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**5G and Beyond**  
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**Emerging Trends in NGN Virtualisation-Evolution to 5G**

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**AGENDA**

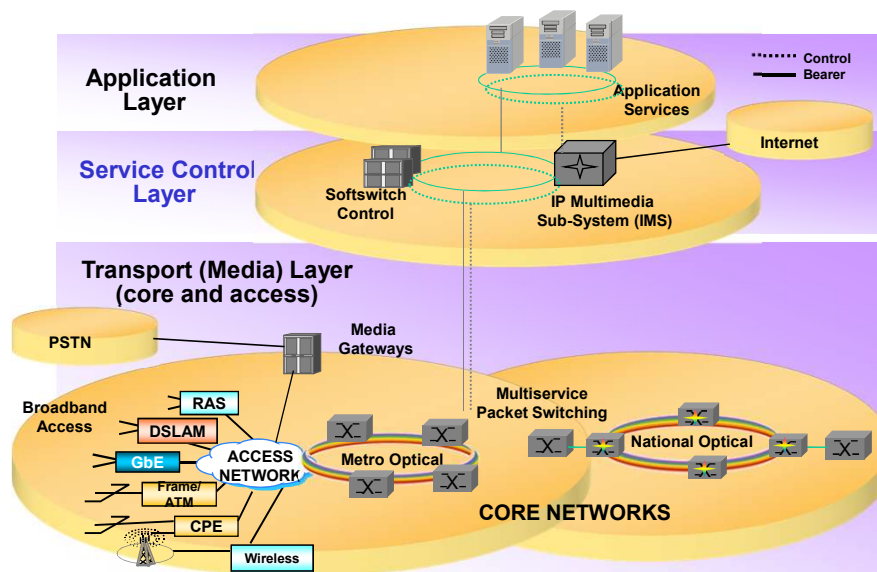
- **Emerging Technological Developments fueling ICT- Ind Rev 4.0**
- **Network Function Virtualisation (NFV)-ITfication of NGN**
- **Evolution to 5G**
- **Evolution of Last Mile NGA Technologies**
- **Next Generation Access – FTTH ( Fiber-to-the-Home)**
- **Device to Device communication- Internet of Everything ( IOE)**
- **Emerging Virtualisation Trends -Everything-as-a-Service - Digi.Gaon Job Factory- Creating Rural Intrapreneurship**
- **Work-Life Blend (WLB) through Virtualisation**

## Emerging Drivers in ICT – Technology and Connectivity advancing everyday fueling Cognification.

“Any advanced Technology is indistinguishable from  
Magic”--- Arthur C. Clarke

- Increased speed and density of Integrated Circuits-Devices becoming Faster, Cheaper, more Powerful, Parallel Computation (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).
- Capacity Growth and new Application Services on Wireless (Coopers Law-wireless capacity doubles every 30 months)- Evolution to 5G.
- Networking Effect ( Metcalf's Law)- Value of a network increases proportional to the square of no. of its connections. Dollar-for-Data (Personal Information).
- Zuck's Law-Amount of information shared in world doubles every two year-Deep Algorithm, Machine Learning, AI, QOS based multimedia traffic on IP-based networks (VOIP, IPTV, VOD, UC,FMC), IPV6, IOT, M2M, D2D,IOE,BYOD.
- Cloud and Open Software (APIs) and Knowledge-discovery through Big-Data, VR, AR, Cognetics, SMAC, Network Functions Virtualisation (NFV), Cloudification, IOTisation, Industry 4.0.

## vNGN– Activate(Energise),Digitalise,Packetise (IPfication),Divide(Layering),Virtualise (ITfy), Cognify



## Future NGN Transformation- Network Function Virtualisation- vNGN

**Move Towards Virtualisation: Digitalise- Packetise- ITfy- Cognify**

*Main Motivation-Cost Cutting , Simplification, More Revenue, Futuristic*

*From Specialised-To General Purpose (Off-the-Shelf), White-Boxing*

*From Tangible- To Virtual*

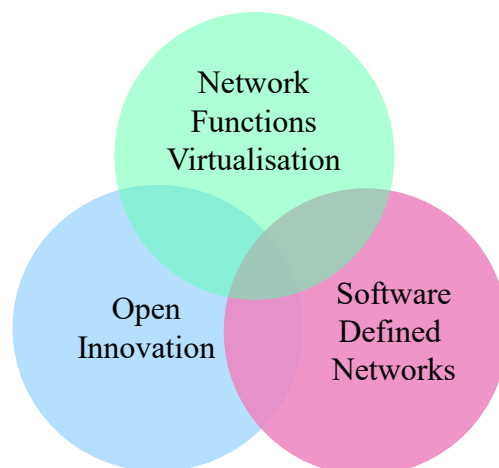
*From Complex- To Simple*

*From Packetisation-To ITfication,*

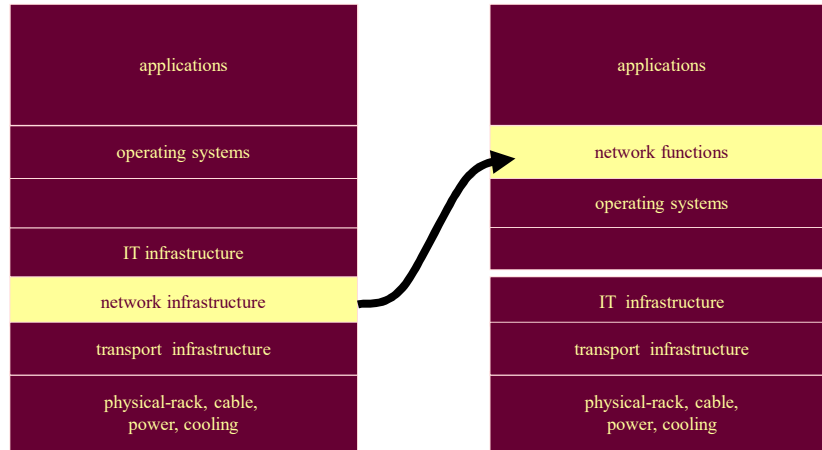
*Examples:*

1. **Virtual Private Network (VPN)**
2. **Virtual Container (VC)**
3. **Virtual Path, Tunnel (VP)**
4. **Virtual LAN (VLAN), vWAN (SD-WAN)**
5. **Virtual Node (VPOP)**
6. **Virtual Machine (VM),VMware**
7. **Virtual Applications ( APIs)**
8. **Virtual Service Control (IMS)**
9. **Virtual Network Operator (VNO),MVNO**
10. **Virtual Network (NFV), vRouter, vRAN,vIMS,vCPE--- vNGN**

## NFV- Complementary but Independent Developments



## NFV- ITfication of Network Infrastructure



- **NGN-Network Infrastructure-Specialised, Tangible**
- **vNGN-Network Functions-General Purpose, White-Box**

## vNGN- Move from Old IP to New IP( lightreading)

The Old IP( NGN)	The New IP ( VNGN)
Designed to scale clients (devices/nodes)	Capable of scaling clients and resources on-demand (cloud-like)
Rigid topology and architecture	Fluid in topology and architecture
Hardware-centric	Software-centric
Network-centric	User-centric
Integrated control and data planes	Disaggregated control and data planes
Decentralized intelligence and management	Centralized intelligence and management
Proprietary but standards-driven innovation	Open platform and open-sourced innovation
Time-bound provisioning and change management	On-demand provisioning and programmability
Key success metric: performance (speeds and feeds)	Key success metric: agility (usability)
Killer apps: data networking communications (email, ecommerce, voice/video/data integration (VoIP, unified comms)	Killer apps: Cloud everything, mobile data centers, big data analytics, virtualization everywhere
Management considers your network as an essential budget line item ( Capex, Laibility)	Management considers your network to be a strategic asset that serves both the bottom and the top line by saving/making money

### Comparison between 4G and 5G

Specifications	Fourth Generation (4G)	Fifth Generation (5G)
Peak Data Rate	1 Gbps	10 Gbps
AV. Bandwidth	2Mbps to 100Mbps	1Gbps and higher as per need
Spectral Efficiency	30 b/s/Hz	120 b/s/Hz
TTI (Transmission Time Interval)	1 ms	Varying (100 $\mu$ s (min.) to 4ms (max.) )
Latency	10 ms (radio)	<1 ms (radio)
Mobility	350 Kmph	500 Kmph
Connection Density	1000/Km <sup>2</sup>	1000000/Km <sup>2</sup>
Frequency Band	1 to 8 GHz	3 to 300 GHz
Standards	All access convergence including OFDMA,MC-CDMA, Network-LMPS	IMT-2020
Technologies	Unified IP, seamless integration of broadband LAN/WAN/PAN and WLAN	Unified IP, seamless integration of broadband LAN/WAN/PAN/WLAN and advanced technologies based on OFDM modulation used in 5G
Multiple Access	CDMA	CDMA,BDMA
Core network	All IP network	Flatter IP network, 5G network interfacing(5G-NI)
Handoff	Horizontal and vertical	Horizontal and vertical

### How 5G is being Built

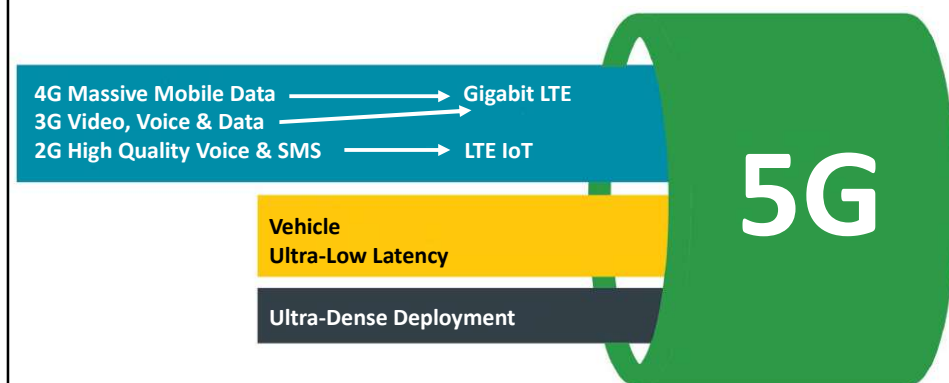
Eventually 5G will encompass all wireless technologies, including 5G New Radio, Gigabit LTE for super-fast speeds; LTE-IoT for low power, long battery life, and long-range coverage; Digital TV, C-V2X\*, or vehicle to everything; and ultra-low latency- **Ubiquity**

5G will build on the architecture of voice (2G); voice, video, and data (3G); and massive mobile data (4G)—and add massive bandwidth and density, as well as ultra-low latency. 5G also will integrate many aspects of WiFi and long-range/low-power networks- **Backward Compatibility**

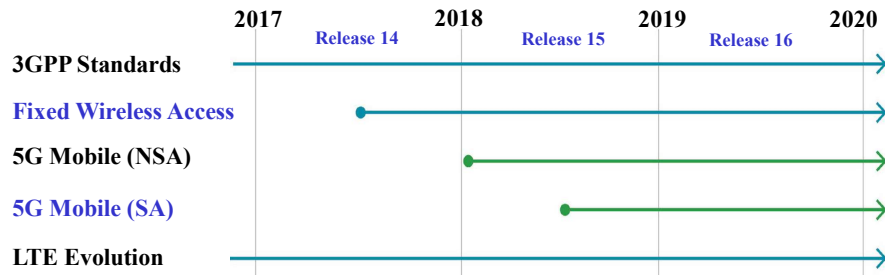
## Path to 5G

- Basic process is to continue to evolve the current LTE standard towards reaching the 5G specifications.
- The standard is looking to become a rather large, all-encompassing wireless communication system that not only caters for faster data speeds, but also supports many more devices online at the same time with greatly reduced latency.
- Groups working on the early trials of 5G has come up with two views
- The Hyper-Connected Vision: Create a blend of pre-existing technologies covering 2G, 3G, 4G, Wi-Fi and others to allow higher coverage and availability enabling M2M/D2D & IoT.
- Next-Generation Radio Access Technology: This is more of the traditional 'generation defining' view, with specific targets for data rates and latency being identified, such that new radio interfaces can be assessed against such criteria.

## Next Generation WAN



## Timeline for 5G Radio



*\*This timeline does not reflect commercial availability.*

*NSA = Non-Standalone (5G using LTE Core)*

*SA = Standalone (5G using 5G Core)*

## Emerging Applications and Services enabled by 5G

Verticles	Drivers	Enablers	5G Requirements
<b>Education</b>	<ul style="list-style-type: none"> <li>Remote delivery</li> <li>Immersive experiences</li> </ul>	<ul style="list-style-type: none"> <li>Video streaming</li> <li>Augmented reality/Virtual reality</li> </ul>	<ul style="list-style-type: none"> <li>Large bandwidth</li> <li>Low latency</li> </ul>
<b>Manufacturing</b>	<ul style="list-style-type: none"> <li>Industrial automation</li> </ul>	<ul style="list-style-type: none"> <li>Massive IoT networks</li> </ul>	<ul style="list-style-type: none"> <li>High connection density</li> <li>Ultra reliability</li> <li>Low power consumption</li> </ul>
<b>Health Care</b>	<ul style="list-style-type: none"> <li>Remote diagnosis and Intervention</li> <li>Long term monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Video streaming</li> <li>Augmented reality/Virtual reality</li> <li>Embedded devices, advanced robotics</li> </ul>	<ul style="list-style-type: none"> <li>Low power</li> <li>High throughput</li> <li>Low latency</li> </ul>
<b>Smart Grid</b>	<ul style="list-style-type: none"> <li>Intelligent demand/supply control</li> <li>Powerline communication</li> </ul>	<ul style="list-style-type: none"> <li>IoT sensors and networks</li> </ul>	<ul style="list-style-type: none"> <li>High reliability</li> <li>Broad coverage of network</li> <li>Low latency</li> </ul>
<b>Entertainment</b>	<ul style="list-style-type: none"> <li>Immersive gaming and media industry</li> <li>Multimedia experience at 4k, 8K resolution</li> </ul>	<ul style="list-style-type: none"> <li>Video streaming</li> <li>Augmented reality/Virtual reality</li> </ul>	<ul style="list-style-type: none"> <li>Large bandwidth</li> <li>Low latency</li> </ul>

Contd.....

Verticles	Drivers	Enablers	5G Requirements
<b>Automotive / Autonomous Cars</b>	<ul style="list-style-type: none"> <li>Collision avoidance</li> <li>Intelligent navigation and transportation systems</li> </ul>	<ul style="list-style-type: none"> <li>Vehicle-to-vehicle (V2V),</li> <li>Vehicle-to-infrastructure (V2I) and other intelligent transport systems (ITS)</li> </ul>	<ul style="list-style-type: none"> <li>Large bandwidth and low latencies (&lt; 5 ms) and high connection reliability (99.999%)</li> </ul>
<b>Smart Cities</b>	<ul style="list-style-type: none"> <li>Connected utilities, Transportation, Healthcare, Education and all amenities</li> </ul>	<ul style="list-style-type: none"> <li>Massive IoT networks</li> <li>Automation</li> <li>Cloud infrastructure</li> <li>Artificial intelligence</li> </ul>	<ul style="list-style-type: none"> <li>Large bandwidth</li> <li>High throughput</li> <li>High connection density</li> <li>Low latencies</li> </ul>

Possible future extensions and verticals might also include the following:

- **Aerospace**
- **Ocean**
- **Threat response**
- **Mobile platform**
- **Terrestrial and distributed computing (Cloud/IoT-fog)**

### Global 5G initiatives

	EU Programs	CHINA	KOREA	JAPAN
<b>Programs</b>	Horizon 2020 /5GPPP/5GIA	IMT2020 Promotion Group	5G Forum	5GMF
<b>Goals/ Outcomes</b>	3GPP+ DECT Enhancements	Focus on 500 kph Mobility	Focus on ITS	Focus on UHDTV, new radio and tech beyond 5G
<b>Key Milestones</b>	In sync with IMT 2020	In sync with IMT 2020	Rollout in 2020 Olympics	3 Pillars UHDTV, 5G, ITS, 2019 Rugby World Cup
<b>Funding Model</b>	EU 5 Billion PPP funding – EU 700 Mn seed funding	2 Billion USD		
<b>Govt.</b>	EU Commission	MIIT, NDRC and MOST		
<b>SDO (Members)</b>	ETSI (>800)	CCSA (474)	TTA (205)	ARIB (189)
<b>Other Participants</b>	Industry/SMEs operators, service providers, researchers		IoT/Cloud/Big Data/Mobile, industry, academia, R&D	



## 5G Industry Progress Around the World



Europe

**2018-2019 Trial**  
 • 3.4 -3.8 GHz  
 • eMBB, IoT



USA

**2017-2018 Trial**  
 • 28 and 39 GHz  
 • Fixed Wireless Access, eMBB



China

**2017 Trial, 2019 Commercial**  
 • 3.4-3.6 and 4.8-5 GHz; uplink sharing with sub-2 GHz  
 • eMBB, NB-IoT



Korea

**2017 Trial, 2019 commercial**  
 • 28 GHz, 3.4-3.7 GHz  
 • eMBB



Japan

**2017 Trial, 2020 Commercial**  
 • 3.6-4.2 and 4.4-4.9 GHz, and 28 GHz  
 • eMBB

## INDIA Specific Challenges Using TECHNOLOGY to Leapfrog Socio-Economic Development

	Area (million sq km)	Population (in Billion)	GDP nominal (Trillion \$)	Average Watts/ Person
USA	24.71	0.579	38.1	1378-USA
Europe	10.18	0.743	19.07	651 - EU
USA + Europe	34.89	1.323	57.0	
China	9.597	1.379	11.2	492
India	3.287	1.324	2.64	87

### Unique Challenges:

1. Rural Broadband for all – Fibre to Villages
2. Diversity ++  
 - language  
 - culture  
 - last mile  
 - geographical
3. Greenfield deployment
4. Leapfrog Technology Solutions

## Networking Architecture of 5G

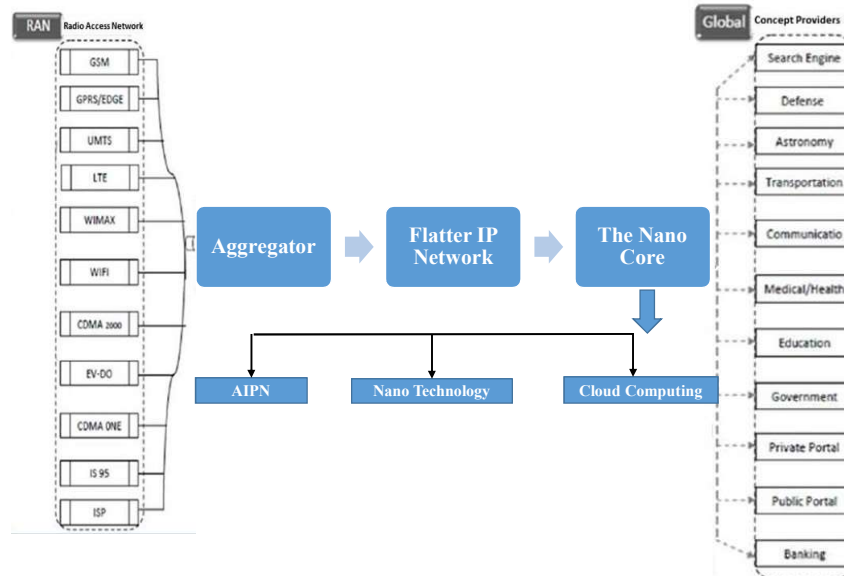
### ➤ OSI Layers

### 5G mobile network layer

Application Layer	Application(Service)
Presentation layer	
Session Layer	Open Transport Protocol
Transport Layer	
Network Layer	Upper network layer
	Lower network layer
Datalink Layer	Open Wireless Architecture
Physical Layer	

- **OWA-Open Wireless Architecture** layer is to be used as **Physical Layer + Data link Layer**.
- **Network Layer** is divided into two sub layers
  - 1) **Lower Network Layer**
  - 2) **Upper Network Layer**
- **Network Layer** is used to route the data from source to destination.
- **Open transport layer** perform the operation of both **Transport Layer** and **Session Layer**.
- **Transport Layer + Session Layer=OTL**.
- **Application Layer** marks the data into proper format i.e. ,it decrypt the data which is in encrypted form and selects the best wireless connection for a given service.

## DATA TRANSFER ARCHITECHTURE OF 5G



### RAN

A radio access network (RAN) is part of a mobile telecommunication system. It implements a Radio Access Technology. Conceptually, it resides between a device such as a mobile phone, a computer, or any remotely controlled machine and provides connection with its core network.

### FLAT IP NETWORK

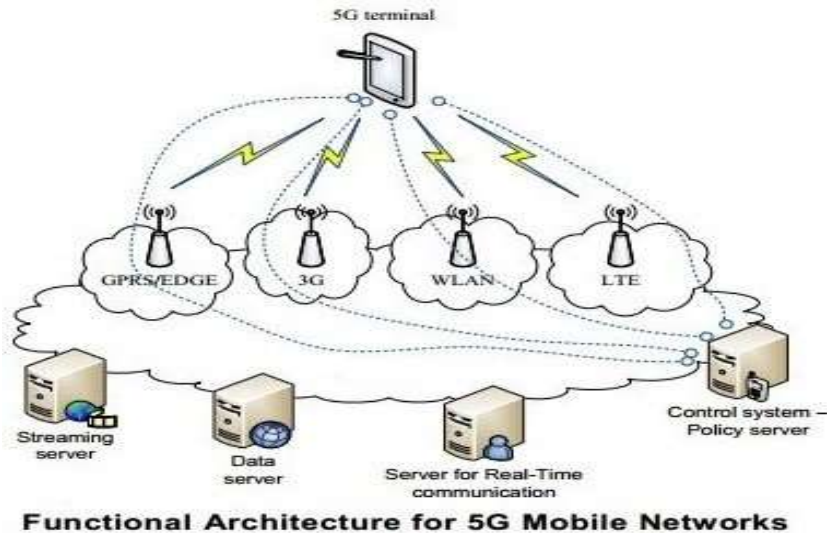
Certainly Flat IP network is the key concept to make 5G acceptable for all kind of technologies. To meet customer demand for real-time data applications delivered over mobile broadband networks, wireless operators are turning to flat IP network architectures.

### 5G NANOCORE

The 5G Nanocore is a convergence of below mention technologies. These technologies have their own impact on exiting wireless network which makes them in to 5G.

- Nanotechnology.
- Cloud Computing.
- All IP Platform.

## FUNCTIONAL ARCHITECTURE OF 5G



### ❖GPRS (General Packet Radio Service)

- a) It is used to transmit data at 60kb/sec.
- b) It consume less battery during sending & receiving mail or browsing internet.

### ❖EDGE (Exchanged Data Rate for GSM Evolution)

- a) It is an advance version of GPRS .
- b) It provide a data speed of 473kb/sec.

### ❖3G

- a) 3G makes it possible to do video call on mobile network.
- b) It also provide efficient way to browse internet on mobile networking.

### ❖WLAN( Wireless LAN)

- a) Wireless LAN provides short range, high speed wireless data connection between mobile data device using radio or signal.

### ❖ LTE(Long Term Evolution)

- a) LTE is standard for mobile communication for high speed data transmission for mobile network. Its Speed is up to 100mb/sec.

### ➤ Nano Technology :-

Nanotechnology is the application of nano science to control process on manometer scale. i.e. between 0.1 and 100nm. The field is also known as molecular nanotechnology (MNT). It deals with control of the structure of matter based on atom-by-atom and molecule by molecule engineering. The term nanotechnology was introduced by Nori Taniguchi in 1974 at the Tokyo international conference on production engineering.

### ➤ Cloud computing :-

Cloud computing is a technology that uses the internet and central remote server to maintain data and applications. In 5G network this central remote server will be our content provider. Cloud computing allows consumers and business to use applications without installation and access their personal files at any computer with internet access. The same concept is going to be used in Nanocore where the user tries to access his private account from a global content provider through Nanocore in form of cloud.

### ➤ The All-IP Network (AIPN) :-

The All-IP Network (AIPN) is an evolution of the 3GPP system to meet the increasing demands of the mobile telecommunications market. To meet customer demand for real-time data applications delivered over mobile broadband networks, wireless operators are turning to flat IP network architectures.

## Principle Of Data Transmission

- In 5G mobile IP, each cell phone is expected to have a permanent "home" IP address, along with a "care-of" address that represents its actual location.
- IPv6 is needed for many addresses and the multiple layers of sub netting.
- 128 bits (4 times more than current 32 bit IPv4 address) may be divided into four parts (I thru IV) for supporting different functions. The first 32-bit part (I) may be defined as the home address of a device while the second part (II) may be declared as the care-of address allowing communication between cell phones and personal computers.

## **Hardware Used in 5G**

- **Uses UWB (Ultra Wide Band) networks with higher BW at low energy levels.**
- **BW is of 4000 Mbps, which is 400 times faster than today's wireless networks**
- **Uses smart antenna**
- **Uses CDMA (Code Division Multiple Access) and BDMA ( Beam Division Multiple Access)**

## **Software Used in 5G**

- **5G will be single unified standard of different wireless networks, including WLAN technologies, LAN/WAN, WWW- World Wide Wireless Web, unified IP & seamless combination of Broadband Access**
- **Software Defined Radio, Encryption, Flexibility, Anti-Virus**

## **ADVANTAGES**

- ❖ **Data Bandwidth of 1Gbps or higher.**
- ❖ **Dynamic information access.**
- ❖ **Available at low cost.**
- ❖ **Finest Quality Of Service(QOS).**
- ❖ **Pages will upload almost instantly.**
- ❖ **Support interactive multimedia, voice, streaming video, Internet, and other broadband services.**

## **DISADVANTAGE 5G**

- ❖ **Since 5G services are likely to run on ultra-high spectrum bands, which travel shorter distances compared with lower bands, they may be more suited to enhanced indoor coverage.**
- ❖ **Higher frequencies could be blocked by buildings and they lose intensity over longer distances. That means, offering wider coverage would be a challenge.**

## APPLICATIONS

- ❖ Wireable devices with AI(Artificial Intelligence) capabilities.
- ❖ 5G iPhones.
- ❖ With 6<sup>th</sup> Sense technology.
- ❖ Global Networks.
- ❖ VoIP(Voice Over IP) enabled devices.
- ❖ Radio resource management.
- ❖ Media independent handover.

## Recommendations for 5G Roadmap & Evolution in India- Becoming Technology Provider

- Accelerate investment strategies for R&D
- Enable visibility into future technology trends
- Concentrate efforts toward future solutions so benefits are maximized for the industry
- Contribute to and be informed of common perspectives in a timely way to address the shared needs and challenges faced in the evolution to the future state
- Be aligned with pre-competitive solutions that can be implemented in collaborative environments, as well as in the competitive domain
- Explore unique innovations to provide potential solutions where it serves individual stakeholders within industry to do so
- Leverage R&D costs through resulting collaborations and partnerships or benefit from the results of enabled research activities
- Regulatory frameworks should embrace the principle of technology and service neutrality ("generation neutral" regulations) for the smooth introduction of the latest available technologies and services in existing and new bands that will be made available for 5G



## **CONCLUSION**

- ❖ **5G technology is going to be a new revolution in wireless systems market ( Industry 4.0).**
- ❖ **5G will be User Centric and Ubiquitous.**
- ❖ **5G is the next frontier of innovation for entire mobile industry.**
- ❖ **5G - a promising Generation of wireless communication that will change people's lives.**

## **Evolution of Last Mile Technologies-Next Generation Access**

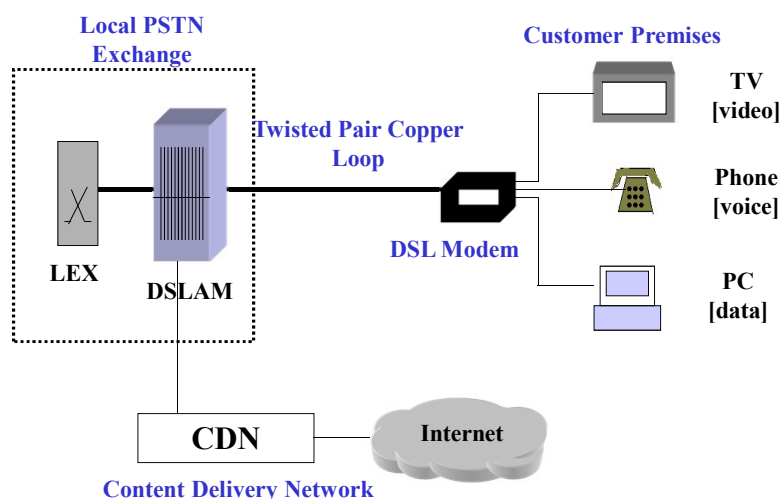
- **Use of Coaxial Cable for Telecom Services (Cable TV Network for Broadband and telephony local loop).**
- **Use of XDSL technologies on traditional Copper Loops.**
- **Wireless Broadband Access for Fixed and Mobile communication.**
- **VSAT-based Access in remote areas.**
- **Power line based Access (BPL), Li-Fi**
- **Free Space Optics (FSO), Fi-Wi**
- **FTTX ( FTTC, FTTP, FTTB, FTTH, FITH, GPON)**

## Technology Alternatives for Wireline Broadband Access

### Evolution of Wireline Technologies

- i) Use of Digital Subscriber Loop (DSL) technology on traditional Copper Loops (DIY, Franchising, Shared Unbundling, Bit stream)/ Active Loop Access, VULA)
- 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, 2 Km
  - Very high Data Rate DSL (VDSL) – 52 Mbps, 1.5 Km
  - Vectoring with VDSL (Vec.VDSL2+)- 100Mbps, 1.5 Km.
  - Bonding+Vectoring+MIMO- 800Mbps, 1.5Km
  - G.fast (ITU)- 1Gbps, 1.0 Km.

### Broadband over copper loop (DSL)- Triple Play



### Cable TV Networks for Broadband Access

- Broadband over cable TV accounts for 75% of total connections in US, and more than 50% in Canada
- 120 million cable homes in India ( against 25M Cu loops), a majority of these support bi-directional communication after digitalisation
- Regulatory environment, via an ISP license, allows this with some MSO's and operators already doing so. Digitalisation is helping the same.
- For advancements to occur, better organization of the industry needed to be implemented
- Cable operators will need to adopt innovative business models to compete in converged environment through broadband services
  - Possible to provide enhanced 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 some Cable TV network which are still uni-directional can be used for downloading, the uplink to be conventional narrow band like dialup/ RADIO
- Operators need training to create awareness about utility of their networks and understanding of the investments required, returns possible, and technical aspects

#### iii) Fiber Optic Cable Technologies

- Fiber To The Curb (FTTC) – by existing operators
- Fiber To The Home (FTTH) – Fiber in last mile to deliver converged services
- Hybrid Fiber Coaxial (HFC) – by Cable TV operators
- GPON (Gigabit - Passive Optical Network) – triple play over FTTH (20Km of distance and 100Mbps of download speed)

#### iv) Broadband over Power Line (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 not available
- Li-Fi- Using LED as Wi-fi Access point

#### v) Metro Ethernet Networks (MEF)

- Use of Ethernet beyond LAN through Fiber
- Use of high-speed access using hybrid fiber/ copper based Ethernet
- Power over Ethernet (POE)
- Ethernet over Copper (EOC)
- Fi.Wi- Taking Fiber to the Tower ( Antenna), Direct to Radio
- POW ( Power over Wi-fi )

### Mobile Access Technologies Trends

- GSM, GPRS, CDMA, EVDO, 802.11 ( WLAN, Wi-Fi) 802.16d/e (Fixed/Nomadic Wimax), PTT, Bluetooth, UWB, 3G- Already legacy.
- 802.11n/ac/ax, Hot-spot 2.0, OFDMA, HSPA, MIMO, LTE (4G), All-IP cellular networks- Getting matured and heading towards saturation.
- Human Area Network (HAN) associated with body/ clothing, Wearable-Becoming a reality.
- Fixed Mobile Convergence(FMC) leading to inter-operability of handsets for any type of access – Quad Mode Multi Band handsets. (WiFi,LTE, GSM, CDMA)-UMA (Unlicensed Mobile Access).
- Software Defined Radios (SDR) – Multi-Functional, Multiservice, Multiprotocol, Multiband, Multimode (Universal) Radios.
- Cognitive Radio (CR)/Intelligent Radio-Use of White Spaces, Dynamic Spectrum Sharing, Li-fi, White-fi, Gi-fi.
- 5G(IMT-2020)-Unlimited BW,20GBPS,Latency<1ms,1M in IKM, Ubiquitous

### Broadband Wireless Access (BWA) Technologies

<i>Technology</i>	<i>Max Throughput</i>	<i>Frequency Bands</i>	<i>Typical Range</i>	<i>Application</i>
WiFi (802.11x)	54 Mbps/ 11 Mbps	2.4 G, 5.1 G	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
LTE(IMT-adv,4G)	100 Mbps	2.1,2.3,2.5,3.3G	Unlimited(Cellular)	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 – BWA (IMT and Advanced)

	UMTS (3G)	HSPA	EVDO (3G)	802.16 a/d	802.16e	IMT Advanced (4G)
<b>Bandwidth</b>	5 MHz	5 MHz	1.25 MHz	1.25-20 MHz	1.25-20	5-20 MHz
<b>Typical Spectrum</b>	1.9-2.1 GHz	1.9-2.1 GHz	450-1900 MHz	2.3-5.8 GHz	2.3-5.8 GHz	Various
<b>Downlink Peak Rate</b>	0.4 bps/Hz	2.9 bps/Hz	2.5 bps/Hz	3.2 bps/Hz	3.2 bps/Hz	2.4-3.6 bps/Hz
<b>Uplink Peak Rate</b>	0.4 bps/Hz	0.4 bps/Hz	1.4 bps/Hz	2.4 bps/Hz	2.4 bps/Hz	2.4 bps/Hz
<b>Typical Data rate</b>	2Mbps	20 Mbps	4 Mbps	52 Mbps	52 Mbps	>100 Mbps
<b>Typical Latency</b>	300 ms	300 ms	250 ms	<150 ms	<150 ms	<50 ms
<b>Flat IP Support</b>	No	No	No	Yes	Yes	Yes
<b>Mobility</b>	Full	Full	Full	Fixed	Limited	Full

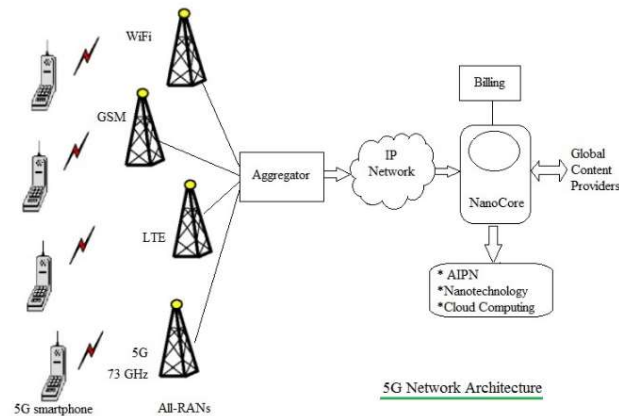
### About 5G

- 5G simply stands for fifth generation and refers to the next and newest mobile wireless standard based on the IEEE 802.11ac standard of broadband technology, although a formal standard for 5G is yet to be set
- 5G mobile technology has changed the means to use cell phones within very high bandwidth.
- According to the Groupe Special Mobile Association (GSMA) to qualify for a 5G a connection should meet most of these eight criteria:
  - Up to 10Gbps data rate - > 10 to 100x improvement over 4G and 4.5G networks
  - One millisecond end-to-end round trip delay
  - 1000x bandwidth per unit area
  - 10 to 100x number of connected devices
  - (Perception of) 99.999 percent availability
  - (Perception of) 100 percent coverage
  - 90 percent reduction in network energy usage
  - Up to ten-year battery life for low power, machine-type devices

## 5G Network Architecture

The 5G network architecture consists of all RANs, aggregator, IP network, nanocore etc. The 5G protocol stack consists of Open Wireless Architecture, lower and upper network layer, open transport protocol and application layer

### 5G TECHNOLOGY RELATED LINKS



## Features of 5G

- Greater speed (enough to download a movie in few seconds)
- Greater capacity(1,000 times capacity of 4G)
- Reduced Latency(stop delays)
- Provide high resolution and larger bandwidth
- It will gather networks on one platform
- Lower battery consumption
- Simultaneous connections can work together
- Provide uninterrupted and consistent connectivity.
- Allow access to parallel multiple services
- The remote diagnostics also a great feature of 5G technology

## Technological Challenges for 5G

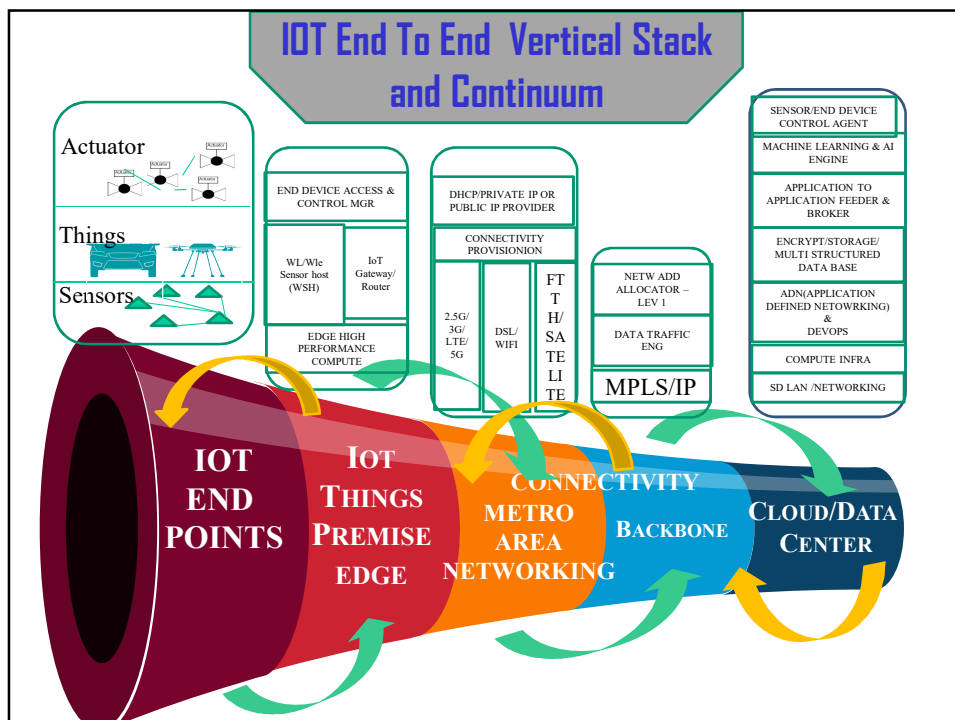
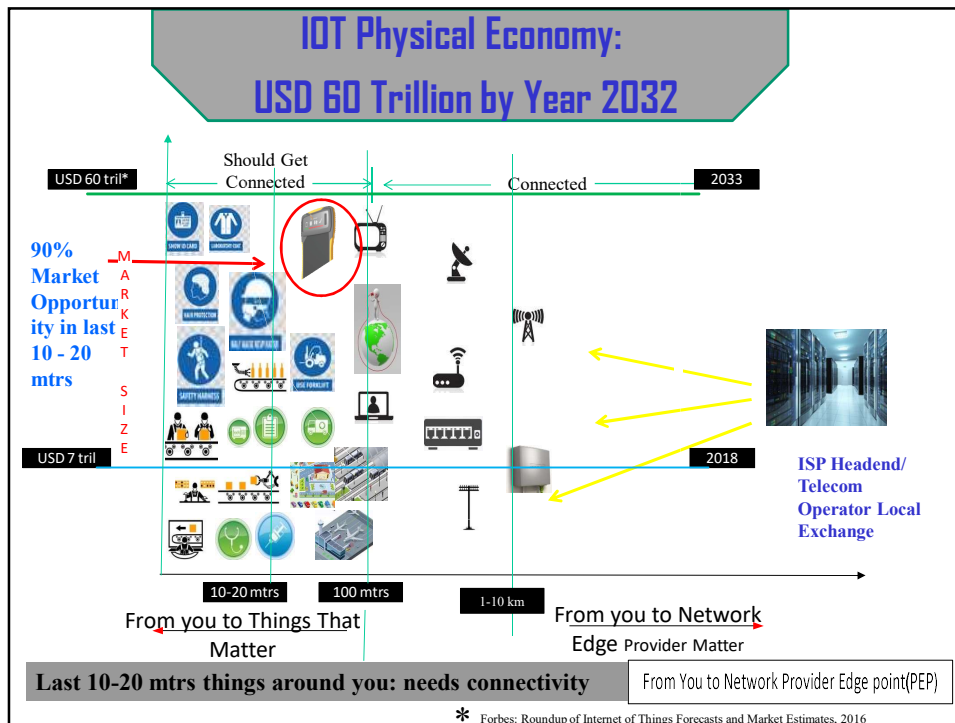
- Inter-cell Interference - There is variations in size of traditional macro cells and concurrent small cells that will lead to interference.
- Efficient Medium Access Control - In a situation, where dense deployment of access points and user terminals are required, the user throughput will be low, latency will be high, and hotspots will not be competent to cellular technology to provide high throughput.
- Traffic Management - Machine to Machine (M2M) devices in a cell may cause serious system challenges i.e. radio access network (RAN) challenges, which will cause overload and congestion.

## IOT

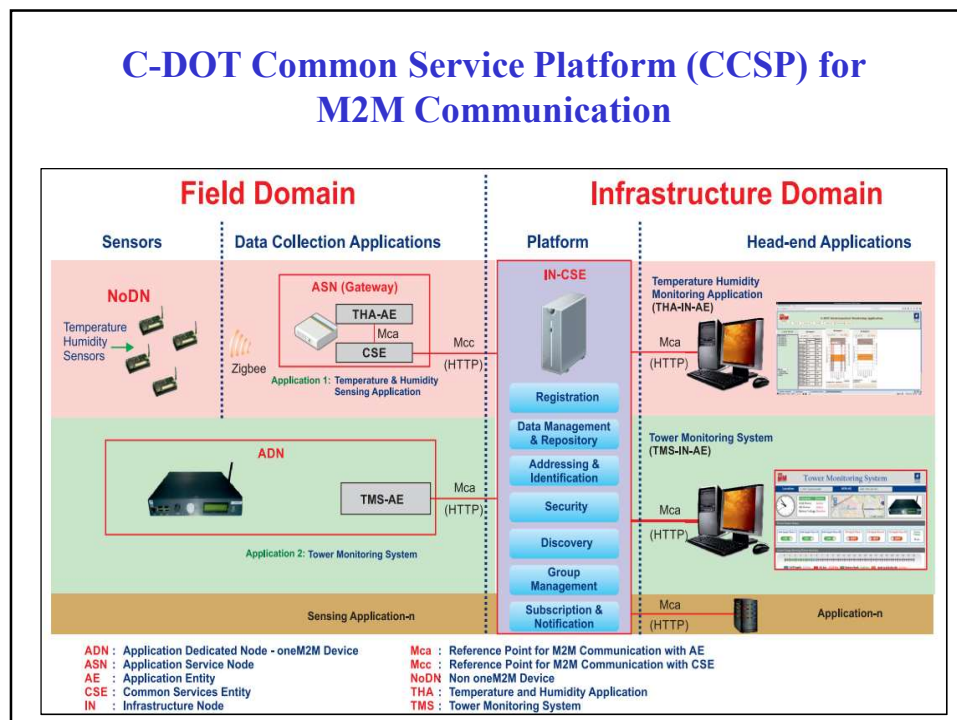
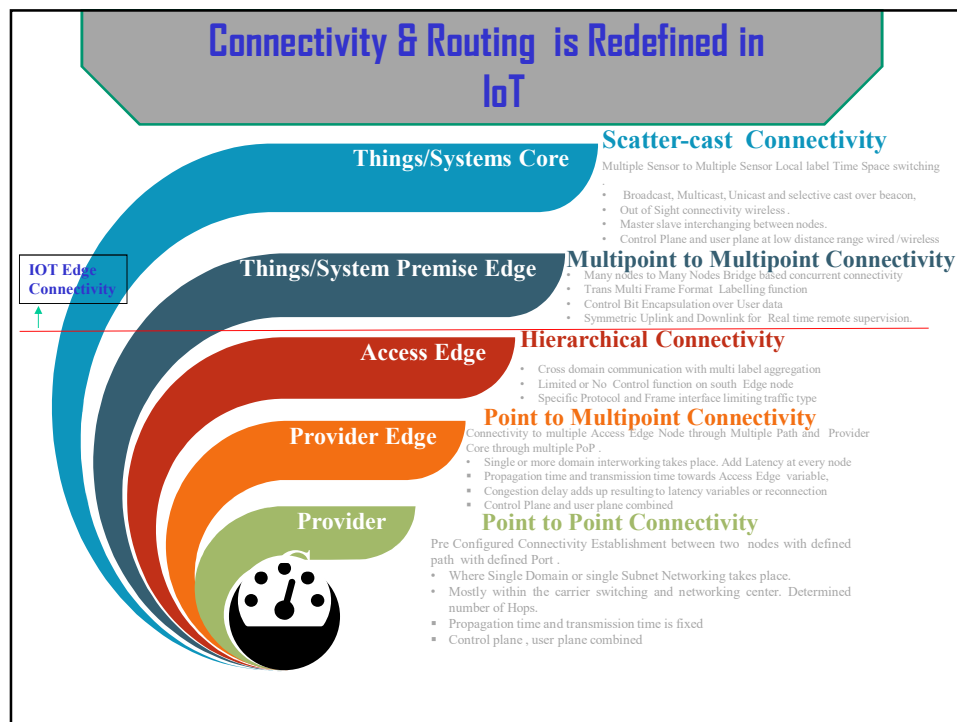
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## Information Technology + Operation Technology

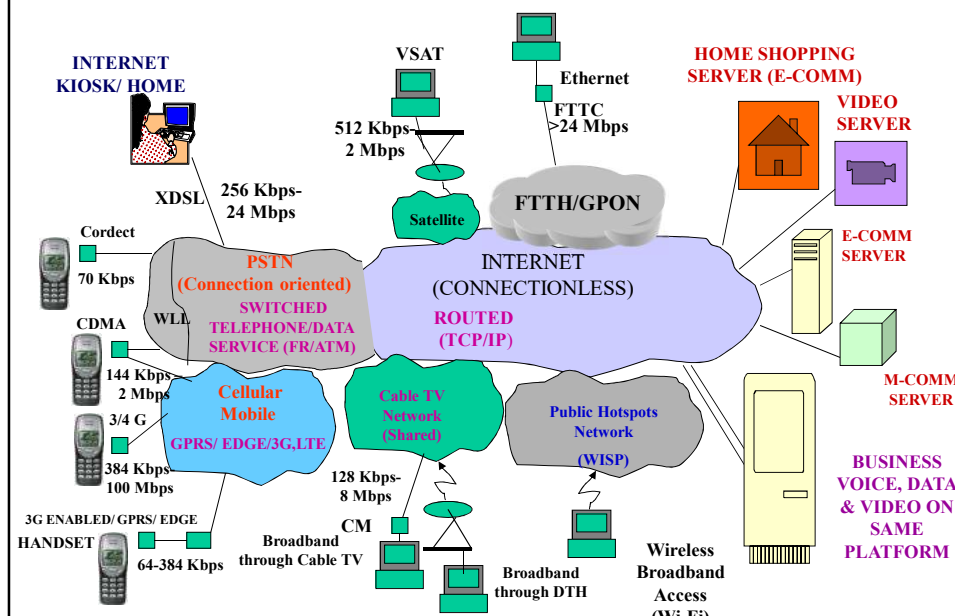
- Internet of Things( IoT) can be taken as **Internetworking Operational Technologies(IOT)**
- Notice how many events/operations are performed through Digital Interworking of Operational Technology with multiple Sensors. ..
- **In IOT – Industrial or Non Industrial, the connectivity is redefined**  
As End to End latency in 2 digit millisecond matters beyond the edge
  - ✓ A Symmetric Uplink and Downlink of a deterministic bit stream is required at last mile by the Edge Node.
- The forecast of ~ 30 billion device connectivity by 2025 will happen though, but this time all device management will not be by Telecom Service Provider alone, but also by Other Service Provider like Cloud Service Provider, ISP, Cable TV Provider, Things Interconnect Provider, etc.







## Enabling Broadband Access–Technology Neutrality (Making use of existing infrastructure & wireless)



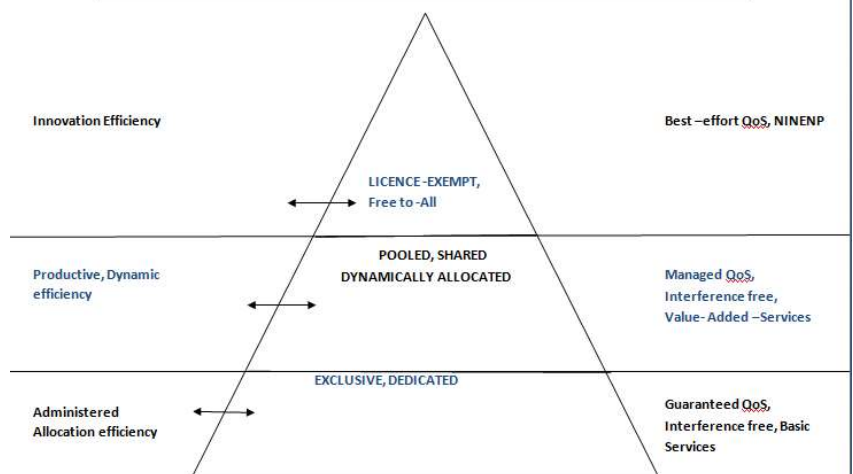
## Emerging Cloudification Applications - “E-a-a-S”

<b>Voice over IP</b>	<b>Unified Messaging</b>	<b>BB - High Speed Internet</b>
<b>Primary line</b>	<b>Content Delivery</b>	<b>PC to Phone</b>
<b>Second line</b>	<b>Games</b>	<b>Phone to PC</b>
<b>IP Centrex usage</b>	<b>Downloads (MP3)</b>	<b>IP VPN (data)</b>
<b>Voice VPN</b>	<b>Gambling</b>	<b>BW on-demand</b>
<b>IP Centrex</b>	<b>Video on demand</b>	<b>QOS on demand</b>
<b>SMS over IP</b>	<b>TV on demand</b>	<b>Quad play</b>
<b>Virtualisation</b>	<b>Cinema of the future</b>	<b>Instant messaging</b>
		<b>Presence management</b>
<b>Multimedia</b>	<b>Long distance bypass</b>	<b>MMS on fixed network</b>
<b>Conferencing</b>	<b>Tele Presence (TP)</b>	<b>Location Based Services (LBS)</b>
<b>IPTV</b>		<b>FMC (Fixed Mobile Con.)</b>
	<b>IP Offload (3G),</b>	<b>3G &amp; beyond applications</b>
<b>Distance learning</b>	<b>VO Wi-Fi</b>	<b>POW (Power Over Wireless)</b>
<b>Distant arrangement</b>	<b>VoLTE, VoLGA</b>	<b>E.Num</b>
<b>Remote lab</b>		

## Spectrum Utilization Trends

- Radio Spectrum availability is key to the success of exploitation of new technology trends.
- Being a limited resource, new technological evolution 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 ,etc.
- Use of Adaptive, Intelligent Antenna Array , OFDM and Scattering.
- Enhancing the information carrying capacity of radio spectrum by Multi-level Modulation, MIMO, Compression, AMR Coding, DTX, DSI ,OFDM, Spectrum Sharing,Dynamic Spectrum Exchange, etc. to move towards Shannon's limit ,  $C = B \log_2(1+S/N)$ .

### Layered Approach for Spectrum Allocation



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### Trend Towards Convergence – Fueled by 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 capable of guaranteed QOS and high level of Security, Reliability and Flexibility.
- Emergence of single “Information Plug” (Quad- Play).
- Customers aspiration – Better, Faster, Cheaper, One Stop Shop, Single/No Bill- “Sasta( Freepium), Sunder aur Tikau”.

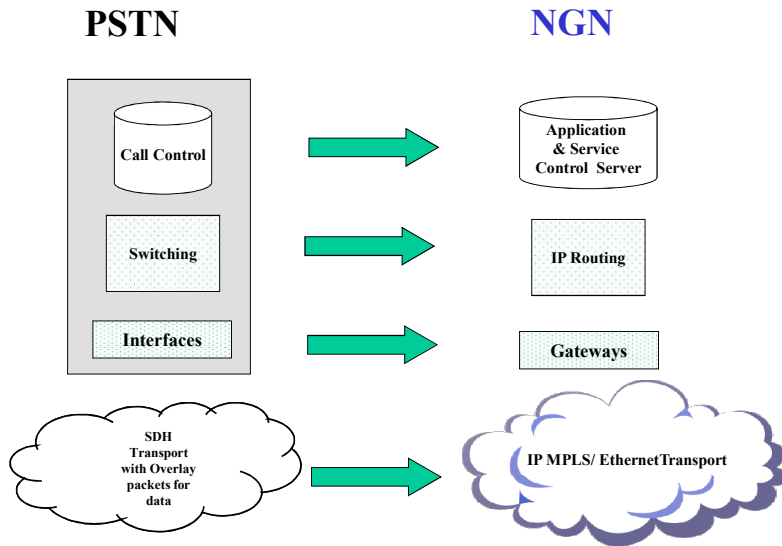
### Definition of Next Generation Network (ITU)

“NGN is a Convergent, Multimode (fixed and mobile) access platform based on the IP and horizontally integrated (Recommendation ITU-T Y.1001) and consolidating the Technologies, Network solutions and the electronic communication Services such as Data, Voice, Audiovisual Content or other Applications. It has a Layered, Packet mode Architecture (Recommendation ITU-T Y.2001), facilitating the delivery of multiple Services over a single Infrastructure.”

**This Architecture includes:**

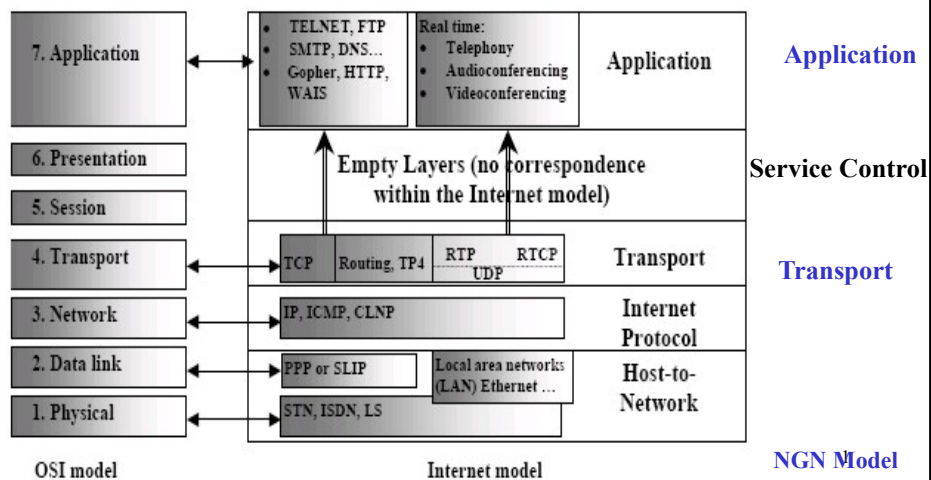
- Application layer (APIs);
- Service Control layer independent of physical Infrastructure;
- Packet-mode Transport/Access layer (ATM, IP, etc.);
- Standardized Open Interfaces between layers (ANI, NNI, UNI)

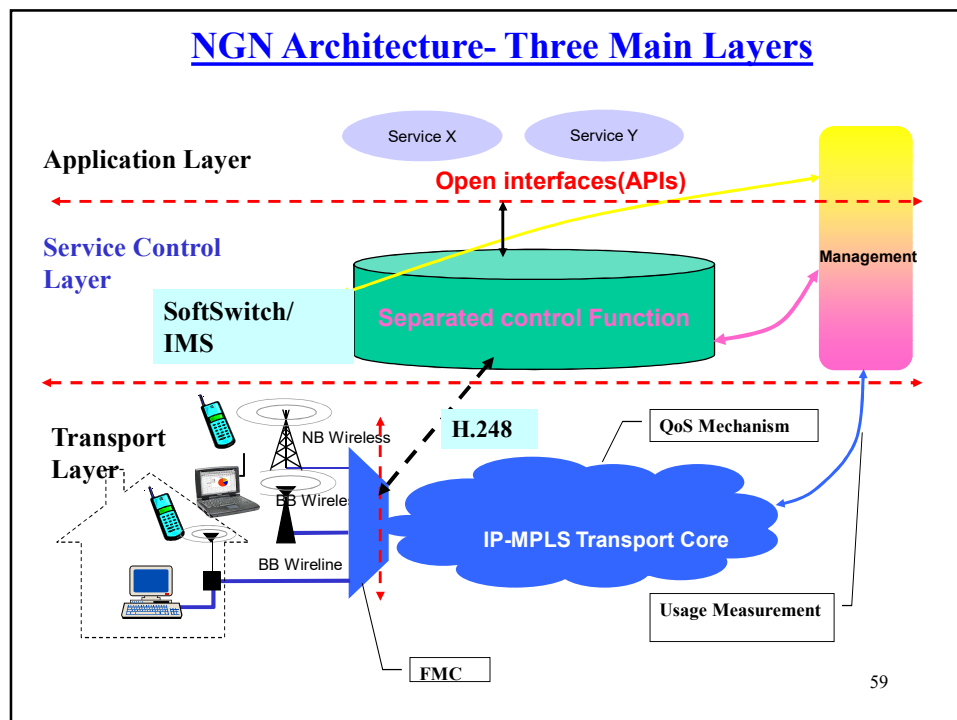
## NGN V/S PSTN Elements



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## All-IP NGN Architecture – Layered Approach





- ### What is All IP-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, LTE, Cable TV, FTTH, PLC)
  - Next Generation Transport - Packet Transport Network (PTN)
  - Next Generation Architecture – Service oriented, Layered (Transport, Control, Application)
  - Next Generation Mobile – VoLTE, IMT-Advanced, 4G, IMT-2020(5G)
  - Next Generation Internet – IPv6
  - Next Generation Interconnect – Capacity and Quality based
  - Next Generation Licensing – Unified and Class Licensing
  - Next Generation Regulation – Converged (Single Regulator for ICE)
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### Advantages of All-IP NGN

NGN makes use of best of both the worlds (flexibility, efficiency & Innovativeness of IP and QOS, Security, Reliability, Customer-friendly features of proven PSTN

#### •*Advantages for Service Providers*

- ✓ Reduced CAPEX due to integrated and efficient IP-based technology (Packetize or Perish)
- ✓ Reduced OPEX due to transmission cost saving, less power consumption, less space requirement, less O&M costs
- ✓ Ability to offer increased range of services
- ✓ More flexibility increasing market penetration by offering personal service, customization and management
- ✓ Single network layer for management
- ✓ Avoidance of separate voice, broadcast and data networks

#### •*Advantages for Customers*

- ✓ Reduced charges due to efficient operation and competition
- ✓ New innovative services at a fast speed and free of cost ( Freepium)
- ✓ Single connection and bill for voice, data, video, mobile (Quad play)
- ✓ Control of application service for flexibility

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### Fundamental characteristics of All-IP NGN

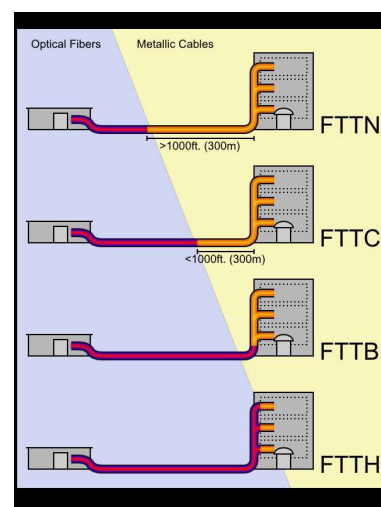
- Packed Based Transport
- Separation of control functions among bearer capabilities, call/session, and application service
- Decoupling of service provision from network, and provision of open interfaces i.e, separation of service-related functions from underlying transport technologies
- Support for a wide range of services, applications and mechanisms based on service building blocks (including real time/ streaming/ non-real time services and multi-media, Triple-play)
- Broadband capabilities with end-to-end QOS and transparency
- Inter-working with legacy networks via Media Gateways
- Generalized mobility support
- Unrestricted access by users to different service providers
- A variety of identification schemes which can be resolved to IP addresses for the purposes of routing in IP networks
- Unified service characteristics for the same service as perceived by the user
- Converged services between Fixed/Mobile (FMC)
- Compliant with all Regulatory requirements, for example concerning access to Emergency services and Security monitoring (LIM)/Privacy, etc.

## Options for Next Generation Access (NGA)- Fixed

	ADSL	ADSL2+	FTTC (+VDSL)	FTTH (Buildings)
Downstream Headline	8 Mbit/s	24 Mbit/s	40 Mbit/s	100 Mbit/s
Downstream Typical	5 Mbit/s	10 Mbit/s	20 Mbit/s	50 Mbit/s
Upstream Headline	0.8 Mbit/s	0.8 Mbit/s	10 Mbit/s	30 Mbit/s
Upstream Typical	0.4 Mbit/s	0.4 Mbit/s	5 Mbit/s	15 Mbit/s
Cost of Deployment	USD 75/Line (Existing Cu Line)	USD 100/line (Existing Cu Line)	USD200/ line	~USD 250/line

## NGA Deployment Scenario- FTTX

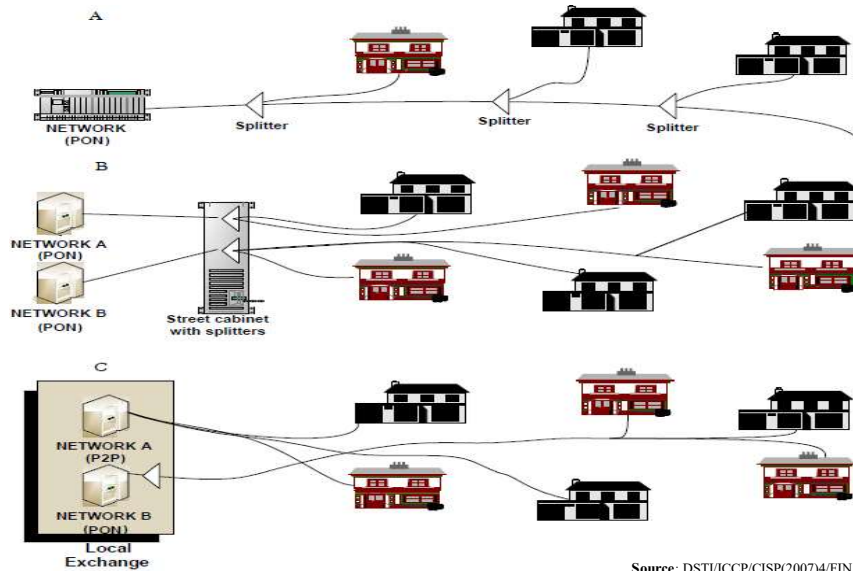
- **FTTN**
  - Fiber-to-the-node
- **FTTC**
  - Fiber-to-the-cabinet/curb
- **FTTB/P**
  - Fiber-to-the-building/premises
- **FITH/FTTH**
  - Fiber-in-the-home



Source: Wikipedia

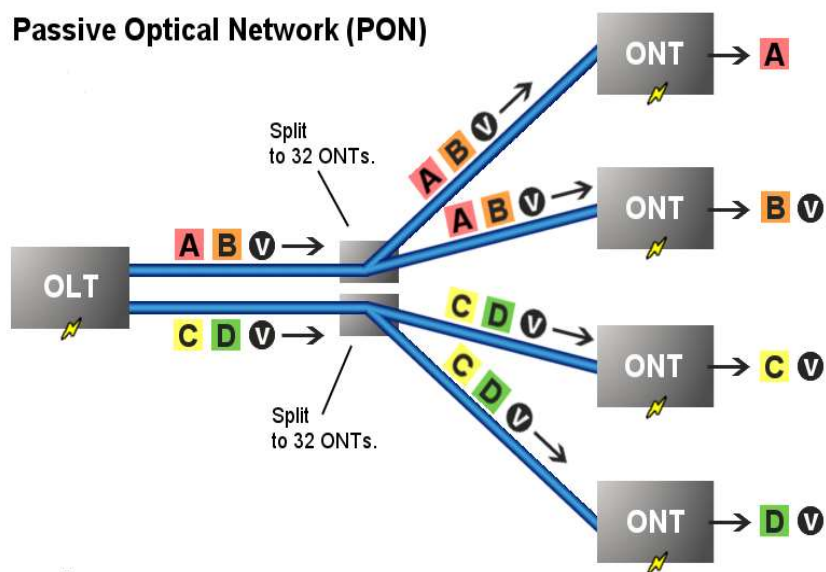


## PON (Passive Optical Network) Topologies



## PON - TDM

### Passive Optical Network (PON)



## Future of Next Generation Access (NGA) – Fiber In the Home (FITH)

1. Enables Superfast Broadband applications to customers. (>100MPBS)
2. Green technology
3. Future proof
4. Enables real-time High Definition Multimedia, Convergence, Collaboration, Work-from-Home and Innovations

## IMS –Standard-based Architecture for Service Control

- IMS defines an open IP-based Service Control layer where service intelligence is located in the servers and mobile devices.

- IMS as originally specified by 3GPP, was aiming to enable real-time multimedia services over the IP bearer in GSM and W-CDMA networks.

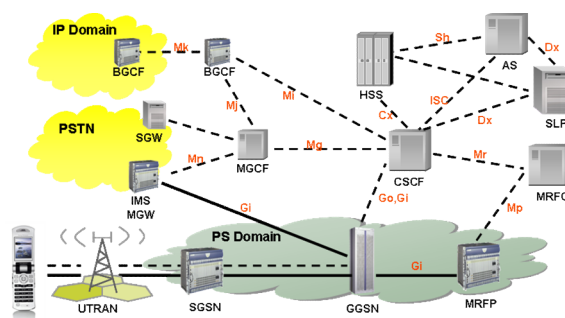
- 3GPP2 defined later the MMD for CDMA2000 networks which is now aligned with IMS.

- TISPAN provided the control specifications for DSL access.

- CableLabs provided the specifications for the cable access and now their work together with 3GPP to incorporate PC 2.0 specifications into IMS release 8.

- Since release 6, interworking with WLAN (Wi-fi) is supported.

- IMS has further evolved to become truly Access-agnostic and server based



### **If IMS is not used:**

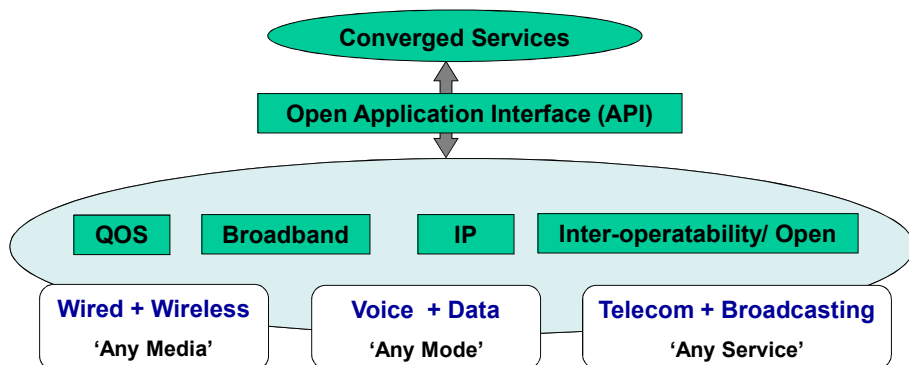
- ✓ Multimedia communication at best effort
- ✓ Service orchestration can be complex
- ✓ Service roaming can be difficult to implement
- ✓ Provisioning and charging are service specific
- ✓ Future Virtualisation can be an issue

## IMS- Compelling Salient Features

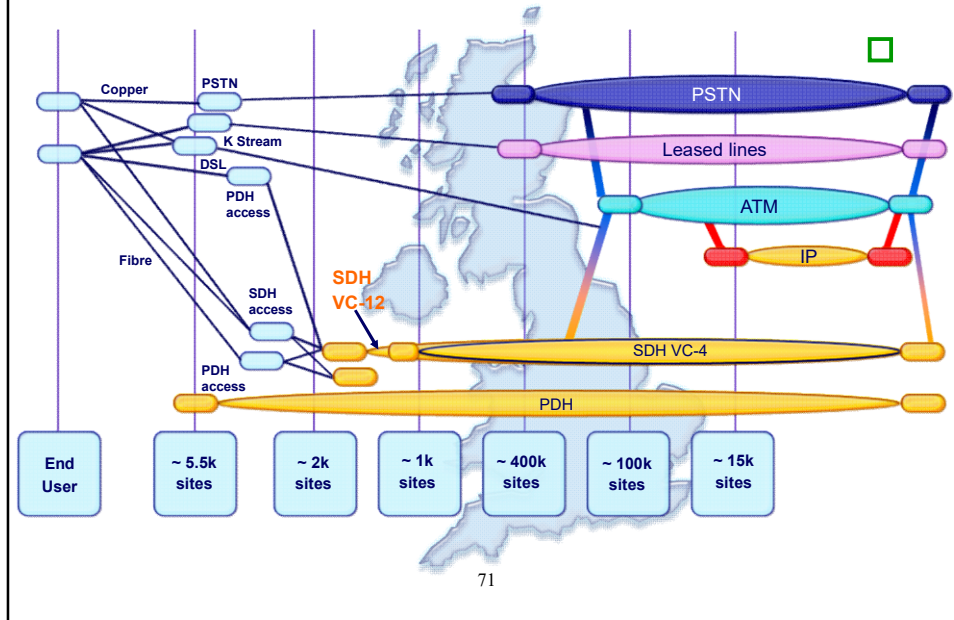
- Being Open and Flexible, advantages over other systems like Softswitch ( Proprietary, Hardware-based, Rigid):
- Independent of a particular access technology
- Integrated mobility for all network applications
- Easier Convergence of applications from fixed to mobile users (FMC)
- Faster deployment of new services based on standardized architecture (SOA)
- End of customized applications ( General Purpose, Open)
- New applications such as presence information, videoconferencing, Push to talk over cellular (POC), multiparty gaming, community services , content sharing , multi-media etc..
- Evolution to combinational services, for example by combining instant messaging and voice
- User profiles are stored in a central location
- Deployment based on General Purpose Servers and evolutionary ( Future-proof)

## Next Generation Broadband Converged Network (NGBcN)

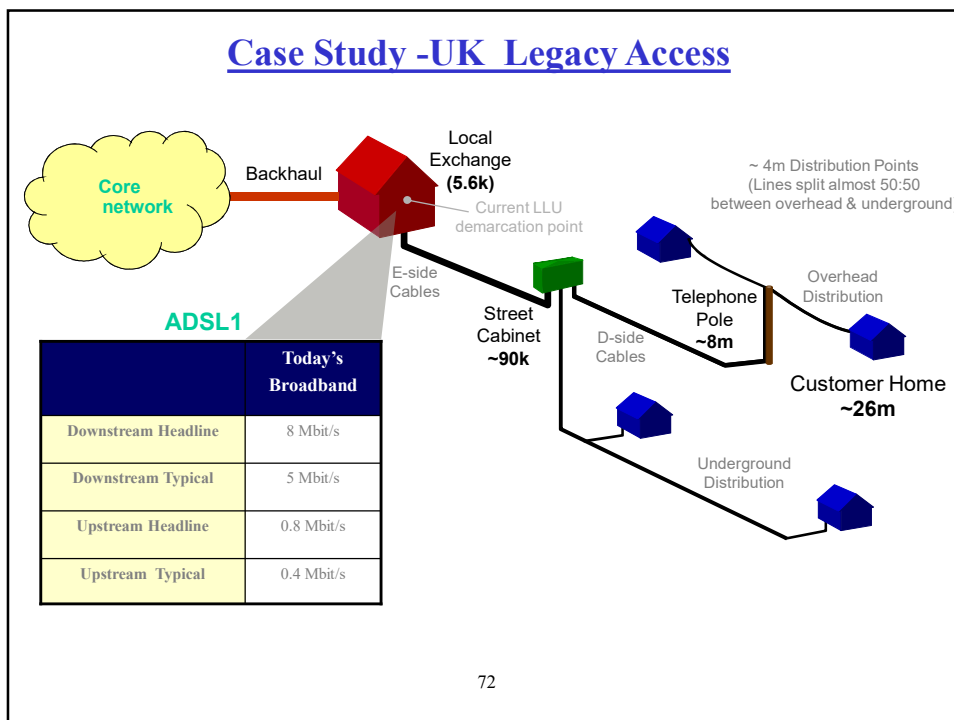
“Next Generation Network(NGN) which provides seamless converged services from Telecom, Internet & Broadcasting infrastructure at any time, anywhere to anywhere, from any device to any device as per the wish of Customer.”



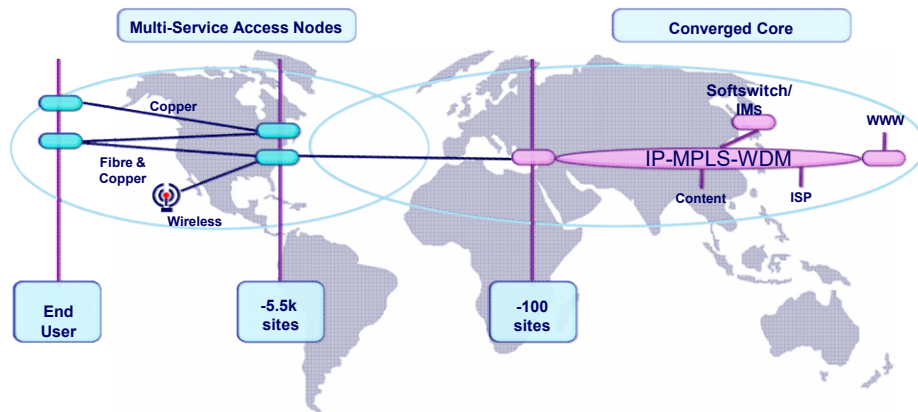
## Case Study-UK Legacy Network



## Case Study -UK Legacy Access



## Case Study-Next Generation Network, BT's 21CN



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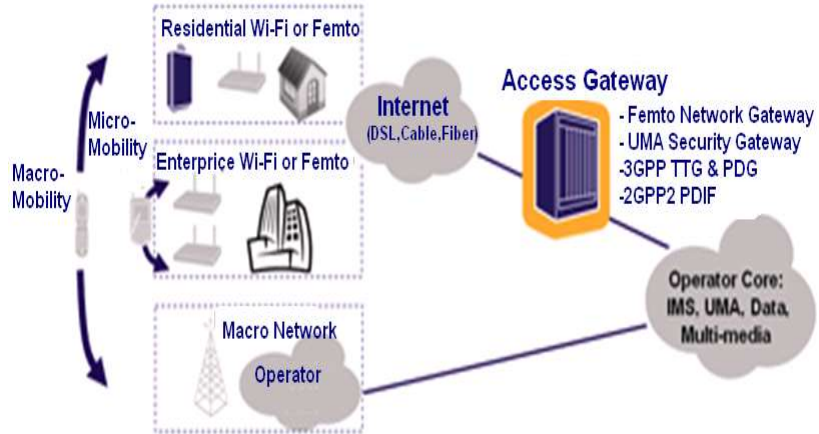
## Fixed Mobile Convergence (FMC) – A compelling NGN application

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/Bluetooth Broadband network on mobile phone.

Main motivation for this is :-

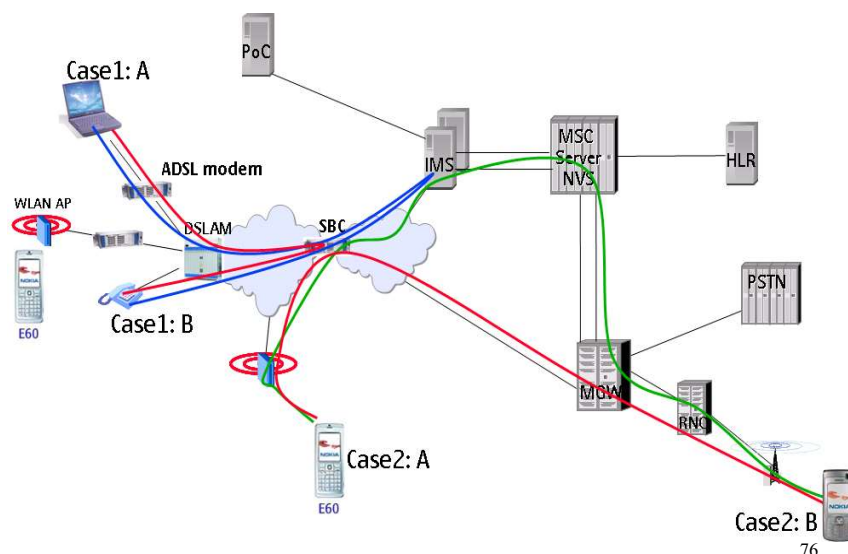
1. **Spectrum shortage leading to congestion and reduced QoS. (It is believed that 70% of the time a mobile call recipient is on a Fixed location/ Wifi-Hot Spot )**
2. **Mobile subscribers saturation, Fixed lines decline (Battle for in-building minutes)**
3. **Broadband becoming ubiquitous and cost effective**
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, Broadband

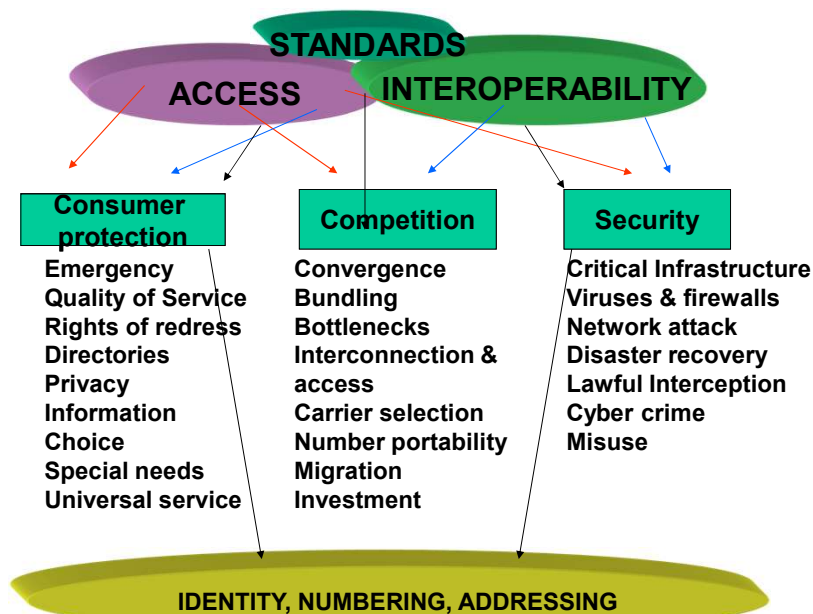


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## FMC Challenges

- **Number plans and number portability**
  - Fixed and mobile numbers come from separate blocks and they have prefixes that contain information for interconnection charging
  - Currently mobile number portability (MNP) available but not fixed/mobile number portability
- **Directory services**
  - Fixed operators provide directory service to their customers. This catalogue contains information on all fixed line customers
  - Currently mobile operators do not offer this kind of service and mobile numbers are considered as personal subscriber data
- **Handset availability**
  - Widespread unavailability of Wi-Fi enabled multi mode handset (always a problem in the early stages of any telecommunications technology)
- **Role of regulators**
  - Permitting interconnection of PSTN and Internet (IP) networks.
  - Determining IP termination charges inline with MTC (mobile termination charges) as a part of IUC.
  - Unify the Numbering system for fixed and mobile , move toward E.Num
  - Regulators should establish the facilitating interconnection rules so that the market forces can guide direction, extent and pace of FMC.

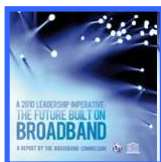
## NGN- Regulatory and Technology Challenges



## UN Vision for Broadband- the New PSTN Avatar (Build and They will Come)

# Build on Broadband and the rest will follow

Broadband needs to be considered as basic national infrastructure, as it will fundamentally reshape the world in the 21st century and change the way services are delivered – from e-health to e-education to e-commerce to e-government.



## What Broadband means for Homes

### TODAY...



**Fast internet...**



**Instant messaging...**



**VoIP, HD voice...**



**IPTV...**



**iPlayer...**

*...But growth of simultaneous usage raises potential peak bandwidth issues for the future*

### TOMORROW...



**Multi viewing High Definition TV..., 3D Mobile TV.**



**Advanced High Definition gaming experience...**



**High Definition video conferencing, Cloud computing, IOE, AI Telepresence, ...**



**A world of possibilities from super-fast broadband, SCAM, AR**

*...Assured high quality experience with simultaneous usage of all new high speed applications and services*



## What Broadband means for SOHO (Offices)



- Bringing big business fibre based services to smaller businesses: speeds > 1 Gigabit



- Improved choice in access speeds providing Home businesses with a competitive edge



- Two way speed allowing collaboration across locations between customers and suppliers



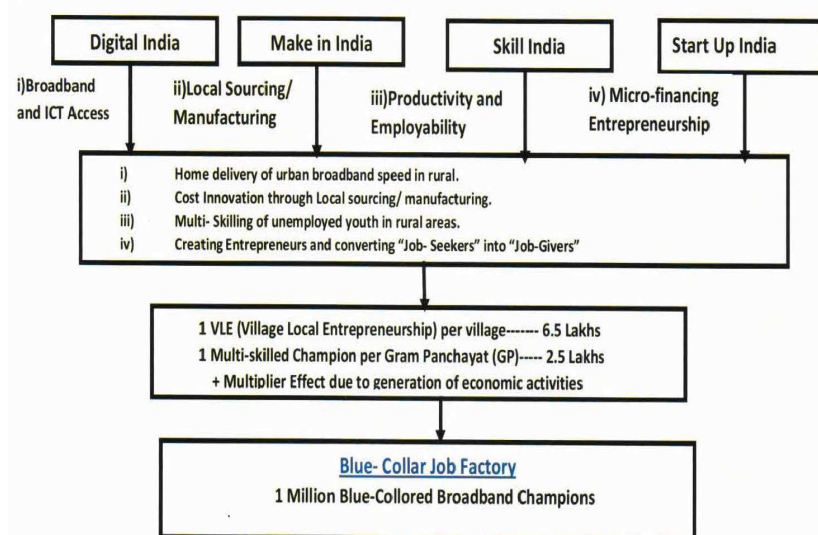
- Improved flexibility in Remote and Home working, Cloud computing, Virtualisation

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## New Delhi- 21<sup>st</sup> Century ( Smart) City

- 70s- Delhi , a City of Villages (38)
- 80s- Became City of Cities- Urbanisation, NCR, Asiad- 82, Color TV Broadcast, FM, Digitalisation of telecom network, Computerisation of Railways reservation, Corporatisation of DTS (MTNL), Establishment of C-DOT.
- 90s- CHOGM, Optical Fiber Trunks, Internet, Mobile, ATMs.
- 2000s- CNG, Broadband, IPTV, CAS, Flyovers, Metro, Teledensity> 100, Mushrooming of Hot-spots, 3G, Privatisation of Power Distribution.
- 2010- Leapfrogging in Infrastructure, CWG-2010, Modern Metro, Green Public Transport, NGN, Tetra, Green Energy, FTTH, IPV6, Femtocells, Establishment of BBNL
- 2015-NGN Core (MTNL), 50% Homes Broadbanded, Cable TV Digitalised, Teledensity>250%, Wirelines Increasing (>3 Mil.) Smart Grid, Muni-Network ( Public Hot-Spots),World largest Metro. Population 17M. Households 4.5 M,200 Urbanised villages
- Per capita income 4,500 USD (3 times of national average)

## Digi.Gaon Job Factory-Creating Rural Intrapreneurship



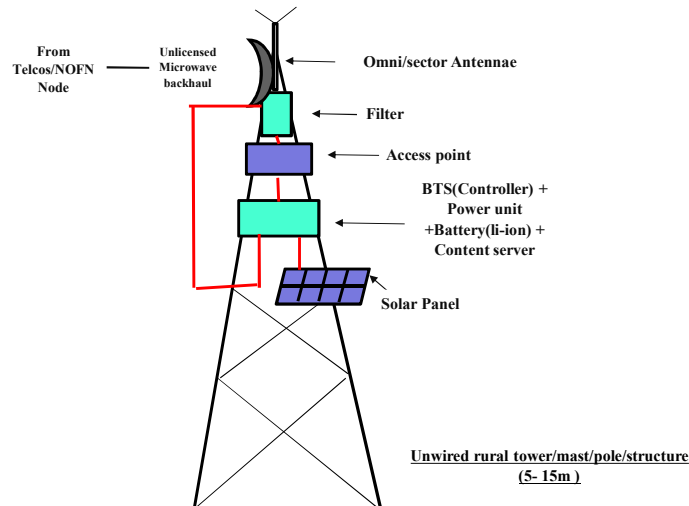
## Using Multiplier effect of an idea whose time has come.- Archimedes Principle

“Look at the world around you. With the slightest push, at just the right place, it can be tipped”

“Give me a rod (mast) long enough strong enough- and we can change the life-style of the rural folks”



## Everything On Tower(EOT)-Creating a Connectivity Platform for DiGi.Gaon IOT for 1Million Jobs



## Work-Life Blend through Virtualisation

- **Work-Life Blend (not Work-Life Balance)- Making Work pleasant like Life, Life's Work , Flexible Working, Work from Home, Homing from Work (BYOD, Bring Your Own Device), Adaptive Time Management, Multi-Tasking, Task Off-loading, Selective/Creative Outsourcing ( Managed Services, If you cant do anything well, Off-load it to someone who can do better), Optimised Work-Life-Play;**
- **Internet Style-Efficient, Flexible, Innovative, Open, Crowd-Source**
- **Commute Less Communicate More, Trade-off Transport with Telecom, Remote-Access, Virtualisation**
- **Use Web2.0, Tele Presence, Web Confrencing, Net- meeting, Audio Confrencing, IM, Collaboration, Virtual-Conversation, WhatsApp.**
- **Form focus discussion groups on Professional Networking sites (LinkedIn), E-learning, E-publishing, Blogging, Digital-profile- "Network is Your Net-worth", ROL ( Return-on-Life)**
- **Exploit the capabilities of Smartphones / Phablets / Tablets/Home Gateways,**
- **Avail e-citizen services and m-banking from Home and outside**
- **Take your office with you on the move – I.Cloud, Office365, Mo-fi**

### Next Step- “Mission Digi.Gaon Job Factory”

- Establishment of a **“Social Business”** at National level consisting of like-minded social entrepreneurs supported by the related agencies of Central , State Govt., PSUs, Corporates, Skill Development agencies and rural development NGOs with a single point Mission to enable **“Delivery of Urban broadband speeds in Rural”** in a cost effective, timely and sustainable manner and creating at least **“One Job Per Village”**.

**THANK YOU**

**Satya N Gupta**  
**[sg.ngnguru@gmail.com](mailto:sg.ngnguru@gmail.com)**