

*BSNL,
Dept. of Telecom.*

welcomes & thanks

*ITU-APT Foundation of India
& other partners*



6G

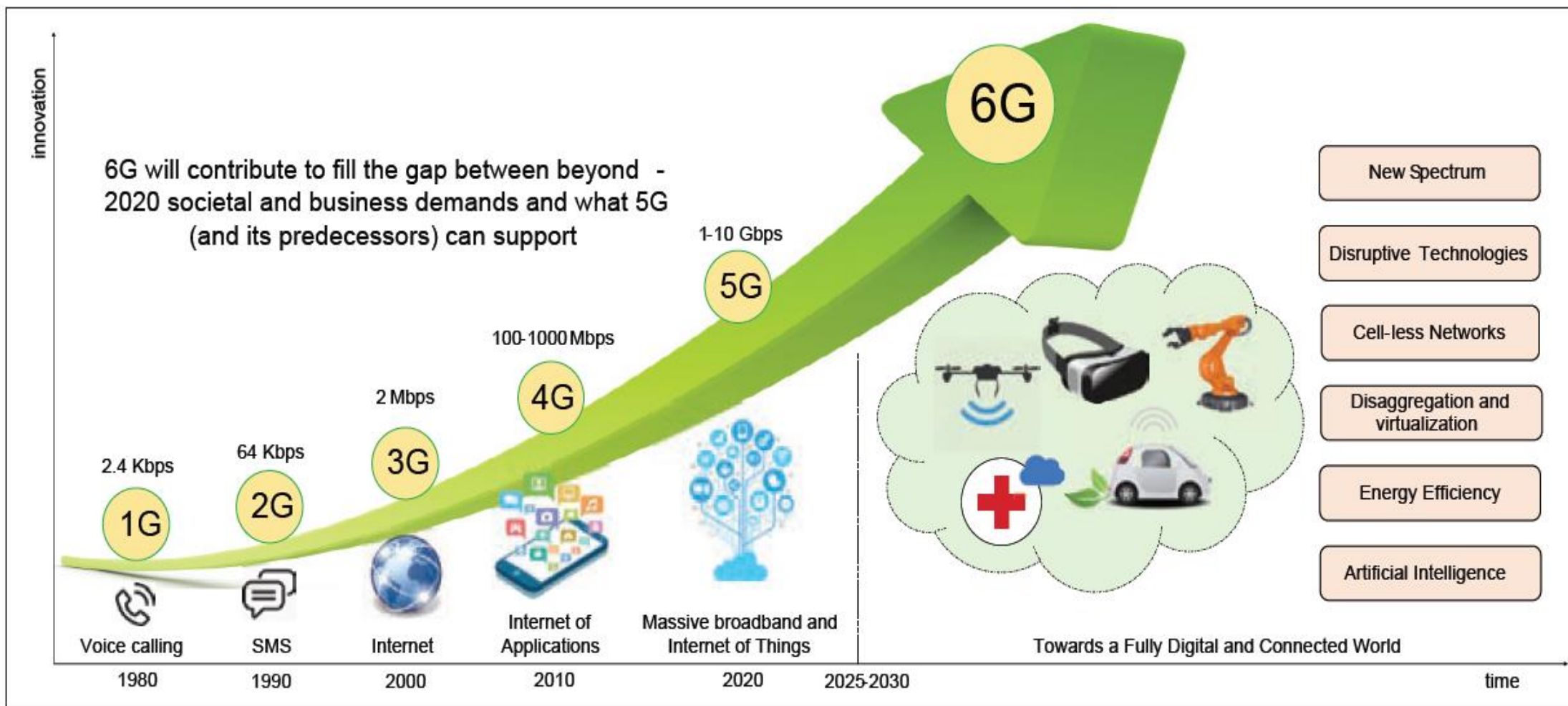
Vision, Spectrum, Technologies & Use Cases

D. M. Ezhil Buddhan I.T.S.

Chief General Manager Broadband Networks

9448010361; cgm_bbnw@bsnl.co.in

Evolution of 6G





What is 6G ?

- ❖ 6G is the name for the sixth generation of cellular networks, which will deliver truly omnipresent wireless intelligence. Expected to become available early in the 2030s, the 6G research journey is already well underway.
- ❖ The vision for 6G is built on the desire to create a seamless reality where the digital and physical worlds as we know them today have merged. This merged reality of the future will provide new ways of meeting and interacting with other people, new possibilities to work from anywhere and new ways to experience faraway places and cultures.
- ❖ By delivering ever-present intelligent communication, 6G will contribute to the creation of a more human-friendly, sustainable and efficient society.



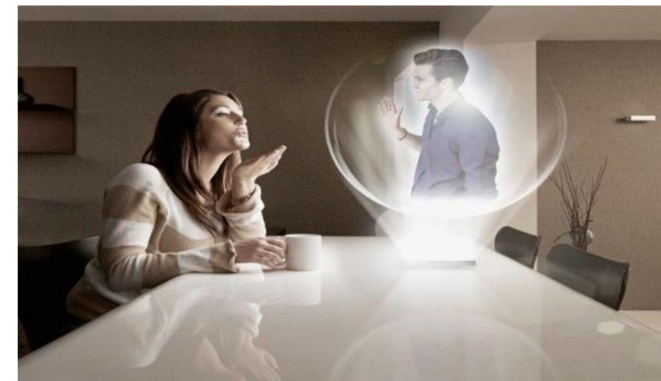
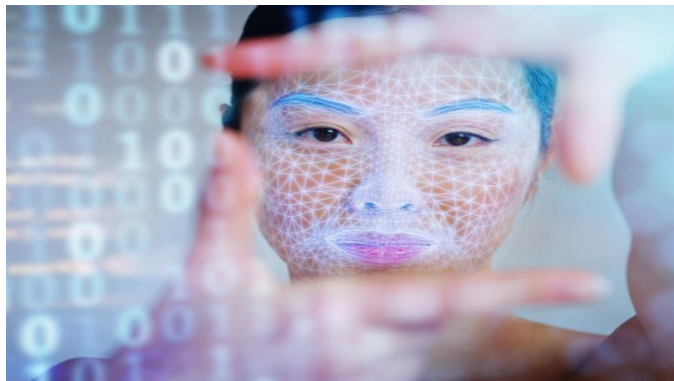
6G: THE ROAD TO A GLOBAL “BRAIN”

In 1926, the visionary Nikola Tesla stated:



“When wireless is perfectly applied, the whole Earth will be converted into a huge brain.”

By 2030, responding to fundamental human and social needs and based on the **expected** progress in ICT Tesla’s prophecy may become a reality!



4G & 5G HAS STARTED ADDRESSING SUCH CHALLENGES . BUT WE ARE JUST AT THE BEGINNING



6G will provide an ICT infrastructure that enables end users to perceive themselves as surrounded by a “huge artificial brain” offering virtually zero-latency services, unlimited storage, and immense augmented cognition capabilities

6G will not only connect the Earth but also the close proximity sky too... **SUSTAINABILITY ISSUES FOR BEYOND 5G**



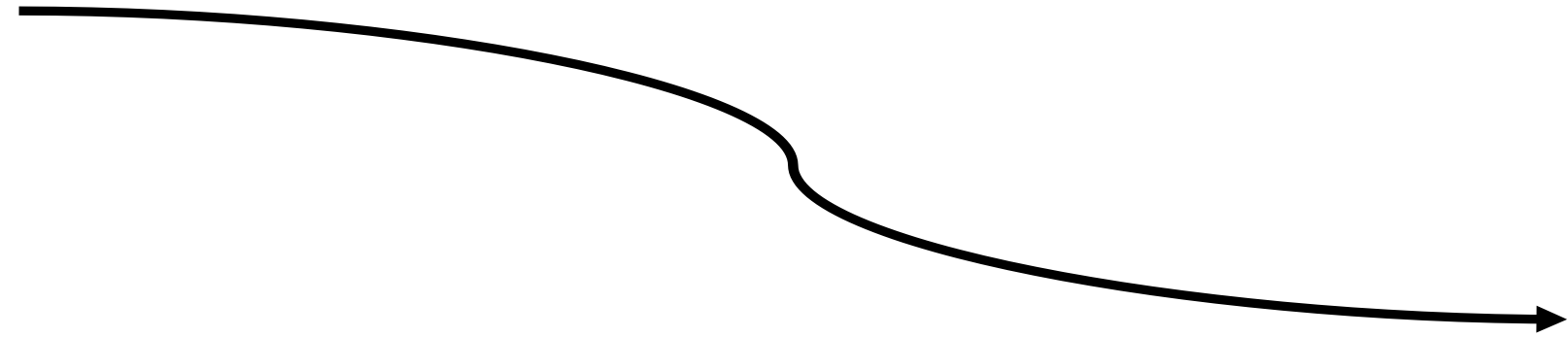
Sustainability issues beyond 5G- What we observe today ?

- Social issues, coverage
 - 3,5 Billion people without wireless Internet
- Energy, sustainability in hyperconnected society
 - « Energy skyrocketing at the edge ».
- EMF raising concerns
 - What impact of untested spectrum usages? How to decrease exposure?
- Human centricity and trust, data control and governance
- Security and Autonomy

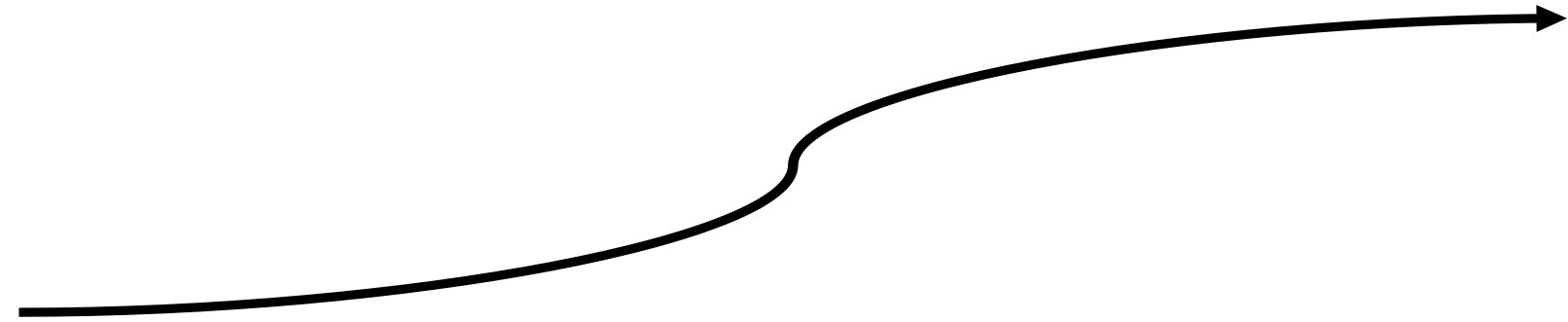


Why we need a new “G”eneration

Technological breakthrough readiness



New services, Applications & use cases

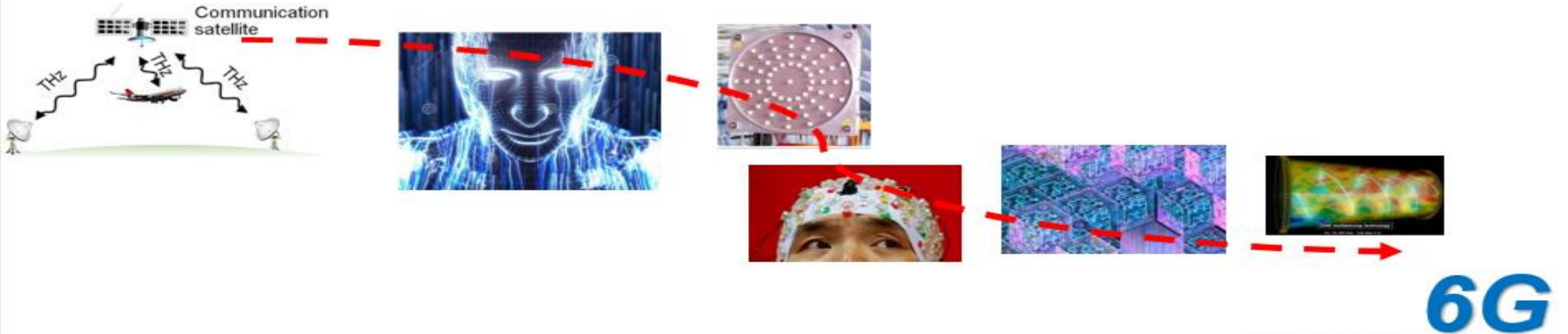


6G



Why we need a new “G”eneration

Technological breakthrough readiness



New services, Applications & use cases



TWO EXAMPLES OF BEYOND 5G APPLICATIONS

Hologram Technology



Haptic Communications



Low Latency (ms - μ s)

Self designing Joint C4 : Communication + Computing + Caching + Control

Ultra-High Capacity (1-10s Tbps)

Deterministic Network Optimization



What will be the world like 6G



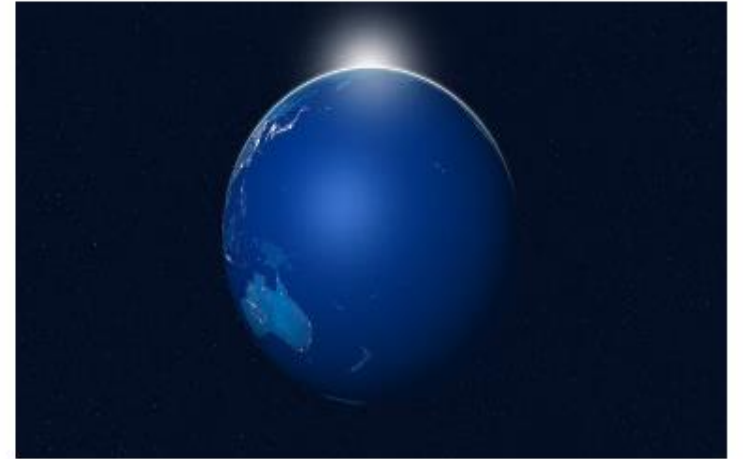
Connected intelligent machines

6G networks will support new types of intelligent entities such as AI-powered intelligent machines that need to be able to communicate with each other and solve problems without human involvement.



The Internet of Senses

In the Internet of Senses, devices, sensors, actuators and context-aware applications will make our digital experiences richer, involving all our senses, and ultimately merging the digital and the physical worlds.



A connected sustainable world

In this transformative time, when we must work together to halve global carbon emissions by 2030, and then halve them again by 2040, both 5G and 6G will be essential tools for building a better, more sustainable future.



6G requirements

Perception of “Infinite” capacity

- Ultra-high data rates
- Massive scalability to millions of devices

3 D Intelligence Coverage

- Ubiquitous consistent user experience in time and location (3D)

Zero Latency networks

- Extreme low latency (interactive services, tactile internet, remote surgery)

Extreme low power & Energy Free Connectivity

- Long battery life/ ultra-low energy consumption

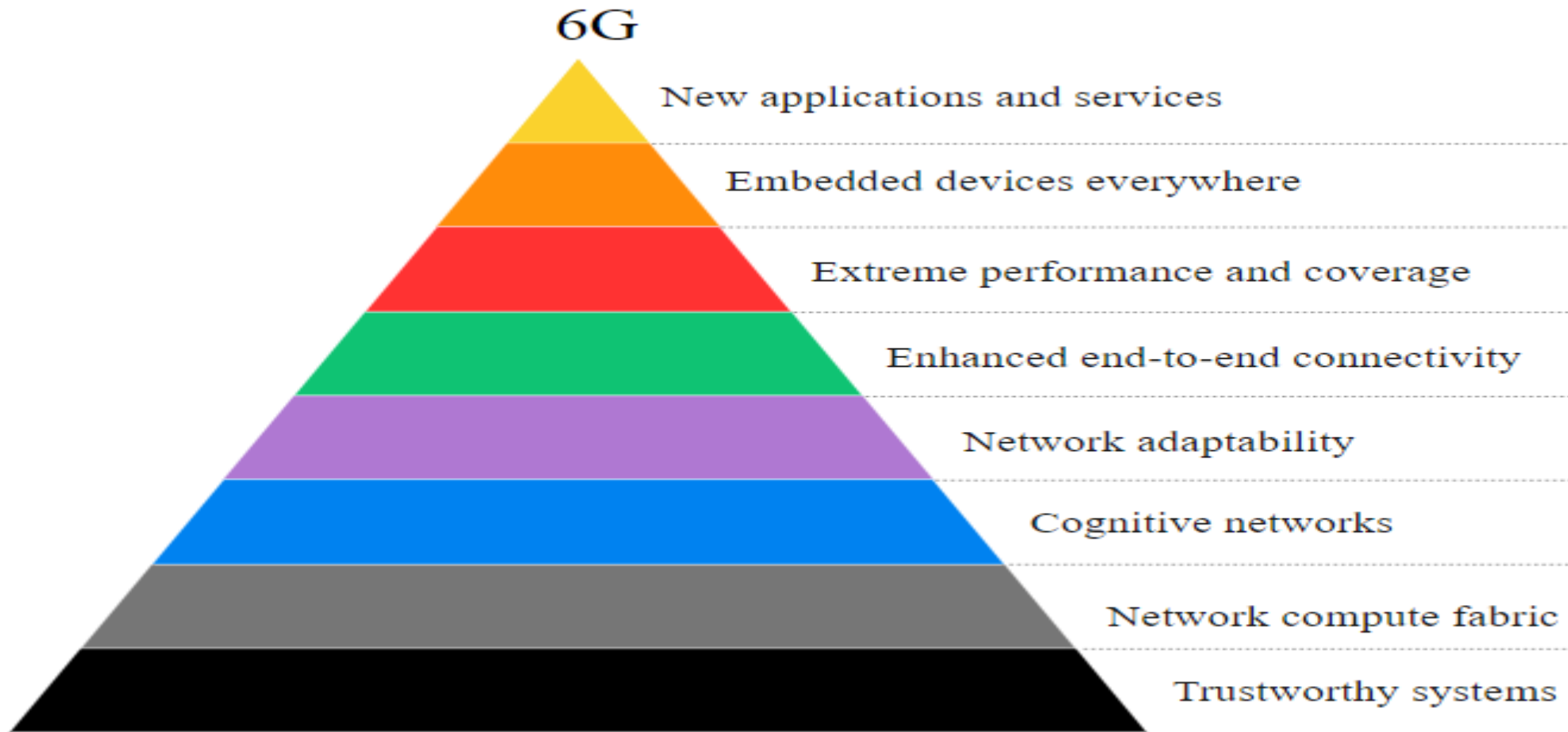


COMPARISON OF MAIN 5G & 6 G KPIS

KPI	5G	6G
Traffic Capacity	10 Mbps/m ²	~ 1-10 Gbps/m ³
Data rate DL	20 Gbps	1 Tbps
Data rate UL	10 Gbps	1 Tbps
Uniform user experience	50 Mbps 2D everywhere	10 Gbps 3D everywhere
Latency (radio interface)	Up tp 1 msec	Up to 0.1 ms
Jitter	How can we achieve them? Will this be enough?	
Reliability (frame error rate)		
Energy/bit	NS	pJ/bit
Localization precision	10 cm on 2D	1 cm on 3D

Source: Calvanese et al., "6G: The Next Frontier: From Holographic Messaging to Artificial Intelligence Using Subterahertz and Visible Light Communication", IEEE Vehicular Magazine September 2019.

Foundations for 6G





6G-Mega trends

- ❖ TREND1: More bits, more spectrum
- ❖ TREND2: 3D Spatial BW & 3D coverage for intelligence support
- ❖ TREND3: New Technologies (Meta materials, in memory computing, quantum c.)
- ❖ TREND4: Ubiquitous Role of Antennas & Reconfigurable Intelligent Surfaces
- ❖ TREND5: New Applications, New Service Classes & new Media
- ❖ TREND6: Energy Free Connectivity (wireless harvesting, Zero energy radio, ...)
- ❖ TREND7: C4 : Convergence of Communication, Computation, Caching & Control
- ❖ TREND8: Ubiquitous support of AI & the path to fully distributed Intelligence
- ❖ TREND9: Breaking Big Data with Massive Small Data
- ❖ TREND10: Network Personalisation



Enabling technologies for 6G

- ❖ Artificial intelligence
- ❖ Machine learning
- ❖ Terahertz communication
- ❖ Visual light communication
- ❖ Machine type communication
- ❖ Low earth orbit satellite communication
- ❖ Orbital angular momentum technique
- ❖ Cognitive radio



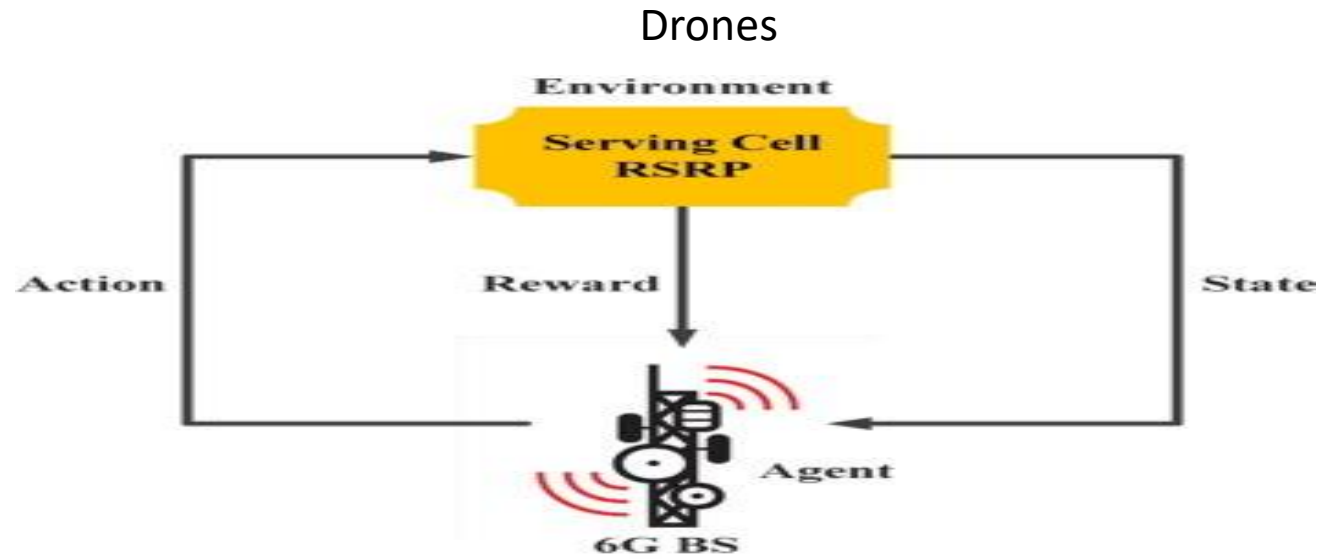
Enabling technologies for 6G

- ❖ Intelligent reflective surfaces
- ❖ Edge intelligence
- ❖ Wireless energy transfer
- ❖ Edge intelligence
- ❖ Free duplexing and spectrum sharing (FDSS)
- ❖ Massive MIMO
- ❖ Blockchain technology
- ❖ Quantum communication & quantum ML
- ❖ Tactile internet

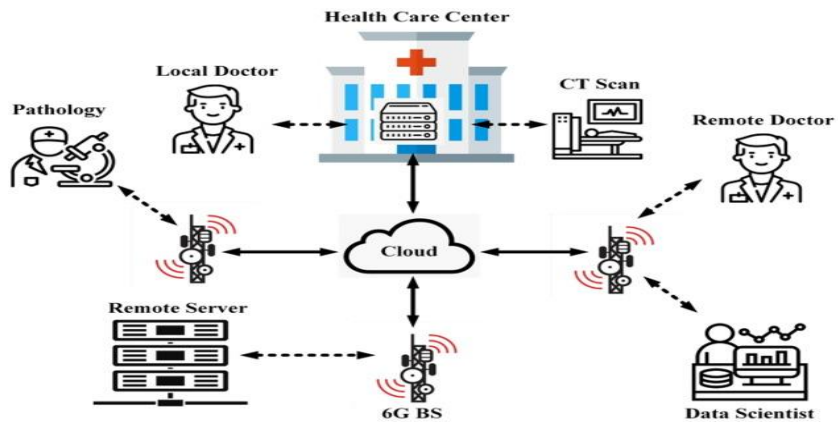


Opportunities of 6G technology

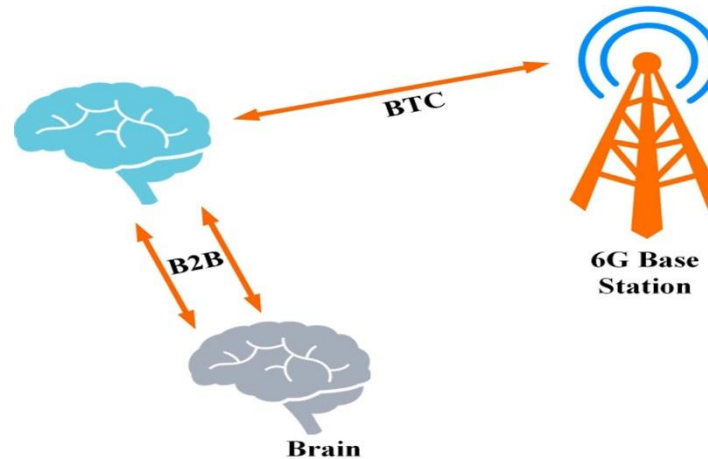
Industrial automation
Internet of space things
Extended Reality



Remote medical operations

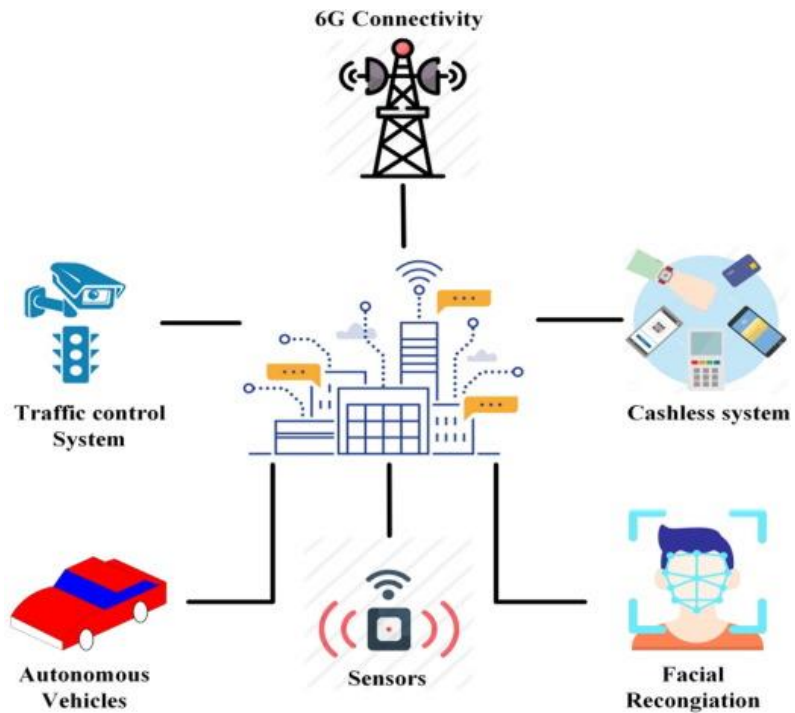


Communication between brain and machine



Opportunities of 6G technology

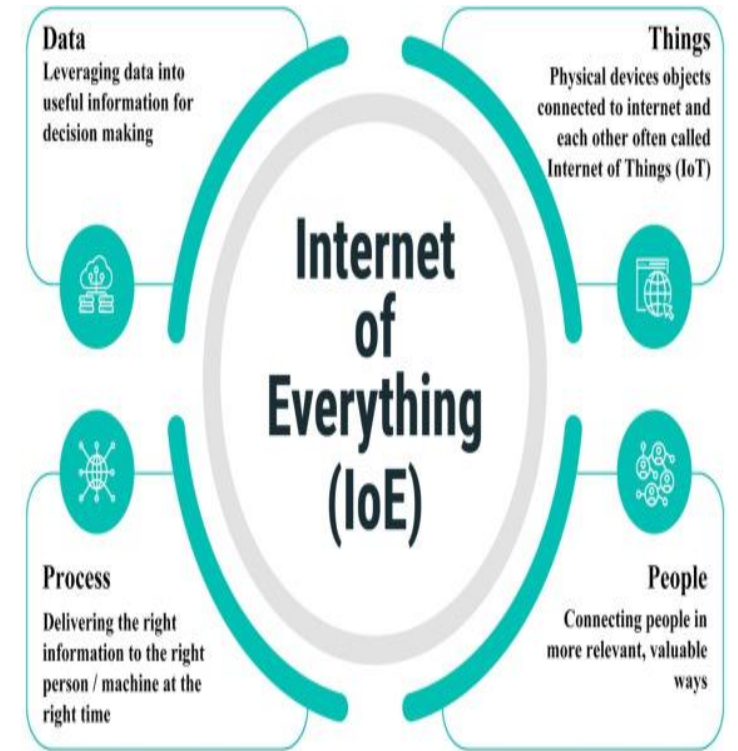
Smart cities



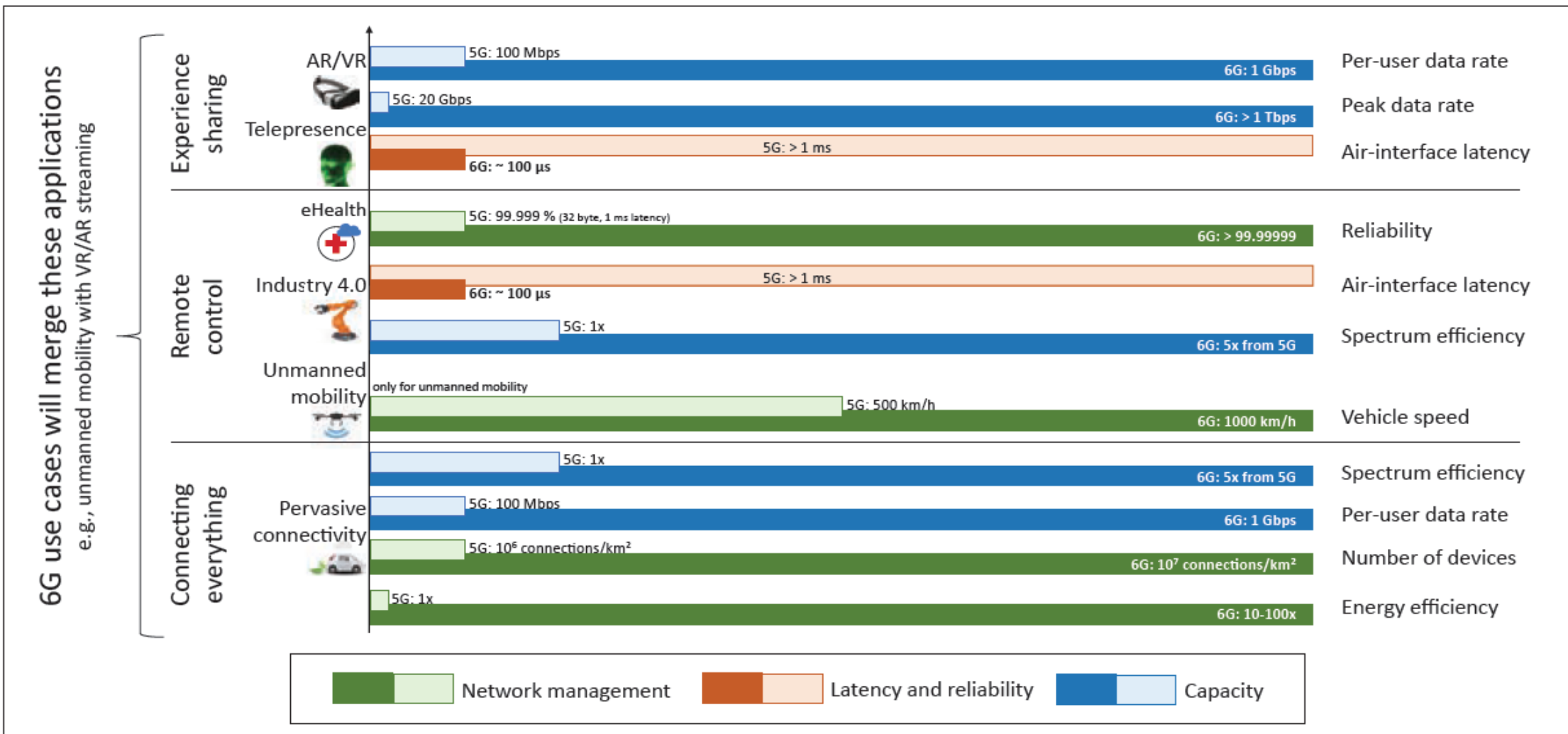
Autonomous vehicles and robotics



IoE with 6G mobile technology.



KPIs for some use cases



Source: M. Giordani, et al., "Toward 6G Networks: Use Cases and Technologies", IEEE Communications Magazine, March 2020



BSNL - BharatNet Infrastructure

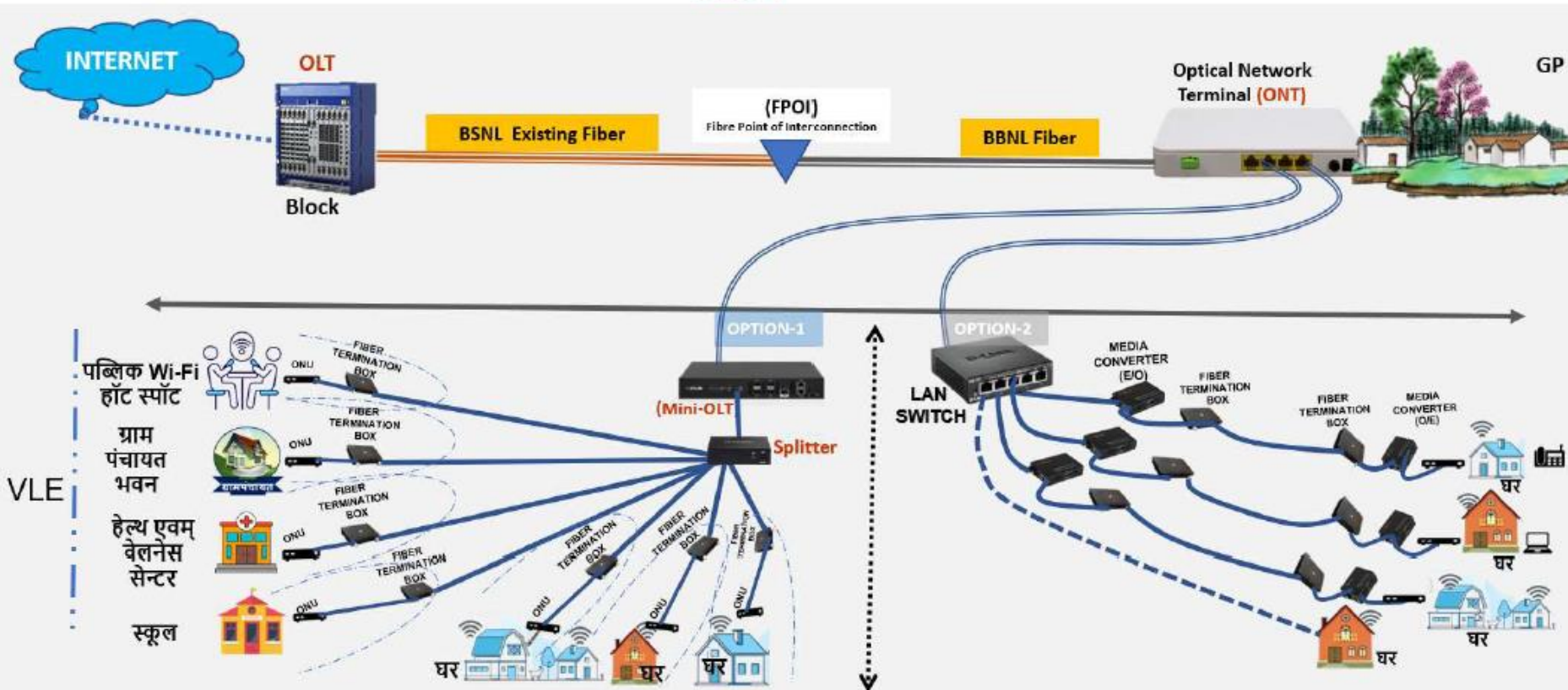
Coverage statistics



BHARATNET ARCHITECTURE



Phase-I



Option-1: In long distance for providing multiple connections by using Mini OLT.
Option-2: In short distance for providing limited connections by using LAN switches

Coverage statistics



BharatNet: Overall Implementation Status



Phase	Target (GPs)			Achievement (GPs Service Ready)		
	On OFC	On Satellite media	Total	On OFC	On Satellite	Total
Phase-I	1,20,291	-	1,20,291	1,19,144	-	1,19,144
Phase-II	1,38,287	5,583	1,43,870	46,418	4,360	50,778
Total	2,58,693	5,468	2,64,161	1,65,562	4,360	1,69,922



Integration Models

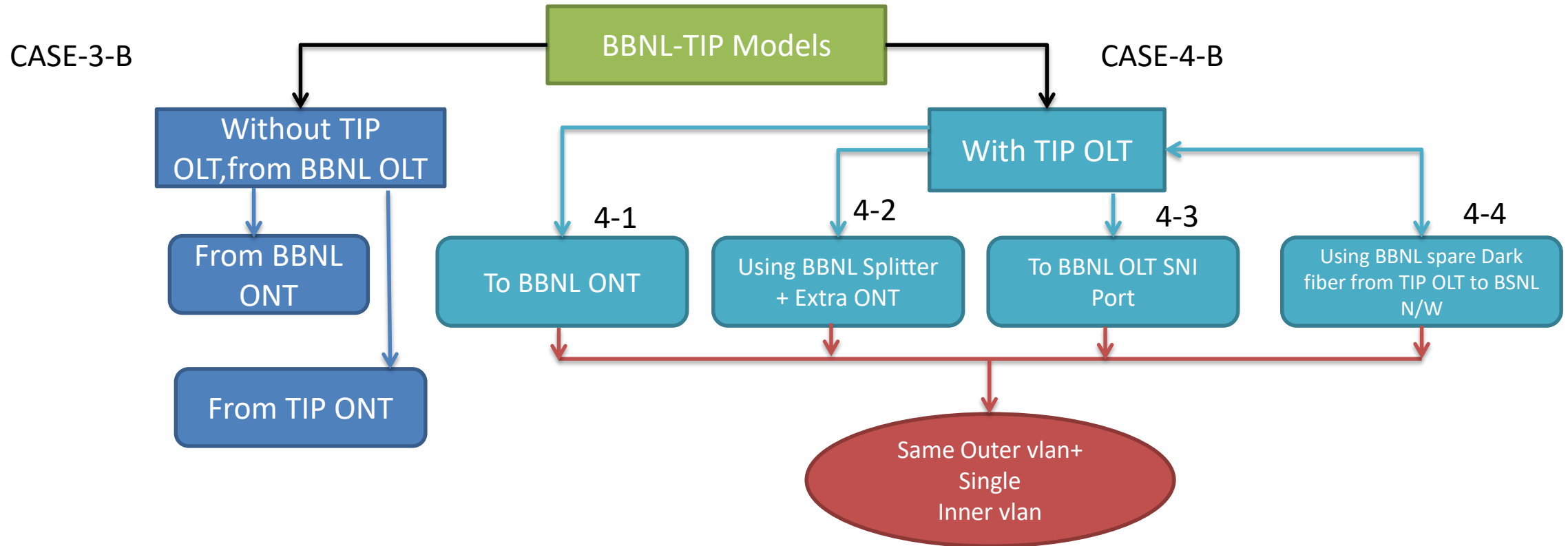
The integration process through which the partner provides FTTH connections by utilizing existing BBNL infrastructure can be broadly classified to two

Case-IIIB BharatNet Rural without a Partner OLT

Case-IVB BharatNet Rural with Partner OLT.

[Case IV has several subcases, based on the actual technical implementation]

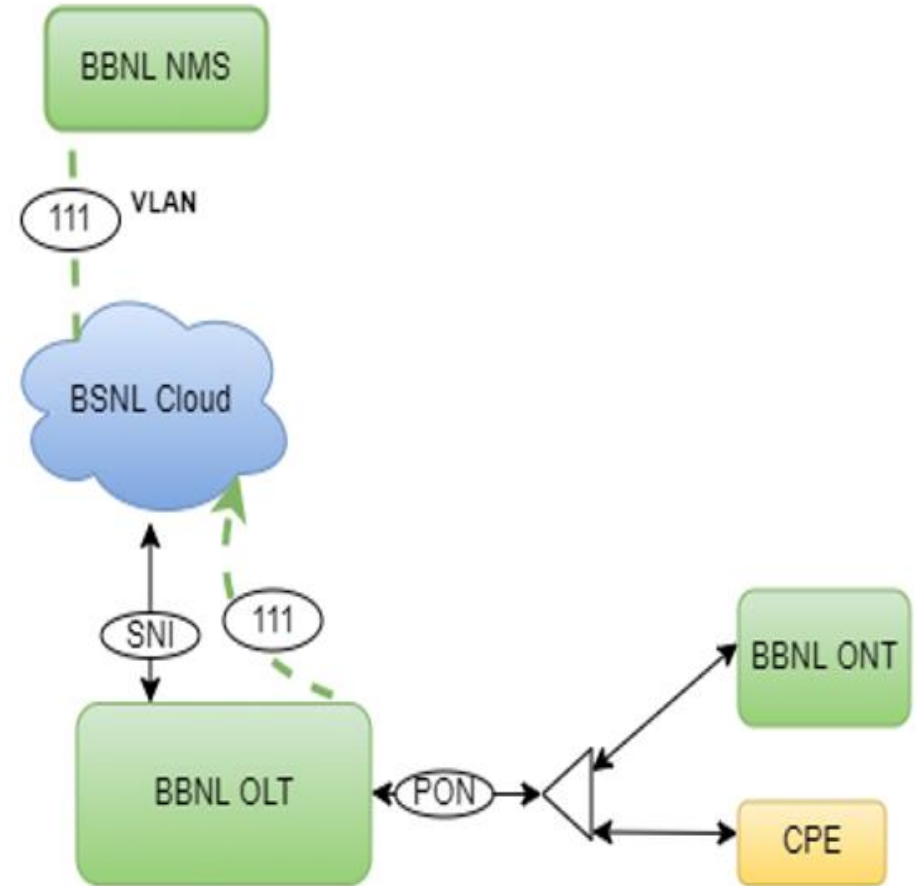
Integration Cases





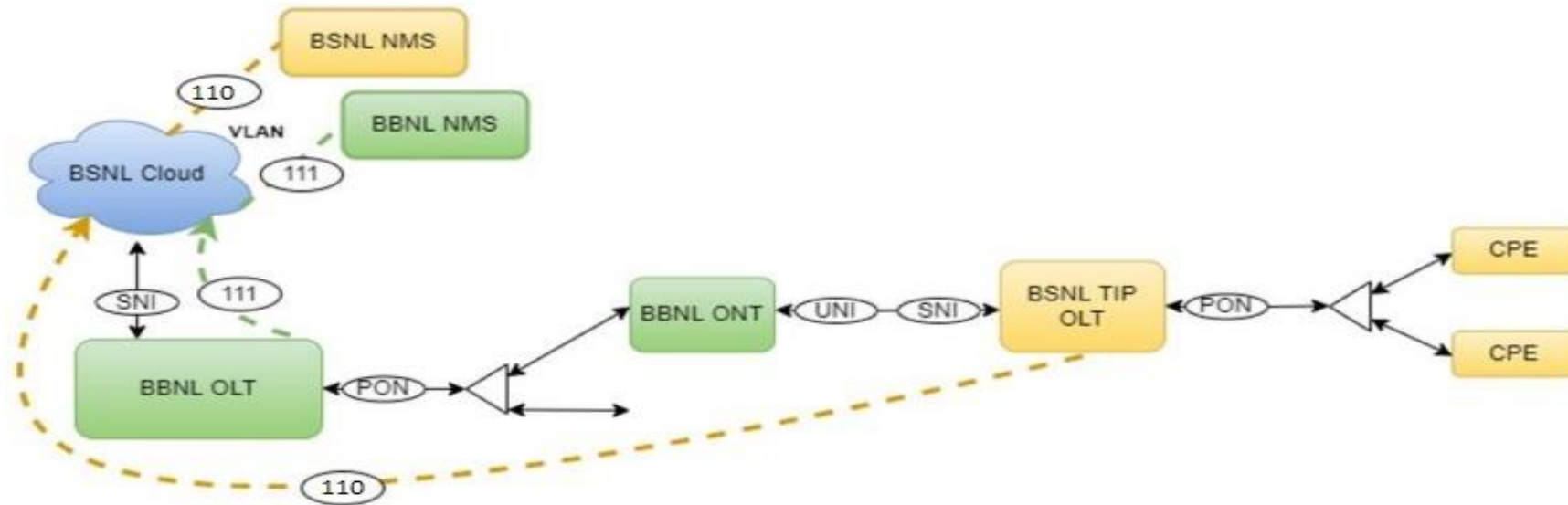
Case-III A BharatNet Rural without a Partner OLT

Placing a Splitter in GP Location .
Extend the connections to end users from that splitter
The access network and ONTs will be maintained by the Franchisee
Inner vlan used should not be in use in the BBNL OLT
In this model connections will be provided through BBNL OLT using splitter without installing a TIP OLT.
As per the present scenario BBNL OLT will support M/s CDOT (UTL/ITI), Tejas and Alphon make ONTs.



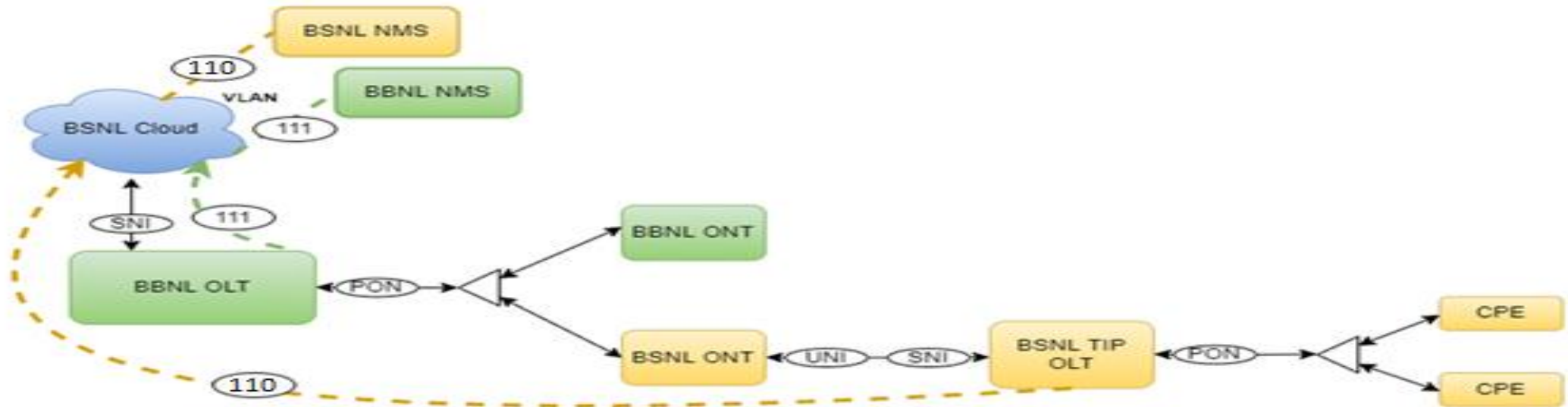


Case 4-1- Case-IV Bharat Net Rural with Partner OLT using BBNL ONT UNI Port.



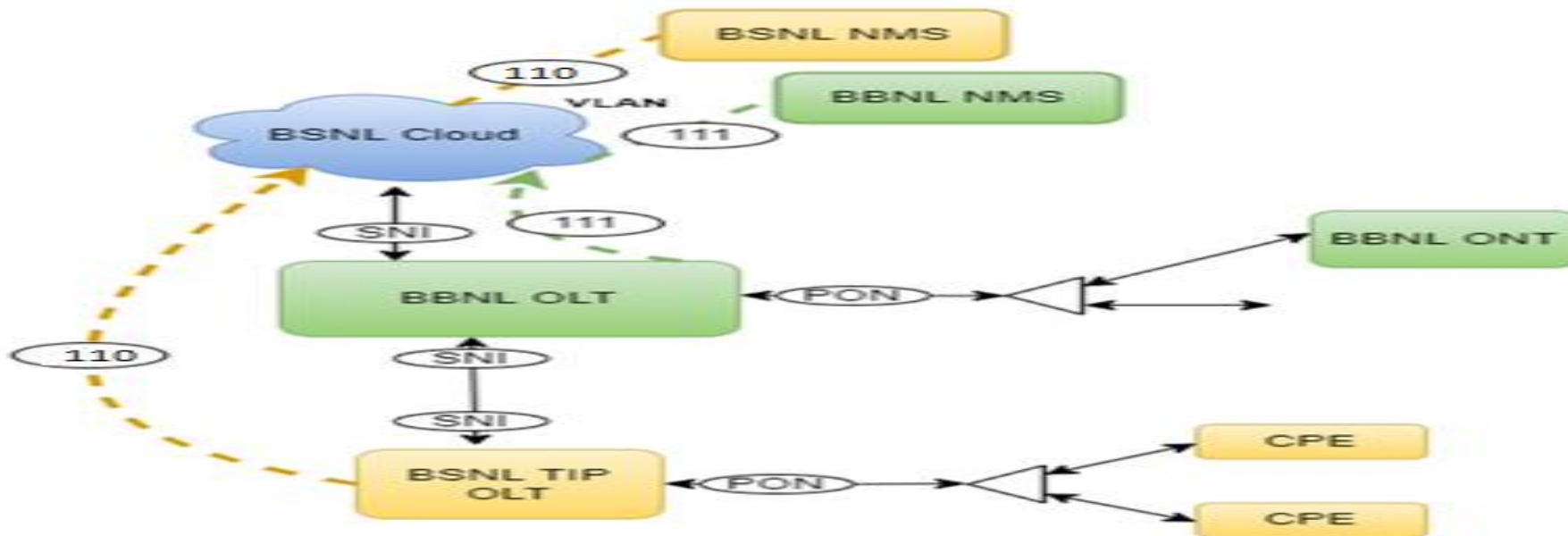
- ❖ The Mini OLT, access network and ONTs will be maintained by the Franchisee.
- ❖ In this model, the partner OLT uplink port will be connected to the BBNL Business ONT UNI Ports (Spare GE ports) installed at GP location. This model can be adopted when there is no spare backhaul fibre available between GP location and the BBNL OLT installed location.

Case 4-2- Case-IV Bharat Net Rural with Partner OLT using an additional ONT through Splitter



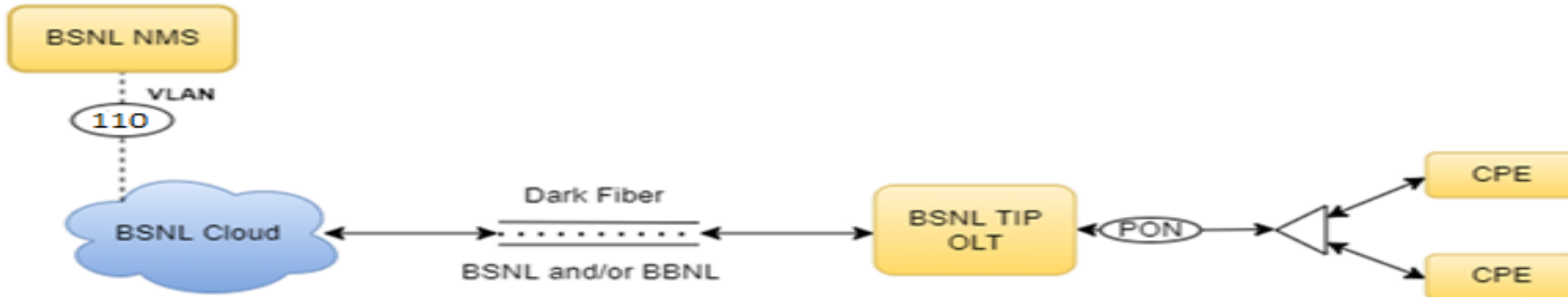
- The partner OLT uplink port will be connected using the existing splitter and an extra ONT other than GP ONT.
- The extra ONT should be procured and maintained by the TIP Franchise.
- This model can be adopted when there is no spare backhaul fibre available between GP location and the BBNL OLT installed location and also when the GP ONT ports are not available / accessible for extending the TIP OLT Backhaul.

Case 4-3- Case-IV Bharat Net Rural with Partner OLT using BBNL OLT SNI Ports



- ❖ In this model, the partner OLT will be connected to the spare GE ports (SNI Ports) available in BBNL OLT.
- ❖ The TIP OLT can be collocated with BBNL OLT or the backhaul can be extended through the transmission media.

Case 4-4 (Rural) - Using BBNL spare dark fiber from BBNL/BSNL



- In this model, only the BBNL/BSNL dark fiber will be used to provide the backhaul to TIP OLT.
- The backhaul can be extended to any nearest BSNL access network elements.

Cases Summarized

Model No	Model Name	Features	Advantages	Limitations	Recommended
Case 3 (Rural)	Without TIP OLT	<ul style="list-style-type: none"> Directly from BBNL OLT and splitters 	<ul style="list-style-type: none"> No OLT Cost involved. 	<ul style="list-style-type: none"> Only Alphon/CDOT/ Tejas make ONTs can be used. Link budget/ Distance issues. 	Barely. ONT Availability
Case 4-1 (Rural)	Using BBNL OLT UNI Port	<ul style="list-style-type: none"> TIP OLT Backhaul is extended from BBNL Business OLT GE port. Existing BBNL OLT outer vlan and <i>single inner vlan is used.</i> 	<ul style="list-style-type: none"> No inner vlan constraint Any make ONT can be used. All services tested OK in Alphon Tejas and CDOT ONT. MAC Binding will be enabled for these TIP OLTs 	<ul style="list-style-type: none"> Cannot readily distinguish between BBNL and TIP OLT customers unless a common inner vlan is used for TIP connections. 	Highly. Alphon, CDOT & Tejas-Tested OK.
Case 4-2 (Rural)	Using BBNL Splitter + Extra ONT	<ul style="list-style-type: none"> TIP OLT backhaul will be build using BBNL splitter and Extra ONT. 	<ul style="list-style-type: none"> No need to maintain an uninterrupted GP ONT Power supply. Any make ONT can be used in TIP OLT. 	<ul style="list-style-type: none"> The New Backhaul ONT should be compatible with the BBNL OLT. Only Alphon, CDOT and Tejas make ONT can be used. 	Recommended with Single vlan – Multiuser mode.

Cases Summarized

Model No	Model Name	Features	Advantages	Limitations	Recommended
Case 4-3 (Rural)	To BBNL OLT SNI Port	<ul style="list-style-type: none"> TIP OLT is directly connected to BBNL OLT SNI Port 	<ul style="list-style-type: none"> Direct GE connectivity from OLT. Normal cascading configuration. Inline with BSNL present configurations. Any make ONT can be used. 	<ul style="list-style-type: none"> Mini OLT should be colocated with BBNL OLT. Backhaul fiber should be extended from BBNL OLT. 	Highly
Case 4-4 (Rural)	Using BBNL spare dark fiber from BBNL/BSNL network	<ul style="list-style-type: none"> TIP OLT backhaul will be extended using BBNL spare dark fiber from BSNL access network to TIP OLT 	<ul style="list-style-type: none"> No BBNL elements involved Inline with normal cascading configuration in BSNL Any make ONT can be used No need to maintain an uninterrupted GP ONT Power supply 		Highly



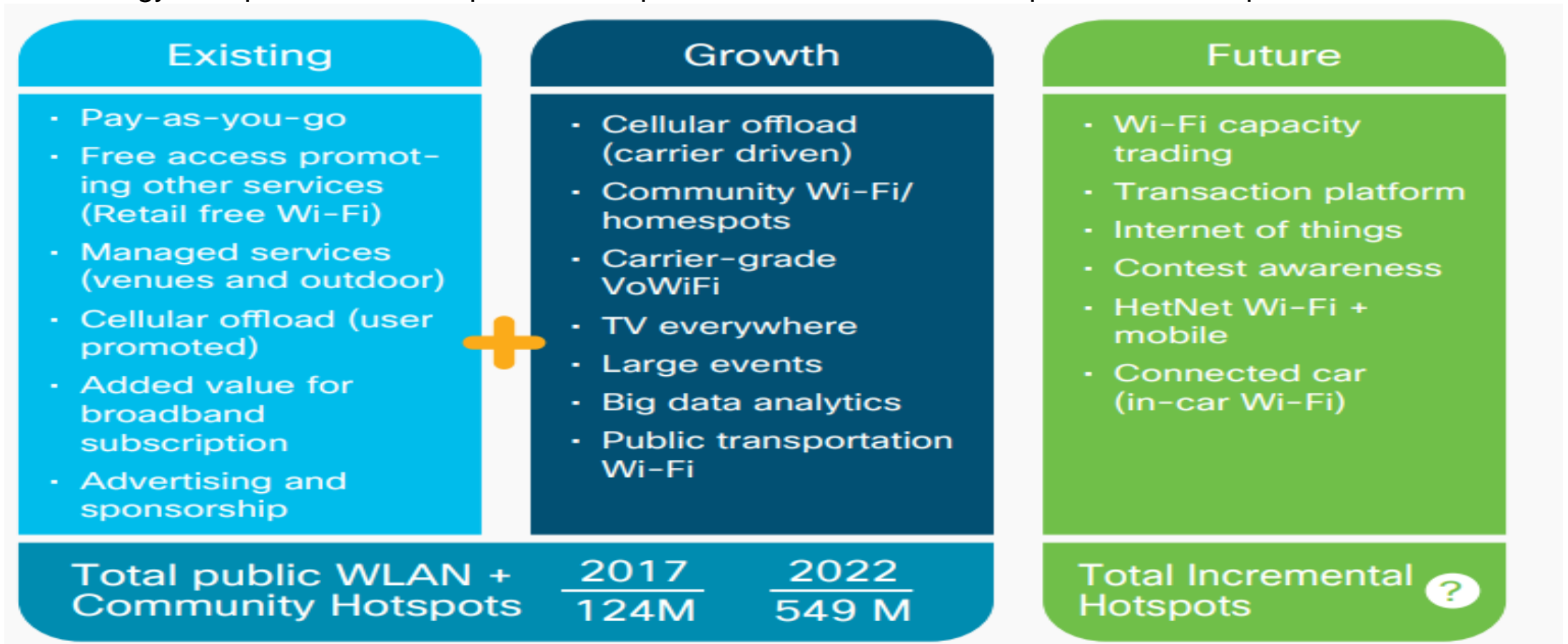
Projected average Wi-Fi speeds (in Mbps)

Region	2018	2019	2020	2021	2022	2023	CAGR (2018-2023)
Global	30.3	36.3	50.8	58.9	72.9	91.6	25%
Asia Pacific	34.5	42.2	62.3	80.2	98.5	116.1	27%
Latin America	10.6	12.1	25.1	27.3	30.4	34.6	27%
North America	46.9	56.8	70.7	87.3	98.4	109.5	18%
Western Europe	30.8	36.3	53.4	64.7	79.4	97.4	26%
Central and Eastern Europe	22.6	24.1	30.0	35.4	42.9	52.7	18%
Middle East and Africa	7.0	7.9	16.3	18.6	21.9	25.7	30%

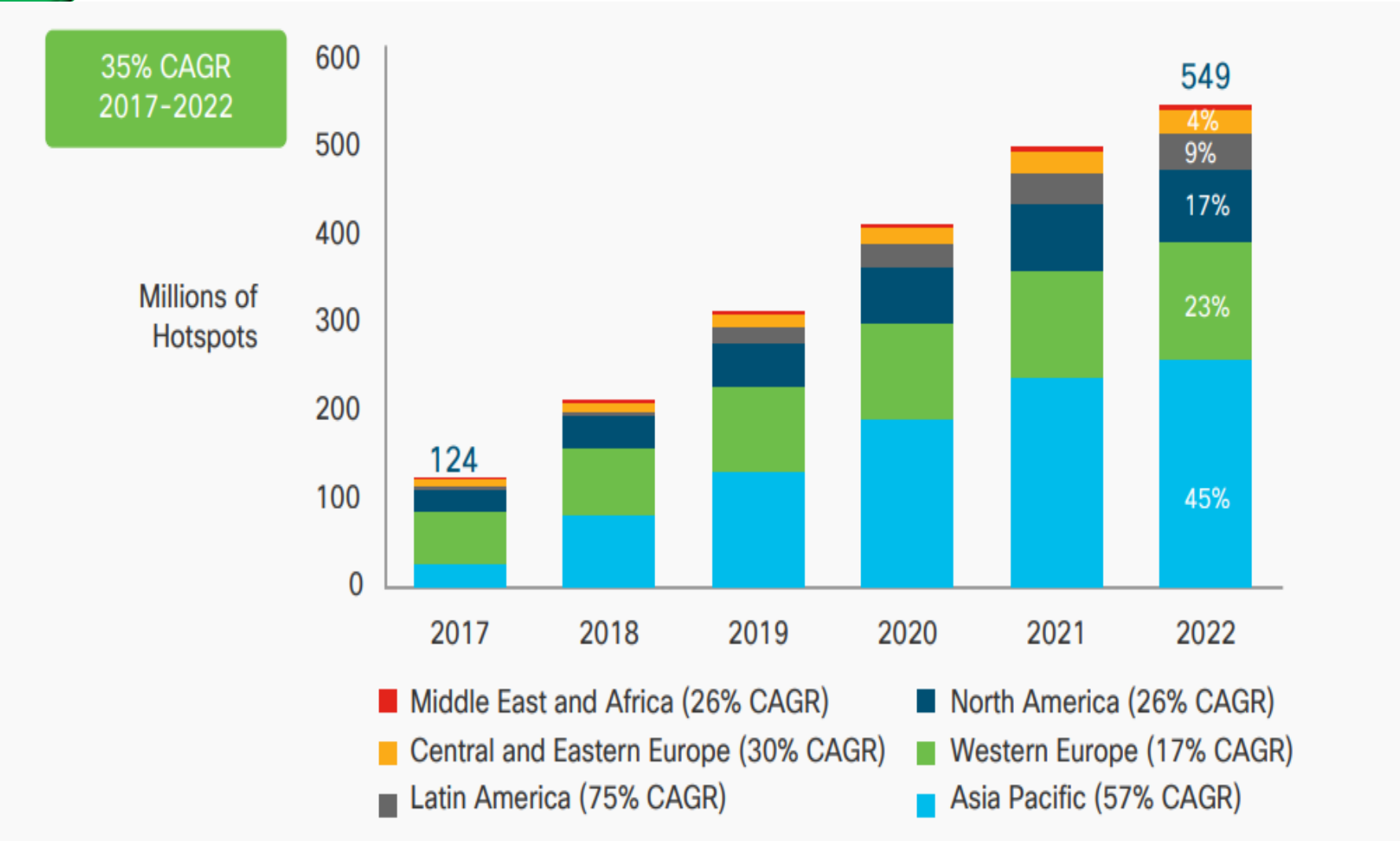


Growth of Wi-Fi Hotspots Globally

❖ Globally, total public Wi-Fi hotspots (including homespots) will grow four-fold from 2017 to 2022, from 124 million in 2017 to 549 million by 2022 (Figure 18). Total Wi-Fi homespots will grow from 115 million in 2017 to 532 million by 2022. Homespots or community hotspots are a significant part of the public Wi-Fi strategy. The public Wi-Fi hotspots include public Wi-Fi commercial hotspots and homespots.

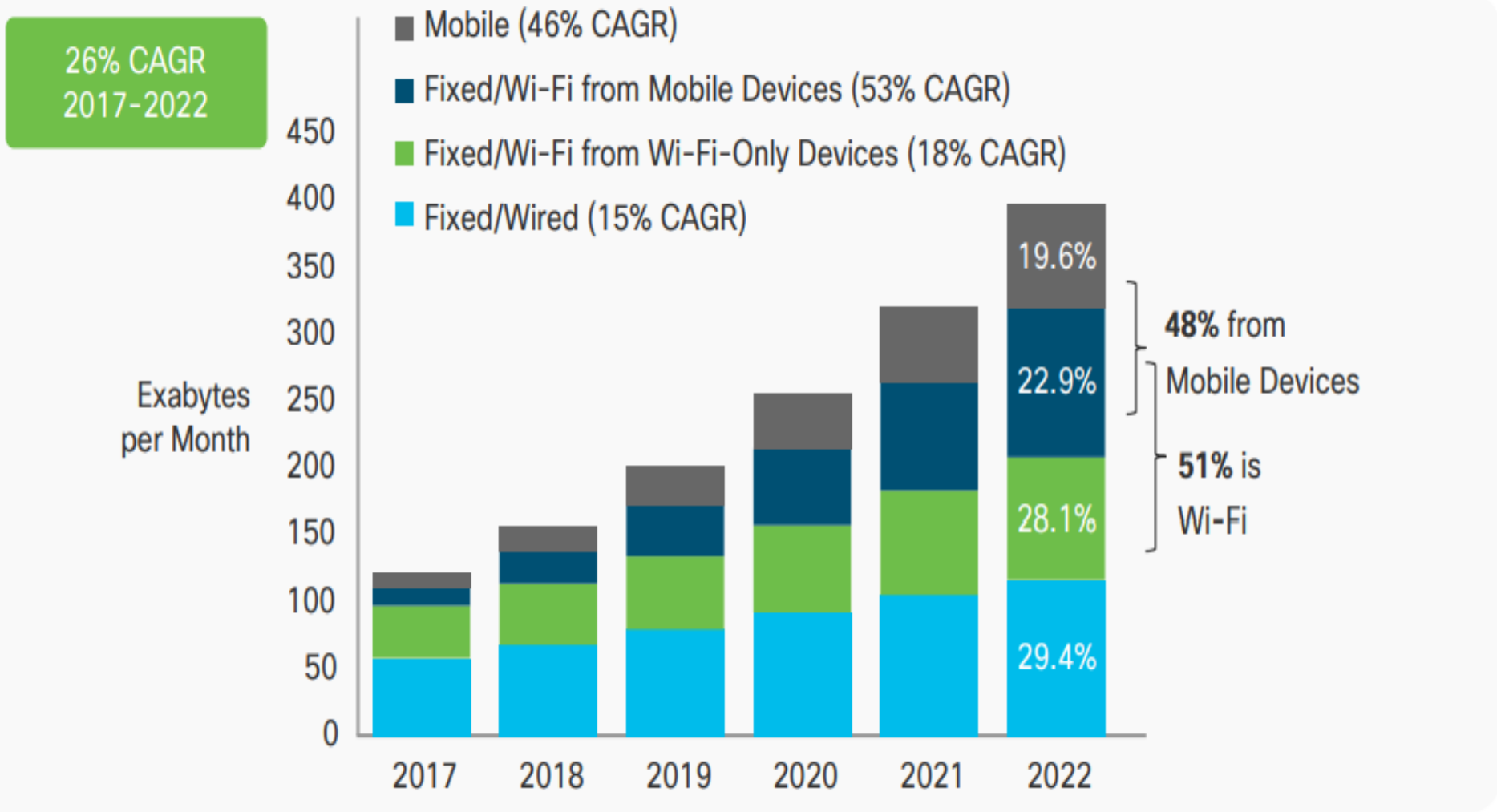


Global Public Wi-Fi Hotspots: Asia Pacific Leads with 45 Percent Hotspots Worldwide by 2022

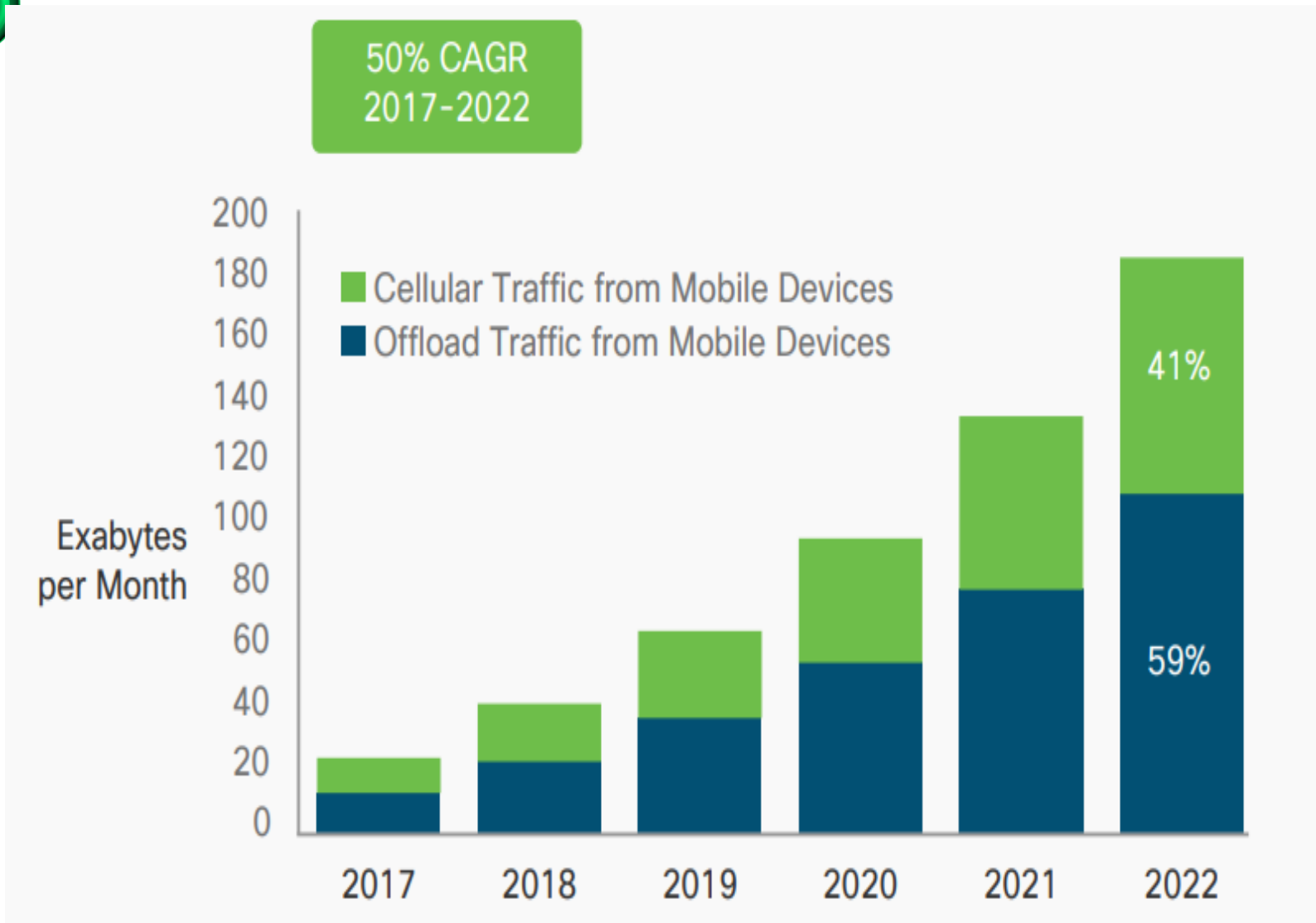




Total Wi-Fi Traffic predictions by access Technology



Global Wi-Fi offload statistics



Source: Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2017–2022 White Paper



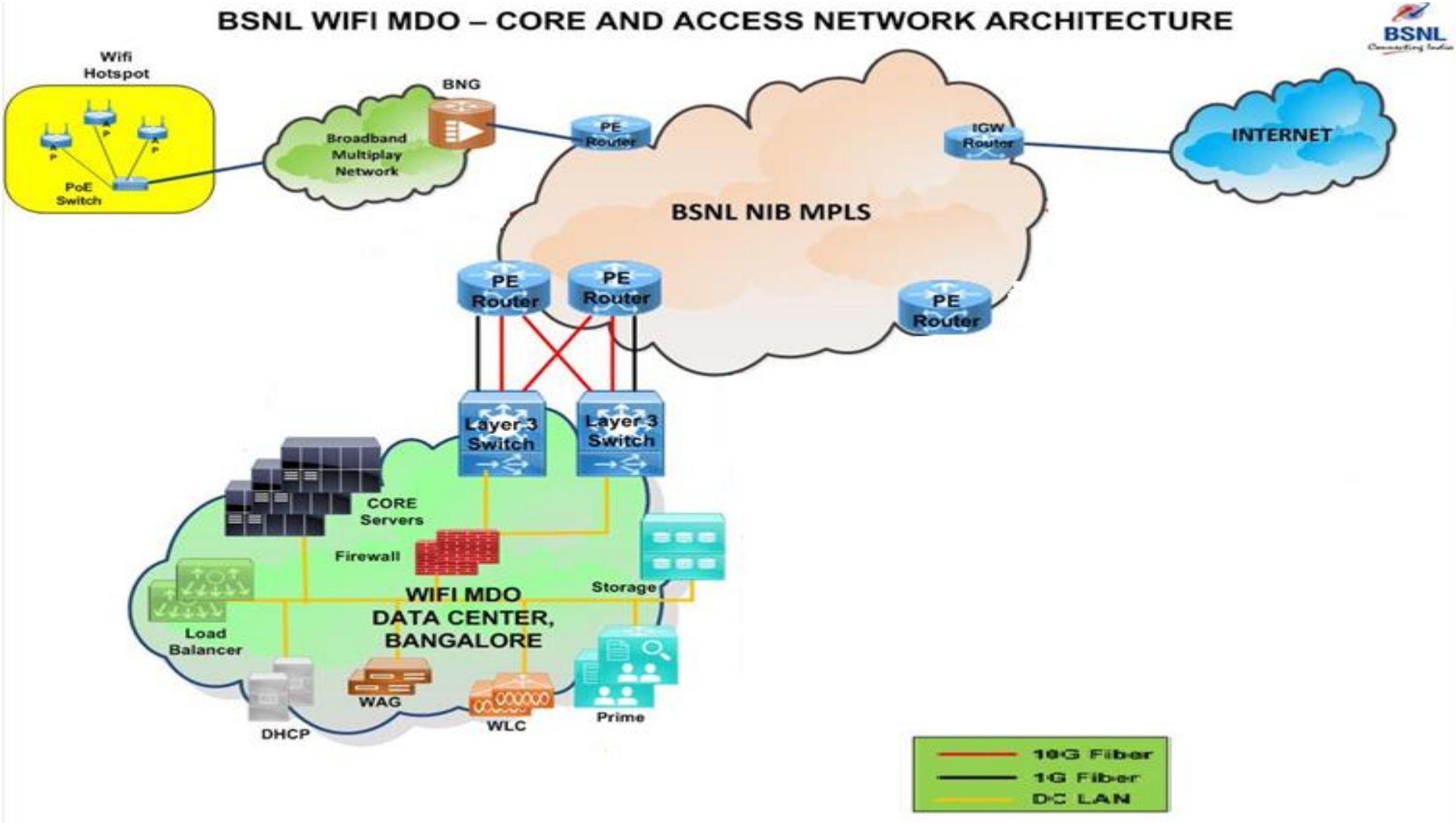
BSNL's Wi-Fi Journey

- ❖ Wi-Fi as a part of Enterprise Solutions
- ❖ Wi-Fi to Interconnect Colleges & Universities under the MHRD's National Mission for Education through ICT (NMEICT)
- ❖ Wi-Fi as a Service and for managing Crisis



Wi-Fi Service Hot spot & Mobile Data Offload Project

Core and RPOP Network Architecture





Wi-Fi Services

WiFi Walkin (Open SSID – BSNL WIFI)

Mobile Data Offload (SSID - BSNL 4G Plus)

BSNL Broadband users (SSID- BSNL BroadFi)

CUSTOMISED SSID FOR BULK HOTSPOT LIKE NaMo WiFi (Gujarat),

MCRHRD WiFi (MCRHRD Training Institute, Hyderabad), AP NIT WiFi (NIT, Tadepalligudem, AP),

NACIN WiFi (NACIN Training Institute, Bangalore), Tawang WiFi, Diwang WiFi (Arunachal Pradesh State Govt, NE-II CIRCLE), RVRJC WiFi (Engineering college, Guntur), BSNL HWiFi (Haryana Road Transport) etc.,



BSNL WiFi Bulk Solutions

❖ WiFi services can be provided in two ways

❑ **Open Wi-Fi** - Open to all who ever enters to the hotspot zone can avail the services by using the mobile number and OTP received to the mobile number with the data plan and band width opted by the customer.

❑ **Authorizing Only Specific Users through the Portal**

Customer are given with a Portal for authorizing the users with the plans of their choice with either throttling QoS, Restricted Usage, Unlimited Usage.

The admin user provided to the customer shall have the privileges to perform above activities and also can suspend/ change the user profile/plans.

Users can avail Wi-Fi services by entering the mobile number and OTP received to the mobile number after admin authorizes by the plan.

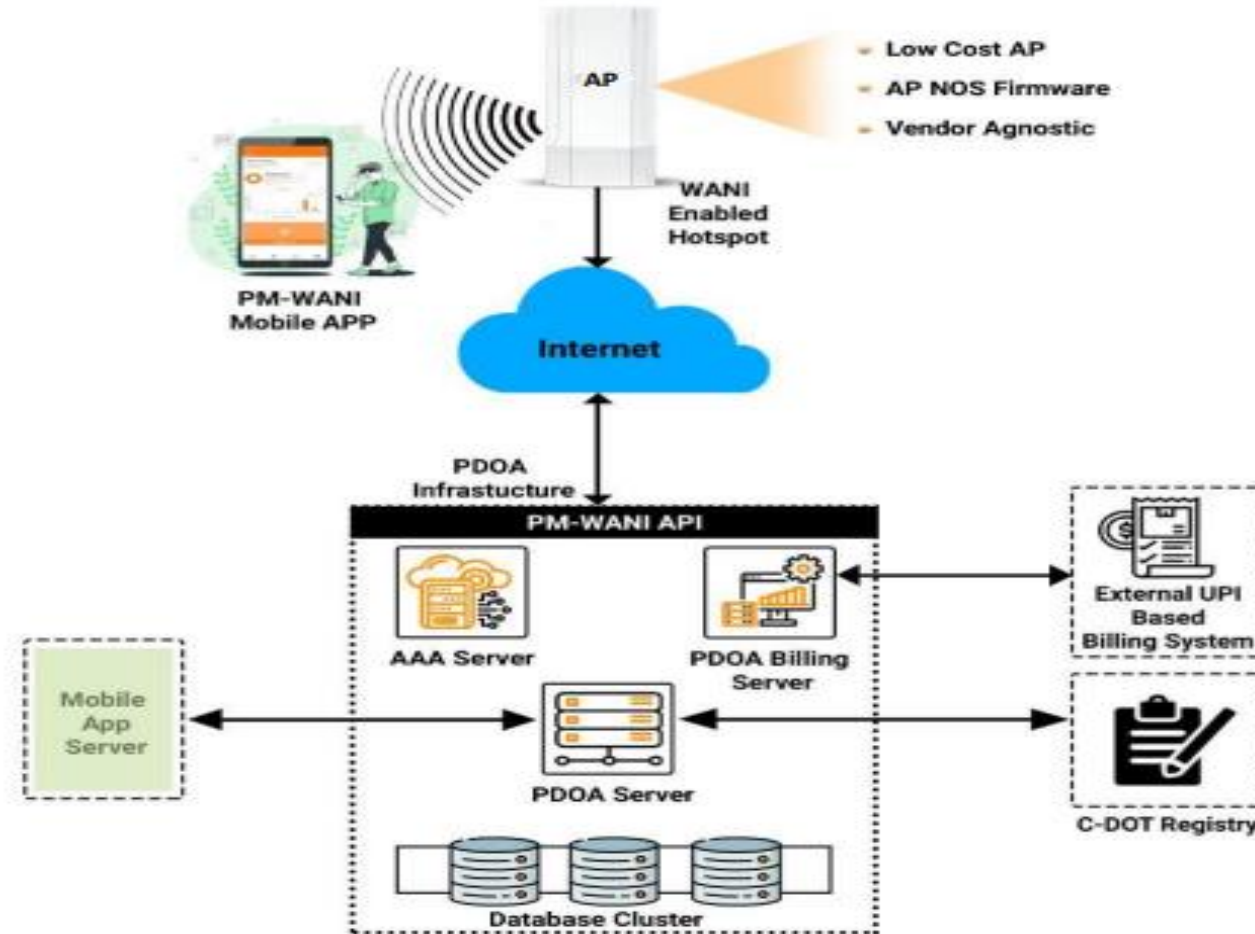
TIME, VOLUME Plans are feasible.



HSSP – PM WANI Framework

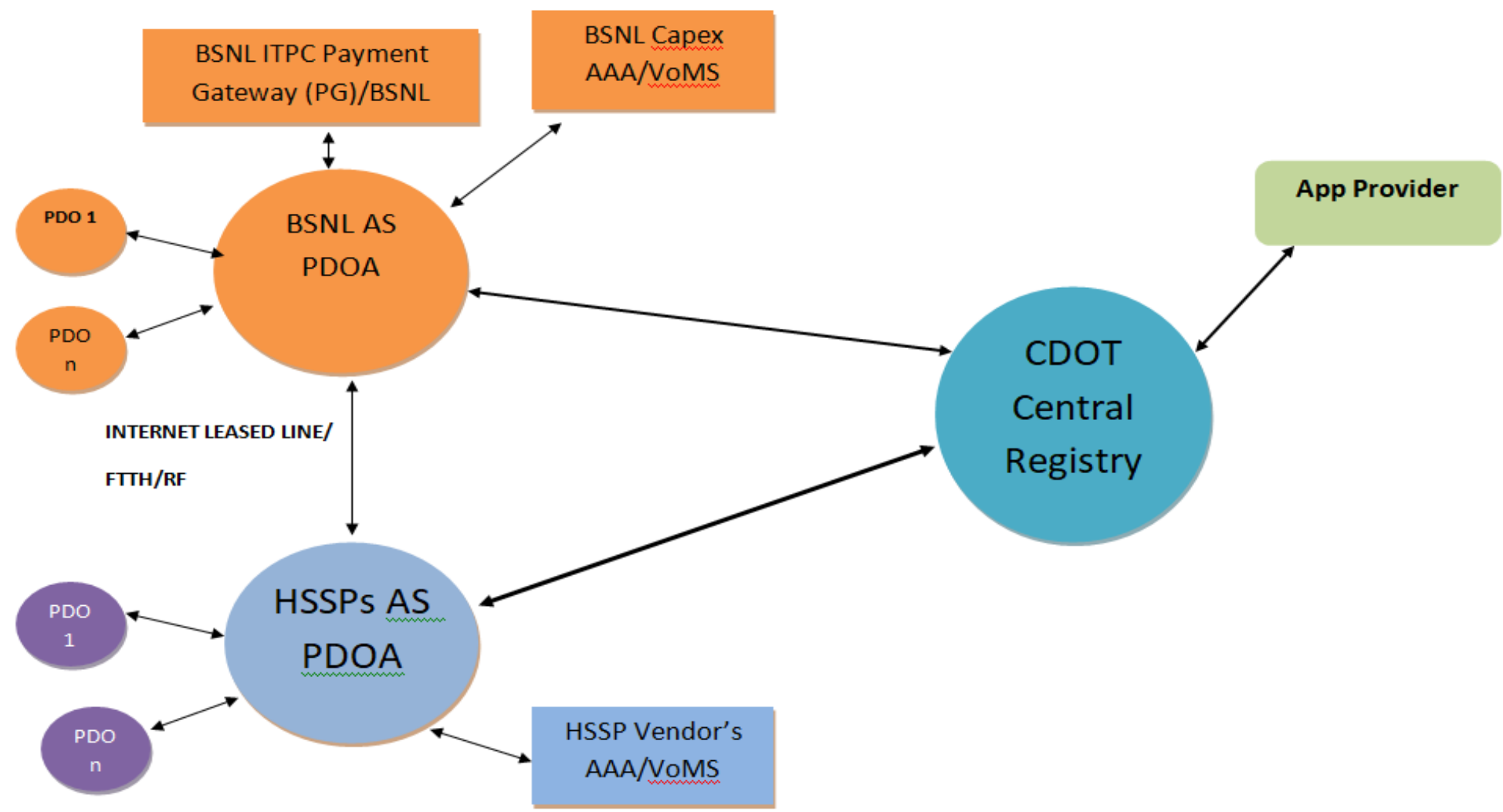
PM-WANI ARCHITECTURE

OPEN-WIFI & WANI ARCHITECTURE

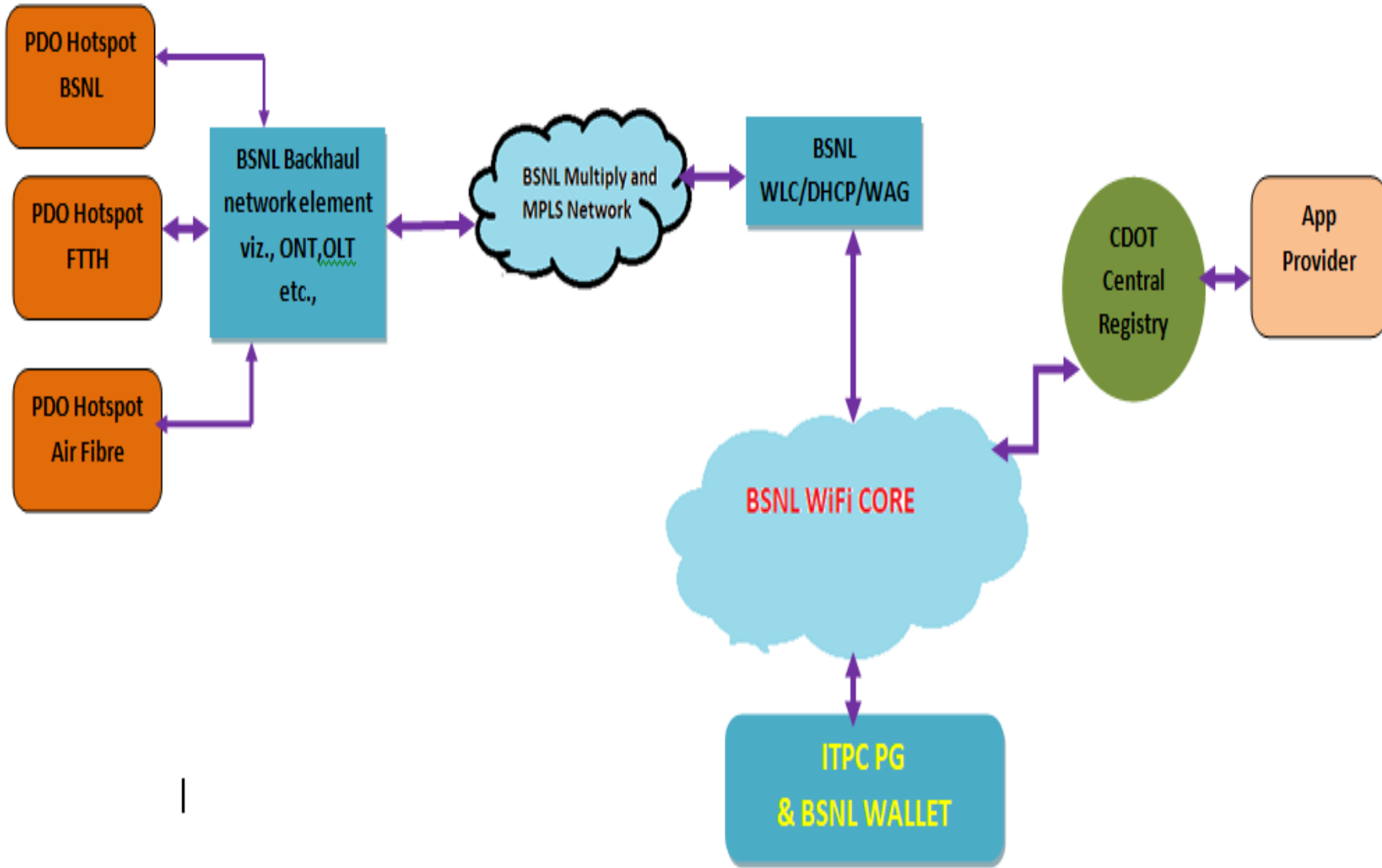




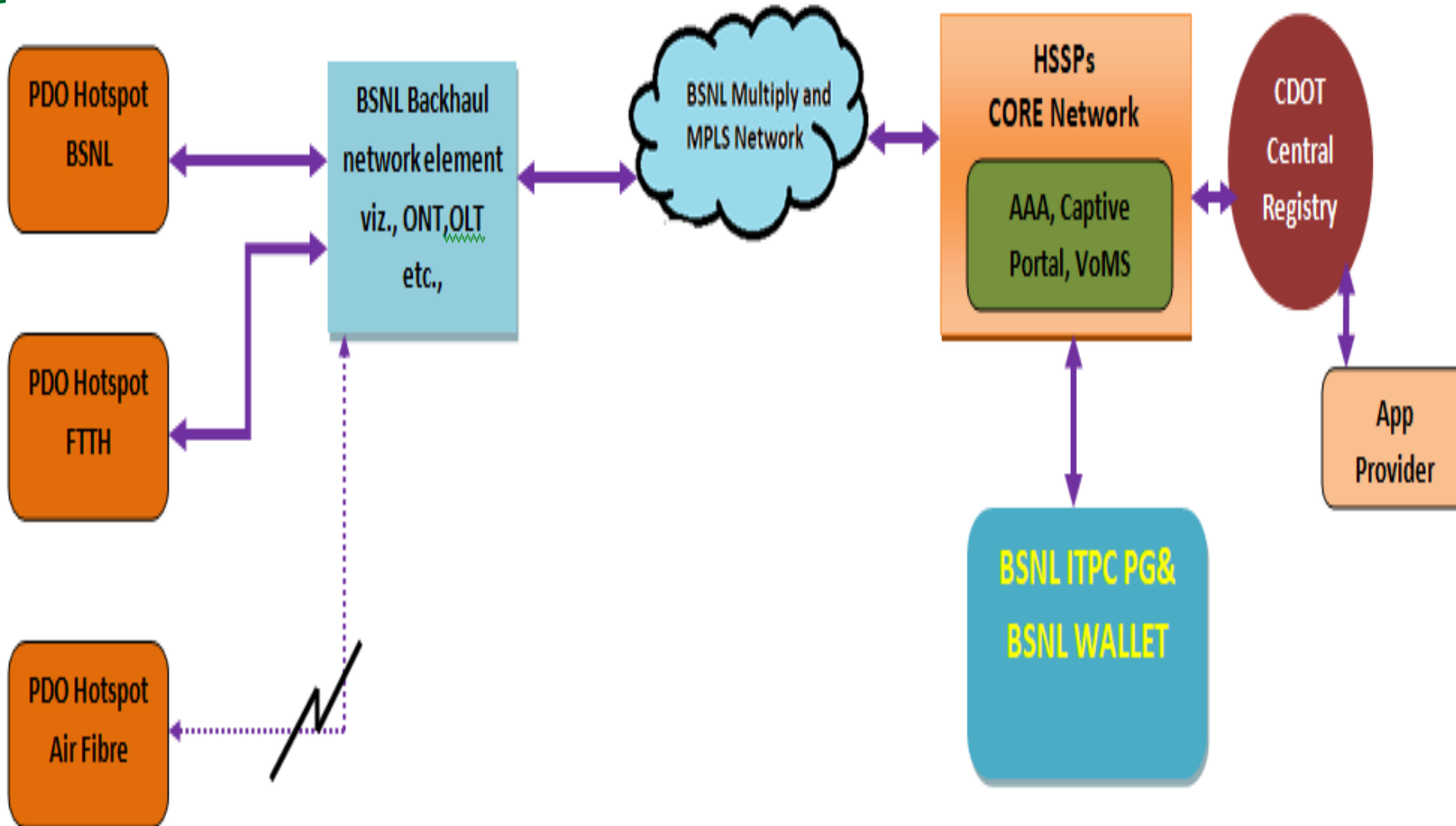
Deployment of WiFi Hotspots by BSNL/HSSP partners under PM WANI Framework



Scenario 1: BSNL as PDOA directly boarding PDO's

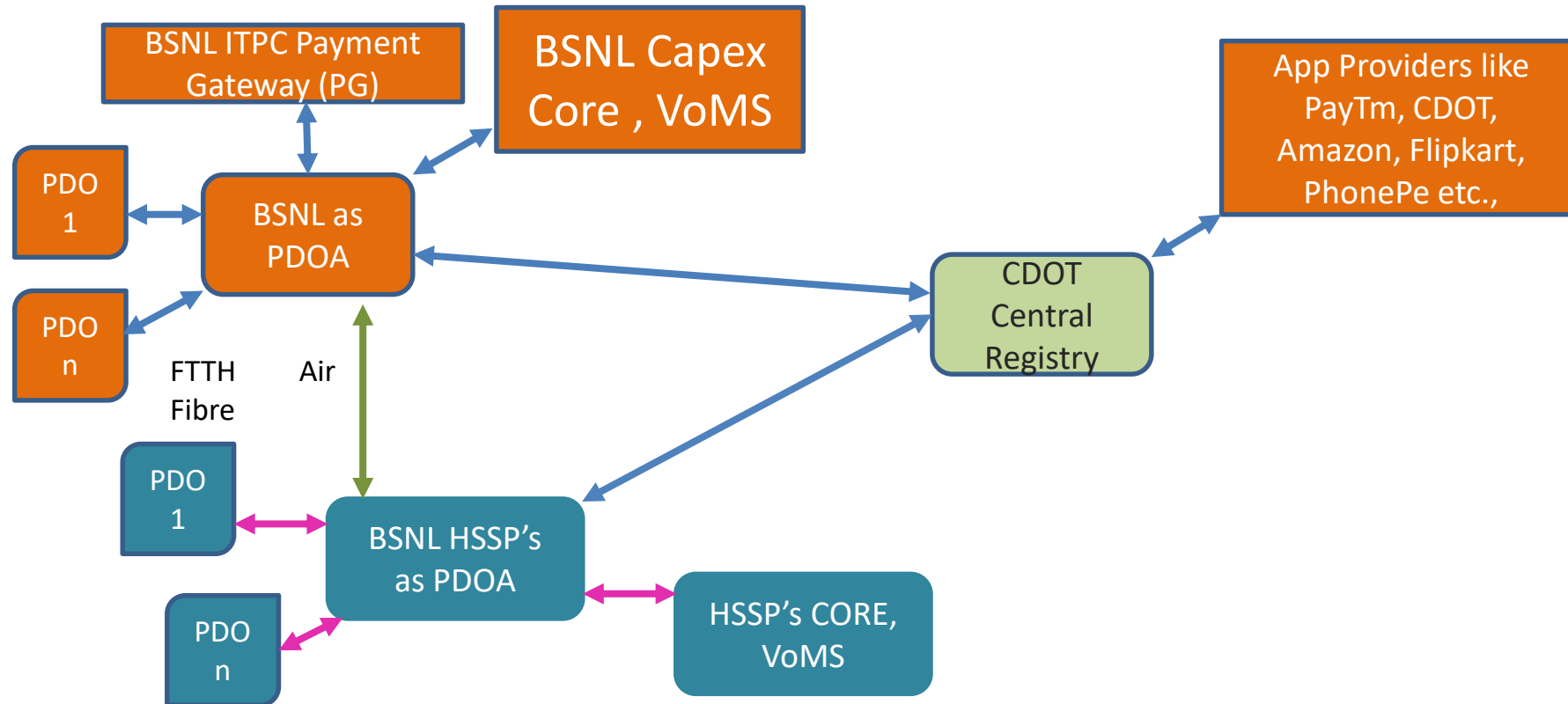


Scenario 2: HSSP as PDOA





Deployment of WiFi Hotspots by BSNL/HSSP partners under PM WANI Framework





Open Wi-Fi Policy Implementation & PDO Initiatives



Advantages of PDO Network

- ✓ No need of investment from the customer
- ✓ Simple and hassle free purchase of Vouchers
- ✓ Vouchers as low as Rs. 9/- (1 GB/ Day) to Rs. 69/- (30 GB/ 30 Days)
- ✓ Ease of deployment of PDO sites as compared to installation of 4G tower
- ✓ Predefined rates as per BSNL CO order No. to shift zero usage retail sites to PDO locations



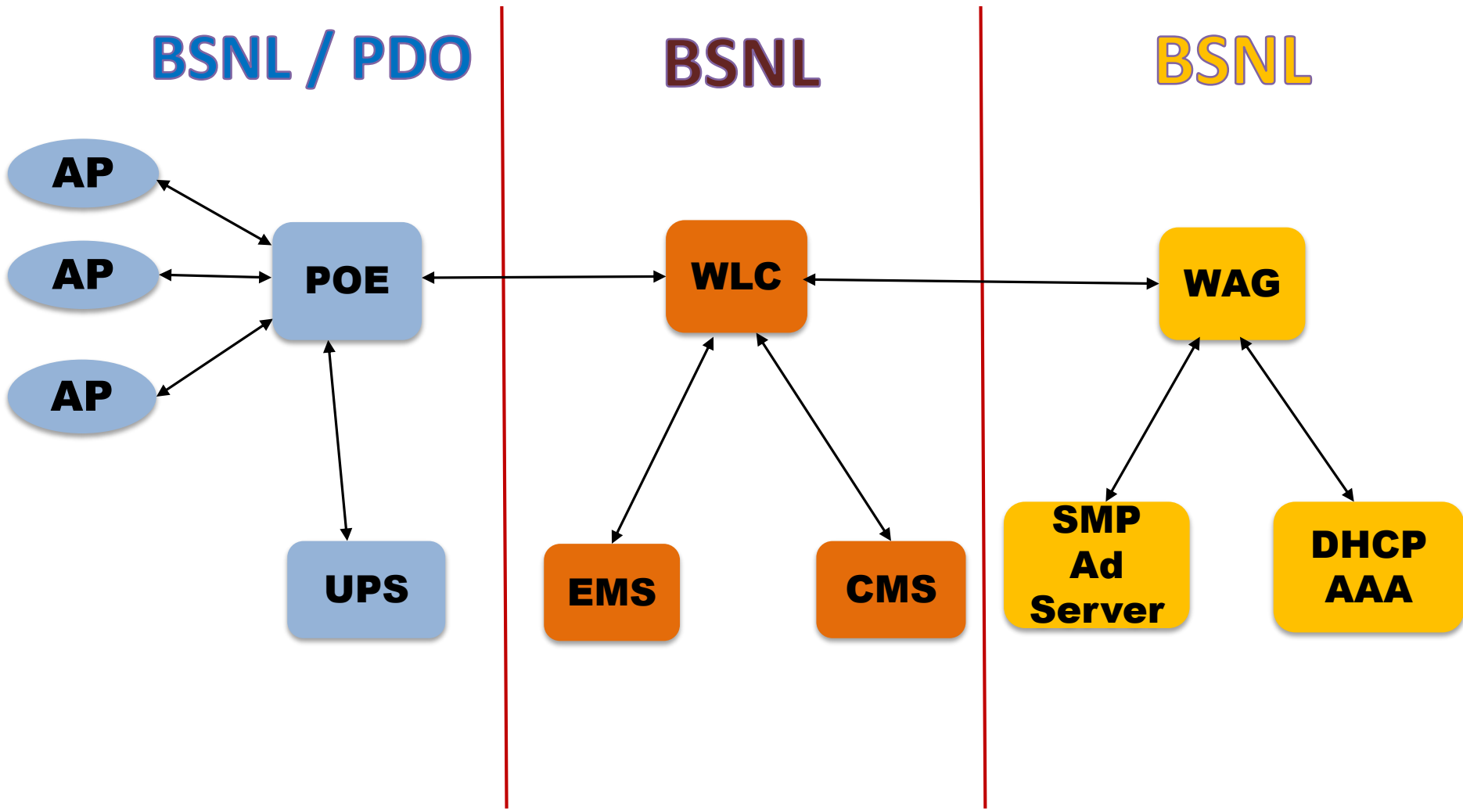
Open Wi-Fi Policy Implementation Models

To provide data services in rural areas, and to generate revenue through bulk hotspots the following Business Models are proposed under WiFi Open policy:

Model Name	Capex and Opex for Wi-Fi Core	Capex and Opex for Wi-Fi access point	Terminology of Wi-Fi Partner for Enterprise customer	Terminology for Retail Services	Sales and marketing of the Vouchers and level 1 mtce. of the Hotspot
Model I	BSNL	BSNL	NA	PWP	PDO
Model II	BSNL	PWP	PWP	PWP	PDO
Model III	PWP	PWP	PWP	PDO	PDO



Open Wi-Fi Implementation Mode (Model-I)

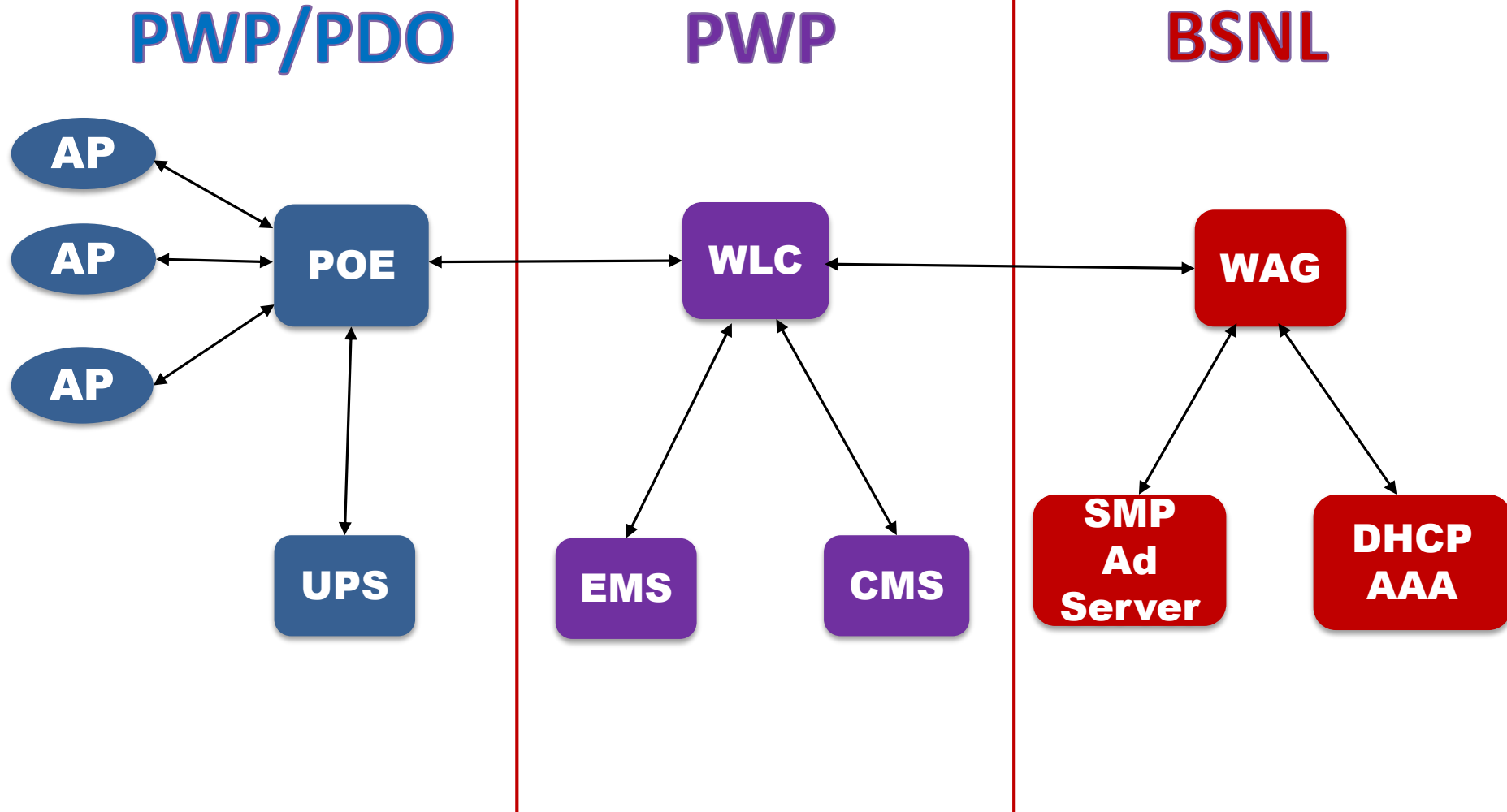




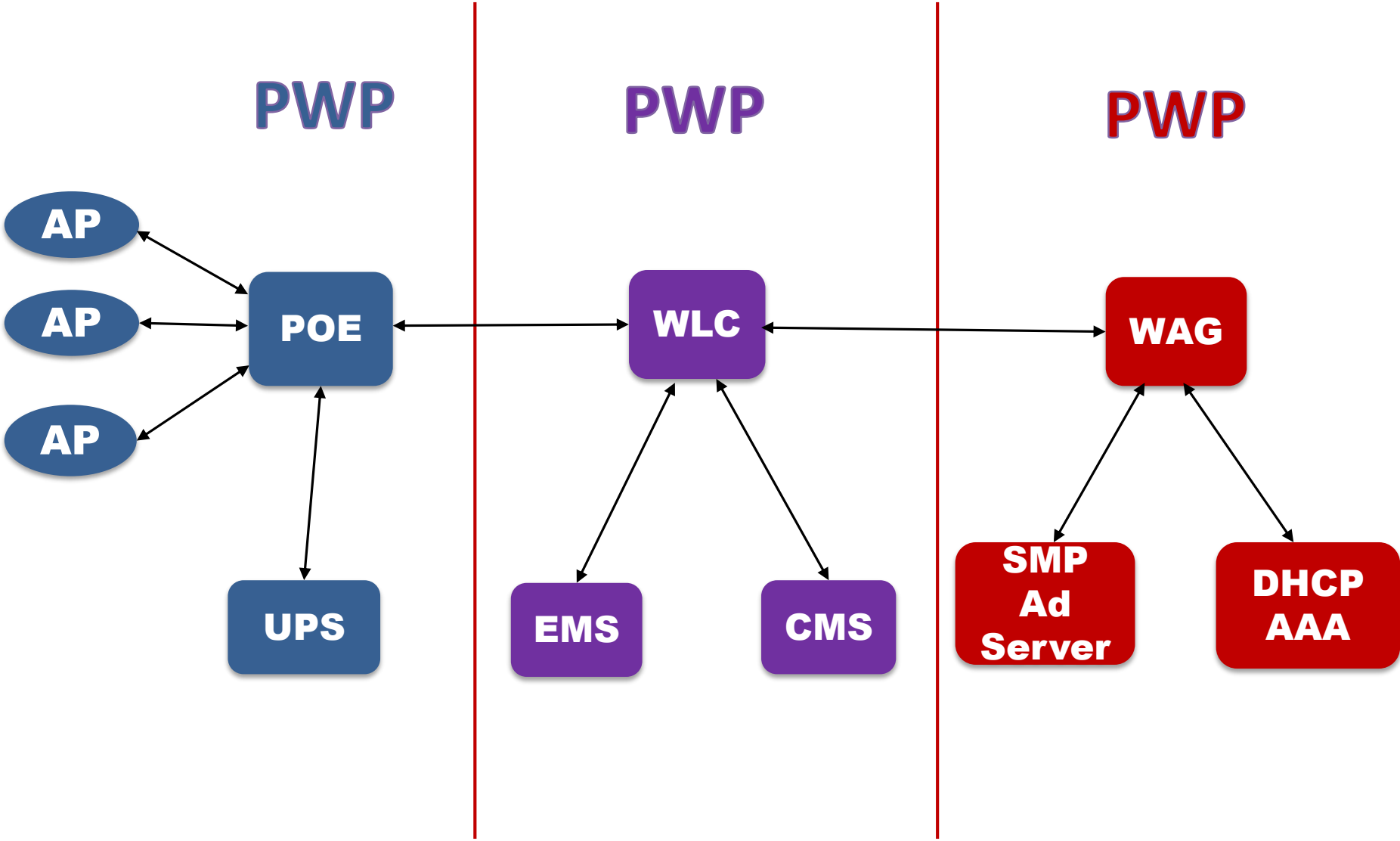
PDO Hotspot @ Tarikere, Chikmagalur SSA, Karnataka



Open Wi-Fi Implementation Model (Model-II)



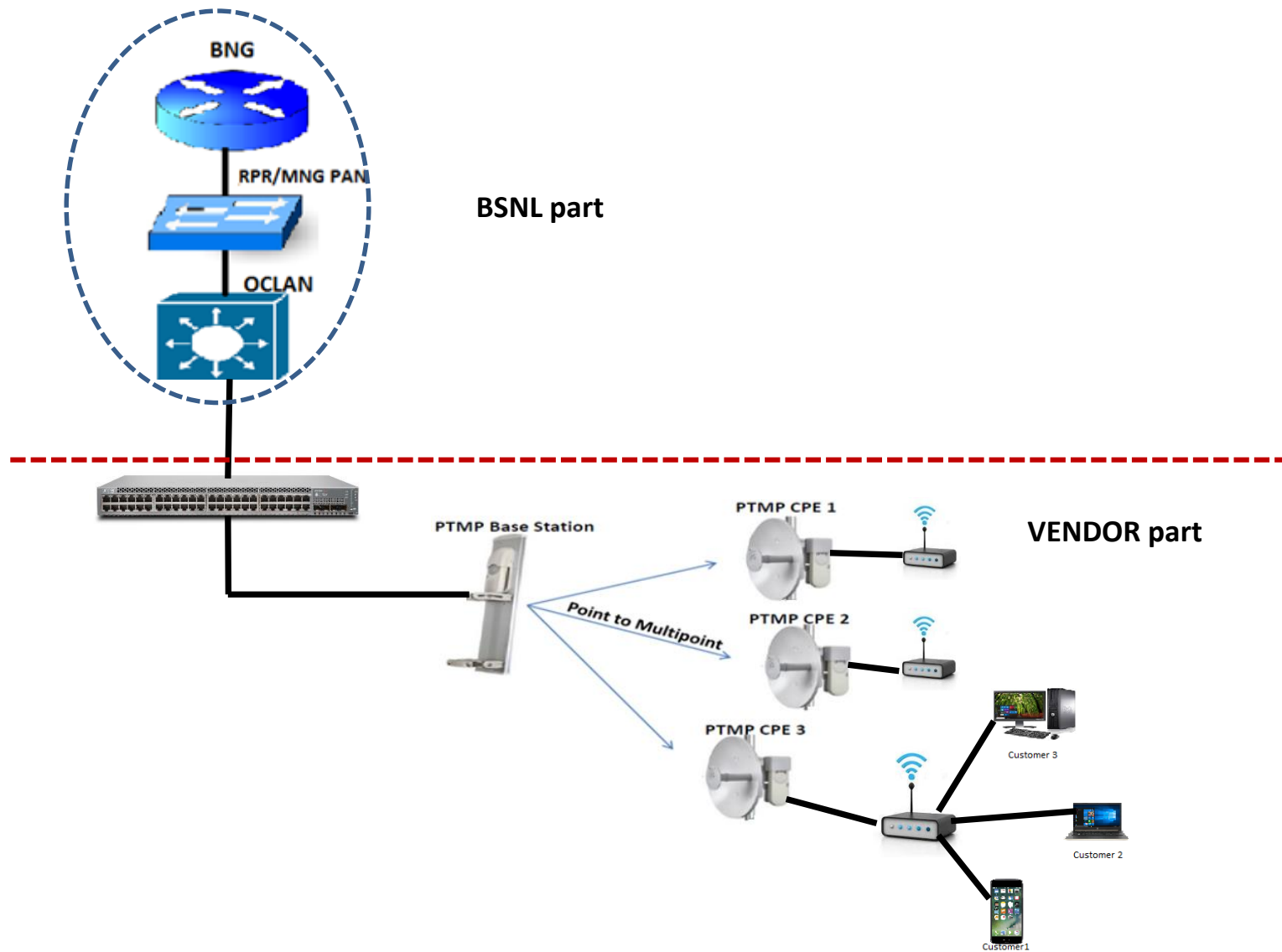
Open Wi-Fi Implementation Model (Model-III)





BBWi-Fi Model

BBoWi-Fi Network Diagram





Existing Setup of BBoWi-Fi

1. At Present BSNL is in partnership with various BWSP for providing broadband connection to the end customers using radio modem.
2. BSNL is giving back-haul to various locations, where the third party vendor is installing their antenna.
3. The vendor partner has installed their WAG equipment in data centers for managing radio modems and customer connections.
4. These WAGs are integrated with Multiplay network.
5. For customer acquisition for BWSP vendors, provisions are there in the IT modules.



BSNL Wi-Fi ROLLOUT HIGHLIGHTS

45000 Hotspots . 49000+ APs .



1500+ Towns . 25000 Villages



200+ Airports Hotspots



300+ Bulk Hotspots for
Universities / Colleges



100+ Tourist Spots



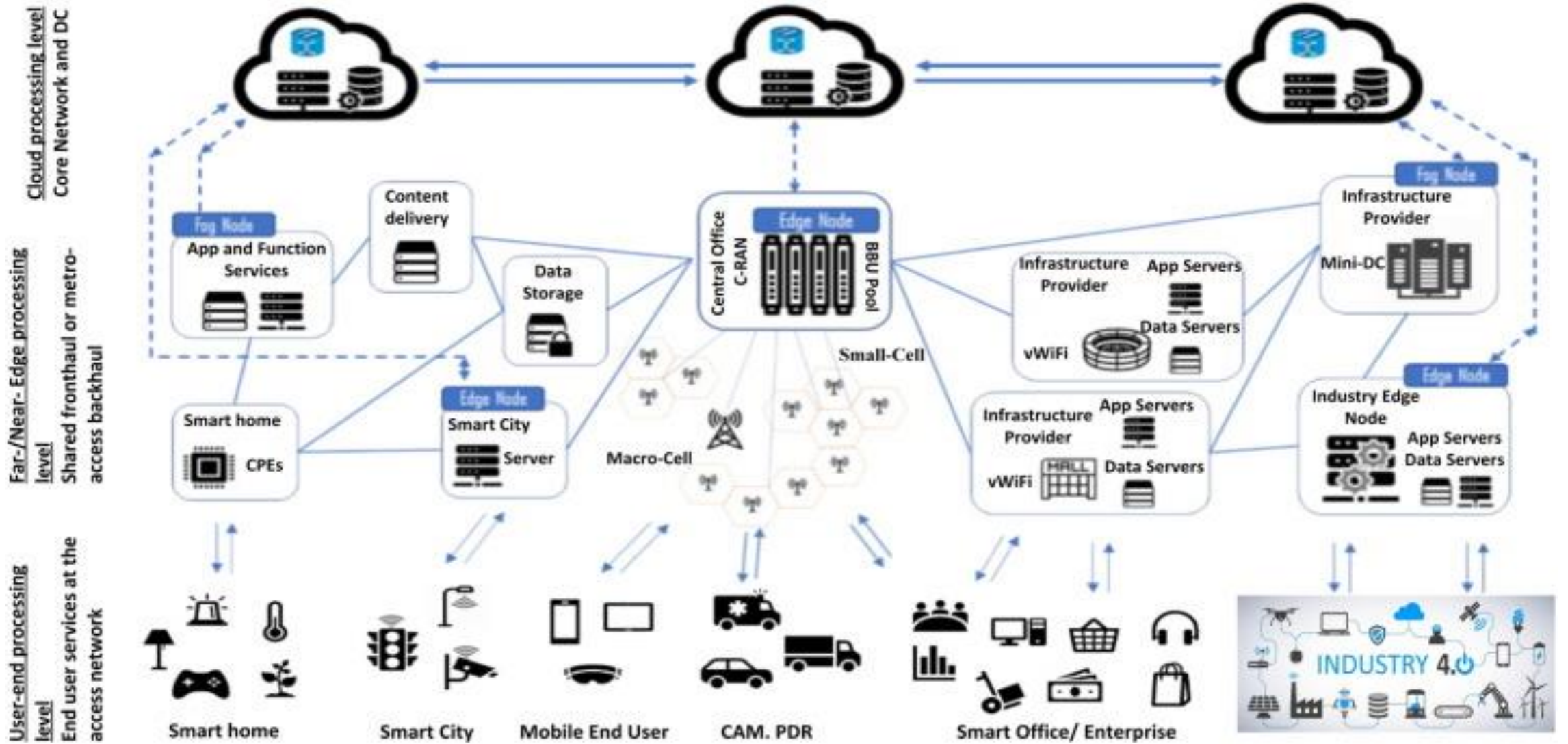


How will citizens use PM-WANI hotspots?

In order to take advantage of PM WANI Hotspots, the citizen would have to go through these steps:

- ❖ Download the PM WANI Hotspot Mobile App
- ❖ Register themselves on the app
- ❖ Complete an eKYC and verification
- ❖ Connect to the nearest WANI Compliant Hotspot
- ❖ Select a data plan from the PDOs Captive Portal
- ❖ Activate the plan and enjoy internet services over Wi-Fi
- ❖ The user should be able to discover all WANI compliant Access Points in all areas
- ❖ The user should be able to decide preferences for payment, also, there should be a provision for a single click renewal of voucher or data plan (available in UPI 2.0)

Challenges in enabling 6G-Integrating different networks





Challenges in providing Wi-Fi Services

1

Interoperability of Network Elements

2

Providing High Speed Services for all Needs

3

Service Level Agreements

4

Service Assurance & Fulfilment in a Static & Dynamic Environment

5

Meeting the customer / Industry requirements

6

Customer Awareness

7

Cut throat competition in telecom market

8

Less discipline in maintenance philosophy of network by operators



Way Forward & Challenges

Bridging the Digital Divide.

Citizen Participation.

Seamless connectivity of systems- AI,ML, IoT etc

Promoting Interoperability feature.

Safe and secure Cyberspace

Sustainable Development Goals



Challenges in 6G security

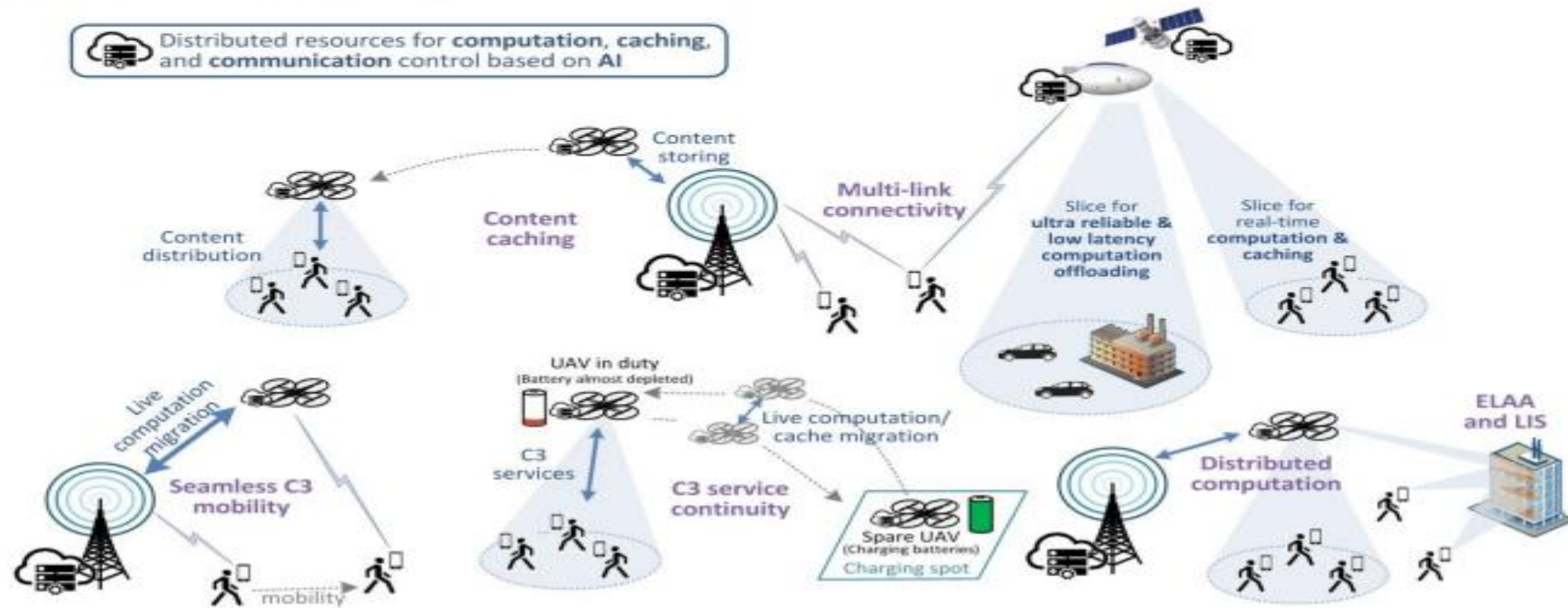
Three main challenges face 6G in terms of security:

- New architecture models enabled by 6G, combining cloud, network, devices;
- The central role of AI/ML in 6G;
- The advances in computing.

FROM 2D CENTRALIZED CONNECTIVITY TO 3D DISTRIBUTED INTELLIGENCE COVERAGE

TREND 2: 3D Coverage and Spatial BW

- 6G networks will integrated terrestrial non terrestrial components in a EE and scalable framework
- E2E resources will be dynamically orchestrate to deal with heterogeneous service requirements, and new connectivity & intelligence paradigms





THE QUEST FOR MORE DISTRIBUTED INTELLIGENCE

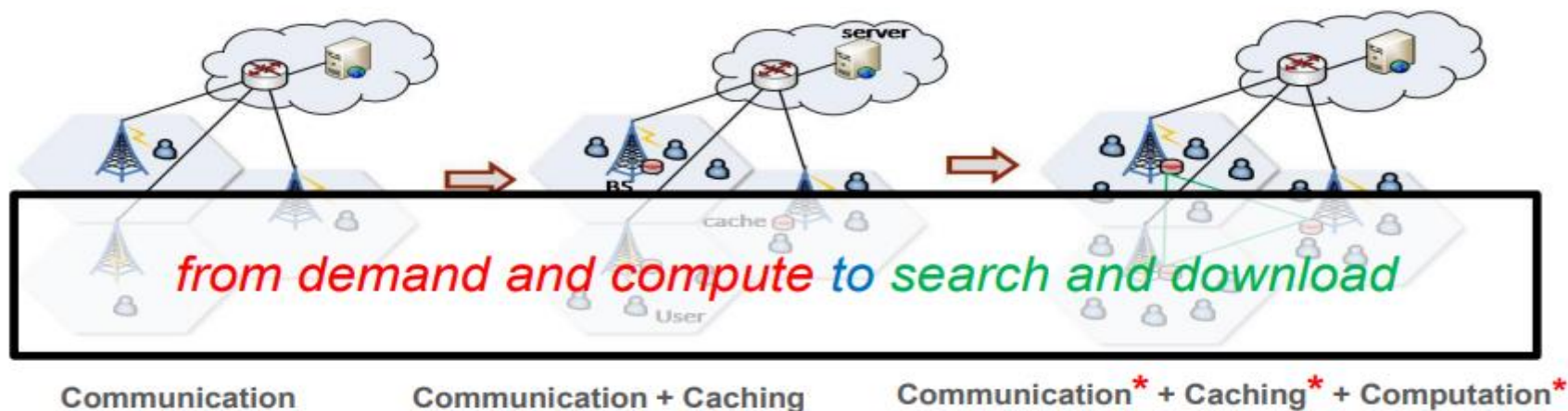
TREND 7: C⁴

In memory computing

- Less data travelling time
- In memory database, in memory applications
- New programming models



- Computational caching





Conclusions

New spectrum:

Ultra high capacity Sub-THz communications

- Multi-Tbps communications at the cost of
- coverage, HW complexity and system fragility to blockage, mobility, energy consumption,...
- Many open issues including how to extend and validate 5G propagation and antenna design to sub-THz communications

Visible Light Communications

- Enabling massive parallelization: 1000 simultaneous VLC connections

New Cooperation schemes

- Exploitation of cooperative intelligent surfaces and meta materials
- Multi-link communications to fight blocking at mmw and sub-THz

Most of beyond 6G will happen locally or in 3 D



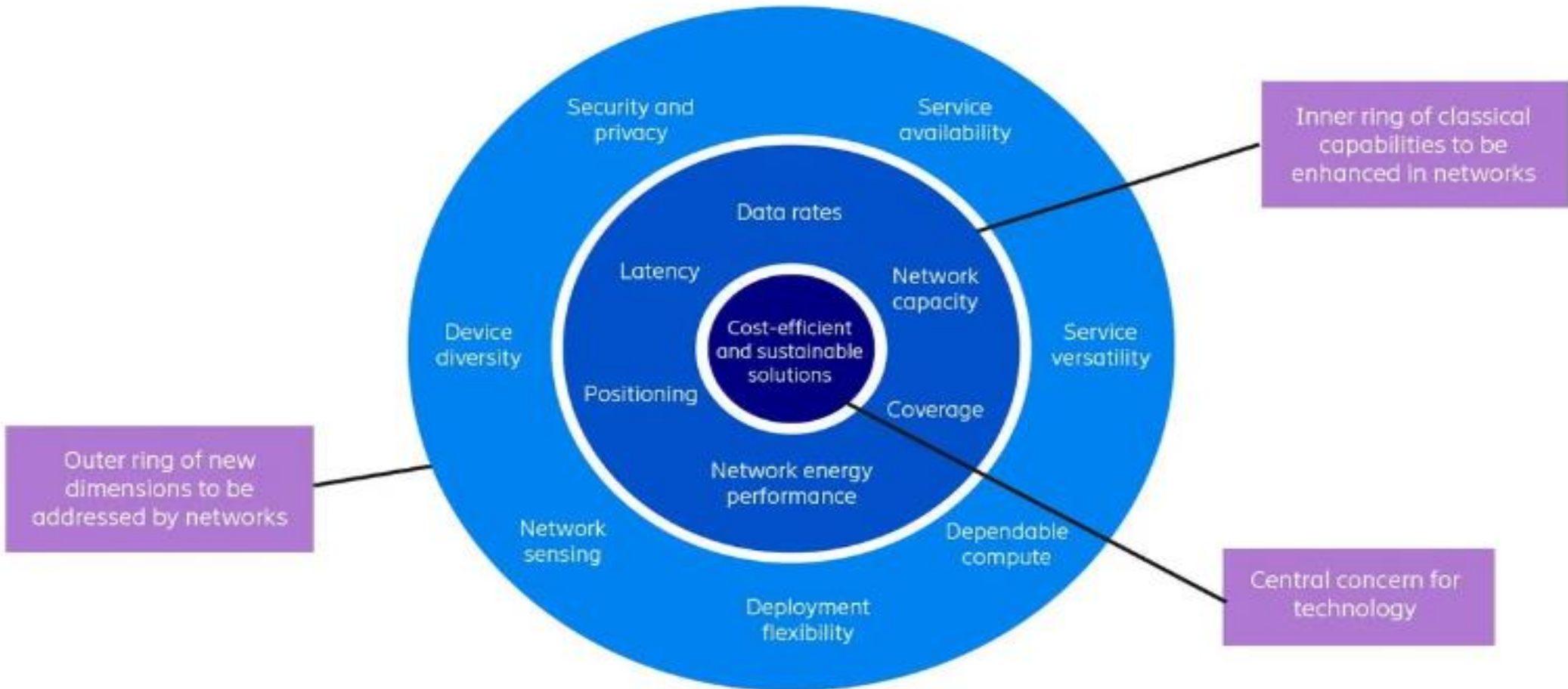
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Thank You very much

6G network capabilities





Additional Slides

Digital India 2030 Mobile and Broadband Policy objectives

2022 Roadmap	2030 Roadmap	Spectrum Requirements 2030 (5G+ and 6G)	Spectrum Bands to be made available
High speed broadband to citizens, Enterprises, public services. Connect all villages	100 Mbps to every citizen (large coverage of 5G and beginning of 6G)	Likely to double from the current planned spectrum quantities (covering lower, mid, millimeter and Tera Hz bands) Diverse access technologies Mobile, GSO, NGSO, HAPS, HIBS, etc.	<1 GHz Bands Mid Band: up to 10 GHz 6.425-24 GHz Bands Millimetre Bands: 26, 28, 40, 66, 70, 90 GHz, etc. Tera Hz bands
10 Gbps to every GP	500 Gbps to every GP	High speed backhaul to complement Fibre connectivity	Q, V, E, D, W Bands Free Space Optics 6.425-24 GHz Bands Free Space Optics
50% Households with Broadband	90% Households with High-speed Broadband	FWA – Fixed Wireless Access (would be a cost-effective option) using 5G and E, V Band links & other access technologies including fibre	Millimeter bands of 37, 50, 66 GHz V Band (57-66 GHz) 6.425-24 GHz Bands Free Space Optics

Digital India 2030 Mobile and Broadband Policy objectives

2022 Roadmap	2030 Roadmap	Spectrum Requirements 2030 (5G+ and 6G)	Spectrum Bands to be made available
10 Million public Wi-Fi Hotspots	→ 50 Million public Wi-Fi Hotspots	→ New License Exempt Spectrum Bands	→ 6 GHz, V-Band, > 95 GHz Tera Hz Bands
5 Billion IoT Devices; Enterprise Digitization (ITS, Urban Management)	→ 25 Billion IoT Devices Smart Enterprises & Factories (Smart Infrastructure Rural and Urban)	→ New License Exempt Spectrum for M2M connectivity to power smart cities and communities	→ 915-935 MHz V Band 95 GHz bands Thz bands
Personal and Home Connectivity (SRDs)	→ Connected and Intelligent Living	→ Extremely low power intelligent devices of all kinds connecting everything around	→ Hundreds of bands to be identified continuously based on innovation

Digital India 2030 Mobile and Broadband Policy objectives

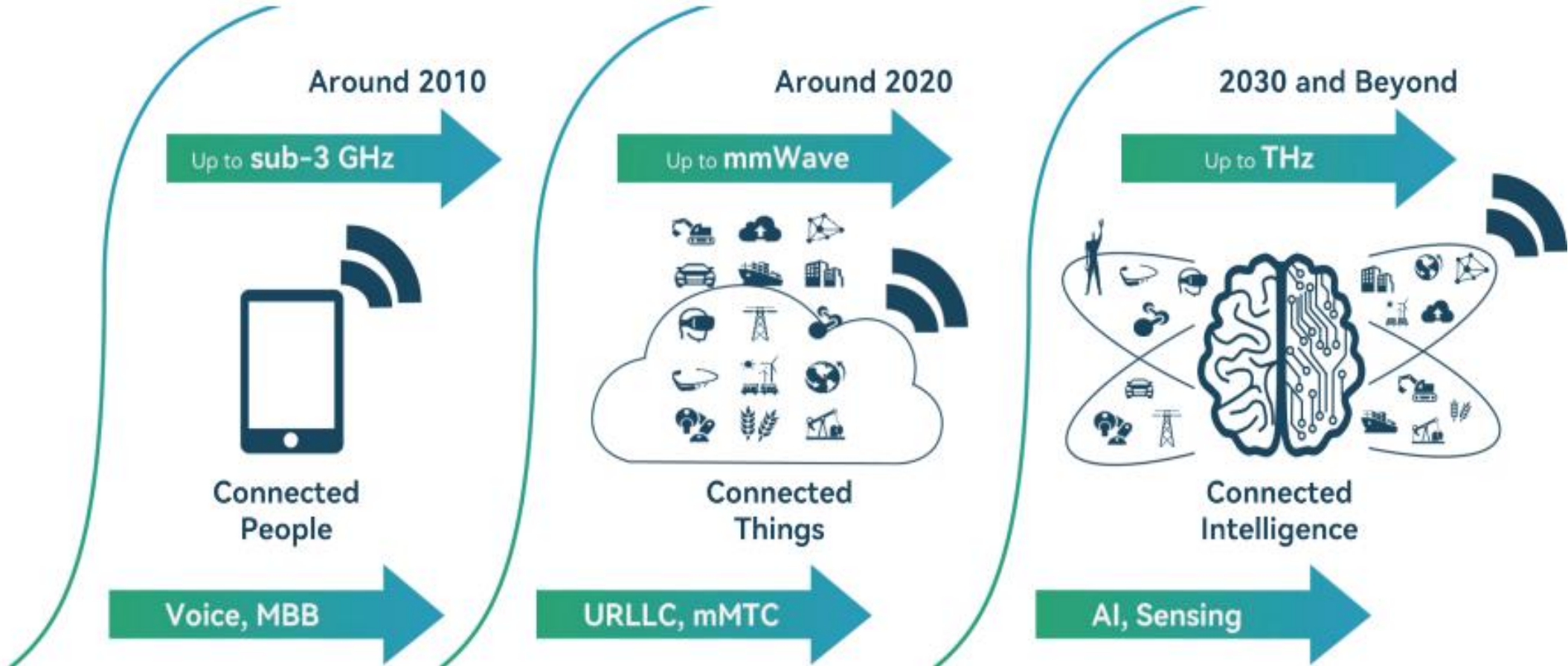
2022 Roadmap	2030 Roadmap	Spectrum Requirements 2030 (5G+ and 6G)	Spectrum Bands to be made available
Personal and Home Connectivity (SRDs)	Connected and Intelligent Living	Extremely low power intelligent devices of all kinds connecting everything around	Hundreds of bands to be identified continuously based on innovation
UAVs with limited action	UAVs in Delivery Services, Logistics, Disaster Management	Defined IMT and unlicensed bands with ultra-reliability and control (application specific)	1 GHz Bands Band: up to and above 10 GHz

6 Pillars of 6Gkey capabilities



Source:Huawei6G roadmap

Mega trends of Mobile communications towards 2030





Thank You very much