, it is likely that the default standard for global roaming will remain for sometime as quad-band GSM, and tri-band WCDMA. Coupled with SIM based provisioning the user has the ability to move among networks.

- Based on above, we recommend that the capability of LTE devices and network to fall back on legacy systems for voice should be there. In future, voice services through IP on LTE system should follow the standards as defined for LTE with all IP architecture.

18. What are the QoS measurements that can be reported on IMT-A systems? Suggest the appropriate KPI for data and voice services to guarantee customer satisfaction.

- QoS refers to the ability (or probability) of the network to provide a desired level of service for selected traffic on the network. IMT can offer both voice and data services, for voice KPI's can be similar to 2G or 3G.

- Voice KPI

    - Call setup success rate
    - Call drop rate

- BLER/Quality
- Cal setup time
- Handover success rate
- Availability of network
- Coverage

- Data KPI

  Service levels are specified in terms of throughput, latency (delay), jitter (delay variation) and packet errors or loss. Different service levels are specified for different types or streams of traffic.

  To provide QoS, the network identifies or "classifies" different types or streams of traffic and processes these traffic classes differently to achieve (or attempt to achieve) the desired service level for each traffic class. The effectiveness of any QoS scheme can be measured based on its ability to achieve the desired service levels for a typical combination of traffic classes ("traffic profile"). Some of the customer facing KPI's can be

  - Latency
  - User throughput
  - Connection time
  - Availability
  - MOS
  - Packet delay
  - Packet Error rate
  - Coverage

19. In view of the likely deployment of scenarios where the cell radius is scalable to much smaller levels using the concepts of femto and pico cells?

- In general small cells will improve coverage, capacity and therefore user experience in terms of dropped calls, throughput and battery life. However network with small cells requires advanced SON and interference management features. In SON environment, important factors are:

  - Devices should be capable of discovering pico cells to enhance data throughput.
  - Capability of network to do adaptive resource partitioning between pico and macro coverage in the network;

  Capability of devices and network to utilize the effect of macro offload for the non pico coverage;

a) What will be the impact of femto cells/SoN architecture on KPI?

- Femto & self optimization network will enhance the network KPI with proper planning. Femto's will be widely used for Home and Enterprise solutions. Femto and SON should further enhance

the customer experience as users will be closer to e Node B in case of Femto and SON would provide auto optimization features which would directly increase customer satisfaction.

b) What will be the impact of Relays/femto cells on Spectrum policy?

- Relays and Femto would be used in the allocated spectrum only. Spectrum policy should ensure that the quality of same is maintained so that introduction of these devices does not impact other spectrum bands. As such no major impact is foreseen on spectrum policy in case of relays & Femto

a) What will be the impact on infrastructure sharing?

- Infrastructure sharing would be done mainly at eNode B level. Active sharing of Femto or relay is possible but it is unlikely to happen in near future.

b) What policy guidelines are required to encourage low emission low energy and high capacity architecture like femto cells overlaid over macro cells?

- Femto cells should be driven by market forces and aim should be to enhance customer experience. There are obvious advantages of Femto's but it needs to mainly driven by business case. Regulator should encourage active infrastructure sharing to reduce cost to serve the end customer. Sharing may be allowed and enabled through virtual sharing in the base band processor of the femto as per the operator requirements.

- In general small cells will improve coverage, capacity and therefore user experience in terms of dropped calls, throughput and battery life. However network with small cells requires advanced SON and interference management features. In SON environment, important factors are:

    - Devices should be capable of discovering pico cells to enhance data throughput.
    - Capability of network to do adaptive resource partitioning between pico and macro coverage in the network;
    - Capability of devices and network to utilize the effect of macro offload for the non pico coverage;