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Emerging Trends in Broadband Technologies – Next Generation Wireless Access

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AGENDA

- Emerging Technological Developments – Emergence of Next Generation Networks
- Mobile Technologies Trends
- NGN Ecosystem
- Fixed Mobile Convergence (FMC)
- Future of Wireless Broadband - NWBA
- ITU Initiative towards 4G (IMT- Advance)
- Key Features and Challenges for IMT-Advance
- Conclusion

Technology Development Trends

- Increased speed and density of Integrated Circuits (Moore's Law).
- Enhanced Transmission capacities on Optic Fiber Networks and Networking Flexibility (Gilders Law).
- Distributed and Open Platform-based Communication Software.
- Capacity Growth and innovative Application Services on Wireless (Coopers Law).
- Emergence of Next-Generation Networks (IP-based)- Delivering QOS for Real time services.
- Ubiquity of networks through RFID & IPv6 (Next Generation Internet).

Evolution of Alternate Last Mile 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.
- Wireless Access for Fixed and Mobile communication.
- VSAT-based Access in remote areas.
- Power line based Access (BPL).
- Free Space Optics (FSO).

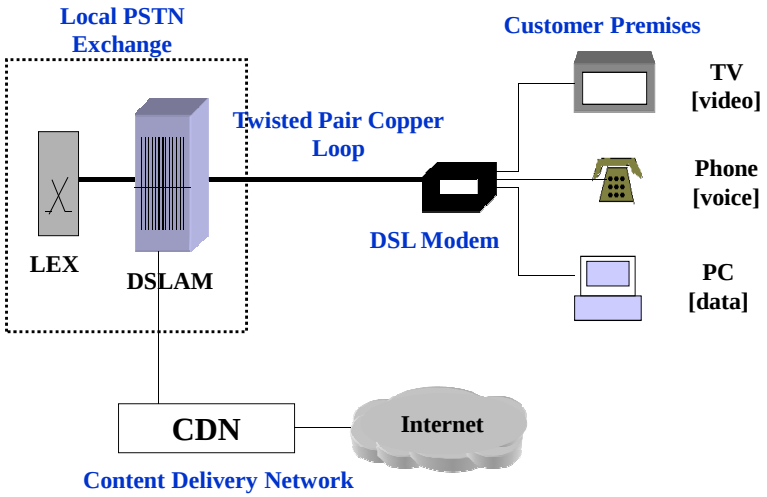
Technology Alternatives for Wireline

1. Evolution of Wireline Technologies

i) Use of Digital Subscriber Loop (DSL) technology on traditional Copper Loops (DIY, Franchising, Shared unbundling, Bit stream access)

- **Asymmetric DSL (ADSL) – 1 Mbps upstream/ 8 Mbps downstream, 3 Km**
- **ADSL (G.Lite) – Splitter free, 512 Kbps upstream/ 1.5 Mbps downstream, 5.4 km**
- **Symmetrical DSL – 1.5 Mbps, 3 Km**
- **Single pair High-speed DSL (SHDSL) – 2.3 Mbps symmetric, 3 Km**
- **ADSL 2, ADSL 2 plus – 8/24 Mbps, 1.5 Km**
- **Very high Data Rate DSL (VDSL) – 52 Mbps, 1.5 Km**

Broadband over copper loop (DSL)



Cable TV Networks for Broadband Access

- Broadband over cable TV accounts for 74% of total connections in US, and 55% in Canada
- 55 million cable homes in India, but infrastructure can not support bi-directional communication and requires upgrade
- Regulatory environment, via an ISP license, allows this with some MSO's and operators already doing so
- For advances to occur, better organization of the industry needed to be executed
- Cable operators will need to adopt innovative business models to compete in converged environment
  - Possible to provide upgraded entertainment services such as interactive digital TV, pay-per-view, video on demand and time-shifted TV
  - Benefits operators with significantly higher ARPU and better customer retention
  - To start with Cable TV network which is uni-directional can be used for downloading, the uplink to be conventional narrow band like dialup/ ISDN/ RADIO
- Operators need training to create awareness about utility of their networks and understanding of the investments required, returns possible, and technical aspects

ii) Fibre Optic Cable Technologies

- Fiber To The Curb (FTTC) – by existing operators
- Fiber To The Home (FTTH) – Fibre in last mile to deliver converged services
- Hybrid Fiber Coaxial (HFC) – by Cable TV operators
- Metro Ethernet (Fibre based) – extending the range of LAN
- GPON (Gigabit - Passive Optical Network) – triple play over TDM
- (No limitation of distance or throughput speeds)

iii) Broadband over Powerline (BPL) Technologies

- Use of existing domestic power connections for sending data
- Throughput in the range of 1 MHz (4 – 6 Mbps)
- Ideal for rural areas where telecom / cable TV infrastructure may not be there

iv) Metro Ethernet Networks

- Use of Ethernet beyond LAN- Carrier Ethernet
- Use of high-speed access using hybrid fiber/ copper based Ethernet technology
- Power over Ethernet (POE)

Mobile 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, 802.16m (WWAN,MBWA), 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/ 11 Mbps	2.4 G, 5.1 G,5.7G	100-400 mtrs	WLAN
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
CorDect	70 Kbps	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	230 Kbps	900,1800 MHz	Unlimited (Cellular)	Mobile Internet
GPRS	58 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

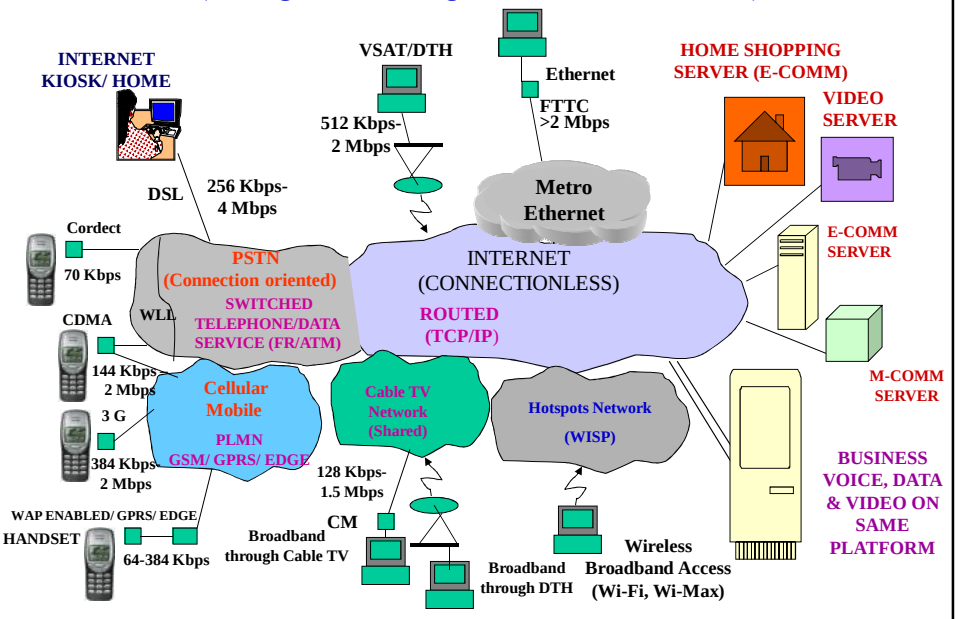
	UMTS (3G)	HSDPA (3G+)	EVDO (3G)	802.16 a/d	802.16e (Wimax)	IMT-Adv(4G)
Bandwidth	5 MHz	5 MHz	1.25 MHz	1.25-20 MHz	1.25-20	1.25-20 MHz
Typical Spectrum	1.9-2.1 GHz	1.9-2.1 GHz	450-1900 MHz	2.3-5.8 GHz	2.3-5.8 GHz	IMT(3G)
Downlink Peak Rate	0.4 bps/Hz	2.9 bps/Hz	2.5 bps/Hz	3.2 bps/Hz	3.2 bps/Hz	15 bps/Hz
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 and Scattering.**
- **Enhancing the information carrying capacity of radio channels by Multi-level Modulation, MIMO, Compression, AMR Coding, DTX, DSI ,OFDMA, BDMA(Beam Division Multiple Access) etc. to move towards Shannon's limit.**

Enabling Broadband Access -Technology-Neutrality

(making use of existing infrastructure & wireless)



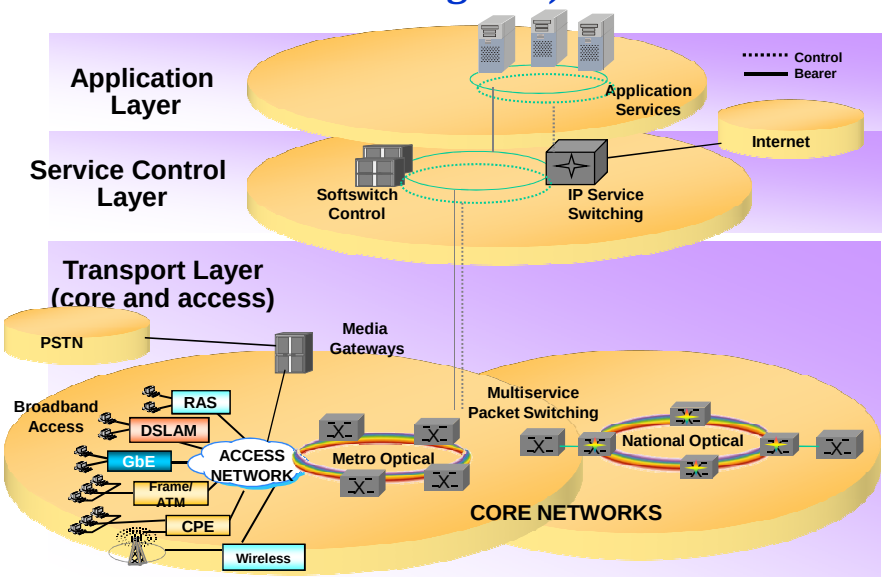
Trend Towards Convergence – NGN

- **Evolving Networks leading to Convergence of Voice, Data & Video services on a common infrastructure resulting into cost saving and performance improvements as well as leading to new avenues for revenue generation.**
- **Convergence of Telecom, Broadcast and Internet leading to Multimedia services.**
- **Evolving NGNs and 21CNs capable of guaranteed QOS and high level of Security, Reliability and Flexibility.**
- **Emergence of single "Information Plug" (Triple- Play).**
- **Customers aspiration – Better, Faster, Cheaper,One Stop Shop, Single Bill.**

What is NGN Ecosystem?
(From Layman's point of view)

- **Next Generation Services – Converged (quad-play-voice, data, video, mobile)**
- **Next Generation Access – High speed (Broadband) IP based connectivity (ADSL,VDSL,Wi-Max,Cable TV, FTTH, BPL)**
- **Next Generation Transport – Carrier Ethernet, IP-MPLS**
- **Next Generation Architecture – Service oriented (SOA), layered (transport, control, application)**
- **Next Generation Mobile – 3G+(B3G)**
- **Next Generation Internet – IPv6**
- **Next Generation Interconnect – Capacity and Quality based**
- **Next Generation Licensing – Unified**
- **Next Generation Regulation - Converged**

NGN–layered architecture (distributed intelligence)



Next Generation Broadband Services

- **High speed Internet access (death of World-Wide-Wait) – Still the killer application for Broadband in India**
- **Video-On Demand, Interactive TV, IPTV, PPV, Time Shifted TV, Videoconferencing**
- **Quad Play (data, voice, video, mobility) – One stop solution**
- **IP-VPN (low cost secured connectivity), EOIP**
- **4 e's (e-Governance, e-Learning, e-Health, e-Commerce), Work-from-Home**
- **Interactive Gaming, Instant Movie Download, Telepresence, HDTV, Collaboration, Cloud computing**

Emerging NGN Applications- EOIP

Voice over IP	**Unified Messaging**	**BB - High Speed Internet**
Primary line	**Content Delivery**	**PC to Phone**
Second line	Games	**Phone to PC**
IP Centrex usage	Downloads (MP3)	**IP VPN (data)**
Voice VPN	Gambling	**BW on-demand**
IP Centrex	**Video on demand**	**QOS on demand**
Basic	TV on demand	**Quad play**
Advanced	Cinema of the future	**Instant messaging presence management**
Multimedia Conferencing	**Long distance bypass**	**MMS on fixed network**
IPTV	**Telepresence**	**Location Based Services (LBS)**
		FMC (Fixed Mobile Con.)
Distance learning	Internal	**3G & beyond applications**
Distant arraignment	External	
Remote lab	**IP offload**	

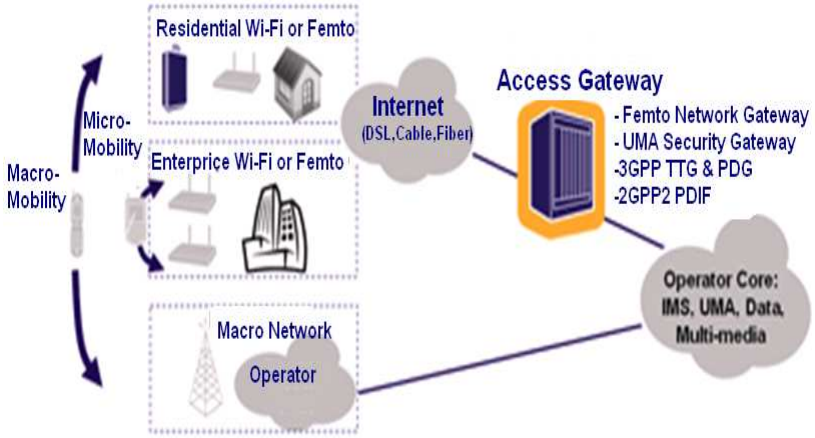
Fixed Mobile Convergence (FMC) – A compelling NGN application

FMC is convergence of access for telephony wherein as per the convenience of the users an mobile call can be delivered on fixed phone or can be terminated through Fixed/ Wi.fi broadband network on mobile phone.

Main motivation for this is :-

1. **Spectrum shortage leading to congestion and reduced QoS. (It is believed that 70% of the time a mobile call recipient is on a fixed location/Hot Spot)**
2. **Mobile subscribers saturation, Fixed lines decline (Battle for in-building minutes)**
3. **Broadband becoming ubiquitous and cost effective**
4. **The "Mobile Handset" is becoming a multi-purpose, multi-band, multi-mode palm-held computer**
5. **NGN Technologies enabling FMC (IMS, UMA ,Femtocells)**

FMC Concept



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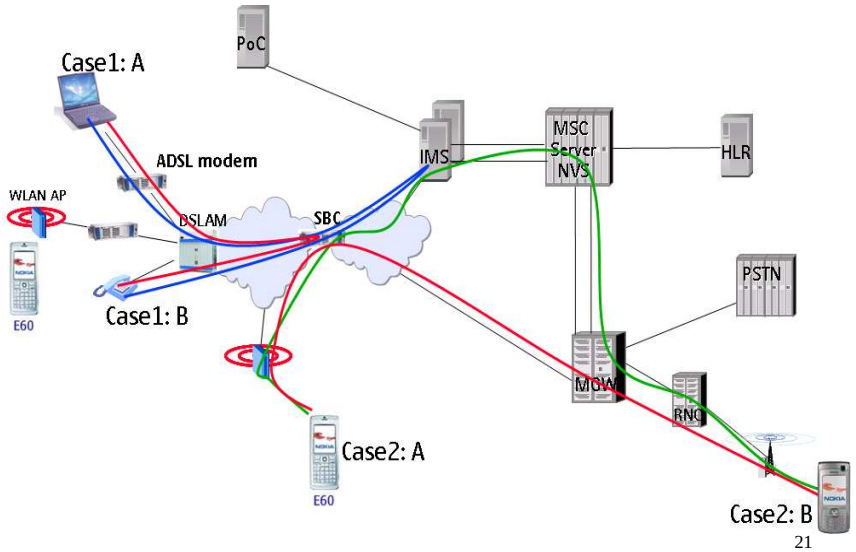
FMC- Convergence of PSTN, PLMN, Internet



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ITU Initiatives towards BWA

- **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" provides a 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-Advanced (4G)? (As defined by ITU)

- **IMT-Advanced systems are mobile systems that include new capabilities that go beyond those of IMT-2000 (3G on Steroid). They will:**
  - **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.**

General Characteristics of IMT- Advanced

- ✓ **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 featuring the full mobility**
- ✓ **Capable of providing 100 Mbps and 1 Gbps speeds both indoors and outdoors,**
- ✓ **4G technologies of the future are expected to be LTE, UMB & IEEE802.16m**
- ✓ **Mobile backhaul transport is the critical link between the Broadband Mobile subscribers 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 tail site should be able to scale to 100Mbps 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 network and also existing TDM services**

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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;
- 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
- Expectation of 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.**

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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 or open up higher-frequency bandwidths. High level of regulatory innovation 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.**
- **For higher level of services, we need about 3 times more base stations to deliver a 10-fold increase in data rate.**
- **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 are 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.**
- **Voice over LTE (VOLTE) is not on horizon yet.**

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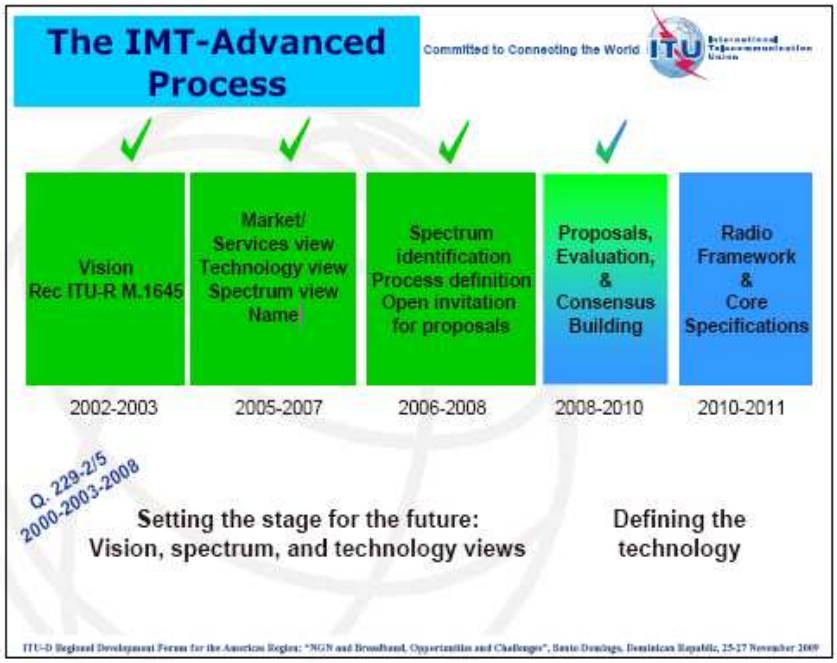
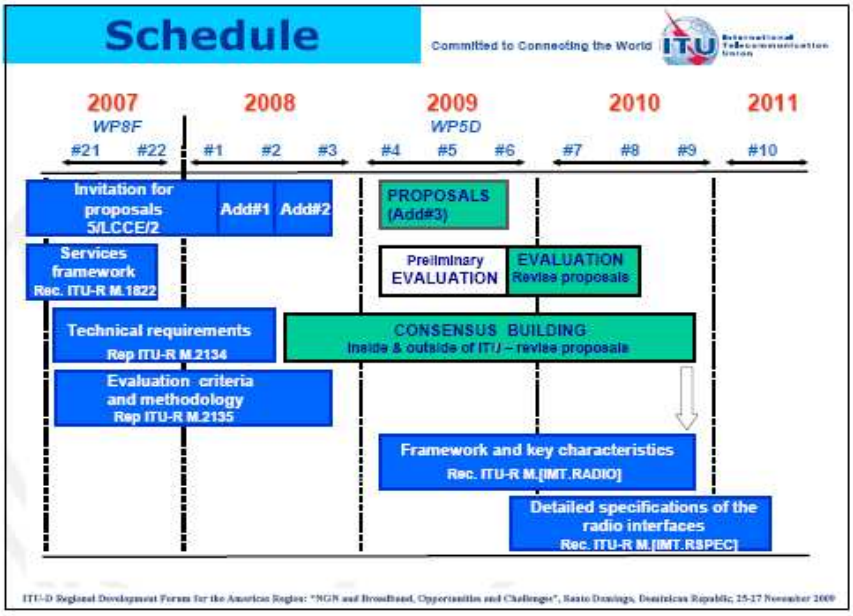

The IMT-Advanced Process
Committed to Connecting the World
Vision
Rec ITU-R M.1645
Market/
Services view
Technology view
Spectrum view
Name
Spectrum identification
Process definition
Open invitation for proposals
Proposals, Evaluation, & Consensus Building
Radio Framework & Core Specifications
2002-2003
2005-2007
2006-2008
2008-2010
2010-2011
Q. 22/1-2/5
2000-2003-2008
Setting the stage for the future:
Vision, spectrum, and technology views
Defining the technology


Schedule
Committed to Connecting the World
2007
WP8F
2008
2009
WP5D
2010
2011
#21
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#2
#3
#4
#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]

Conclusion

- **4G access will enable innovative mobile services requiring high bandwidth and low latency (100Mbps+, <50 ms).**
- **It is based on fully packetised, 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.**
- **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 Now for India to take a call on 4G.**

THANK YOU

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