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CONSULTATION PAPER

ON

IMT – Advanced Mobile Wireless Broadband Services

To,
Shri Sudhir Gupta,
Pr. Advisor (MS)
Telecom Regulatory Authority of India
Mahanagar Doorsanchar Bhawan,
Jawahar Lal Nehru Marg, New Delhi-110 002
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Dear Sir,

Subject: Consultation Paper on "IMT – Advanced Mobile Wireless Broadband Services"

We welcome the opportunity to respond to the Telecom Regulatory Authority of India's (TRAI) Consultation Paper on "**IMT – Advanced Mobile Wireless Broadband Services**". We appreciate TRAI for this excellent consultation which will help in establishment of new standards as well as finding new policies for offering broadband services.

Please find below our selective response to the consultation paper.

We would like to participate in any case any further opportunity is provided to discuss these issues. Also, we are available for discussions in taking some of these recommendations forward.

Yours Sincerely,

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Disclaimer: Please note that the views presented in the paper are of the students and not of the Institute.

Q1. 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?

Ans: One of the key ITU requirements for IMT-advanced is user equipments should be suitable for worldwide use. So it is imperative to define particular user equipment architecture to be used worldwide so that the user experience for 4G technologies such as LTE advanced is same in part of the world. The functionality and effectiveness of user equipment has a direct impact on the user experience and the value and cost of the traffic offered to a network. A lap top with a large screen and keyboard and LTE dongle or embedded connectivity, a touch screen tablet or slate, a smart phone and a standard phone are different both in terms of the amount and type of traffic they generate, realizable user experience value and delivery cost. Smart phones for example generate additional signaling load which adds to the cost of delivery. On the other hand, an open policy of permitting multiplicity of UE vendors is important for delivering value to the subscriber's at the most competitive prices. A minimal set of qualifications for a UE should be specified before it is permitted by an operator to enter a network. Vendors should comply with the user equipment architecture for providing services and should not be left on market forces.

Q2. Whether there is a minimal set of performance characteristics the UE has to meet before it is permitted to enter a network? These characteristics are over and above the inter-operability, protocol conformance and emission tests which presumably the UE has already passed.

Ans: Yes there is a minimal set of performance characteristics the UE has to meet before it is permitted to enter a network. The characteristics are as below:

- **Carrier aggregation:**
  LTE currently supports channel bandwidths up to 20 MHz To achieve significantly higher data rates as specified in LTE-Advanced, channel bandwidth size must be increased. IMT-Advanced sets the upper limit at 100 MHz, with 40 MHz the expected minimum. Because large amounts of contiguous spectrum are not available to most operators, the ITU allows the creation of wider bandwidths through aggregation of contiguous and noncontiguous component carriers (see *Fig. 1*). Thus spectrum from one band can be added to spectrum from another band in user equipment that supports multiple transceivers.

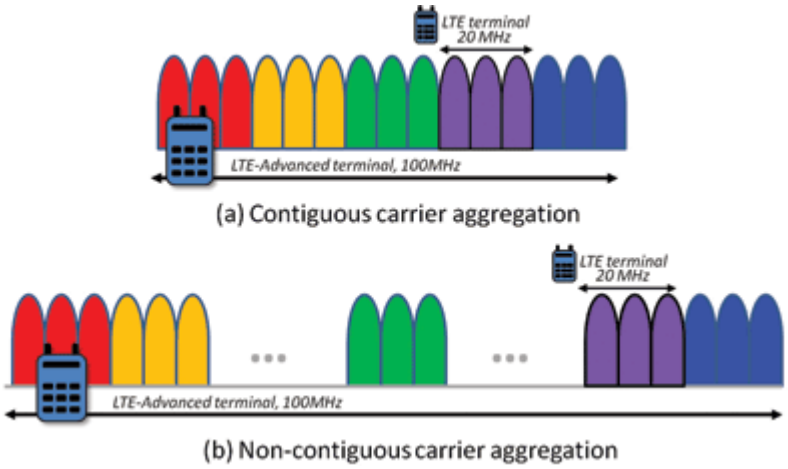

Fig. 1: The concept of contiguous and non-contiguous carrier aggregation illustrated here contrasts the bandwidth support requirements of the LTE and LTE-Advanced user equipment.

Carrier aggregation will undoubtedly pose major difficulties for LTE-Advanced user equipment, which must handle multiple simultaneous transmit and receive chains. The use of simultaneous, non-contiguous transmitters will create a highly challenging radio environment in terms of spur management and self-blocking. And simultaneous transmit or receive with mandatory MIMO support will add significantly to the challenge of antenna design.

- **Enhanced Multi-antenna transmission:**
  In addition to wider bandwidth, LTE-Advanced is also expected to provide higher data rates and improved system performance by further extending the support for multi-antenna transmission compared to the first release of LTE. For the downlink, up to eight layers can be transmitted using an 8□8 antenna configuration, allowing for a peak spectral efficiency exceeding the requirement of 30 bit/s/Hz and implying a possibility for data rates beyond 1 Gbit/s in a 40 MHz bandwidth and even higher data rates with wider bandwidth. This calls for the introduction of additional reference signals not only for channel estimation but also for measurements such as channel quality to enable adaptive multi-antenna transmission. Backwards compatibility needs to be considered and both additional cell-specific as well as additional UE-specific reference signals are possible candidates.

- **Coordinated Multi-point Transmission:**
  Coordinated Multi-Point transmission and reception (CoMP) is another technique being extensively discussed within the context of LTE-Advanced. The basic idea behind CoMP is to apply tight coordination between the transmissions at different cell sites, thereby achieving higher system capacity and, especially important, improved cell-edge data rates. Coordination schemes can be divided into two categories, used either alone or in combination:
  □ Dynamic scheduling coordination between multiple cells
  □ Joint transmission/reception from multiple cells

- **Enhanced Uplink Multiple Access:** LTE's uplink is based on single-carrier frequency division multiplexing (SC-FDMA), which allocates carriers across a contiguous block of spectrum, thus limiting scheduling flexibility. LTE-Advanced introduces clustered SC-FDMA in the uplink, which allows frequency-selective scheduling of component carriers for better link performance. The PUCCH and PUSCH can be scheduled together to reduce latency. However, clustered SC-FDMA increases peak-to-average power ratio, leading to transmitter linearity issues, and the presence of multi-carrier signals increases opportunity for in-channel and adjacent-channel spur generation.

- **Advanced MIMO:** To improve single-user peak data rates and meet spectral efficiency requirements, LTE-Advanced specifies up to eight transmitters in the downlink (with the requisite eight receivers in the UE) enabling 8x8 spatial multiplexing in the downlink. The UE supports up to 4 transmitters allowing up to 4x4 transmissions in the uplink when combined with 4 receivers in the base station.

- **Relaying**: In-channel relays receive, amplify, and retransmit downlink and uplink signals to improve coverage. More advanced relaying enables the use of some subframes in a channel to carry backhaul traffic. The main use cases for relays are to improve urban or indoor throughput, to add dead zone coverage, or to extend coverage in rural areas.

- Support for heterogeneous networks

- LTE self-optimizing network (SON) enhancements

- Home enhanced-node-B (HeNB) mobility enhancements
- Fixed wireless customer premises equipment (CPE)

The LTE business model is dependent on delivering a user experience which creates value from higher data rates delivered efficiently both in terms of cost and power consumption. The user equipment performance gains have to be realized in both single and multi band devices. Multi band devices are needed to achieve global scale economy and to realize an improved (more valuable) user experience by providing the best connect multi band broadband connectivity needed to realize application value and meet future user experience expectations. Additional bands have to be added in as new spectrum is introduced to the market.

LTE user equipment will have to be capable of working at 700 and 800 MHz, 2600 MHz, and any one or all of several existing bands including 850/900 MHz, 1800 and 1900 MHz and 3GPP Band 1(1900/2100 MHz).

Q3. In addition to what has been described above, what can be the other security issues in IMT-Advanced services? How these security issues can be addressed?

Ans: The security issues in IMT-Advanced services are as follows:

- Network access security: the set of security features that provide users with secure access to 4G services and against attacks on the (radio) access link.
- Network area security: the set of security features that enable nodes in the provider domain to securely exchange data, and protect against attacks on the wired network and network entities.
- User area security: the set of security features that enable secure access to ME/USIM and provide security environment in ME/USIM.
- Application security: the set of security features that enable applications in the user and in the provider domain to securely exchange messages.
- User authentication, authorization, and auditing
- Secure infrastructure, protocols, communication, and data storage
- Software integrity
- End to end compliance
- Secure network control, signaling and management
- Protection from unsolicited traffic

The verification of users and the limitation of network access in the heterogeneous architecture. Other vulnerabilities involve providers utilizing different systems and the basis of user-centered design, which allows users to select their preferred connection method. Due to their shared nature, naturally broadcasted states, unclear perimeters, and invisible access; wireless networks are treated as having more vulnerabilities than wired networks.

Because the system will allow for multiple available connections, a potential attacker will have more systems to evaluate, giving them a better chance of finding vulnerabilities. Finding a systems exploit in one protocol might give access to another, thus complex management systems are necessary that can provide control systems and signaling for devices.

Because devices will be connected to different interfaces and through multiple providers, the device will be exposed to attacks from each connection. The device will be exposed at different intervals to attacks based on code related to drivers, communication protocols, transportation and signaling stacks, file-sharing, update features, and other installed applications. Physical security should also be considered with these applications.

Device deactivation and erasure are all necessary features for a device that will be utilized on so many fronts.

Finding the balance between creating practical applications and secure systems will yield the most difficult problems for developers. With the heterogeneous makeup of the 4G system, it will be necessary to ensure that each security measure is universally utilized across each type of network. Thus, the security measure have to be technology-independent, meaning that they will be applied in a top-down nature and be overlaid upon the entire system, not necessarily one of the specific networks, however this often comes at a price. It is considered to be inefficient to secure applications through overlay technologies, which is why previous systems have enforced security through device measures to protect revenues through access controls. This is usually applied through the networks interface hardware. Because of access networks in 4G, such as terminals for local access, it would be best kept as a hardware authentication system so that authentication would be processed on the first network chosen by the user and so that user devices, such as those detailed earlier for access networks, would be authenticated by the device and secure. Each type of network allowed by device will have many different requirements when authenticating user identifies and handling sessions.

Q4. What basic security frameworks should be mandated in all networks to protect customer?

Ans: The basic security requirements on radio interface and network operator to protect customers are:

(1) Security requirements on ME/USIM:
 It shall protect the integrity of the hardware, software and OS in mobile platform.
 It shall control access to data in ME/USIM.
 It shall to protect the confidentiality and integrity of data stored in the ME/USIM or transported on the interface between ME and USIM.
 It shall retain user's identity as privacy to ME.
 It shall prevent the stolen/compromised ME/USIM from being abused and/or used as an attack tool.

(2) Security requirements on radio interface and network operator:
 Entity authentication: mutual authentication between user and network shall be implemented to ensure secure service access and provision. Ensure confidentiality of data including user traffic and signaling data on wired or wireless interface.
 Ensure integrity and origin authentication of user traffic, signaling data and control data.
 Security of user identity: It shall protect user identity confidentiality, user location confidentiality and user untraceability.
 Lawful interception: It shall be possible for law enforcement agencies to monitor and intercept every call in accordance with national laws.

(3) Security visibility, configurability and scalability:
 the security features of the visited network should be transparent to user.

 the user can negotiate acceptable security lever with the visited network when user roams outside HE (home environment).
 the security mechanism shall be scalable to support increase of user and/or network elements

Q5. Which spectrum bands should be identified for the IMT-Services in India?

Ans: 700 MHz (698-806 MHz) spectrum band is suitable from the point of both capacity and coverage. Spectrum in the UHF range has very good propagation characteristics and is highly suitable for the roll-out of mobile broadband in rural and other difficult-to-reach areas. The propagation characteristics of UHF could facilitate the deployment of networks reaching sparsely populated areas that are uneconomic to cover with networks operating at higher bands. Lower the frequency, lower is the propagation loss. Hence network operators require fewer base stations, meaning less capital investment is needed to bring broadband to all areas .
This band of frequency also helps reduce the complexity of equipment. This particular band (700 Mhz) is considered to be very efficient.

Q6. 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?

Ans: In order to avoid hoarding of spectrum and also to encourage fair competition among service providers, there is a need to put a limit on the amount of spectrum that can be allotted to the operators. Spectral efficiencies of 4G technologies typically kick in when larger bandwidths are available with the operator. Internationally; a minimum of 2x15 MHZ of spectrum has been allocated to operators for rolling out 4G networks. Considering the under penetration of broadband in India, 2X 20 MHz bandwidth chunks for FDD and 30MHz for TDD spectrum should be made available to the operators.

The no of blocks to be auctioned may vary from 3 to 5 subject to availability in different telecom service area. Each successful bidder will be allotted only 1 block in the telecom service area.

Q7. What is the minimum spectrum block size for effective use of 4G technologies?

Ans: 4G technologies such as LTE can operate using a minimum of 2×1.25 MHz carrier. Since large bandwidths would be required to cater to the high speeds Keeping international practices in mind a minimum of 2x15 MHZ of block size of spectrum should be allocated to operators for rolling out 4G networks.

Q8. What should be the maximum amount of spectrum which a service provider can be allocated through auction?

Ans: 2X 20 MHz block of bandwidth for FDD and 30MHz for TDD spectrum should be made available to the operators. Each successful bidder will be allotted only 1 block in the telecom service area.

Q9. 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 and a permissible set of Uplink/Downlink sub-frame schemes compatible with the IMT-A standards?

Ans: All the operators who owns a legacy network of 2G/3G might opt for FDD and the Greenfield operators might opt TDD because of higher spectrum efficiency. There is no need to specify the use of particular duplexing scheme based on the band in which spectrum allocation is done.

Q10. What should be the reserve price per MHz in different spectrum bands?

Ans: Broadband technologies like 4G need to be encouraged by the Government to increase the penetration of broadband. The reserve price of 4G spectrums should be in line with the reserve price set for BWA auctions.

Q11. What should be the eligibility conditions for bidding for spectrum?

Ans: The eligibility conditions include CMSPs , New Entrant Nominee ,UAS Licensee, ISPs (A & B) .

Q12. Should there be any roll out obligations for spectrum given through auction? Should it be different in different bands?

Ans: Yes, there should be roll out obligations for spectrum given through auction. The available spectrum with the service providers should be put to effective and efficient use at the earliest .This would prevent the tendency of spectrum hoarding.

No , the roll out obligations should be same for all the bands.

Q13. Whether there should be any specific rollout obligations in respect of rural areas?

Ans: Keeping in mind the broader objective of increasing the broadband penetration in rural area and also the profitability of operators in mind, the roll out obligation of 4G in rural area should be changed from the existing obligation of 3G. Simultaneous rollout for rural and urban areas should be done and the time line for rural rollout should be reduced.

Q14. What should be the spectrum usages charges? Should it be based on revenue share or be a fixed charge?

Ans: Annual spectrum charges should be applied at a flat rate. This can avoid different amount of Annual spectrum charges for different licensees for the same amount of IMT spectrum, depending upon their 2G/3G spectrum.

Q15. Using MIMO technology what can be the possible infrastructure sharing issues and what can be the probable solutions.

Ans: MIMO makes use of multiple antennas on both the base station and device to help achieve the higher data rates of LTE over current 3G UMTS technologies, but it also adds a lot of additional complexity. The performance of MIMO is very sensitive to the implementation of the antennas, the environment in which the devices is being used, and even the orientation of the device itself. This means that a small change in the position of the device when in use can result in significant change in data rate. For example, the user experience of a streaming video could go from excellent to marginal or poor just because the device was moved slightly during use.

In order to precisely model the signals arriving at the MIMO antennas, fading emulators or channel emulators are used, which accurately emulate the characteristics of the radio channel between the base station transmitter and the device's receiver antennas, or vice versa. So the delivery of expected data rates by MIMO technology will be affected if infrastructure sharing takes place between operators. It will lead to interference related issues and will ultimately affect the QOS delivered to the consumer.

Q16. What regulatory mechanisms are to be provided for delivery of voice services over IMT-A systems?

Ans: IMT-A services are basically deployed worldwide for providing high speed broadband access and offer interactive multimedia services. Most of the operators deploying LTE globally are not rushing for providing voices services over LTE.

Voice services can be provided over LTE by using the following methods:

- VoLGA, Voice over LTE via GAN
- CSFB, Circuit Switched Fall Back
- One Voice / later called Voice over LTE, VoLTE

Issues for Voice services over LTE

Unlike previous cellular telecommunications standards including GSM, LTE does not have dedicated channels for circuit switched telephony. Instead LTE is an all-IP system providing an end-to-end IP connection from the mobile equipment to the core network and out again.

In order to provide some form of voice connection over a standard LTE bearer, some form of Voice over IP, VoIP must be used.The aim for any voice service is to utilize the low latency and QoS features available within LTE to ensure that any voice service offers an improvement over the standards available on the 2G and 3G networks.

The following issues should be considered while deciding regulatory mechanisms for delivering Voice services available over LTE:

- It will be necessary to ensure the continuity of Voice calls when a user moves from an LTE coverage area to another where a fallback to another technology is required. This form of handover will be achieved using Single Radio Voice Call Continuity or SR-VCC).
- It will be important to provide the optimal routing of bearers for voice calls when customers are roaming.

- Another area of importance will be to establish commercial frameworks for roaming and interconnect for services implemented using VoLTE definitions. This will enable roaming agreements to be set up.
- Provision of capabilities associated with the model of roaming.
- For any services, including LTE, it is necessary to undertake a thorough security and fraud threat audit to prevent hacking and un-authorized entry into any area within the network.

Q17. Should the interoperability of services to legacy 2G/3G systems be left to market forces?

Ans: Yes the interoperability of services to legacy 2G/3G systems should be left to market forces. Interoperability is not the final target but the basic vehicle to ensure that switching from network to network can be performed. As the current legacy networks comprising of both 2G and 3G will remain in place for some years to come yet, it is important for Operators to understand how their current networks will both evolve and support handovers and roaming. As it is likely that most Operators will offer upgrade incentives, it is widely predicted that most 2G and 3G subscribers will migrate to 4G (LTE). This in turn will create an encumbrance on providing service and feature parity, as after the upgrade, the end user will demand their existing call feature sets remain the same. The interoperability of services if left to market forces will increase the competitiveness in the industry and as a result end user will get better QOS and QOE wrt voice and data services.

Q18. 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.

Ans: QoS measurements on IMT-A systems are as follows:

1. Capability to distinguish between different service flows and satisfying the QoS for each flow.
2. Dynamic creation, modification and deletion of QoS flows
3. Admission control, traffic mapping and negotiation of QoS parameters
4. End-to-end QoS
5. Link layer QoS
6. User QoS and policy requirements.

For eg: activities such as video, realtime streaming are categorized in streaming class which has the highest priority since these applications are delay sensitive where as the interactive class which includes applications such as gaming has higher priority than the conversational and background classes of services. These will help improve the QoS of IMT-Advanced systems

Data networks are very different from voice networks. Voice and data traffic have significantly different characteristics and are difficult to reconcile within a single network. Data traffic tends to be bursty, consuming large volumes of bandwidth for occasional, short intervals, whereas voice traffic is predictable and requires a steady, low-delay, transmission path from end to end.

KPI for voice are: Delay, jitter, real time.
KPI for data are: Throughput, packet loss, transactions latency, object hits

Q19. 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:

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

Ans: Since femto cells would be connected to the mobile operator's core network through broadband connection. Broadband backhaul introduces issues of network jitter/wander and recovered clock accuracy. In shared-bandwidth approaches, which are the majority of designs currently being developed, the effect on Quality of Service may be an issue. The backhaul connection is best effort tunneled over IP. Hence no guarantee for delay and jitter can be assured.

b. What will be the impact of Relays/femto cells on spectrum policy?

Ans: Femtocells can use the same frequency bands as the conventional cellular network, there has been the worry that rather than improving the situation they could potentially cause problems. Femtocells works on licensed spectrum and as the spectrum is the most expensive resource it will be a major technical hurdle for the wireless operator for frequency planning. Operational deployment of uncoordinated femtocells sets out new technological challenges, among which are cross-tier interference between the macro and femtocells, and co-tier interference among femtocells, in the same spectrum band.

c. What will be the impact on infrastructure sharing?

Ans: Femto cells would be sharing the backhaul traffic with broadband backhaul traffic**.** This would have impact on the quality of service.

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

Ans: 1**.** Awareness among end users regarding the benefits of femto cells.

2. Depending on the pricing policy of the MNO, special tariffs at home can be applied for calls placed under femtocell coverage

3. Developing a policy framework that encourages and drives the standardization of key aspects of femto technologies worldwide

4. Building and maintaining an eco-system that delivers the most commercial and technically efficient solutions.

5. Adoption of industry wide standards, regulatory enablers, common architectures and interoperability to enable the widespread adoption and deployment of femtocells by telecom operators.

6. Implement a multi-faceted campaign to raise the profile, drive technology development & deployment and to promote the potential of femto solutions across the industry and to journalists, analysts, regulators, special interest groups and standards bodies.