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Emerging trends in Next Generation Wireless Access (NGWA)- Role of "Dynamic Spectrum Exchange" for IMT-Advanced

SATYA N. GUPTA
Hon. Secretary General, NGN Forum, India
Joint Secy. General, ITU-APT Foundation, India

AGENDA

- Emerging Technological Developments in ICT
- Wireless Technologies Trends
- Dynamic Spectrum Exchange- A Sharing Concept
- Layered Approach to Spectrum Allocation
- ITU Initiatives towards IMT- Advance
- Key Features and Challenges for 4G
- Conclusion

Emerging developments in ICT Technologies-

Leading to Flux in Telecom

- **Increased speed and density of Integrated Circuits (Moore's Law)-CPU processing power doubles every 18 months.**
- **Enhanced Transmission capacities on Optic Fiber Networks and Networking Flexibility (Gilders Law)-OFC carrying capacity doubles every 6 months).**
- **Cloud (virtualisation) and Open Platform-based Communication Software (APIs) and Knowledge- discovery through Big Data.**
- **Capacity Growth and new Application Services on Wireless (Cooper's Law)- wireless capacity doubles every 30 months).**
- **Network Effect (Metcalf's Law)- Power of network, square of Subs.**
- **Carriage of real time QOS-based multimedia traffic on IP networks (VOIP, IPTV, VOD, UC, IPV6)**

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Evolution of Last Mile (Access) Technologies

- **Use of Coaxial Cable for Telecom Services (Cable TV Network for Broadband and telephony local loop).**
- **Use of DSL technology on traditional Copper Loops.**
- **FTTX**
- **Ethernet over cable**
- **Wireless Technologies for Fixed and Mobile communication.**
- **VSAT-based Access in remote areas.**
- **Power line based Access (BPL).**
- **Free Space Optics (FSO).**

Wireless Technologies Trends

- GSM, GPRS, CDMA, CorDect, 802.11 (WLAN,Wi-Fi) 802.16d(Fixed Wimax),PTT,Bluetooth,UWB, 802.16e(Mobile WiMAX), 3G- Already Available.
- LTE, OFDMA, MIMO, 802.16m (WWAN,MBWA), VoLTE, All-IP Cellular networks- Emerging out.
- Human Area Network (HAN) associated with body/ clothing-Becoming a possibility.
- Fixed Mobile Convergence(FMC) , Inter-operability of handsets for any type of access – Quad Mode Multi Band handsets. (WiFi, Wimax, GSM, CDMA)
- Software Defined Radios (SDR) – Multi-Functional, Multiservice, Multiprotocol, Multiband, Multimode (Universal) Radios.
- Cognitive Radio (CR)/Intelligent Radio

Broadband Wireless Access Technologies

Technology	Max Throughput	Frequency Bands	Typical Range	Application
WiFi (802.11x)	54 Mbps	2.4 G, 5.1 G,5.7G	100-400 mtrs	WLAN, Rural BB
WiMax (802.16x)	70 Mbps	700 MHz, 2.3 G, 2.5 G, 3.5 G, 5 G	Up to 50 Kms	WWAN
Mobi-Fi (802.20)`	40 Mbps	2.4, 3.5, 5.5 G	8-10 Kms	Mobile Broadband
DECT	2 Mbps	1900 MHz	10-15 Kms	WWAN
WCDMA/ 3G	2.0 Mbps	1900-2100 MHz	Unlimited (Cellular)	Mobile Broadband
EV-DO, HSPDA	2.4 Mbps (shared)	450,,900,1800 MHz	Unlimited (Cellular)	Mobile Broadband
EDGE	384 Kbps	900,1800 MHz	Unlimited (Cellular)	Mobile Internet
GPRS	60 Kbps	900,1800 MHz	Unlimited (Cellular)	Mobile Internet
CDMA (2000-1X)	144 Kbps (shared)	450,,900,1800 MHz	Unlimited (Cellular)	Mobile Internet
FSO	100 Mbps to few Gbps	Light Wave	Few Kms	CAN
Microwave radio (MMDS/ LMDS)	Few Mbps	3.5 G – 31 G	50 Kms +	MAN
VSAT	20 Mbps	4 G – 11 G	Unlimited	GAN (Remote Area)
Wireless USB 2.0	480 Mbps	2.4 G	10 mtrs	VAN
Bluetooth(802.15.1	3 Mbps	2.4 G	1-10 mtrs	PAN
Infrared	16 Mbps	Light Wave	1-5 meter	BAN
ZigBee/ UWB	200Kbps/400-500Gbps	2.5G-5.8G	1-100 mtrs	PAN
RFID	Few Kbps	2.4 G, 900Mhz	Few Inches	Contact-less Detection

Technology Comparison –IMT and Advanced

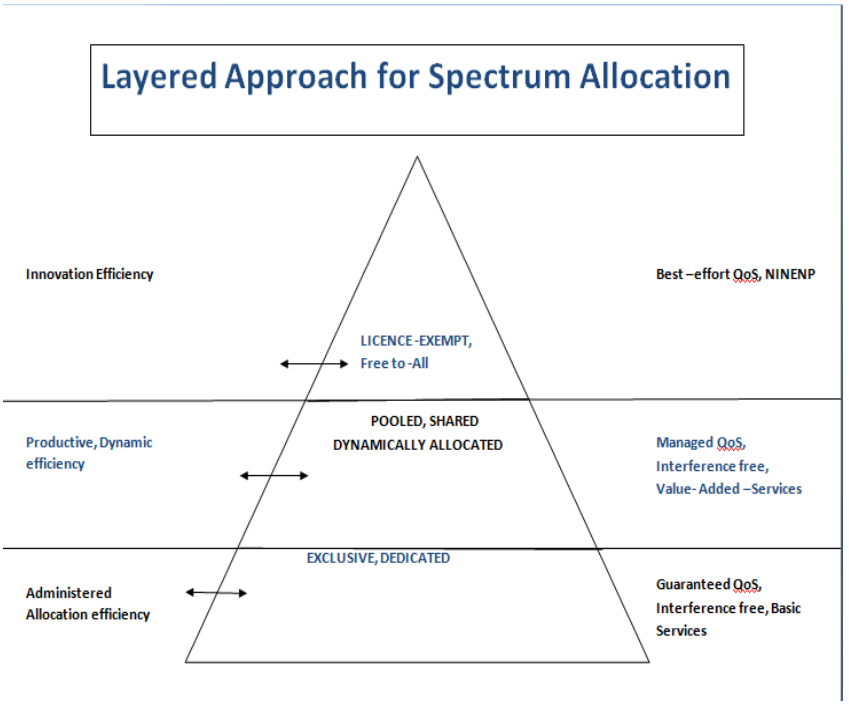
	UMTS (3G)	HSDPA (3G+)	EVDO (3G)	802.16 a/d	802.16e (Wimax)	IMT-Adv(4G)
Bandwidth	5 MHz	5 MHz	1.25 MHz	1.25-20 MHz	1.25-20	1.25-20 MHz
Typical Spectrum	1.9-2.1 GHz	1.9-2.1 GHz	450-1900 MHz	2.3-5.8 GHz	2.3-5.8 GHz	IMT(3G)
Downlink Peak Rate	0.4 bps/Hz	2.9 bps/Hz	2.5 bps/Hz	3.2 bps/Hz	3.2 bps/Hz	15 bps/Hz
Uplink Peak Rate	0.4 bps/Hz	0.4 bps/Hz	1.4 bps/Hz	2.4 bps/Hz	2.4 bps/Hz	6.75 bps/Hz
Ave DL Thr put	0.1 bps/Hz	0.7 bps/Hz	0.9 bps/Hz	0.53 bps/Hz	0.75 bps/Hz	-
Round trip Delay	150 ms	100 ms	100 ms	100 ms	100ms	<50 ms
Flat IP Support	No	No	No	Yes	Yes	Yes
Mobility	Full	Full	Full	Fixed	Limited	Full

Spectrum Utilization Trends

- **Radio Spectrum availability is key to the success of exploitation of emerging wireless technology trends.**
- **Being a limited resource, innovative allocation and management techniques required for optimum utilization.**
- **Usage of Multi-Layer, Hierarchical structures based on Micro , Pico and Femto cells, Cell splitting, Synchronous Frequency Hopping, Narrowbanding , Beam-splitting, etc.**
- **Use of Adaptive, Intelligent Antenna Array, Beam forming, Spectrum-stretching tuned Anteenae and Scattering.**
- **Enhancing the information carrying capacity of radio channels by Multi-level Modulation, MIMO, Compression, AMR Coding, DTX, DSI, DSX, OFDMA, BDMA(Beam Division Multiple Access) etc. to move towards Shannon's limit, C=BLog2(1+S/N)**

Dynamic Spectrum Exchange- A sharing concept

- **In US and Europe, there is move towards "Authorised Shared Access" and "Pooled Spectrum" to share the under-utilised strategic spectrum with operators without Interference.**
- **An innovative, forward looking approach for efficient spectrum sharing makes use of learnings from past, present and some out-of –box futuristic thinking.**
- **One solution is establishment of " Dynamic Spectrum Exchange (DSX) for dynamically allocating the spectrum chunks from "Public Switched Spectrum Pool (PSSP)" to the most needy one and temporarily withdrawing from the allottee who is not using it at the given time-period.**
- **This work as a Spectrum Highway or a Clearinghouse, wherein Spectrum Usage Charge (SUC) are paid based on the usage and not as upfront charge and can save the spectrum-hungry IMT operators from the "Winners Curse" as they "pay-as-you-eat".**



ITU Initiatives towards IMT Advanced

- **For the last 25 years, ITU has been coordinating the development of a global broadband multimedia international mobile telecommunication system, known as IMT.**
- **Since 2000, the world has seen the introduction of the first family of standards derived from the IMT concept –IMT 2000 (3G).**
- **"IMT-Advanced"/4G provides a standardised global platform on which to build the next generations of mobile services - fast data access, unified messaging and broadband multimedia in the form of new innovative services.**

What is IMT-Advance (4G)? (As defined by ITU)

- **IMT-Advance systems are mobile systems that include new capabilities that go beyond those of IMT-2000 (3G on Steroid). These:**
  - **provide access to a wide range of telecommunication**
  - **services including advanced mobile services, supported by mobile and fixed networks, which are packetised;**
  - **support low to high mobility applications and a wide range of data rates in accordance with user and service demands in multiple user environments;**
  - **provide for high quality multimedia applications within a wide range of services and platforms, providing a significant improvement in performance and quality of service.**

IMT Advanced- Objectives from Multiple Perspective

Perspective	Objectives
End User	Ubiquitous mobile access, Easy access to applications and services, Appropriate quality at reasonable cost, Easily understandable user interface, Long equipment and battery life, Large choice of terminals, Enhanced service capabilities, User-friendly billing capabilities
Content Provider	Flexible billing capabilities, Ability to adapt content to user requirements depending on terminal, Location and user preferences, Access to a very large marketplace through a high similarity of application programming interfaces
Service Provider	Fast, open service creation, validation and provisioning, Quality of service and security management, Automatic service adaptation as a function of available data rate and type of terminal, Flexible billing capabilities
Network Operator	Optimization of resources (Spectrum and equipment), QoS and security management, Ability to provide differentiated services, Flexible network configuration, Reduced cost of terminals and network equipment based on global economies of scale, Smooth transition from IMT-2000 to systems beyond IMT-2000, maximization of sharing capabilities between IMT-2000 and systems beyond IMT-2000 (Sharing of mobile, UMTS subscriber identity module, Network elements, radio sites), single authentication (Independent of the access network), flexible billing capabilities, Access type selection optimizing service delivery
Manufacturer/application Developer	Reduced cost of terminals and network equipment based on global economies of scale, Access to a global marketplace, open physical and logical interfaces between modular and integrated subsystems, Programmable platforms that enable fast and low-cost development

Source: TRAI 2011

LTE- Specification Overview

Parameters	Details
Peak downlink speed with 64QAM in Mbps	100 (SISO), 172 ((2x2 MIMO), 326 (4x4 MIMO)
Peak uplink speeds (Mbps)	50 (QPSK), 57(16QAM), 86 (64 QAM)
Data Type	All packet switched data (voice and data). No Circuit Switched
Channel Bandwidth (MHz)	1.4, 3, 5, 10, 15, 20
Duplex Schemes	FDD, TDD and half FDD
Mobility	0-15 km/h (optimized), 15-120 km/h (High performance)
Latency	Idle to active less than 100ms ,Small packets~ 10ms
Spectral efficiency	Downlink: 3-4 times Rwel 6 HSDPA Uplink: 2-3 x Rel 6 HSUPA
Access Schemes	OFDMA (Downlink), SC-FDMA (Uplink)
Modulation types supported	QPSK, 16QAM, 64QAM (Uplink and downlink)

Source: TRAI 2011

LTE Advanced/ IMT Advanced- Features

	WCDMA	HDPA	HSPA+	LTE	LTE Advanced
Max downlink speed(bps)	384K	14M	28M	300M	1G
Max uplink speed (bps)	128k	5.7 M	11M	75M	500M
Latency round trip time (approx)	150ms	100ms	50ms	~ 10ms	Less than 5ms
3GPP releases	Rel 99/4	Rel 5/6	Rel 7	Rel 8	Rel 10
Apprx. years of initial roll out	2003/4	2005/6 HSDPA 2007/8 HSUPA	2008/9	2009/10	2011 onward
Access methodology	CDMA	CDMA	CDMA	OFDMA/ SC-FDMA	OFDMA/ SC-FDMA

Source: TRAI 2011

IMT Advance -IEEE 802.16m and LTE-Advance

Requirements	IMT-Advance	IEEE 802.16m	3GPP, LTE-Advance
Peak Spectrum efficiency (bit/sec/Hz) System Level	DL: 15 (4x4) UL:6.75 (2x4)	DL:8/15 (2x2/4x4) UL:2.8/6.75 (1x2/2x4)	DL:30 (8x8) UL:6.75 4x4(
Cell Spectral Efficiency (bit/sec/Hz/Sector) System Level	DL:2.2 (4x2) UL:1.4 (2x4) (base coverage Urban)	DL:2.6 (2x2) UL:1.3 (1x2) (Mixed mobility)	DL:2.6 (4x2) UL:2.0 (2x4)
Cell-edge user spectral efficiency (bit/sec/Hz) System Level	DL: 0.06 (4x2) UL:0.03 (2x4) (Base coverage urban)	DL:0.09 (2x2) UL:0.05 (1x2) (Mixed Mobility)	DL:0.09(4x2) UL:0.07(2x4)(Base Coverage Urban)
Antenna Configuration	Not Specified	DL: 2x2, 2x4, 4x2, 4x4, 8x8 UL: 1x2, 2x4, 2x4, 4x4	DL: 2x2, 2x4, 4x2, 4x4, 8x8 UL: 1x2, 2x4, 2x4, 4x4
Operating Bandwidth	Up to 40 MHz (with Band Aggregation)	5-20MHz	1.4-20 MHz
Duplex Scheme	Not Specified	TDD, FDD	TDD, FDD
Latency	C-plane: 100 msec U-plane: 10msec	C-plane: 100 msec U-plane: 10msec	C-plane: 50 msec, 10msec U-plane: 10msec

Source: TRAI 2011

ITU Spectrum Bands for IMT- Advance

- 450 MHz
- 585-806 MHz
- 800 MHz
- 900 MHz
- 1800 MHz
- 1900MHz
- 2.1 GHz
- 2.3-2.4 GHz
- 2.5-2.69 GHz
- 3.3-3.4 GHz
- 3.4-3.6 GHz

Source: TRAI 2011

Regulatory Issues for IMT-Advance in India

- As per the NFAP 2011 footnote IND 37, the 585-806 MHz band is primarily for broadcasting services including mobile TV, and the requirements of IMT and BWA services may be considered and coordinated in the 698-806 MHz band.
- Regarding 1900-2100 MHz band, NFAP 2011 mentions that " Requirements of IMT (3G) applications in the frequency bands 1920-1980 MHz paired with 2110-2170 MHz (FDD mode) and 2010-2015 MHz (TDD mode) may be coordinated with existing users depending upon the availability, as far as possible".
- Regarding 2.5- 2.69 GHz Band, 40 MHz of spectrum being in use for local Multipoint Distribution Service (LMDS) and multi-channel Multipoint Distribution Service (MMDS) (2.535- 2.550 GHz and 2.630-2.655 GHz) be vacated or refarmed and that an additional 40 to 80 MHz be coordinated with Department of Space in the same timeframe.

Source: TRAI 2011

Advantages/Disadvantages of TDD and FDD

Parameter	TDD	FDD
Paired Spectrum	Does not require paired spectrum	Requires paired spectrum
Hardware Cost	Lower cost as no diplexer is needed to isolate the transmitter and receiver.	Diplexer is needed and cost is higher
Channel reciprocity	Channel propagation is the same in both directions which enables transmit and receive to use on set of parameters	Channel characteristics different in both directions as a result of the use of different frequencies
UL/DL Asymmetry	It is possible to dynamically change the UL and DL capacity ratio to match demand	UL/DL capacity determined by frequency allocation set out by the regulatory authorities.
Guard period/guard band	Guard Period required to ensure uplink and downlink transmissions do not clash.	Guard band required to provide sufficient isolation between uplink and downlink.
Discontinuous transmission	Discontinuous transmission is required to allow both uplink and downlink transmissions.	Continuous transmission is required
Cross Slot Interface	Base stations need to be synchronized with respect to the uplink and downlink transmissions times.	Not applicable

Source: TRAI 2011

General Characteristics of 4G

- ✓ from Users' Point of View
  - ✓Mobile multimedia services
  - ✓Anytime anywhere access
  - ✓Global mobility support
  - ✓Integrated wireless solution and
  - ✓Customized personal service
- ✓Quadruple IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis including the full mobility
- ✓Capable of providing 100 Mbps and 1 Gbps speeds both indoors and outdoors,
- ✓Technologies of the future are expected to be LTE, UMB & IEEE802.16m
- ✓Mobile backhaul transport is the critical link between the Broadband Mobile Access Node and the Network
  - ✓Constitute up to 25 % of their OPEX
- ✓Backhaul systems designed to serve 4G deployments should address following:
  - ✓Higher capacities: Backhaul to a single cell site should be able to scale up to 1 Gbps and even beyond
  - ✓Lower Latencies: The requirement for <50 millisecond end-to-end leads to select a solution that supports extremely low latency (10 ms)
  - ✓All IP: Support IP traffic from the first mile
  - ✓Capable to support 4G services and also existing PSTN services (CSFB)

Key features of 4G

- **A high degree of commonality of functionality worldwide while retaining the flexibility to support a wide range of services and applications in a cost efficient manner;**
- **Compatibility of services within IMT and with Fixed networks;**
- **Capability of inter- working with other radio access systems (CSFB);**
- **User-friendly applications, services and equipment;**
- **Enhanced peak data rates to support advanced services and applications (100 Mbit/s for mobility and 1 Gbit/s for limited mobility).**
- **Low Latency (<50 ms)**

Why move to 4G?

- **Need for Higher data speeds applications.**
- **Need for higher spectral efficiency in dense areas.**
- **Limited broadband wireline networks**
- **As an alternative, enterprise broadband access can also be on wireless through 4G**
- **Availability of future proof 4G technologies and equipment at competitive costs**
- **Lower Costs for VOIP calls (VOLTE)**

4G-Challenges Ahead

- **Multiple changes in technology and network infrastructure, in handsets and software.**
- **One major challenge is power consumption. This is critical because it will add multiple processing and communication elements to drive higher levels of MIPS (throughput) in mobile devices. All of these elements will increase current drain.**
- **Additional hardware acceleration technology required to manage power.**
- **OFDM-based technology to manage some of the process streams and power challenges for these applications and devices.**
- **Unavailability of Ecosystem, specially affordable access devices**

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4G-Challenge on Spectral efficiency

- **Challenge of spectral efficiency is a matter of availability of sufficient suitable and harmonized radio spectrum.**
- **To make more spectrum available, either re-farm existing spectrum in 2G and analogue broadcast TV (Digital Dividend)or open up higher-frequency bandwidths. High level of regulatory innovation, (Dynamic Spectrum Sharing/Access, Layered allocation approach) required to deliver on that promise.**
- **4G radio access network to provide significantly better spectral efficiency of the order of 10BPS/Hz compared with only 1–2 BPS/Hz available today for 3G systems.**

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Challenge on Spectral efficiency (cont…)

- **For better spectral efficiency and coverage more number of base stations required- Freq. reuse.**
- **For higher level of services, we need about 3 times more base stations to deliver a 10-fold increase in data rate- Capex issue.**
- **To reduce base station density, advanced antenna techniques such as MIMO and Space-Time Coding (STC) used.**
- **These techniques improve spectral efficiency & reduce number and growth rate of base stations.**
- **With these coverage required to deliver the bandwidth necessary for the applications wanted by consumers can be achieved.**

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Challenge on Spectral efficiency (cont…)

- **Higher capital costs associated with growth in the number of base stations required to deliver coverage at high data rates.**
- **On the handset side, there are significant challenges in continuing to drive down the cost of integrating greater and greater processing capability in multimode RF technology. The sufficient eco-system in this domain is still to be established.**

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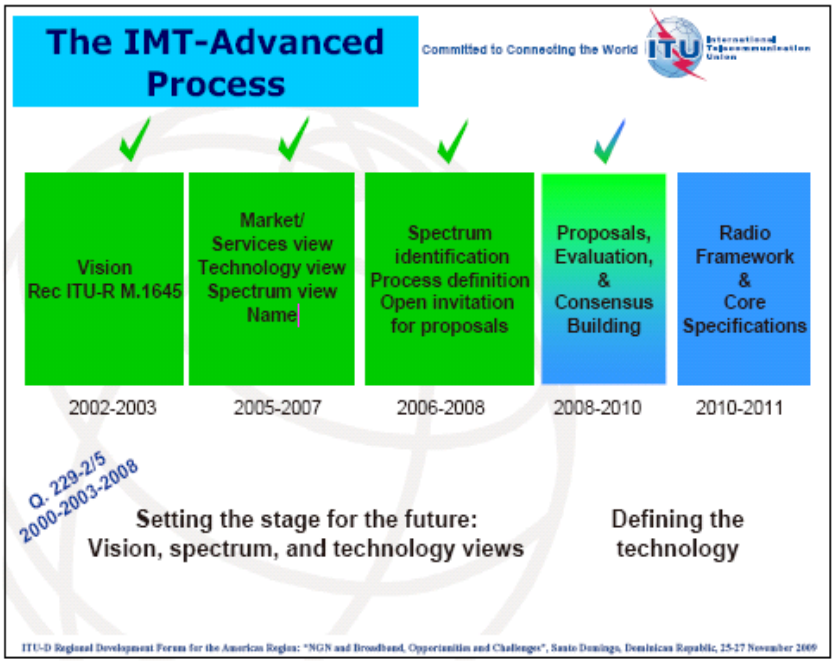
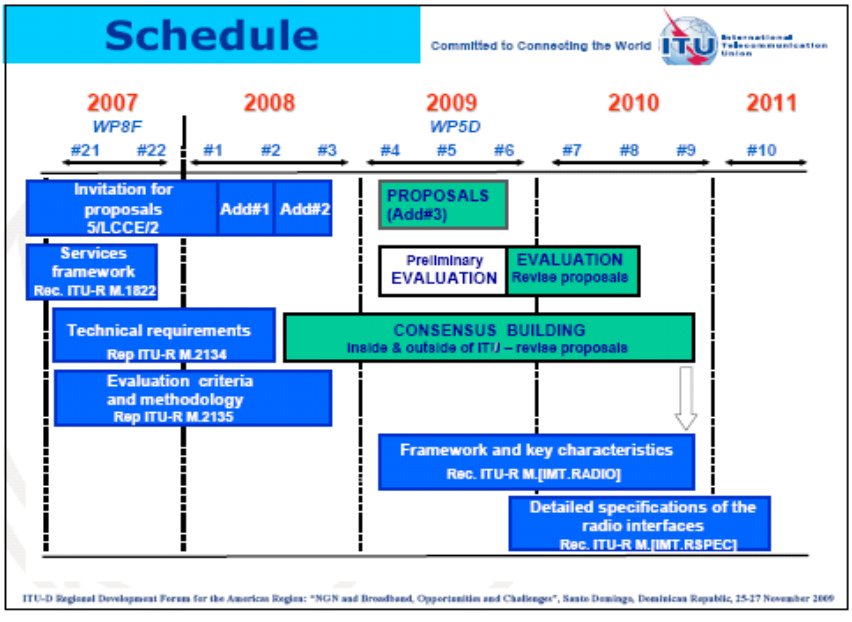

The IMT-Advanced Process
Committed to Connecting the World
Vision
Rec ITU-R M.1645
Market/
Services view
Technology view
Spectrum view
Name
Spectrum identification
Process definition
Open invitation for proposals
Proposals, Evaluation, & Consensus Building
Radio Framework & Core Specifications
2002-2003
2005-2007
2006-2008
2008-2010
2010-2011
Q. 229-2/5
2000-2003-2008
Setting the stage for the future:
Vision, spectrum, and technology views
Defining the technology
ITU-D Regional Development Forum for the Americas Region: "NGN and Broadband, Opportunities and Challenges", Santo Domingo, Dominican Republic, 25-27 November 2009


Schedule
Committed to Connecting the World
2007
2008
2009
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2011
WP8F
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#3
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#5
#6
#7
#8
#9
#10
Invitation for proposals 5/LCCE/2
Add#1
Add#2
PROPOSALS (Add#3)
Services framework
Rec. ITU-R M.1822
Preliminary EVALUATION
EVALUATION
Revise proposals
Technical requirements
Rep ITU-R M.2134
CONSENSUS BUILDING
Inside & outside of ITU – revise proposals
Evaluation criteria and methodology
Rep ITU-R M.2135
Framework and key characteristics
Rec. ITU-R M.[IMT.RADIO]
Detailed specifications of the radio interfaces
Rec. ITU-R M.[IMT.RSPEC]
ITU-D Regional Development Forum for the Americas Region: "NGN and Broadband, Opportunities and Challenges", Santo Domingo, Dominican Republic, 25-27 November 2009

Conclusion

- **4G access will enable innovative mobile services requiring high bandwidth and low latency (100Mbps+, <50 ms).**
- **It is based on fully packetised (IP), spectral-efficient, green and future proof technologies.**
- **It will support Ubiquity of services through backward compatibility with all fixed and mobile networks.**
- **It requires Licencing and Spectrum Allocation based on technology- neutrality and service –agnosticness ie .Unified Licence, Authorised Shared Access, Dynamic Spectrum Exchange, Layered spectrum allocation.**
- **The broad standard for 4G is already there and trials and commercial deployments are on all over the world (Americas, Europe, Asia Pac).**
- **Time is ripe for India to Leapfrog to 4G.**

THANK YOU

Satya N.Gupta

sngupta57@yahoo.com