

IEEE P2061 - Frugal 5G Networks

Abhay Karandikar

Director, Indian Institute of Technology Kanpur, Kanpur, India

(On leave from Indian Institute of Technology Bombay, Mumbai, India)

director@iitk.ac.in

karandi@iitk.ac.in

Agenda

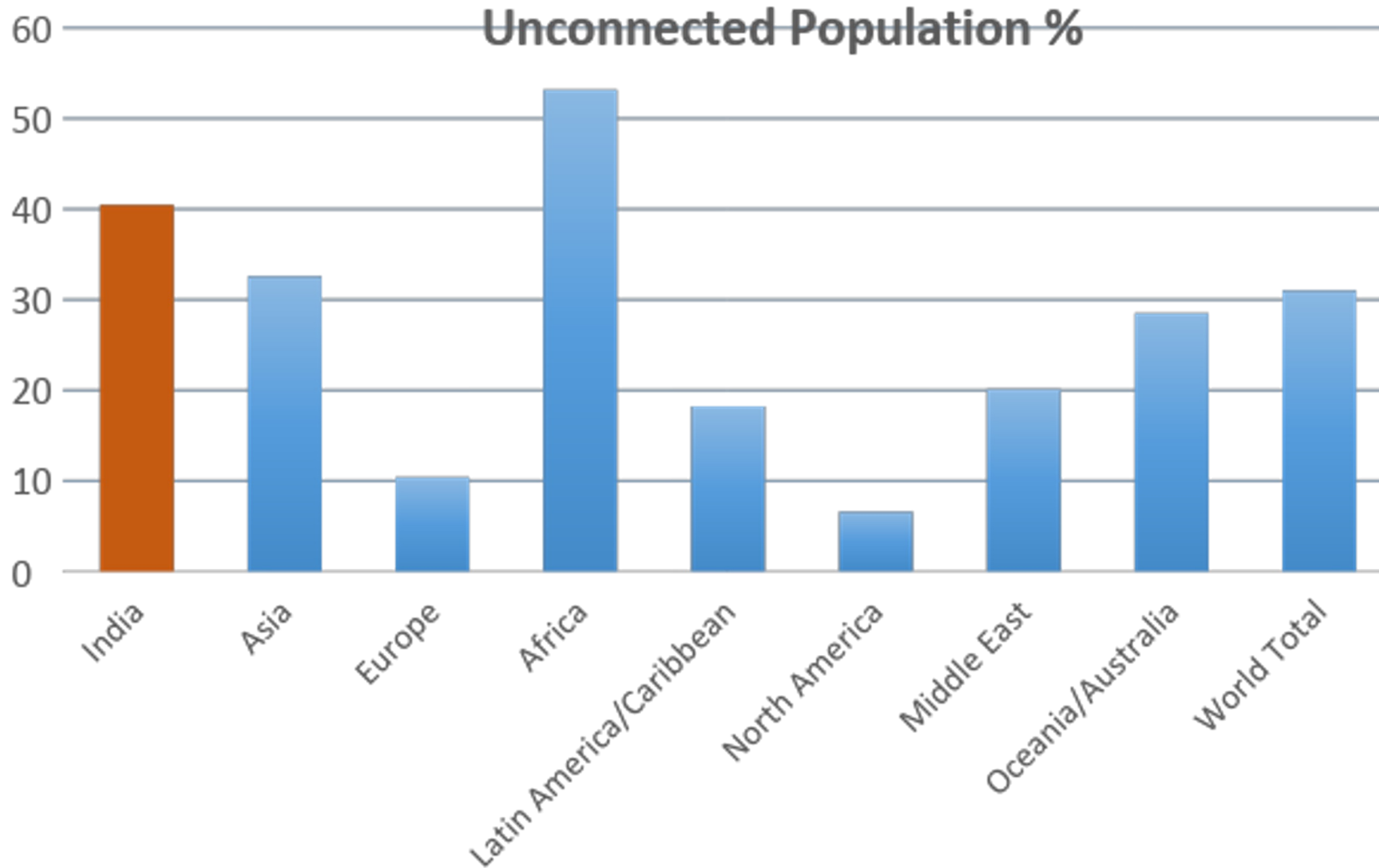
- IEEE P2061
 - Introduction & Standardization Status
- Connecting the Unconnected
 - Key Challenges & Requirements
- IEEE P2061 Architecture
 - Overview
 - Middle Mile Network
 - Edge Components
 - Architecture Framework
 - Summary

IEEE P2061 - Introduction & Status

- IEEE Standard for Frugal 5G Networks
 - Architecture for Low Mobility Energy Efficient Network for Affordable Broadband Access
- The Standard defines
 - Wireless access network (AN)
 - (Wireless) middle-mile network (MMN)
 - Control architecture for AN and MMN
- Standard Draft Ready
- WG Balloting initiated on 10th January 2023
 - Expected Completion 28th February 2023
- Expected IEEE SA Approval - 2023

Connecting the Unconnected

Global Internet Connectivity Status



~32 % of the World Population is Unconnected - Majority in Developing World and in Rural Areas

Connecting the Unconnected - Key Challenges

Sparsely Populated Rural Settlements



India



Ethiopia

**Source: Google Earth*

Circles denote habited areas, Rest of the areas have no population

High Deployment Cost

Spectrum cost

Cost of backhaul

Scarcity of Resources

Uninterrupted power supply from the grid not available

Lack of Relevance

Most Internet content in English and a few other languages

Relevance of content limited

Relatively Lower Income

Unaffordable devices

Low average revenue per user

Challenges of Manageability


Unavailability of trained manpower

Access Constraints

Right of way issues

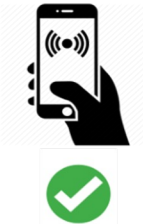
Internet/Broadband Access- How is it enabled?

Developed Countries

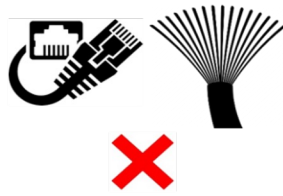


Mostly enabled through wired communication infrastructure, Fiber and DSL

Developing Countries




Cellular Technology - Primary broadband access mechanism



Fiber/DSL Infrastructure - Inadequate

Cellular Infra is much easier to deploy viz-a-viz fixed-line Infra
But is Cellular enough?



Challenges in using Cellular Technology in Rural Areas

Focus on urban usage scenarios, Limited support for rural connectivity requirements in specs

Limited commercial incentive for operators to target rural areas

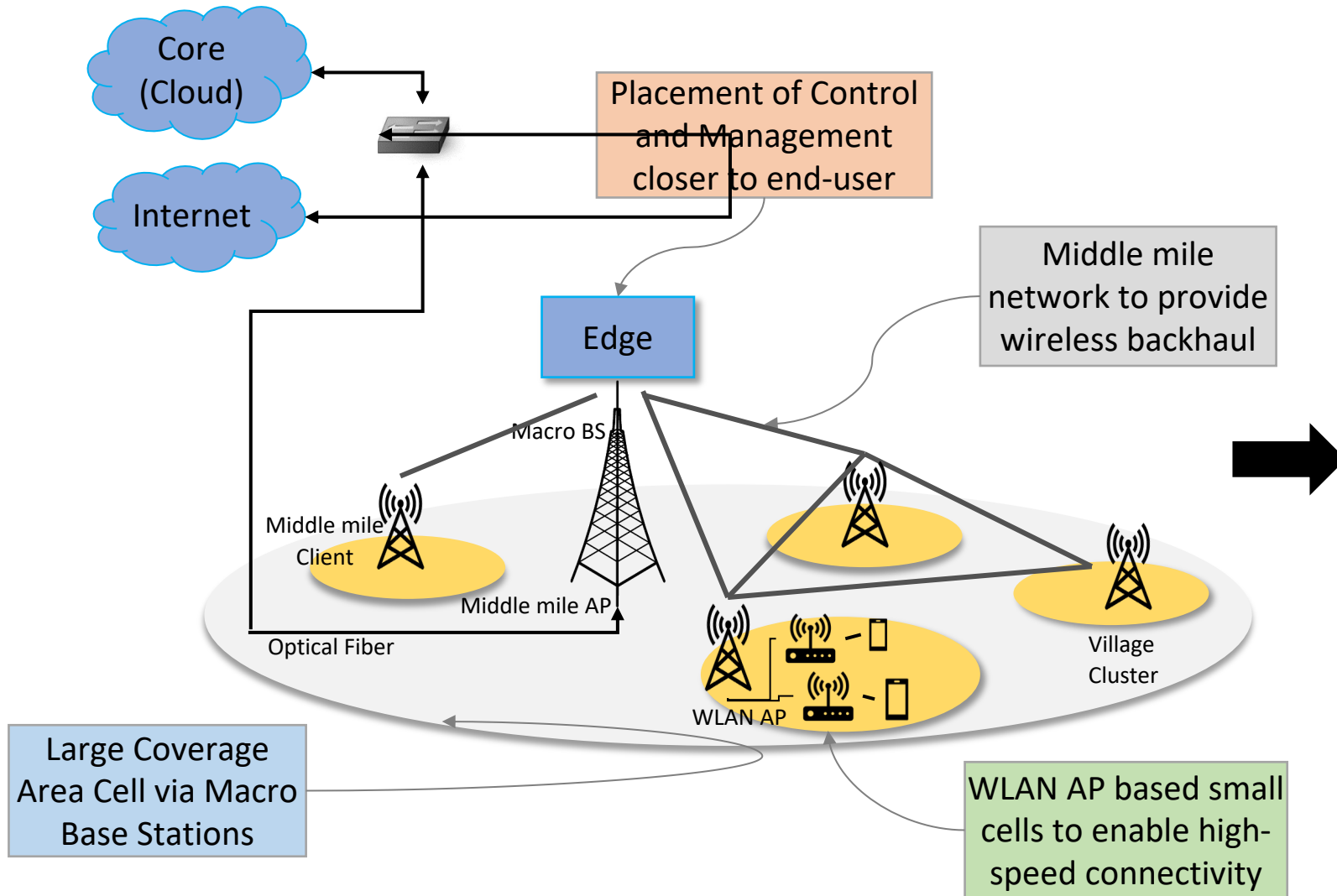
Slower deployment in rural areas, Lower data rates

Rethinking 5G Requirements for Rural Areas



IEEE P2061 Architecture

IEEE P2061 - High Level Architecture



Frugal 5G Networks (IEEE P2061)

Refers to the vision of providing broadband access to rural areas by addressing rural area requirements and challenges

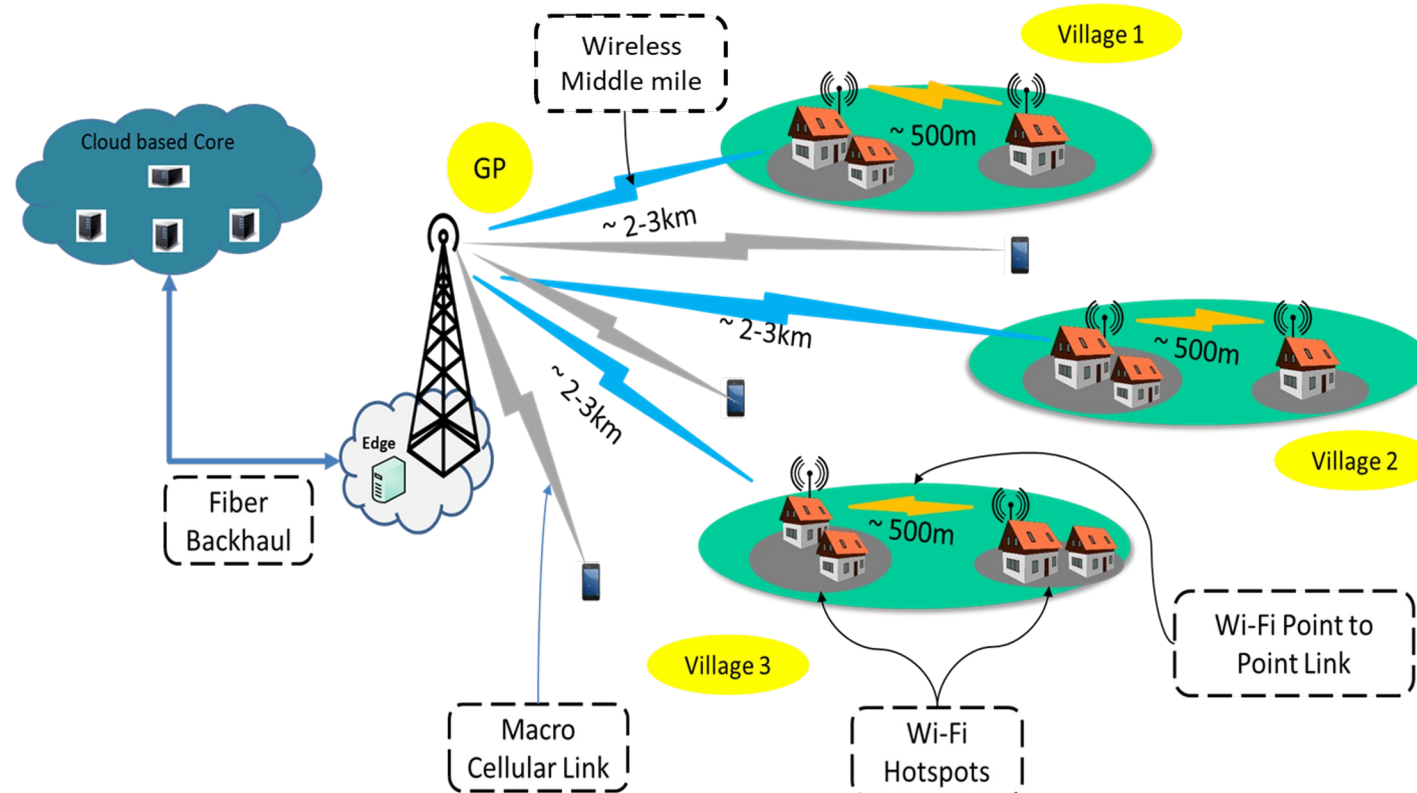
IEEE P2061 - High Level Architecture contd.

Large Coverage Area Cells to provide ubiquitous connectivity

Small Cells (WiFi Hotspots) as high speed access points

Wireless Middle Mile Network to backhaul data

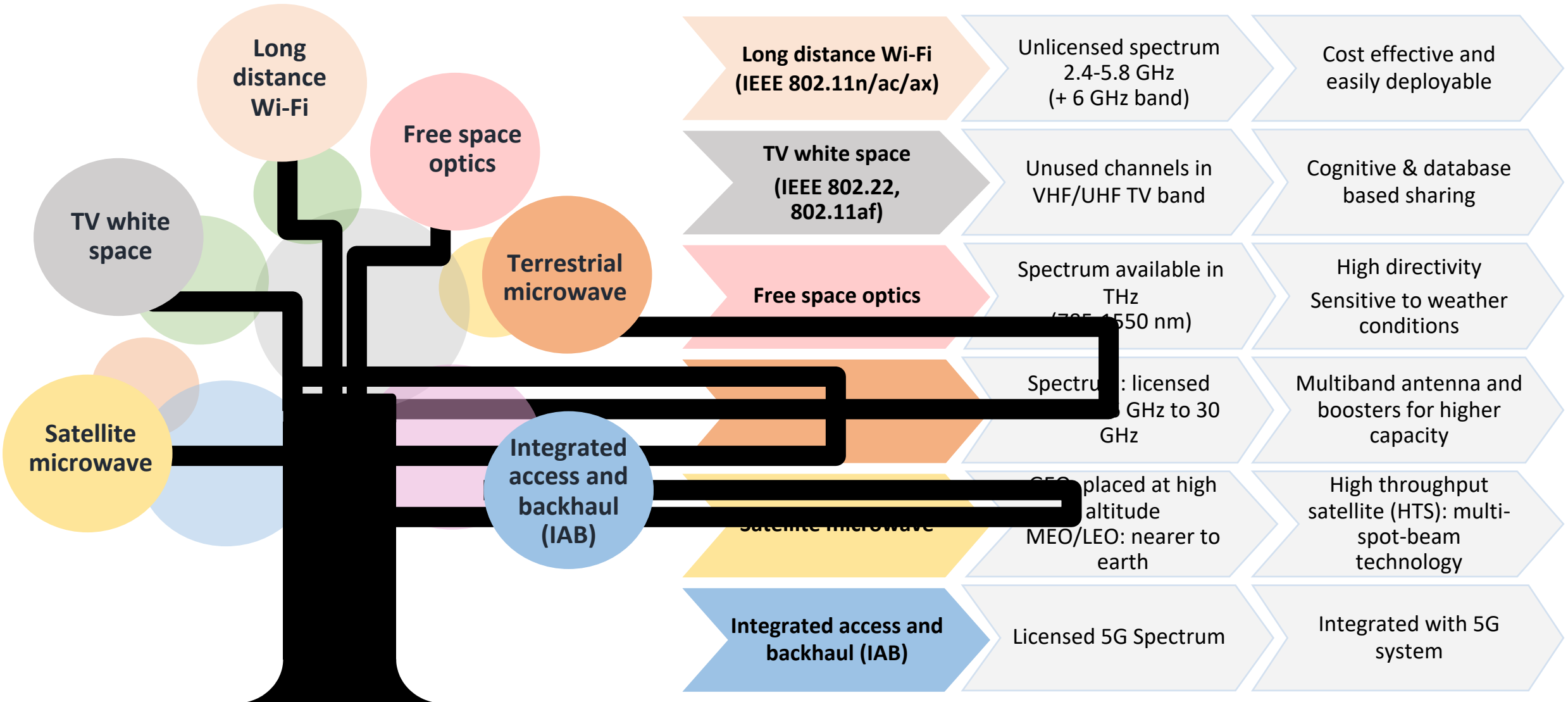
Point to point wireless links to connect the nodes in villages



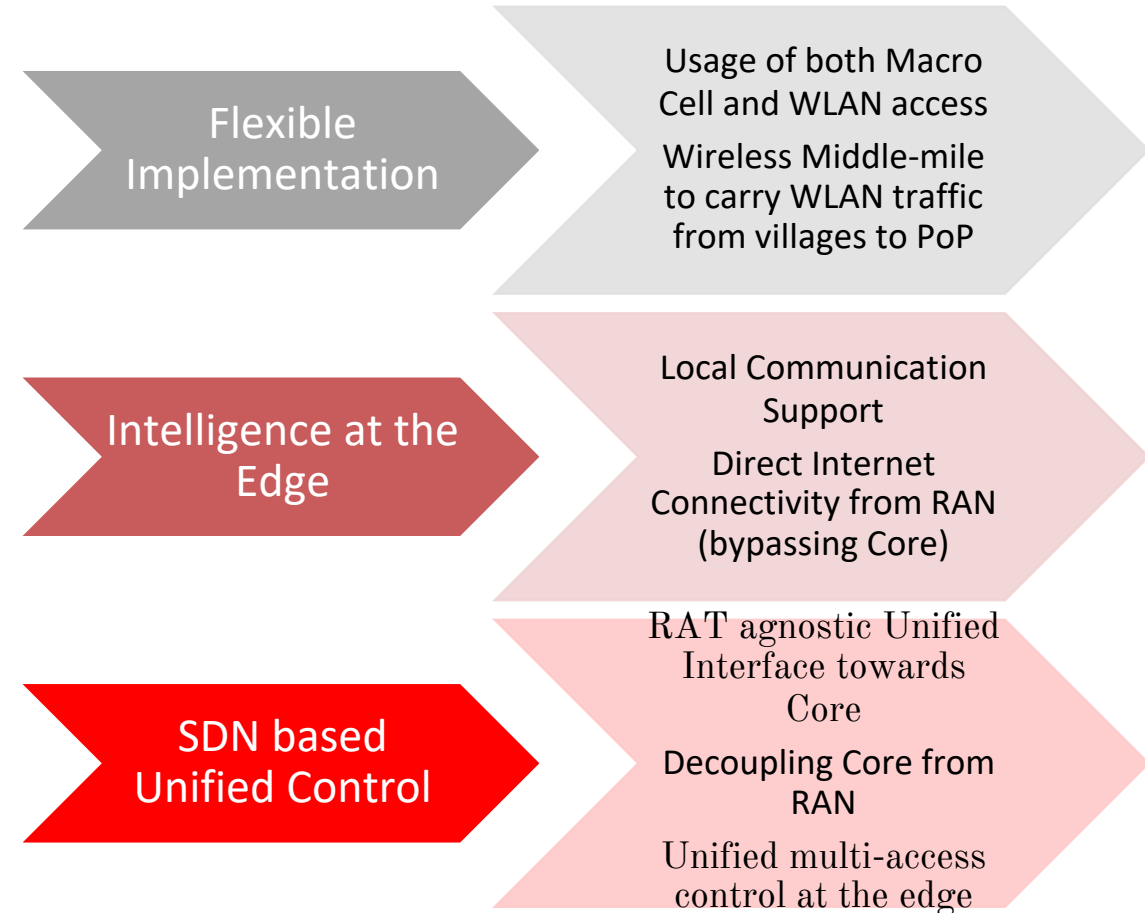
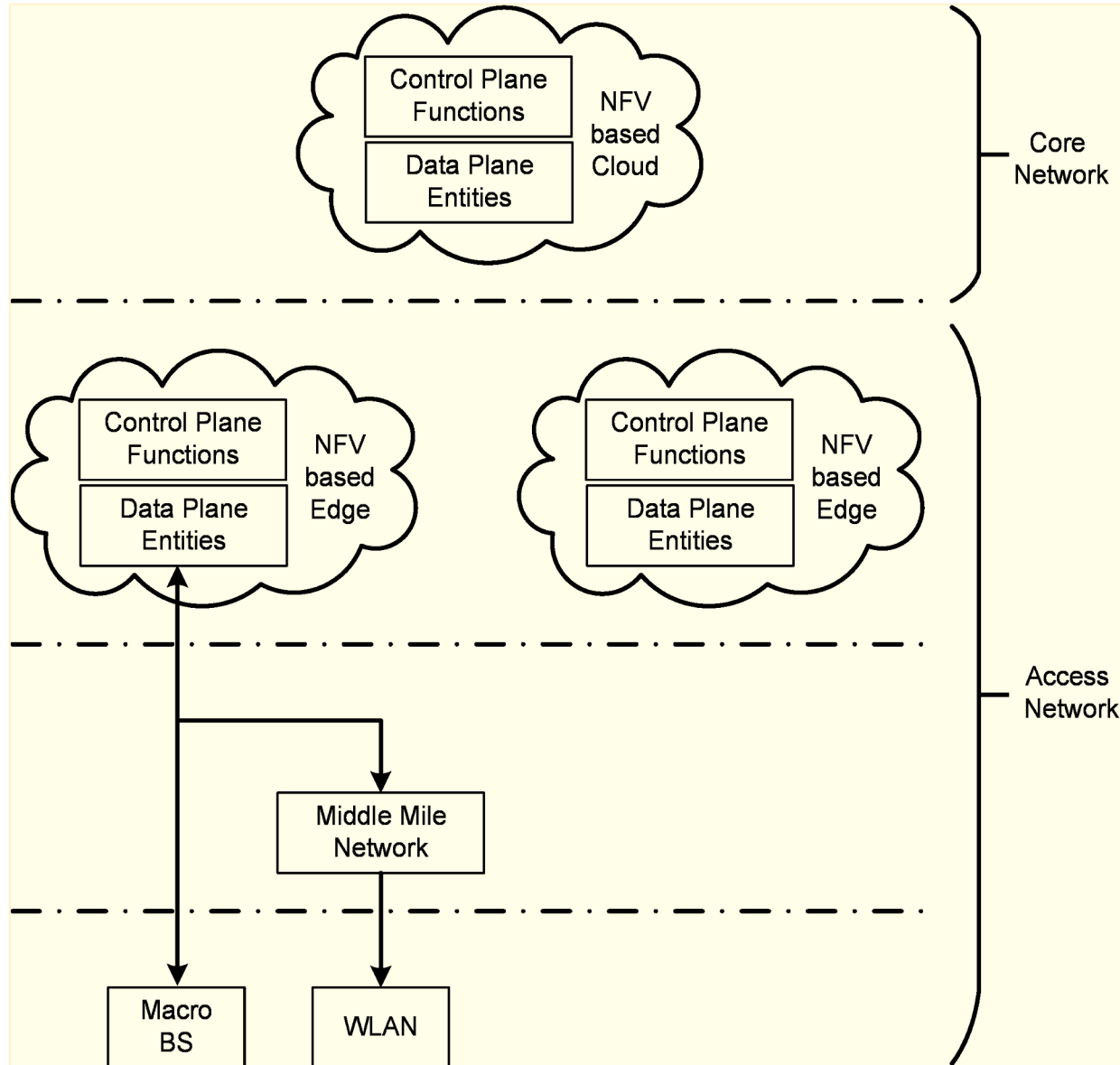
IEEE P2061 - Middle Mile Network

- Indian Example
 - Optical fiber terminates a few km away from villages (@ GP)
- Wireless Middle Mile
 - Extension of Optical PoP from (GP) to the villages
- Wi-Fi APs in villages
 - To provide broadband connectivity
- Wi-Fi APs in villages connected to PoP
 - Through Wireless Middle Mile
- Fiber/DSL can be used in place of Wireless Middle Mile
 - If available

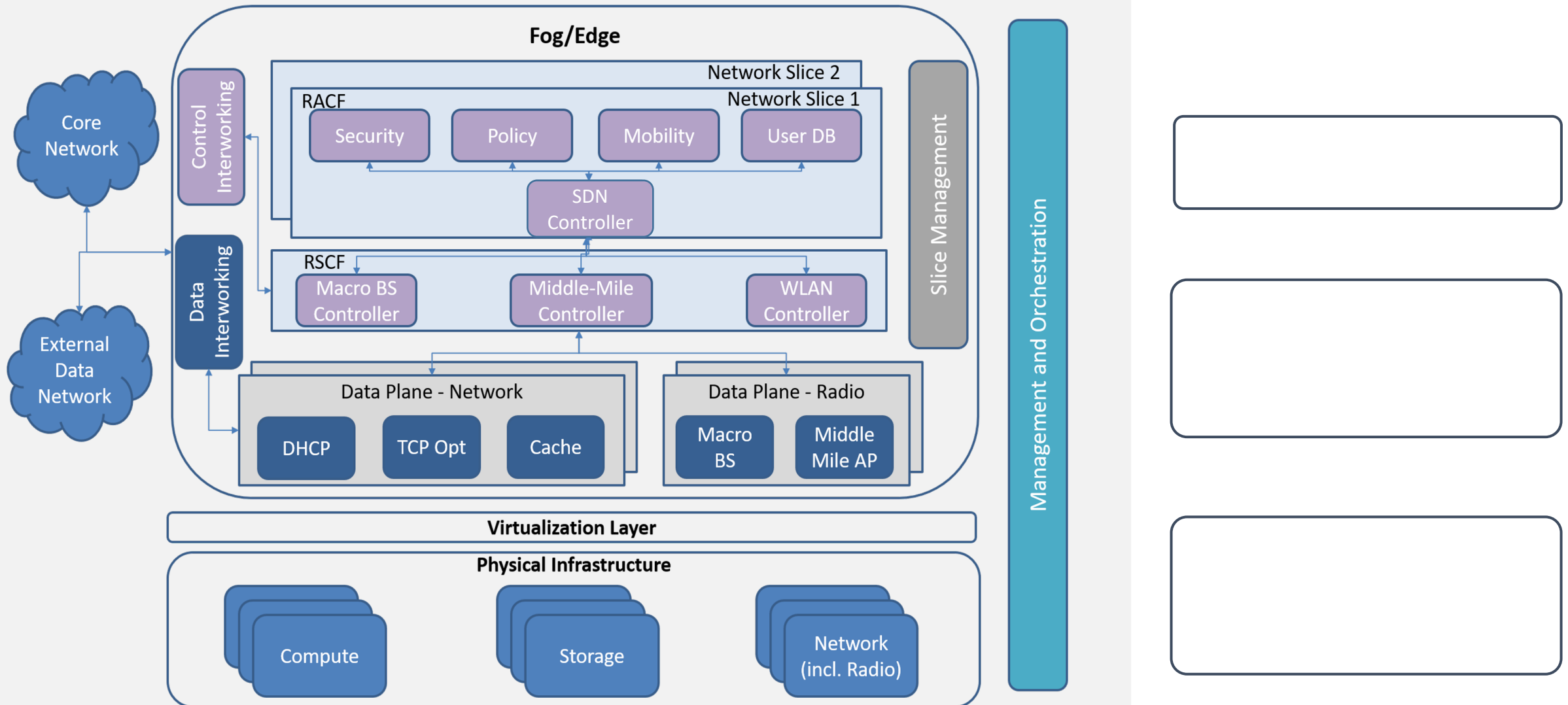
IEEE P2061 - Middle Mile Technologies



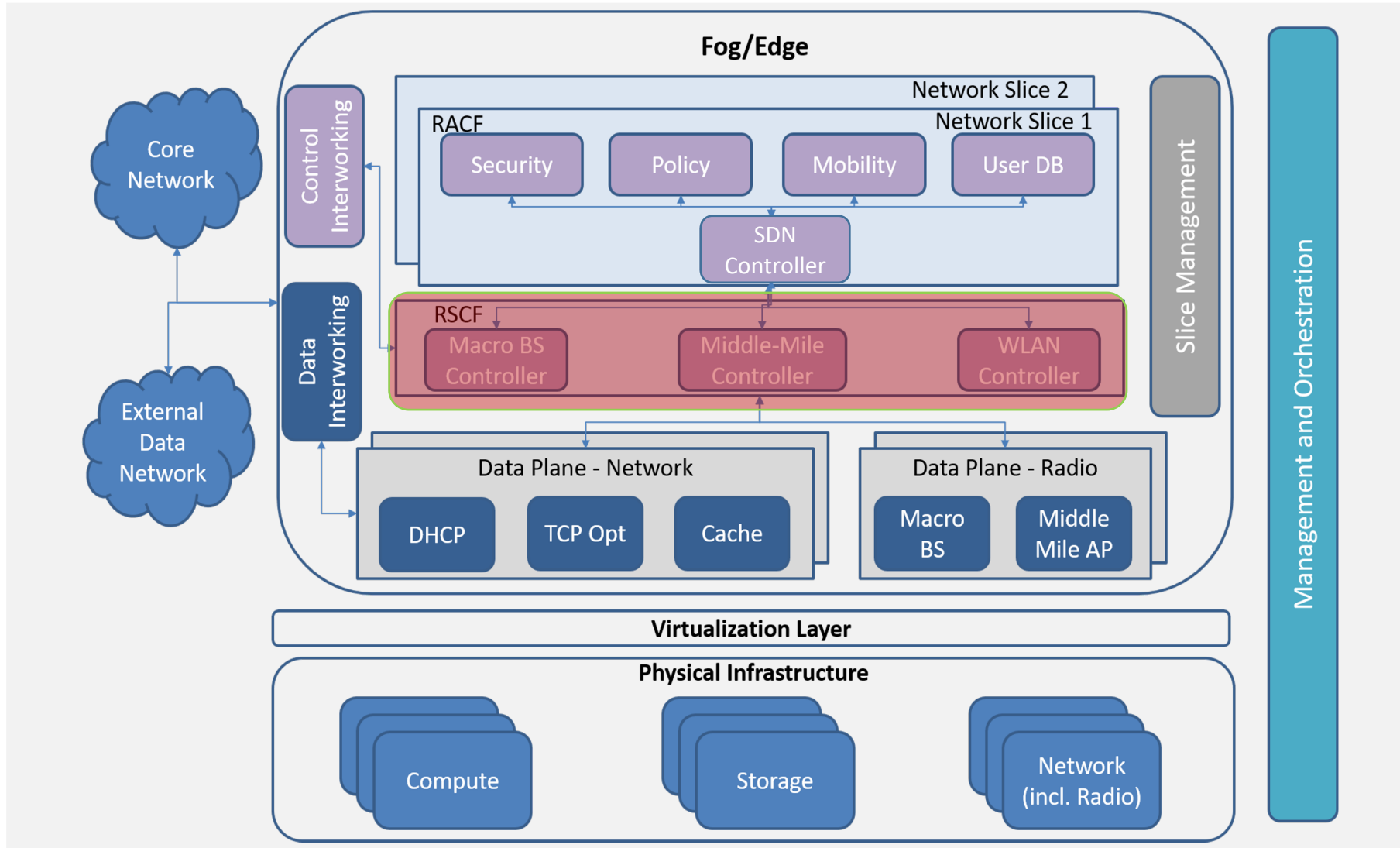
IEEE P2061 - Key Design Principles



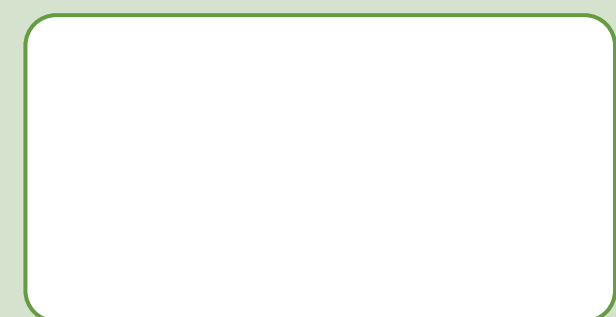
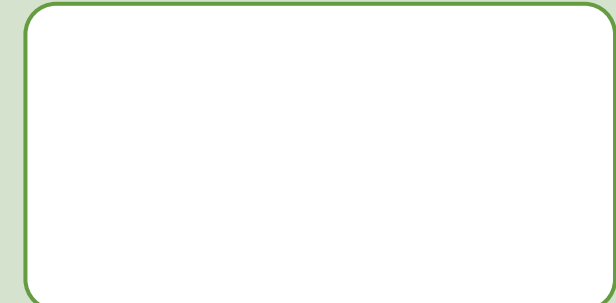
IEEE P2061 Architecture



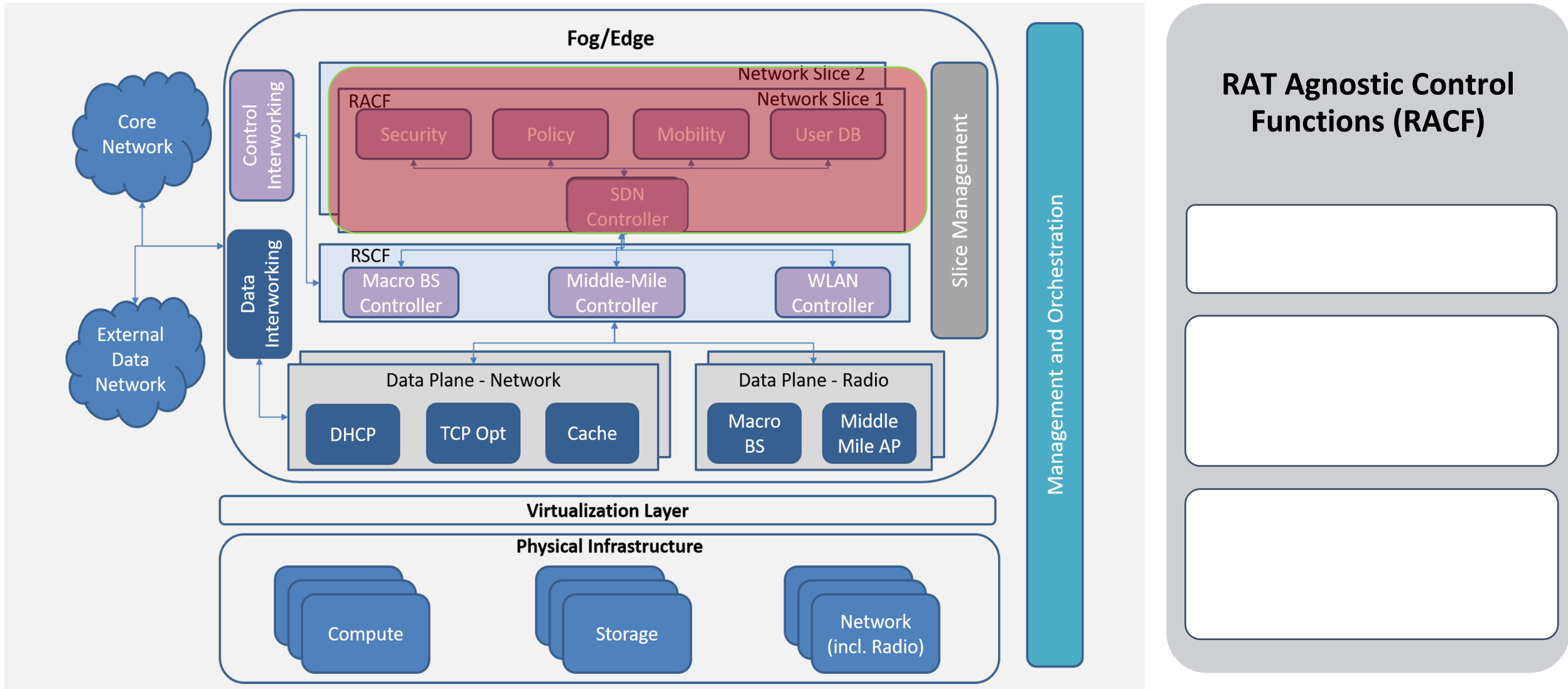
IEEE P2061 Architecture - Edge Components



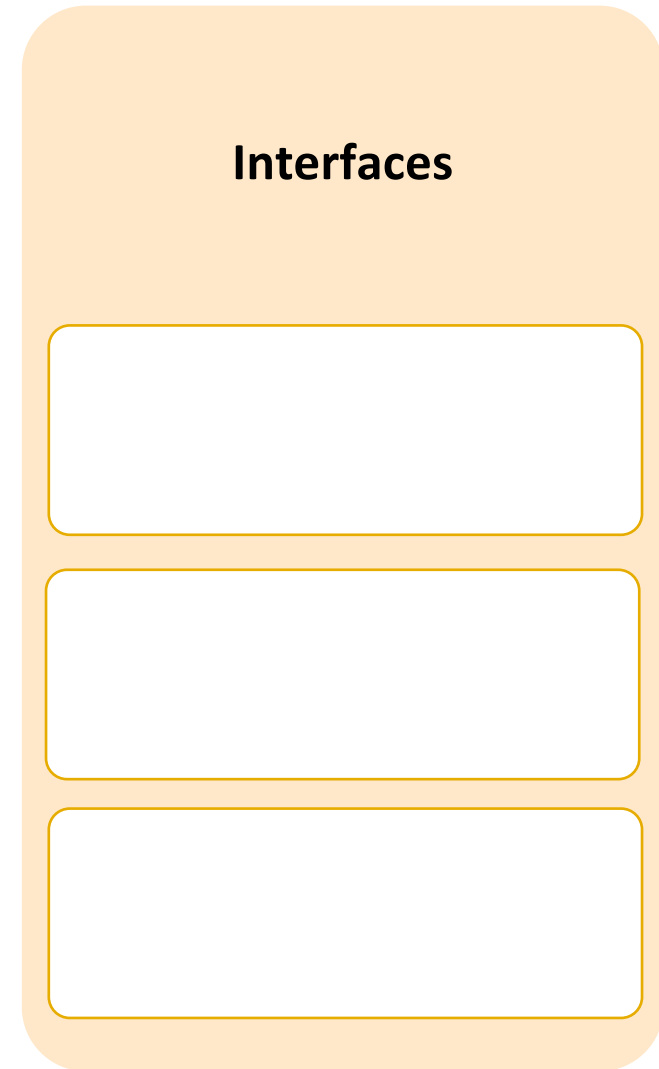
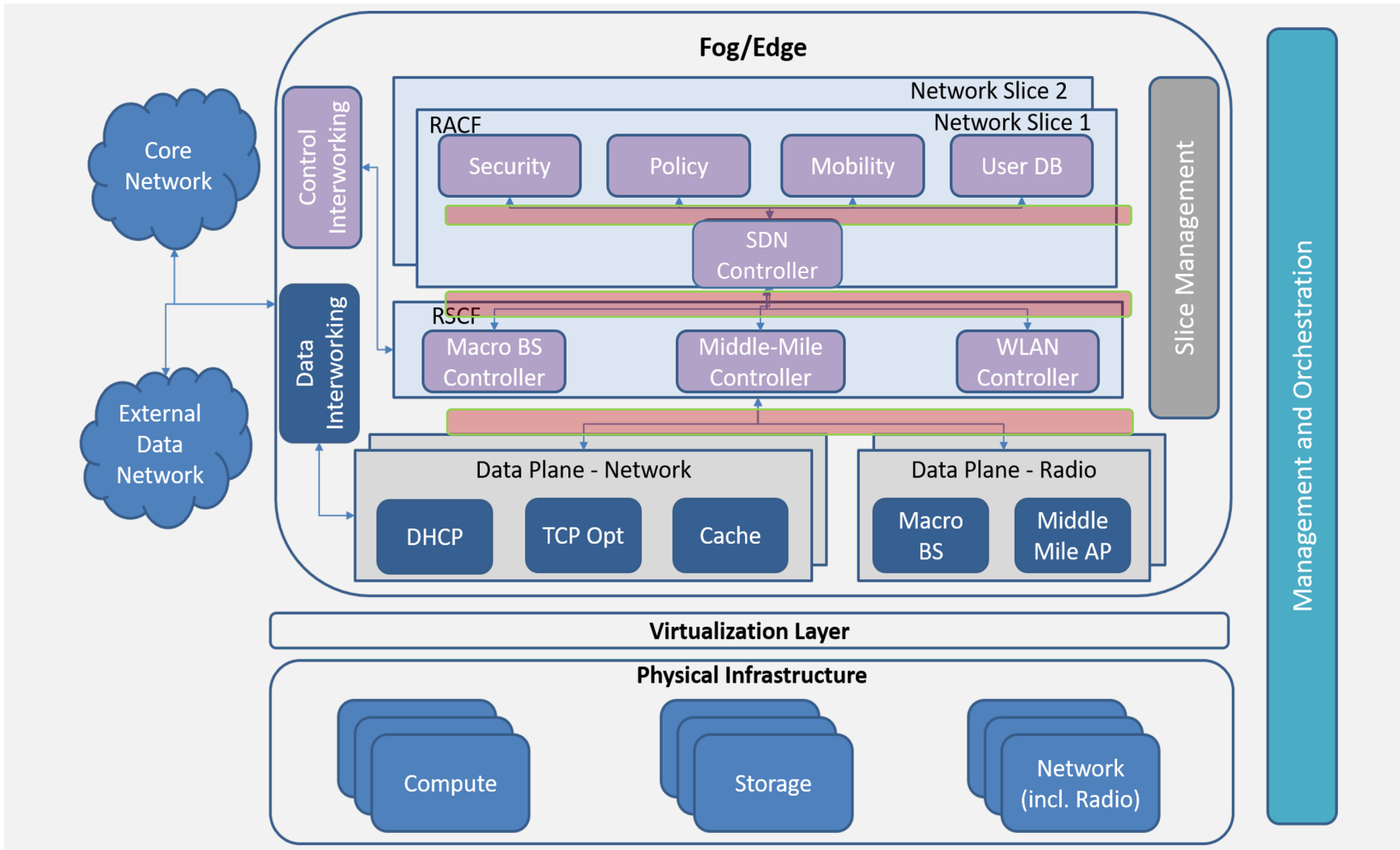
RAT Specific Control Functions (RSCF)



IEEE P2061 Architecture - Edge Components



IEEE P2061 Architecture - Edge Components



IEEE P2061 Architecture Framework

SDN based RAT agnostic controller

- Unified RAN level control & management

SDN Controller

Multi-RAT Network Switch

Data Network Interface

Unified Core Network Interface

SDN Switch

Macro BS Radio IF

WLAN Radio Interface

Other Radio Interfaces

Edge Storage and Compute

DHCP Server

Auth Server

Content Server

Introduction of SDN switches and controller in access network

- Replaces proprietary interfaces
- Enables unified interworking

Introduction of SDN switches at UE

- Replaces proprietary interfaces

UE

WLAN IF

Macro BS IF

SDN Switch

Data

CN Comm. (Signaling)

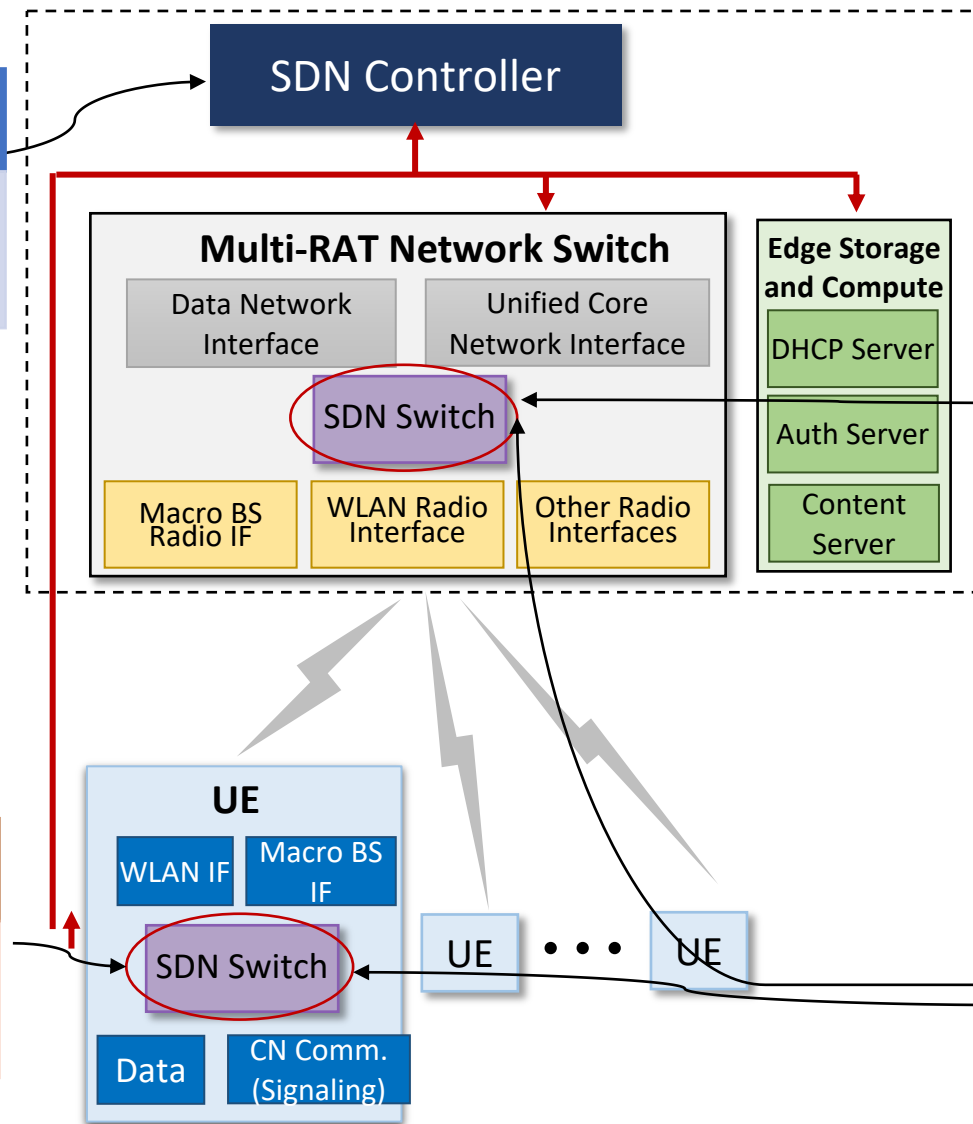
UE

...

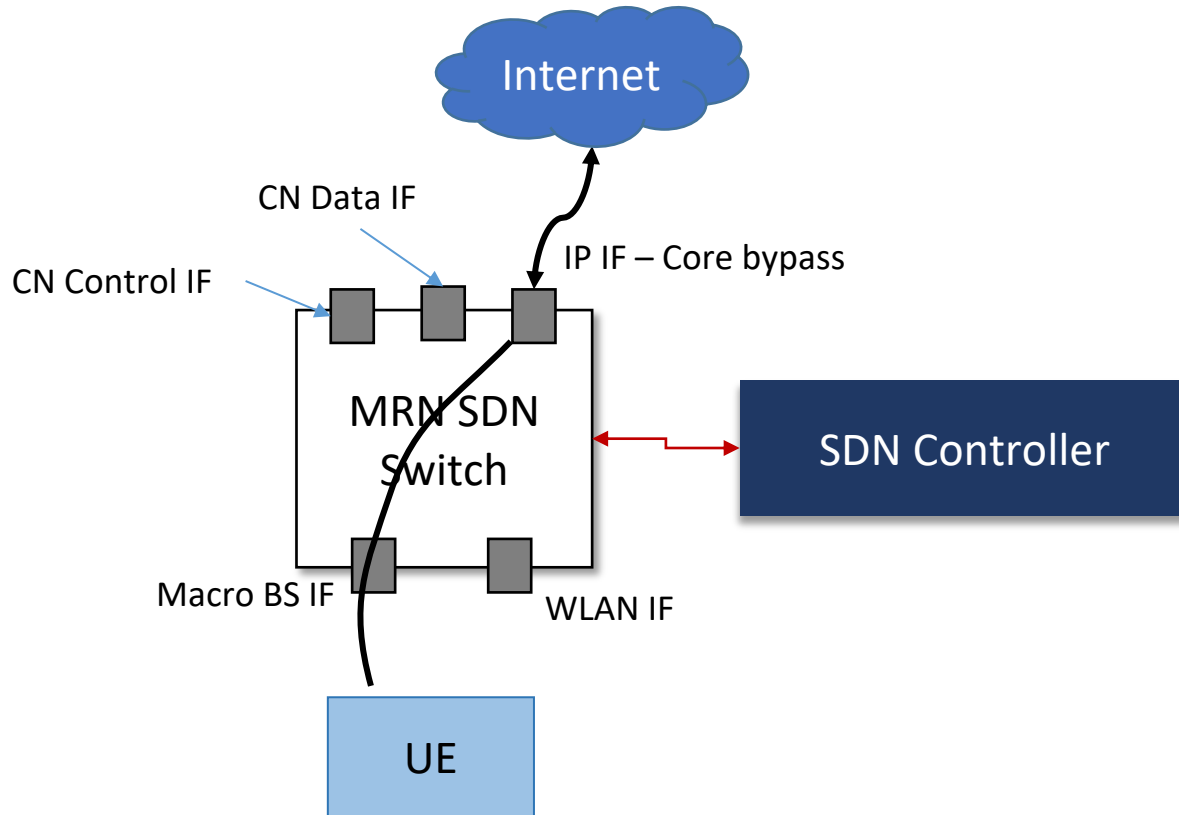
UE

Decouples UE's communication with CN from its communication with RAN

- UE - CN communication - Overlay over UE - RAN communication



IEEE P2061 Architecture Framework - Core Bypass



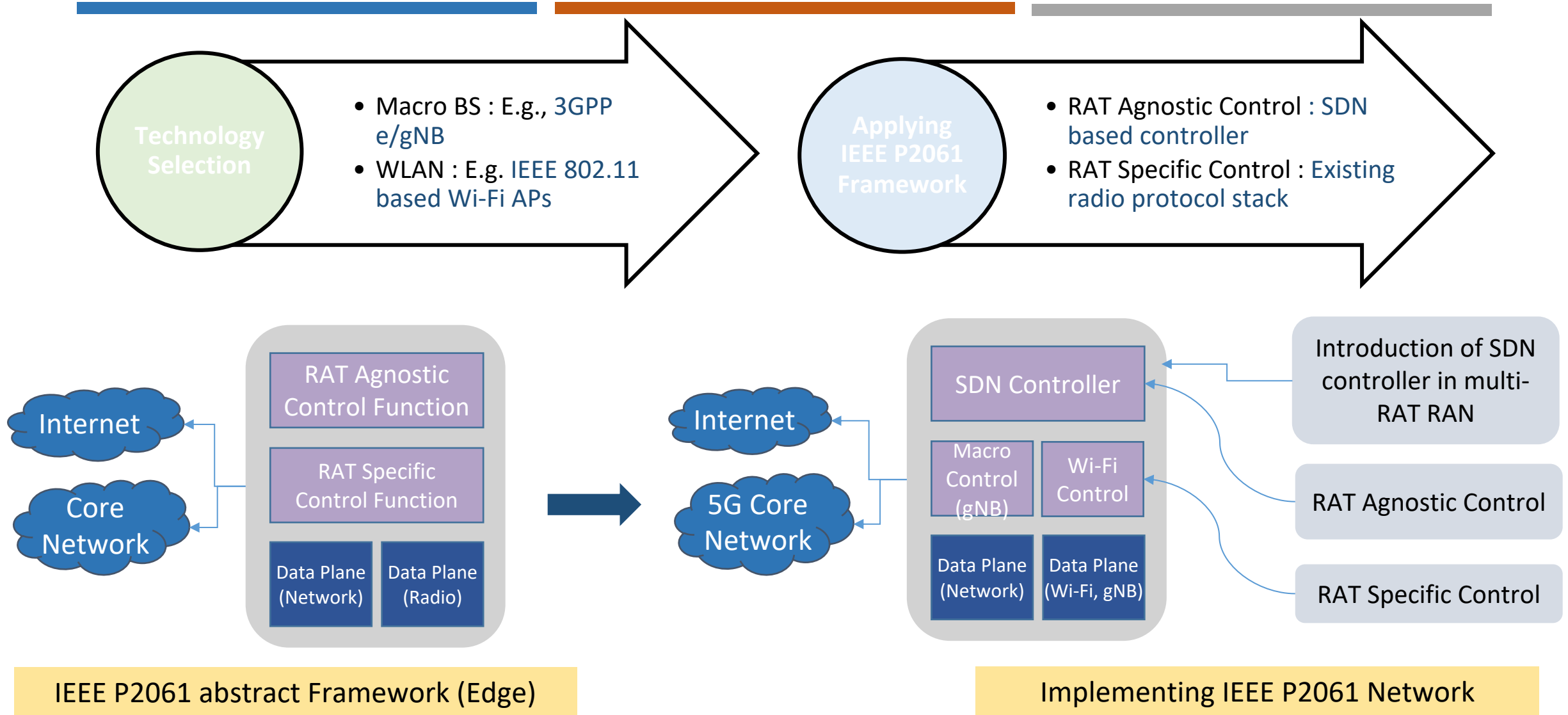
Existing cellular technologies, e.g., LTE/5G NR requires support of Core Network (CN)

- Can not work in a standalone manner without CN

IEEE P2061 network architecture allows usage of cellular technologies (5G NR...) without involving CN

- UE's connectivity with RAN is decoupled from it's connectivity with CN
- SDN controller sets up the flow entry and creates radio bearer at RAN to enable direct connectivity with Internet

Realizing IEEE P2061 Architecture with 3GPP 5G



IEEE P2061 Architecture - Key Points

- SDN can be used to decouple RAN from Core
 - e.g., an OpenFlow like protocol
 - Other protocols/mechanism can also be used
 - Existing 3GPP protocols can continue to be used w/o much changes
 - SDN augments the existing wireless network architectures
- Flexible Mobile Network Architecture
 - Any RAN can be used with any Core
 - Use Core Selectively
 - Only for mobile users
 - For Authentication...
- Other Use Cases
 - Direct Connectivity to DN (Internet...) from RAN
 - (Simpler) NSA Implementation
 - Captive Networks

IEEE P2061: Requirements vs Capabilities

Requirements	Capabilities	
Affordability	Low Cost & Low Power WLAN and Middle Mile Network Elements, Usage of Unlicensed Spectrum, Lesser No of Macro BSs	Usage of SDN/NFV, Usage of Commercial off the self Platforms
Limited need for High Speed Mobility Support	Majority of the users served by WLAN	Mobile users supported via large coverage area macro BS
Reduced Energy Consumption	Usage of WLAN and Point-to-point Middle Mile Link	Sub-Ghz band for longer reach by macro BS with lesser amount of power required
Ease of Manageability	Simpler Network Elements (IEEE 802.11 Devices)	
Local Content Generation and Storage	Local Storage in the Edge, Usage of SDN and NFV enabling local access	
Sparse & Clustered Population Distribution	Network Architecture aligned with the population distribution – Macro cell to cover a large area and WLANs to support village clusters	

THANK YOU

