“Frugal 5G”:Connecting the Unconnected World !

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IEEE Activities related to Frugal 5G

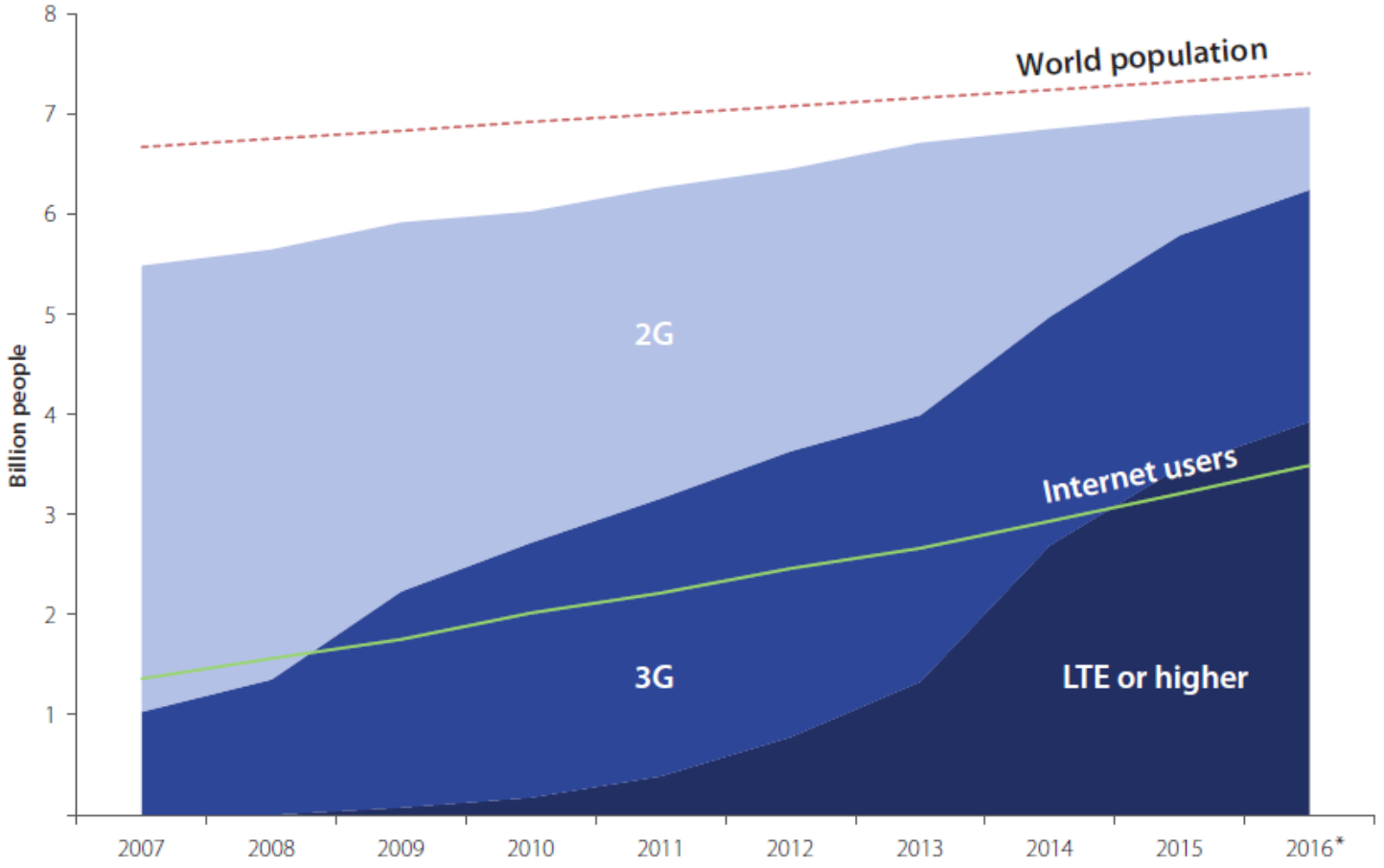
- Frugal 5G Rapid Reaction Standardization Activity Phase
  - Pre-standardization study phase expected to be approved by IEEE ComSoc Board by the end of this month
- SDN based Middleware
  - Standards project P1930.1 approved in December 2016 by IEEE SA Board
  - Working Group formed

Outline of the Talk

- Broadband Penetration Status in India and Rest of the world
- Challenges in Affordable Broadband
- Re-thinking 5G Requirements for connecting the unconnected world
- Frugal 5G architecture
- IEEE ComSoc Frugal 5G RRSA
- IEEE SA upcoming standards activity-P1930.1

Broadband Penetration Status: Worldwide

Around half of the global population is unconnected



Source: International Telecommunication Union

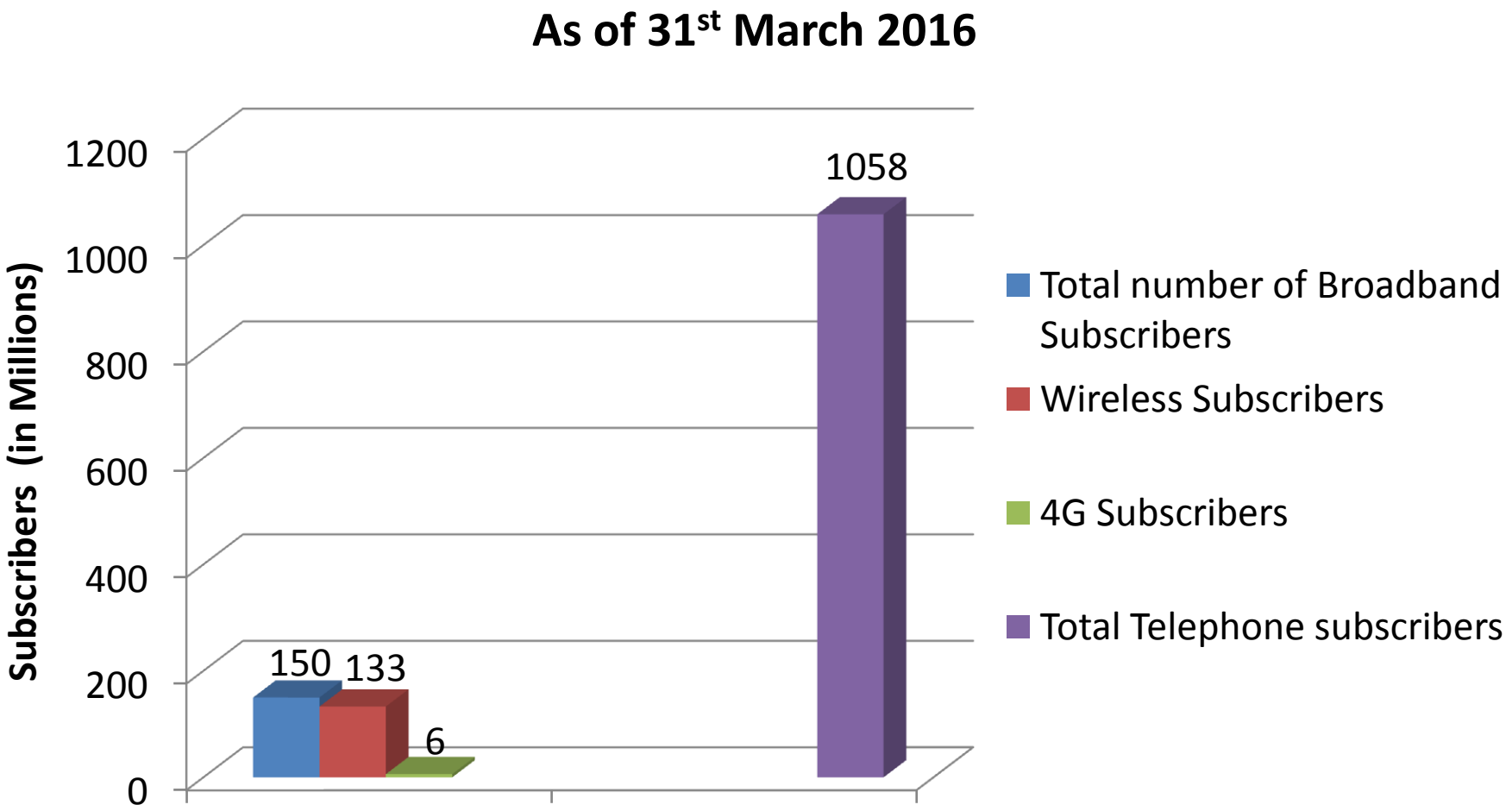
Around 84% of global population lives in regions which are covered by wireless broadband (3G/4G) but the adoption rate is only 47%

Broadband Penetration Status

- A large part of the world is still deprived of broadband connectivity
  - It is estimated that 3-4 Billion people do not have access to Internet
- Around 95%* of the unconnected population belongs to developing regions and countries like India, Africa, Brazil, Argentina etc.
- The broadband penetration in rural areas of developing regions is even marginal

*Source: International Telecommunication Union

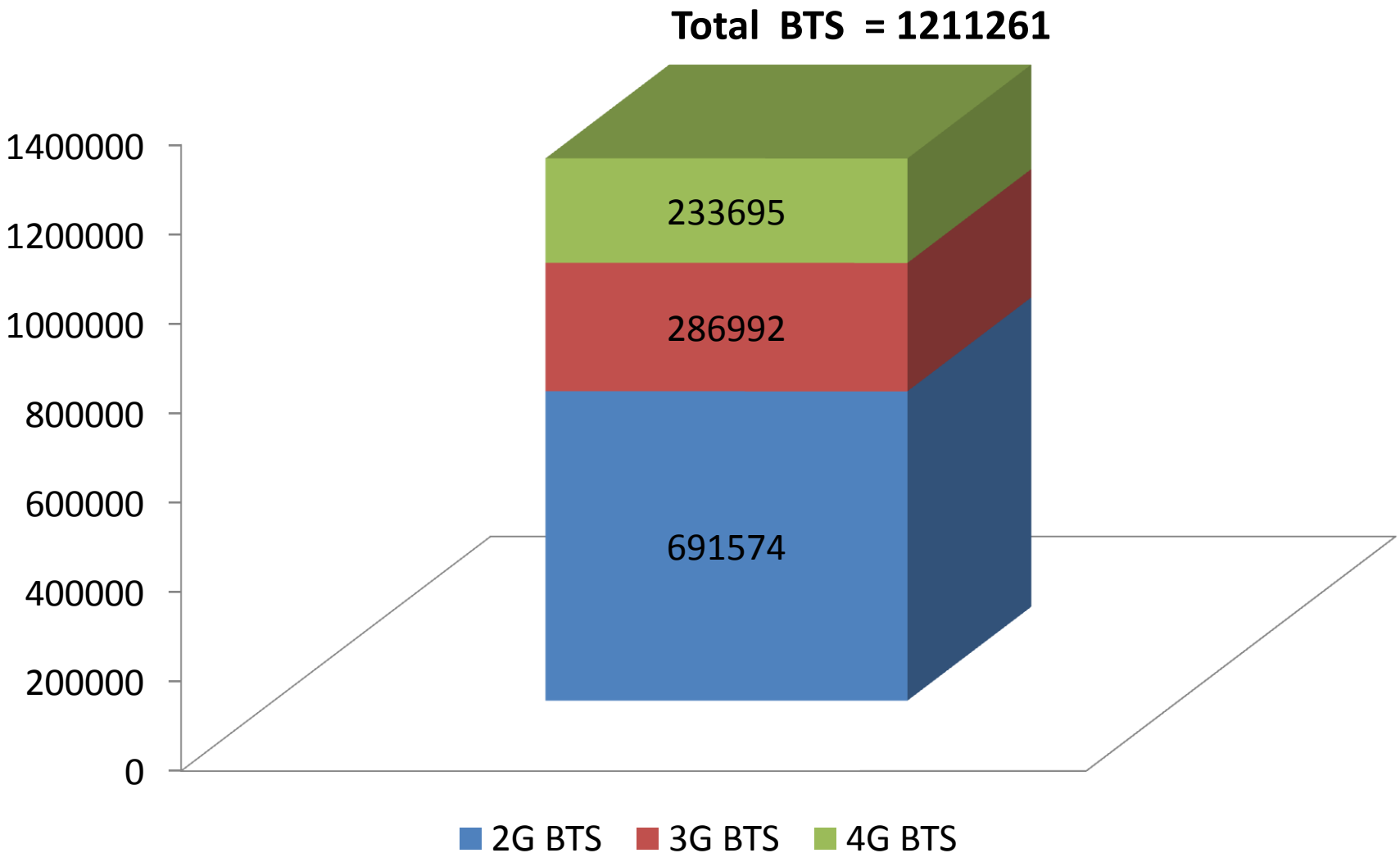
Broadband Penetration Status: Indian Scenario



Around 1 billion people do not have broadband access in India

Source: TRAI, Cellular Operators Association of India (COAI)

2G vs 3G vs 4G in India



Source: COAI

Urban and Rural Challenges

Images from Wikipedia- Digital Divide: Mumbai; an Indian village

Urban India or metro cities have optional access to broadband

Rural India, even though it contributes 50% to the GDP, has no access to broadband (mere 1.5%)

Challenges in Rural Areas

ARPU/Total Revenue

CAPEX & OPEX

Tele-density is just `50%

Government Initiatives

USOF

BBNL

NOFN/ BharatNet

Challenges in Broadband Penetration Status

- Low Average Revenue Per User (ARPU)
- Lack of affordable backhaul
  - Fiber –Right of Way and Time/cost of deployment
  - High CAPEX
- High energy cost
  - The base station equipments operate at high powers leading to high OPEX.
- Scarcity of electricity
  - The equipment is non-operational for a large part of the day

Changes in 5G Requirements needed to bridge the digital gap

Traffic Growth in India – 5G?

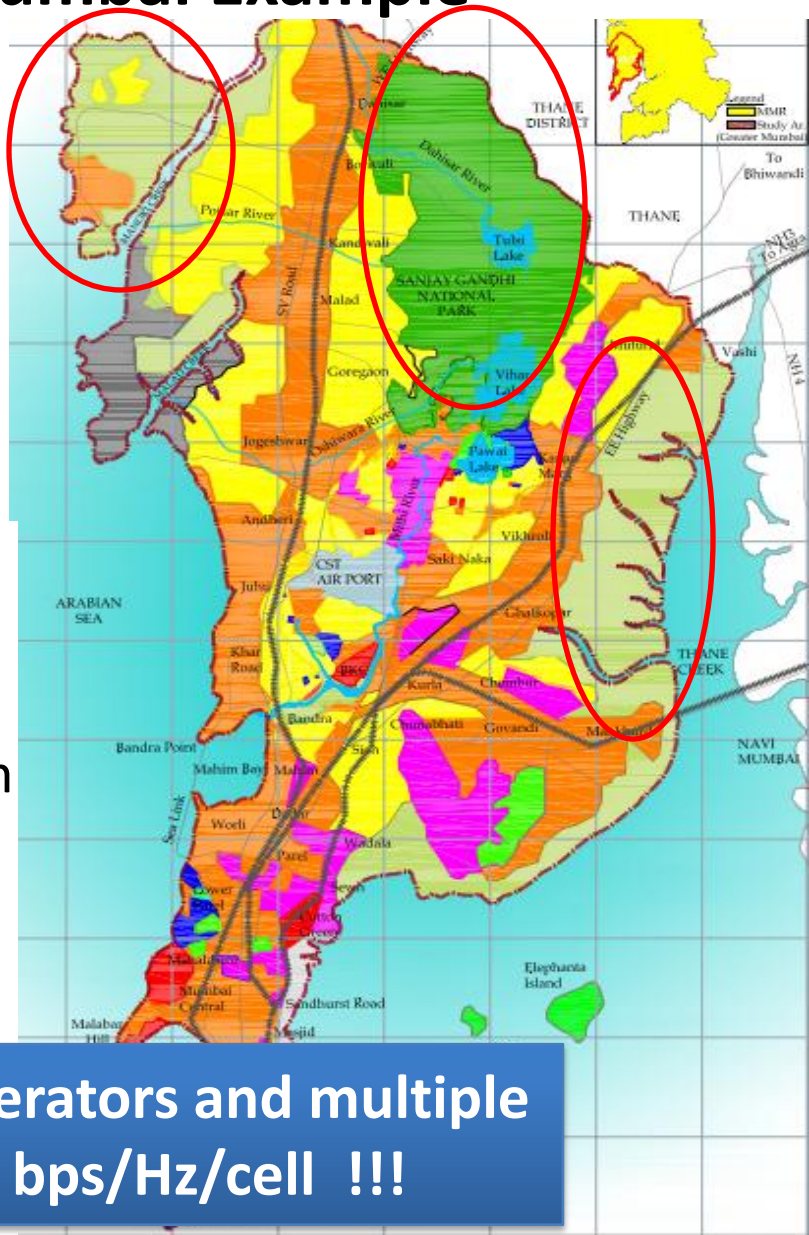
- India needs primary broadband connectivity to 250 M homes, for 250 GB/month being delivered at 2 Mbps

- Translates to 100 Exabytes per month for India alone which is 8x the expected global mobile traffic by 2017!!

Future Wireless Broadband Demand

Broadband through Wireless – Mumbai Example

- Population density – 21k/sq. km
- Approx 34% wet land and forests
- Actual population density
  ~ 90-100k/sq. km in some areas
  or even more
- 25k households/sq. km
- Assume 100% households have broadband
- 2 Mbps per household
- Very high capacity required: 50Gbps/sq. km
  - Assuming 3-4 cells/sq. km (radius less than 500m)
  - We need about 12 Gbps per cell



With 100 MHz per cell (multiple operators and multiple technologies) ~ whopping 120 bps/Hz/cell !!!

Rural Broadband: BharatNet/Gram Panchayats

- Approximately, 13 % Gram Panchayats have been connected.
- 6,38,619 villages will still remain unconnected even if all Gram Panchayats are connected by BharatNet i.e. 2.56 Villages per Gram Panchayat

Number of Blocks (BhartNet Phase-I)	6,382
Number of Gram Panchayats (BhartNet Phase I/II)	2,50,000
Number of Villages	6,38,619
Avg. number of Gram Panchayats per block	40
Avg. number of Villages per Gram Panchayat	2.56
Avg. number of Hamlets per Village	4
Number of Gram Panchayats connected by BharatNet	32,272
Number of Active Gram Panchayats	4,754

Spectrum Challenges in India

What does India need for 5G?

- Can we have more efficient use of spectrum?
  - Cost is transferred to end-customer
  - Makes the solution unaffordable
- Do we need to support high-speed mobility (300 km/h)?
  - in cities 40-60 km/h; 80-100 km/h on highways
  - Mobility is required but Fixed Primary Access is key
- Do we need to address multiple device connectivity?
  - Urgent need is for primary broadband connectivity

We need a focussed and cost-effective solution!

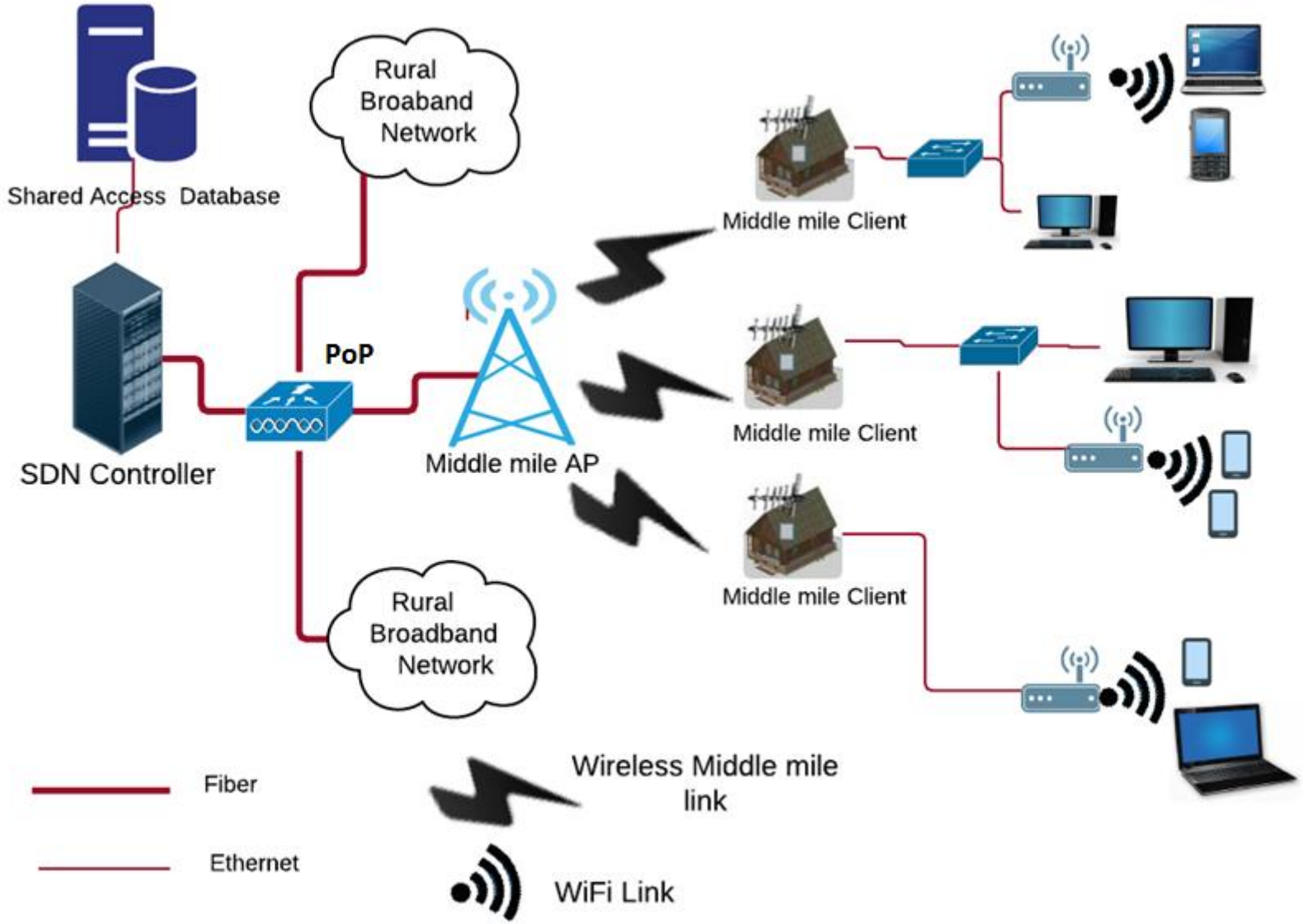
Rethinking 5G Requirements

- Low cost solutions
  - Low Device costs
    - Simpler Hardware and RF Design reducing the device costs
  - Low cost Connectivity / backhaul solutions
    - Using wireless backhaul/middle mile instead of fiber
  - Lower spectrum cost
    - Efficient usage of spectrum
    - Using network sharing options to share spectrum across Radio Access Technologies (RATs) across operators
- Limited mobility support
  - Mobility is required but not very high speed
  - Fixed primary access is the key

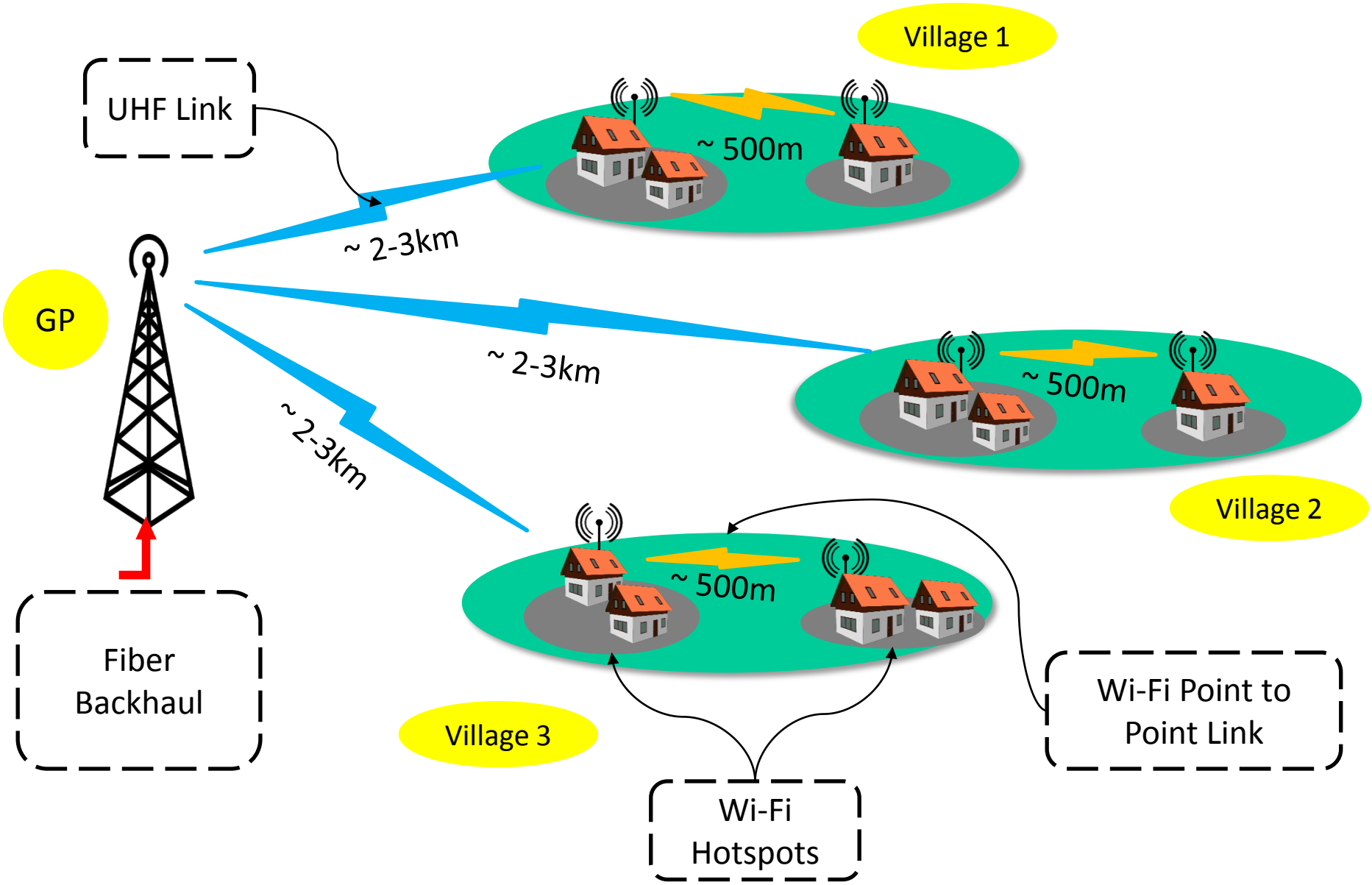
Rethinking 5G Requirements (Contd.)

- Energy efficient solutions
  - Lowering system energy consumption
  - Support for operation in power saving mode
  - To enable working off non-conventional energy sources
- Large coverage area support
  - Support for large cells to reduce CAPEX and OPEX
- Less stringent availability requirements

Frugal 5G – Envisioned Architecture



Rural Broadband



Frugal 5G – IEEE ComSoc RRSA Study

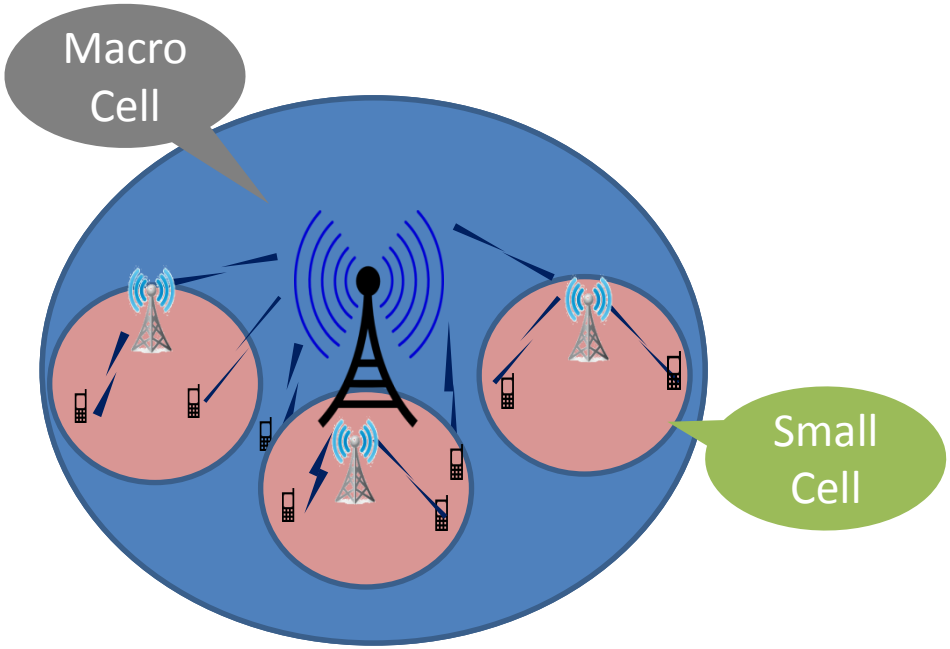
- Study & analysis of existing wireless broadband technologies
  - IEEE 802.11 WLAN, IEEE 802.22 WRAN, 3GPP-UMTS, 3GPP-LTE
  - Gap analysis with respect to following requirements
    - Low Cost Solution
    - Reduced Energy Consumption
    - Low Mobility scenarios
    - Usage of non-conventional energy sources

Frugal 5G – RRSA Study Phase(Contd.)

- Usage of affordable Wireless middle-mile network to connect the core network to IEEE 802.11 based access network
  - TV UHF spectrum based solution
  - Mesh network in mmWave
- Dynamic spectrum sharing for multi-operator co-existence
- Scalable control and management of access and middle mile network
  - Software defined network (SDN) based control and management
  - A simplified IP based network architecture

SDN in 5G

- Current scenario
  - Network elements: closed boxes with no flexibility in functionality
  - Network is complex, distributive, poorly managed and unresponsive to failures
  - No coordination between management of data flows



- SDN for wireless Networks
  - For robust and failsafe telecom infrastructure
  - Reduce expenditure on proprietary devices and Intellectual property
  - For ensuring quality of service and experience to every user

- Cellular Technology :Small Cells
  - 3GPP technologies like UMTS / LTE / LTE-A and beyond
- Fixed Wireless Access solutions
  - IEEE technologies like IEEE 802.11 and its variants

IEEE Standard Project P1930.1

Recommended Practice for Software Defined Networking (SDN) based Middleware for Control and Management of Wireless Networks

Scope

- To specify a middleware for vendor independent management and control of Wireless Networks in accordance with the Software Defined Networking (SDN) paradigm
  - For management & control of Access Points (APs) for IEEE 802.11 based Wireless Local Area Networks (WLAN) & Base Stations for IEEE 802.22 based Wireless Regional Area Networks (WRAN)

Thank you