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To,
Telecom Regulatory Authority of India
New Delhi, India.

Consultation on "IMT-Advanced (4G) Mobile Wireless Broadband Services"
by
TICET, IIT Bombay

This consultation is made by TTSL - IITB Center for Excellence in Telecom (TICET) at IIT Bombay. TICET conducts both basic and applied research related to 4G standards and allied evolving technologies. TICET has made significant contributions to 4G-candidate standards, such as IEEE 802.16m, and is actively participating in evaluations for IMT-A. TICET has significant intellectual property rights (IPR) in 4G and allied communication systems. An up-to-date account of TICET research is maintained at http://www.ticet.iitb.ac.in

This consultation is representative of our views on technology growth in wireless communications, and places the evolution to 4G into a broader context of packet-based all-IP network evolution. Also, to the best of our knowledge, barring a few recent exceptions (like TICET, IIT Bombay, and CEWiT, Chennai); none of the IPRs in 4G is owned by Indian institutions - public or private. We believe that a 4G regulatory strategy must take into account the context in which 4G technology will evolve, and most importantly, prepare the baseline for future generations of wireless communications.

We begin the consultation with our key recommendations. Then we describe the detailed consultation in two parts - ***Part A*** consults the regulator on aspects related directly to 4G, whereas ***Part B*** focuses on the preparatory framework required for technologies beyond 4G.

Key Recommendations:

1. Promote IPv6 deployments for 4G. This is required to scale for nation-wide broadband Internet use.
2. Review spectrum allocation policies to promote self-configuring and self-optimizing networks (SON) with a distributed access infrastructure. SON in 4G may prove to be a highly cost effective infrastructure for India but this requires a careful regulatory framework.
3. Ensure that the security infrastructure deployed for 4G is scalable and accounts for new usage patterns like social networking, peer to peer applications.
4. Define new capacity models for packet-based voice. Capacity models based on voice carried on circuits are no longer relevant for 4G.
5. Apart from capacity, Quality of Service (QoS) models and Key Performance Indicators (KPI) are completely different in 4G. A comprehensive study is required to investigate such models in detail and enable appropriate monitoring mechanisms.
6. Prepare for India to lead future generations of wireless by promoting Indian IPR and Indian requirements in telecom standards.

***Part A*: Regulatory Considerations for 4G Networks**

Cellular communication technology has evolved in *generations* defined by the ITU. While the present 3G is a set of technologies that conform to IMT-2000, IMT-Advanced defines conformance guidelines for 4G. It is important to realize that technology evolution in the 4G architecture is not only in the air-interface but also in the IP based packet core.

The effect of technology evolution in the following allied areas is also crucial to consider in a 4G policy:

1. Packetized Applications: All telecom applications, most notably the canonical application of voice, are evolving to a packet-based architecture. This will have significant impact on the way we compute capacity and spectral efficiency.
2. Internet applications: Social networks and their content are set to dominate Internet use in the near future. This is a paradigm shift from *browser - website* interactions of the erstwhile Internet to *peer-to-peer* interactions. This new paradigm will significantly alter the core network design.
3. Security: The proliferation of Internet connected hardware in telecom networks carries with it a commensurate increase in security risks. This risk is further enhanced by packet-based radio access.
4. Content: Creation and dissemination of video and audio content is becoming increasingly accessible, given the vast variety of equipment available and their ease of use.
5. IP policy: Nations are becoming increasingly aware of the need to hoard IPR, and use their IPR reserves to position their international trade policy.
6. Telecom ecosystem: The telecom ecosystem has evolved to mixed business models-like outsourced networks, virtual network operators and infrastructure-shared networks.
7. Green networks: The global energy and climate crises steer the evolution of telecom equipment and architecture to increased energy efficiency even at infrastructure level (not just at mobile handsets levels).
8. Backhaul: Metro-Ethernet and wireless backhauls (for urban and rural markets, respectively) have matured sufficiently to see major deployments.

Our recommendations for policy development for 4G networks are in the context of the evolutions we see in the above areas. A list of our specific recommendations is as follows:

Recommendation 1: Spectrum Policy

a. Packet-based voice communication systems are significantly different from currently deployed circuit-based systems. The statistical multiplexing gains in packet-switched voice must be incorporated into a decision on the number of users per MHz. This calculation is required so that a spectrum cost model linked to capacity may be derived.

b. QoS models in 4G require a comprehensive study to evolve KPI for operators to guarantee customer satisfaction.

c. Migration from 2G and 3G to 4G must be scheduled such that it is driven by the capacity or coverage requirements of the geography concerned. 4G in dense markets would be deployed for capacity, and 4G in sparse markets for coverage. If the 3G coverage in sparse markets is sufficient to bridge the digital divide, then 4G deployment for capacity alone need to be considered.

d. Re-farming of 2G spectrum needs to be seriously considered. This policy would ensure preference for spectrum use for more efficient technologies. A short lifespan for 2G equipment would also result, thereby improving average Internet quality across India.

e. Spectrum use of 4G for access and backhaul must be segregated by policy. Backhauling 3G access over 4G is a viable option for promoting Internet growth in geographies with low penetration. This obviates the rollout of large amounts of wired infrastructure to reach these markets.

Recommendation 2: Internet Growth

a. IPv6 may have to be mandated on every device and in every core network. This is the only way to ensure sustainable volume and mobility of 4G devices.

c. A joint policy with NGN for supporting metro-Ethernet over fiber for cellular backhaul is highly desirable.

d. Intra-national and international IP peering arrangements may have to be reviewed to be in line with expected increase in bandwidth requirements due to new applications over 4G.

Recommendation 3: Telecom Architectures

a. Self-organizing networks (SON) in 4G may prove to be a very cost effective way of deploying distributed 4G infrastructure. Since self-organizing networks are self-configuring and self-optimizing, a policy framework that allows this with appropriate checks and balances may have to be formulated.

b. In order to allow mobile TV as an application over 4G, converged information broadcast and telecom policy needs to be established. This requires a review of existing policy as well.

c. Vertical handover between three technology generations appears to be a challenge to be addressed in the radio access network.

d. A regulatory framework for multi-generation, multi-technology handsets is critical to infuse broadband Internet growth in India.

e. Passive infrastructure is already being shared in India. Sharing of active infrastructure would allow multiple operators to share the baseband processing, and hence enable efficient energy utilization for the geography covered. This may also lead to energy efficient architectures.

f. 4G also presents a wonderful opportunity for infusing Indian IPR, by way of equipment manufactured locally, and entrepreneurship development in this area is highly desired.

g. Interoperable relay stations and femto-cells are an integrated part of the 4G architecture. A regulatory framework to allow these to be operated independently may have to be specified.

Recommendation 4: Security

a. 4G brings with it packet-based access upto the terminal. A packet infrastructure with a large number of IP addressed devices implies ease of proliferation of malware attacks, and complex requirements for their detection, prevention and cure. A new threat assessment framework and a security policy in line with this framework are necessary to secure 4G networks and their users.

b. 4G networks present significantly higher capacity challenges to legal-intercept systems deployed today. A large, dynamic public IP pool places enormous demands on infrastructure used by law enforcement agencies for call traces, and the capacity of current deployments seems inadequate.

c. Peer-to-peer networks running over 4G networks pose significant challenges for content regulation and ownership, since each mobile user is potentially a broadcaster of (unregulated) information.

***Part B*: Looking beyond 4G**

India's 4G strategy must be forward thinking, and must include policy support for Indian institutions (public and private) to hold significant sway over definitions of future technology generations, standards for equipments realizing these generations, and (perhaps most importantly) Indian IPR in international standards. India would do well to learn from its largest neighbour – China with significant IPR in 4G.

India's technology strategy must also incorporate advances in other areas - like self-organizing networks, transparent relay networks, and cognitive communications. These concepts are already under active research, and will certainly find place in any future wireless communication architecture.

Recommendation 5: Comprehensive Technology Strategy

a. Promote a nation-wide research programme to define the requirements of future telecom technology generations.

b. Form a Standard's Development Organization (SDO) with all stake holders in India- on the lines of CCSA (China), TTA (Korea), ARIB (Japan), ETSI (Europe), and TIA (USA) - that influences international standards to incorporate Indian requirements and IPR, and liaisons with international standardization bodies like IEEE, 3GPP/2, ITU, IETF etc.

c. Promote telecom equipment and component manufacturing in India, perhaps by enabling appropriate tax structures for companies generating and using Indian IPR.

d. Prepare regulation for a more distributed model of spectrum assignment and use - as will be required for effective use of self-organizing networks, relay networks, and cognitive networks.