Frugal 5G Networks and Beyond (IEEE P2061)

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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

- Internet and Broadband Connectivity Status

- Key Challenges to Rural Broadband Connectivity

- Rural Broadband Connectivity Requirements

- Frugal 5G Networks (IEEE P2061) Architecture

Internet Connectivity Status: Worldwide

Unconnected Population
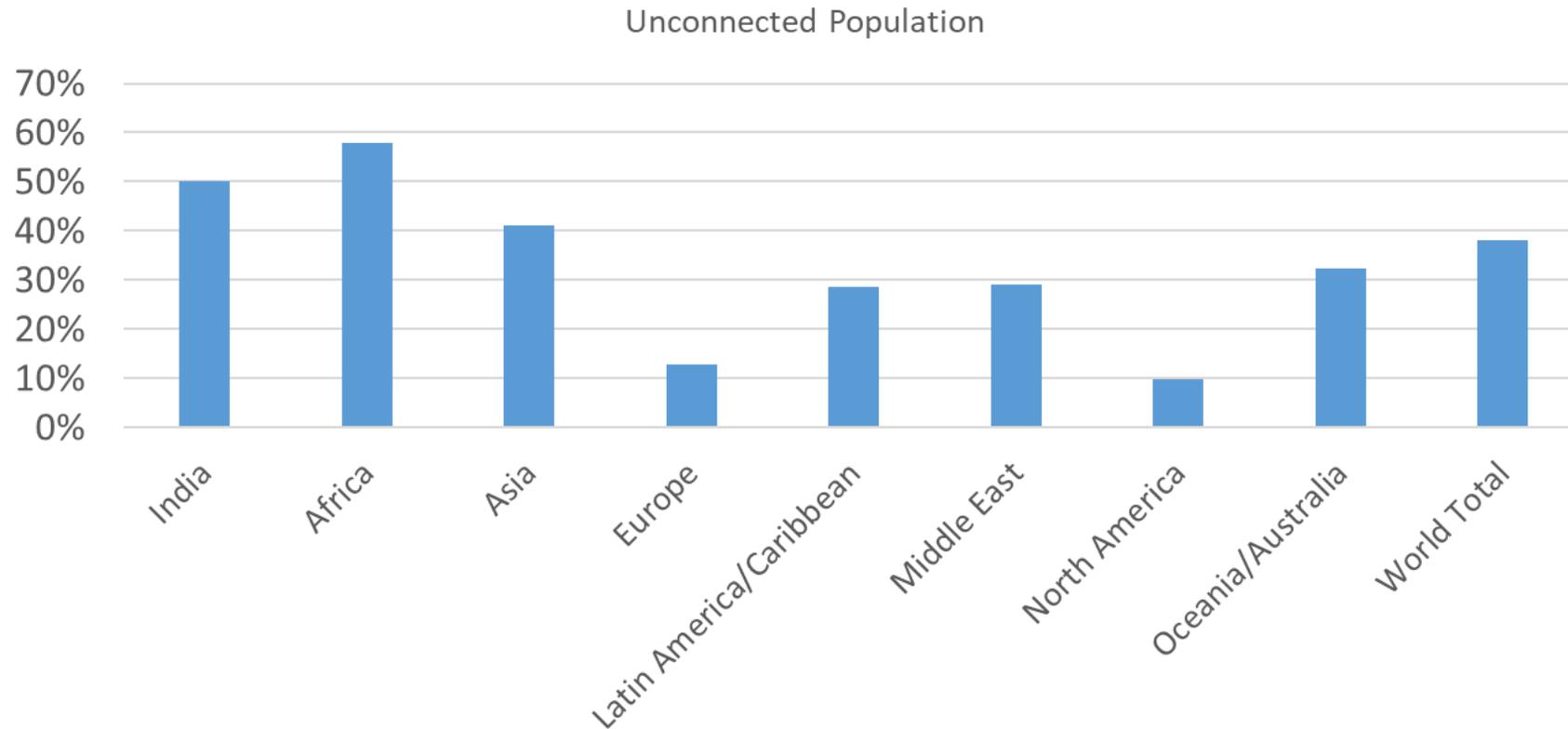
~40% of the world population is unconnected -
Majority in Developing World and in Rural Areas

Internet/Broadband Penetration Status: India
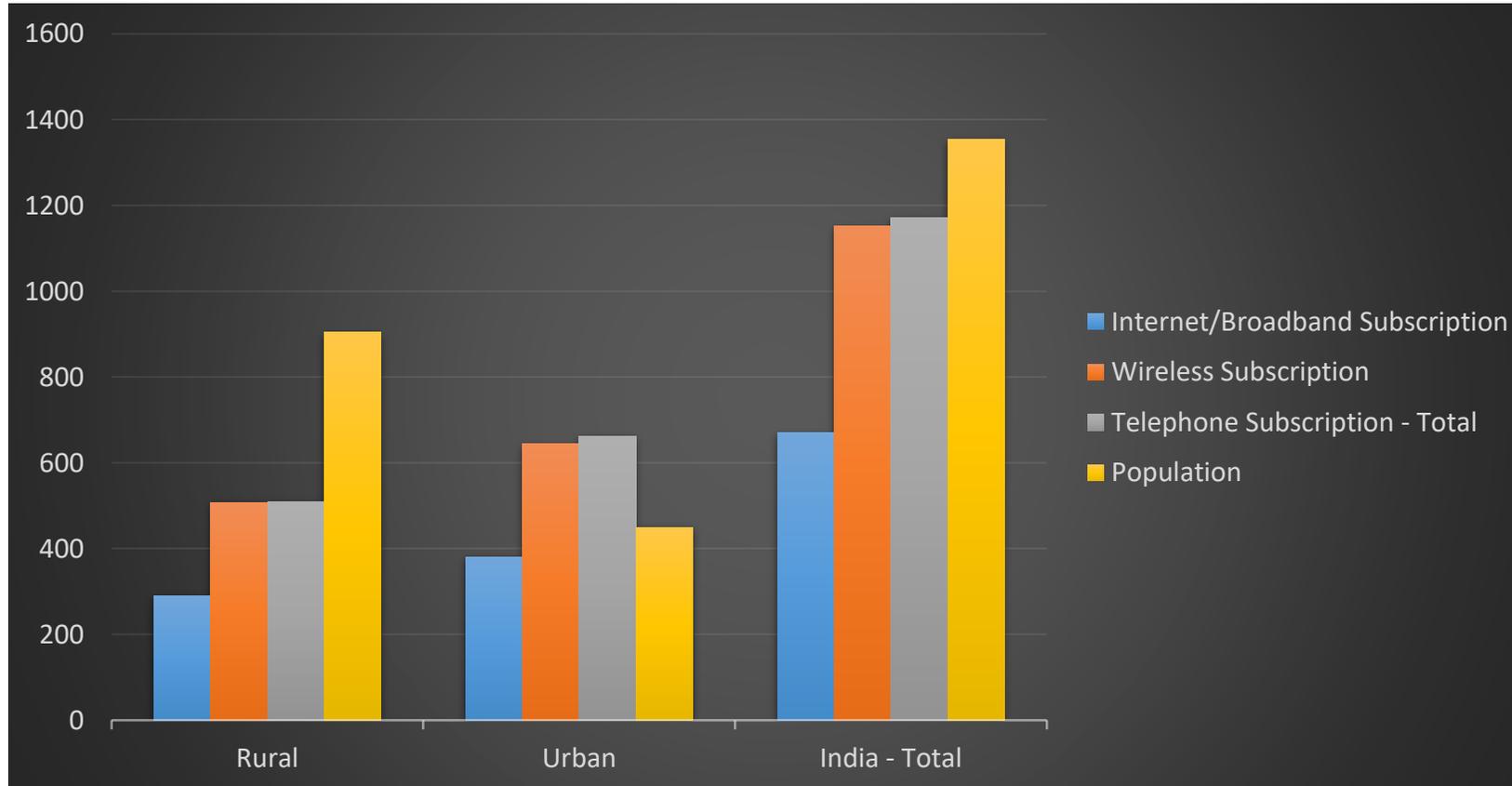
~675 million people do not have Broadband/Internet access in India

Internet/Broadband Access- How is it enabled?

Developed Countries
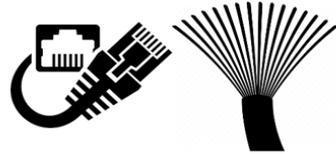
Mostly enabled through wired communication infrastructure, Fiber and DSL

Developing Countries

Cellular Technology - Primary broadband access mechanism ✓

Fiber/DSL Infrastructure - Inadequate ✗

Challenges in using Cellular Technology in Rural Areas

1. Existing/Emerging Cellular Technology Standards

- Focused on urban usage scenarios
  - Key Targets for 5G : 20 Gbps rate, 1 ms latency, 500 km/h mobility
- Challenges and Characteristics of Rural Connectivity
  - Not factored in specification and design
- Variations in use cases across regions, countries, continents ignored

2. Operators Roll our networks in urban/semi-urban areas

- No compelling commercial reason for them to target rural areas

Challenges in Connecting Rural Areas

- Low Average Revenue per user

- Scarcity of Power from the Grid

- Unavailability of Backhaul

- Sparse Population and Clustered Settlements

- Remote and Difficult to Access Areas

- Challenges of Manageability
  - Cost and Access Constraints

- Relevance of content
  - Large % of Content on Internet is in English and only a few other languages

Rethinking 5G Requirements for Rural Areas

- Low cost Solution
  - Low Cost Backhaul Solutions - Wireless backhaul instead of Fiber
  - Lower Spectrum Cost

- Limited Mobility Support
  - Mobility required but not very high speed
  - Small no of vehicles in Rural Areas

- Energy efficient solution

- Large coverage area support

Rural Connectivity Requirements

Frugal 5G Networks
(IEEE P2061)

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

IEEE P2061 - Network Architecture

| 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 |
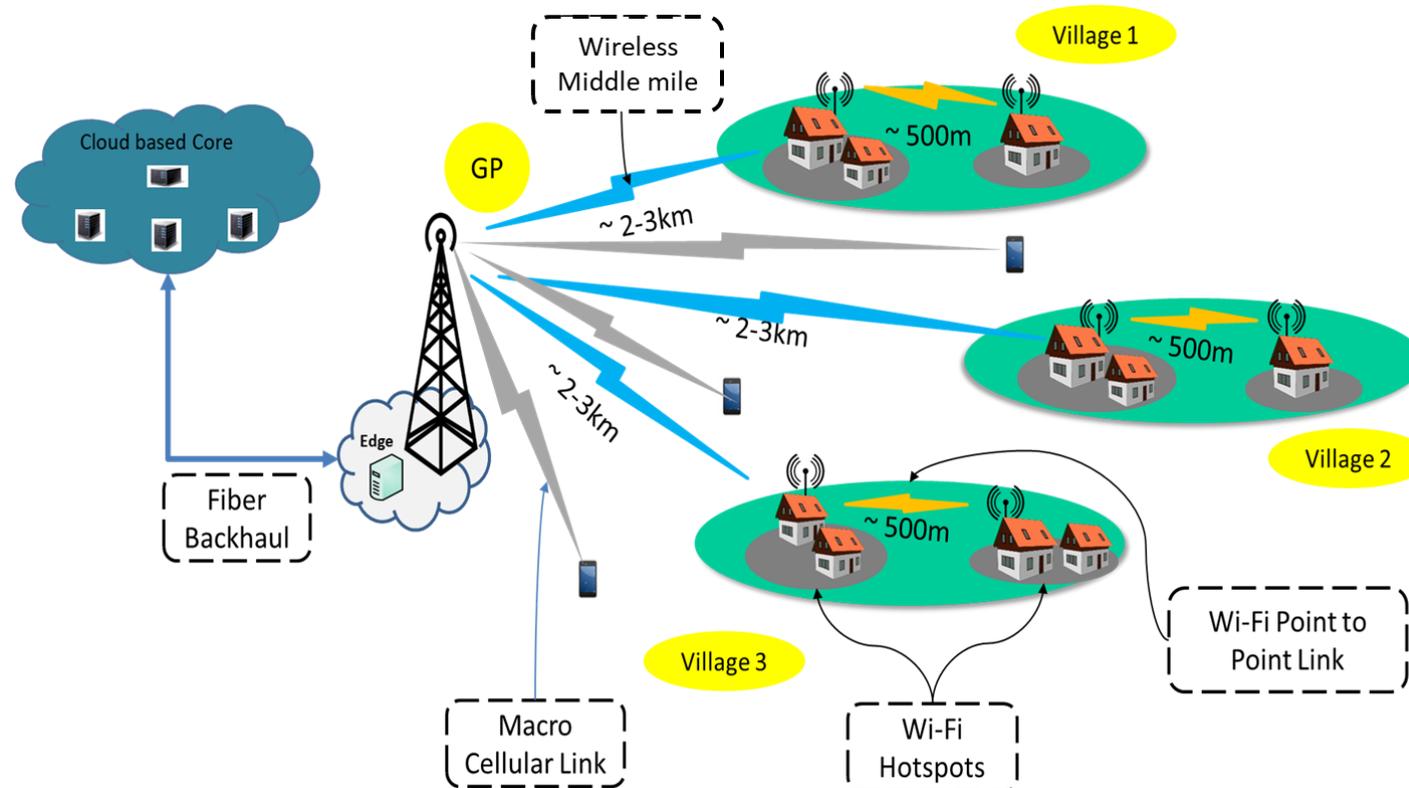
IEEE P2061 Network Architecture (contd..)

- Large Coverage Area Cells to provide ubiquitous connectivity

- Small Cells (WiFi Hotspots) as high speed access points
  - WiFi devices are very low cost devices

- Wireless Middle Mile Network to backhaul the data from WiFi Hotspots to Fiber POP

- Point to point wireless links to connect the nodes in villages

IEEE P2061 – Middle Mile Network

- Optical fiber terminates a few km away from villages

- Extension of optical PoP to the villages

- End users access the broadband through Wi-Fi Access Points

- Wi-Fi APs connected through a wireless middle mile network

IEEE P2061 – Middle Mile Network
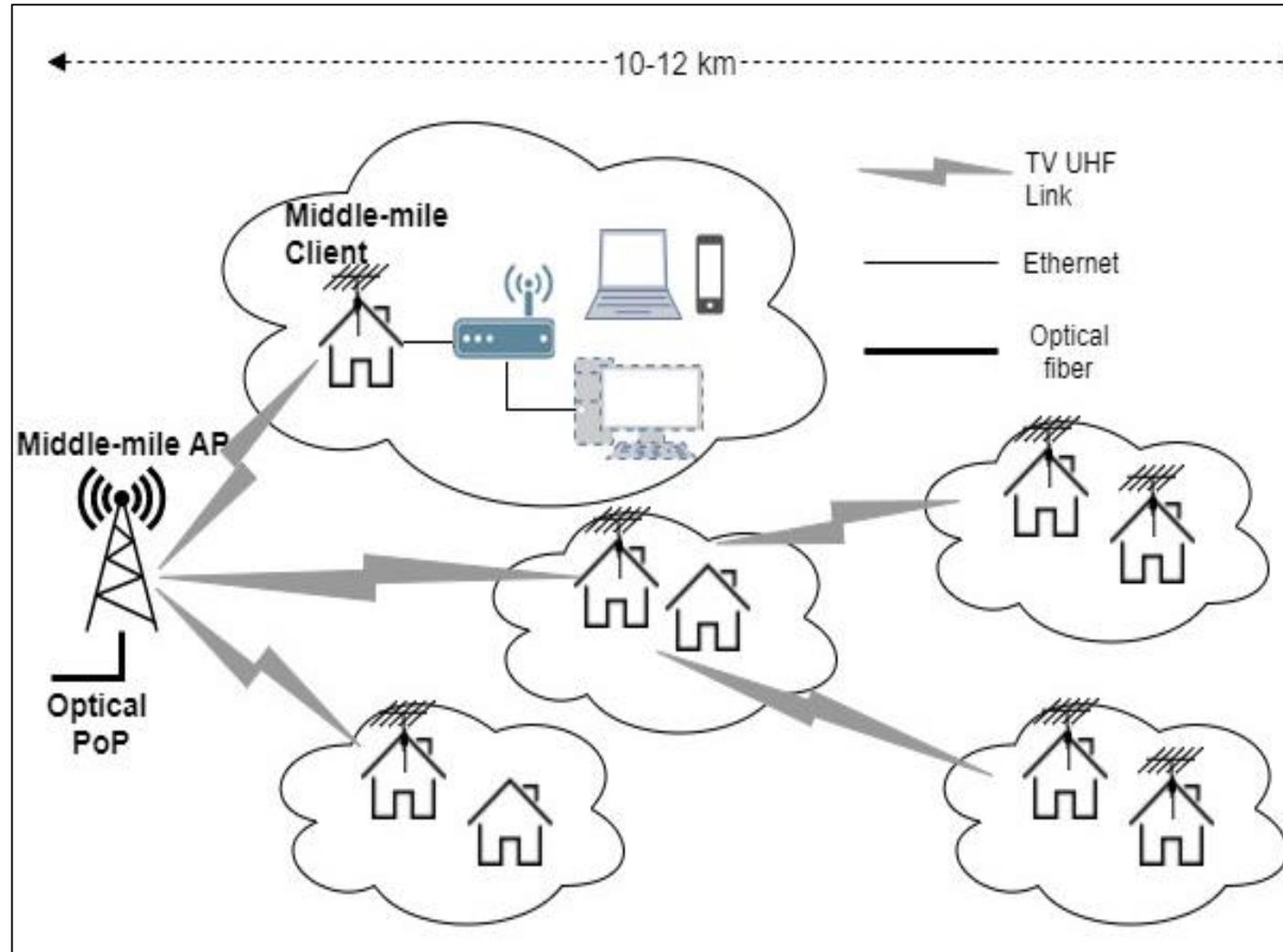
IEEE P2061 – System Architecture

Legend:
- Macro BS
- ↔ Wireless Middle mile Network
- - - - WLAN
- Ethernet Link
- <- - -> Wireless link

Core (Cloud)

Internet

Middle Mile Client

Access (Fog)

Fiber PoP

Middle Mile Client

Middle Mile Client

Middle Mile Client

Village clusters
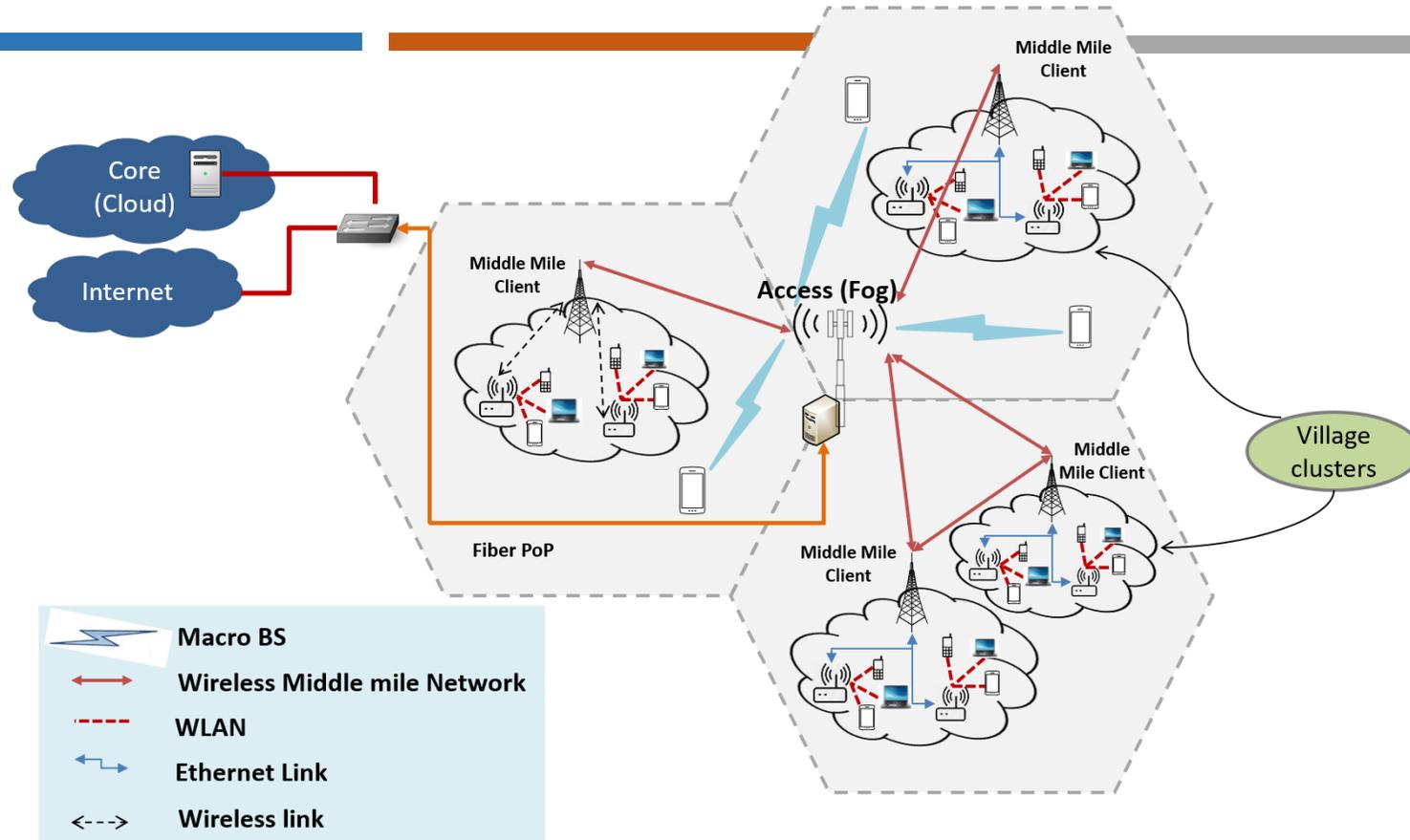
SDN based unified control	Efficient service delivery, Independent Evolution and Development of control/data plane entities
Usage of Virtual Network Functions	To make the system cost-effective
Intelligence at the edge	Enables local communication & reduces resource usage

IEEE P2061 Architecture – Fog/Edge Components
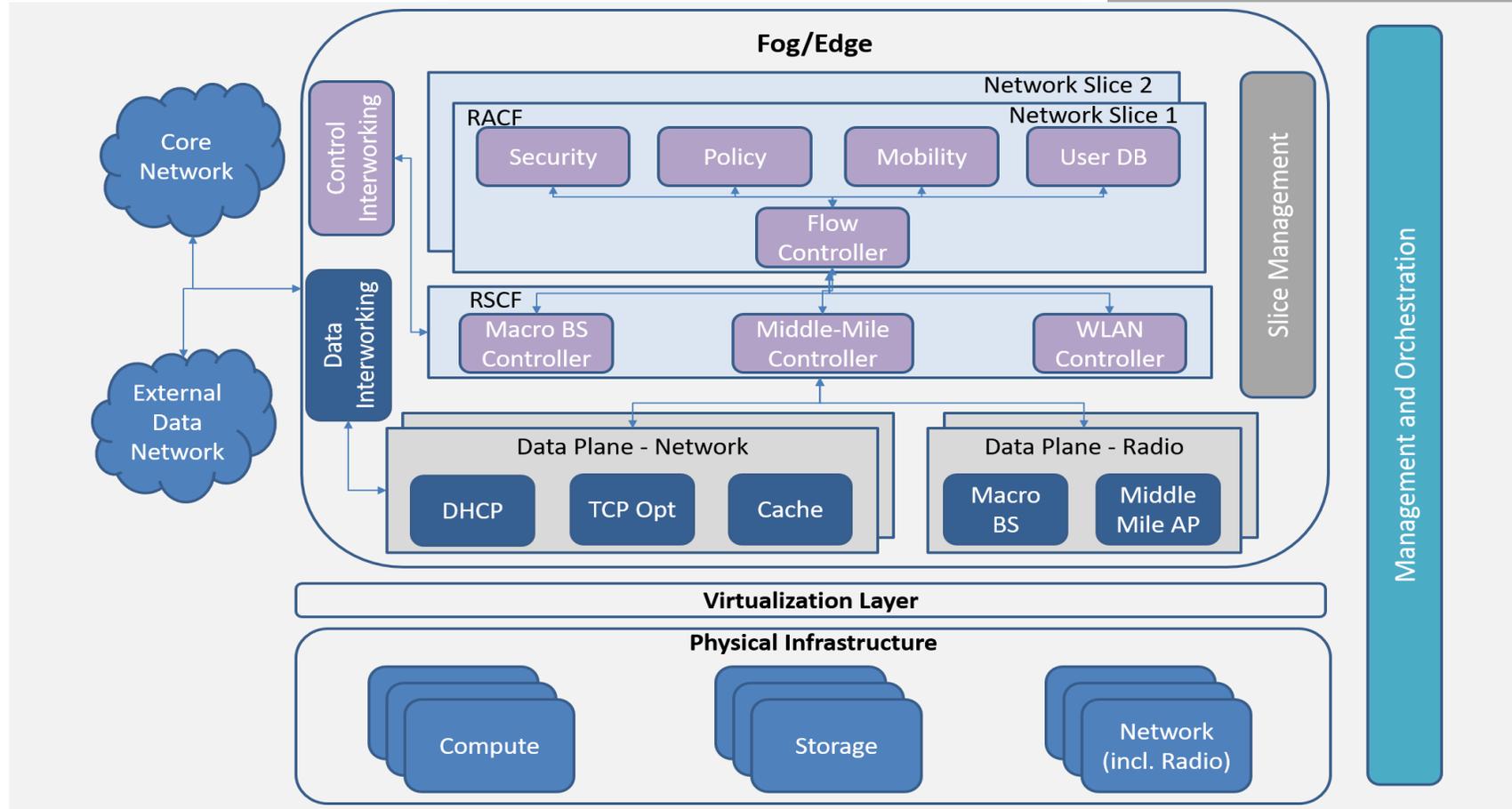
Core Network (CN): Responsible for overall control of the network; Standard Core : 5G

Access Network (AN): Hierarchical SDN based control of the multi-RAT network

Synchronization of network functions over fog & cloud to avoid inconsistencies

IEEE P2061 – RAT Specific Control Functions
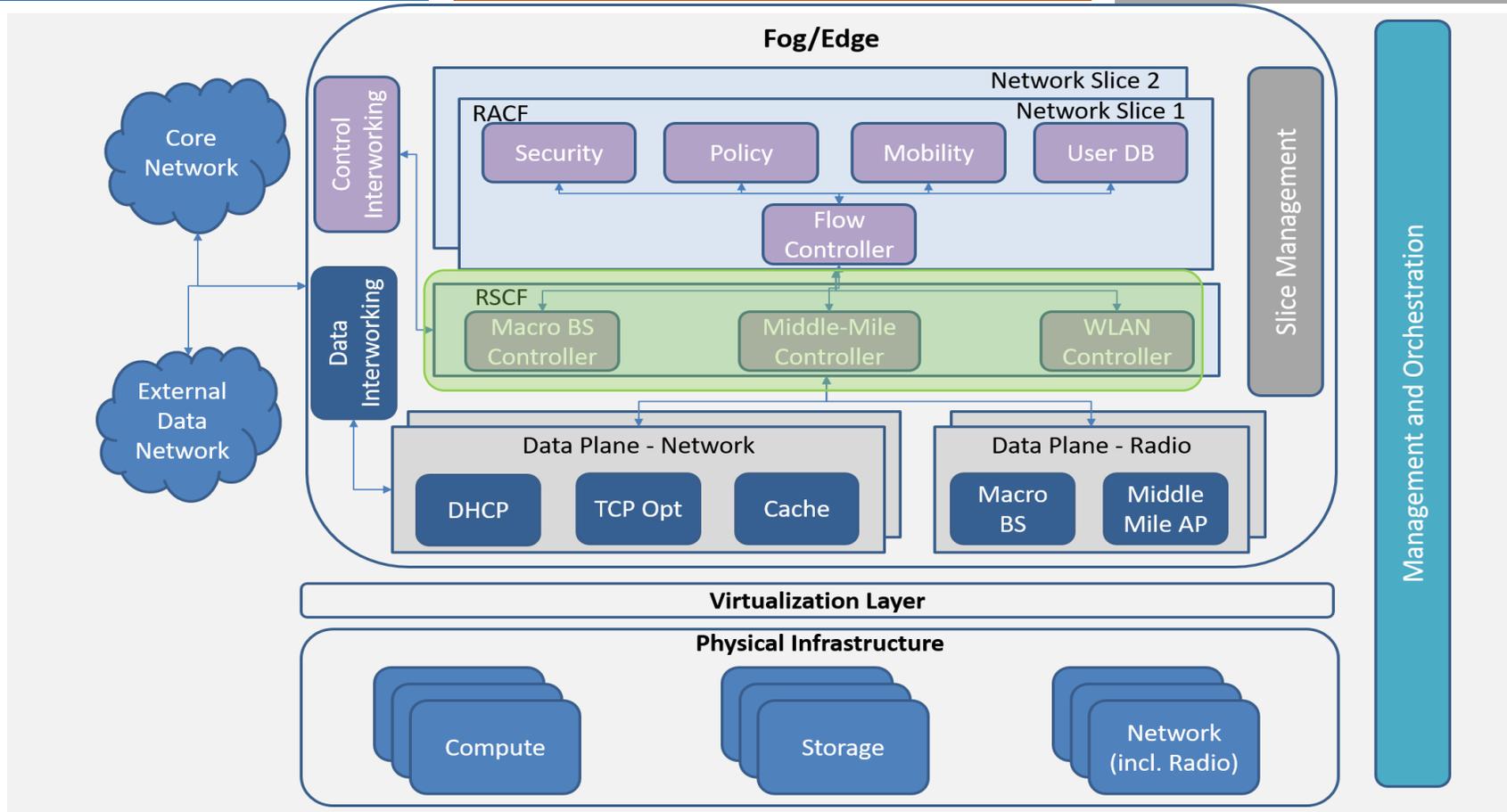
Provides an abstract view of underlying RAN to higher level control entities

Enables unified control of multi-RAT network

Enables RAN virtualization and Network Slicing

IEEE P2061 – RAT Agnostic Control Functions
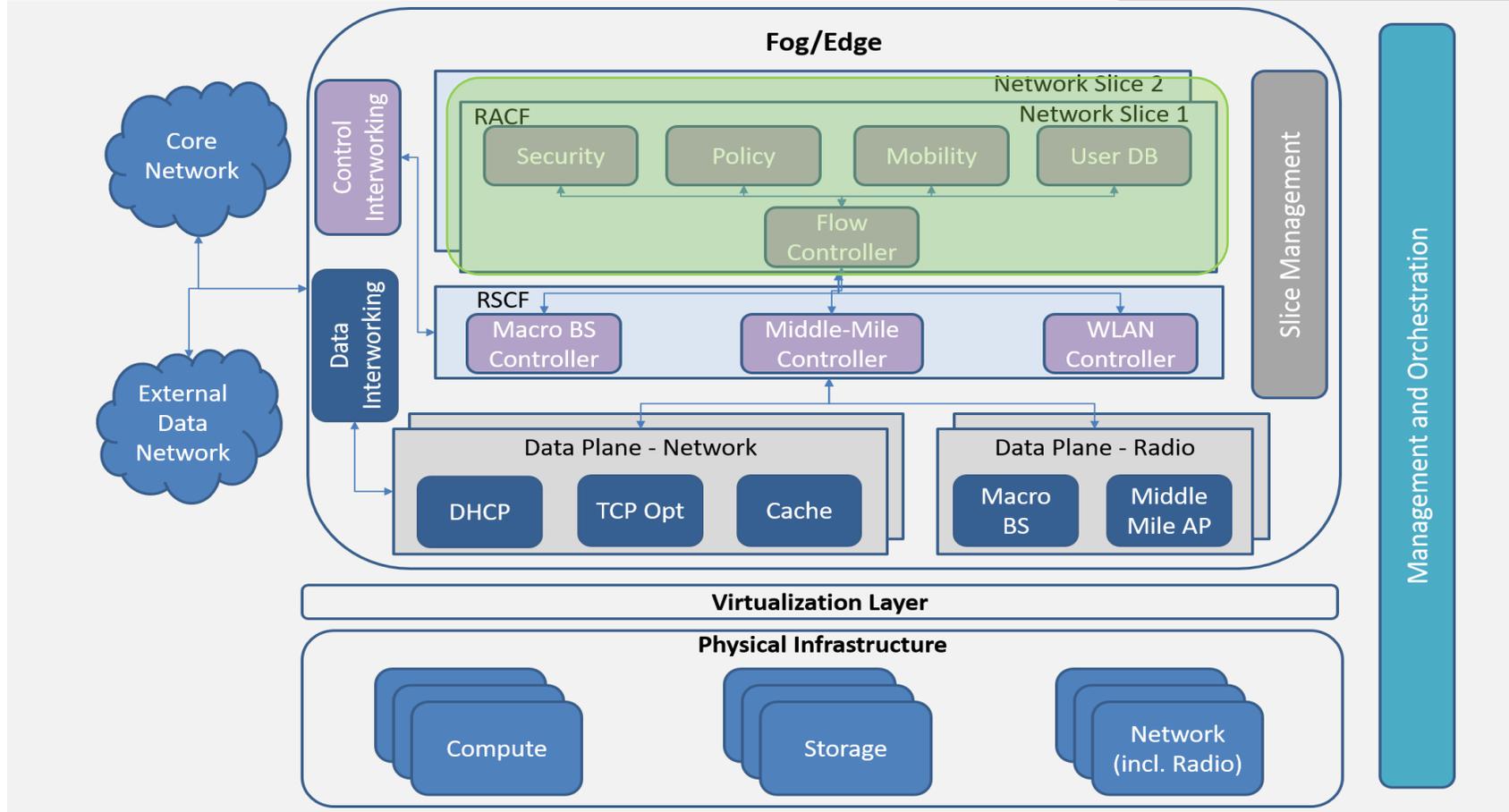
Flow controller

- Operates over abstract resources provided by RSCFs
- Analyses individual traffic flows and acts on it with help from other RACFs
- Enables localized communication under individual fog element

IEEE P2061 Architecture – Interfaces
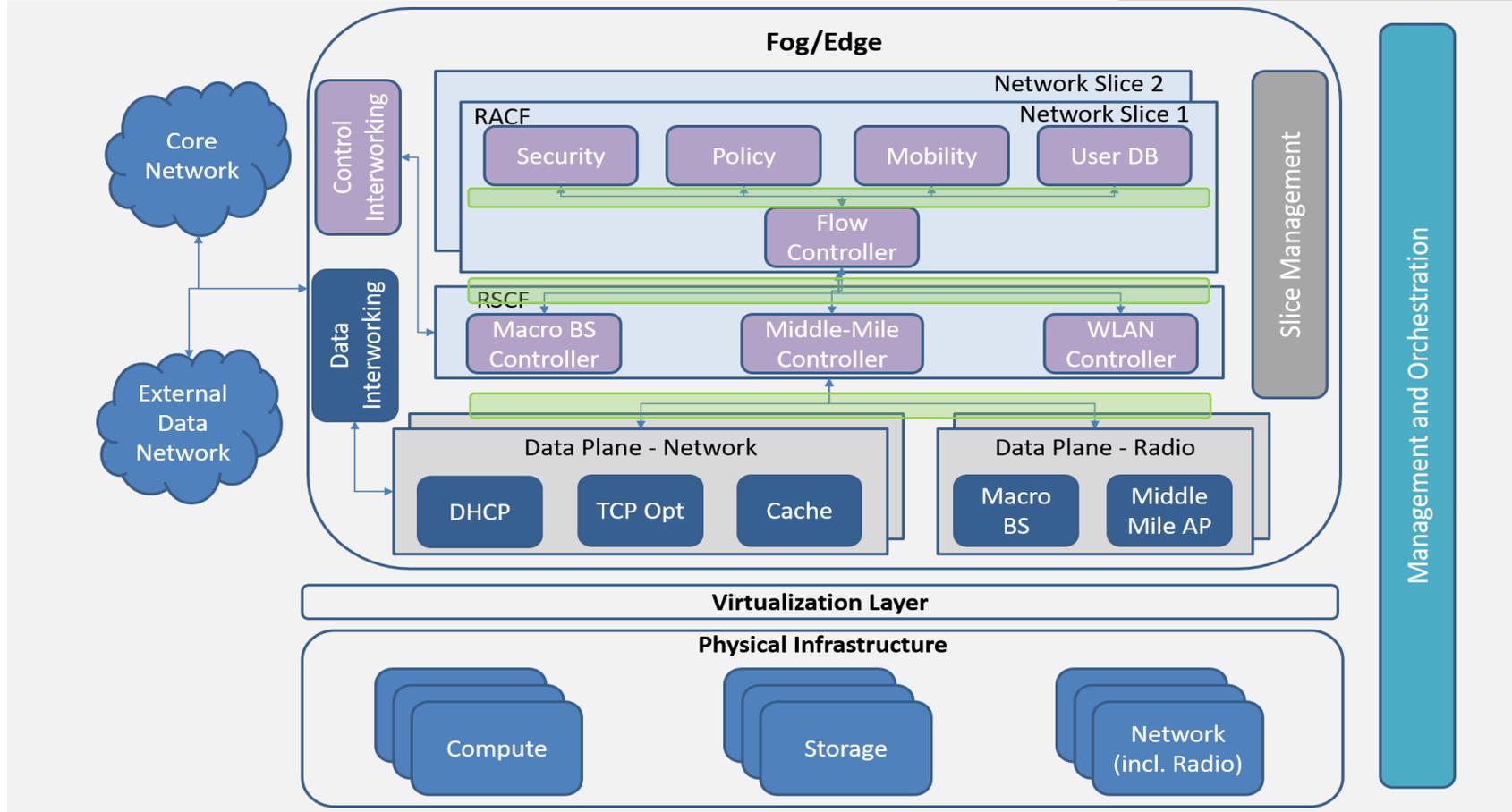
Interactions between RACFs : Service based Interface

Flow controller & RSCFs : OpenFlow (Modified)

RSCFs & the Corresponding Data Plane Entities : Similar to E1AP/F1AP(3GPP)

IEEE P2061 Architecture – Key Working Principles

- Unified Access Control

- Wireless Backhaul Integration
  - Flow Controller Instructs both WLAN and Middle-Mile Controllers
  - Path set up through Middle-Mile and WLAN for data/control transfer

- Direct Internet Connectivity Support from RAN (w/o Core)

- Flexible Edge/Fog Control
  - Flexible Instantiation of Network Functions across Edge/Fog and cloud
  - Dependent on the availability of Resources

- Local Communication Support
  - End-to-end data path may be fully contained within a single edge/fog element
  - Reduced end-to-end latency
  - Optimized Resource Utilization
  - Improved Network Resilience

THANK YOU