# SDN for Mobile Networks: IEEE P1930 & P2061, Frugal 5G

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# Agenda

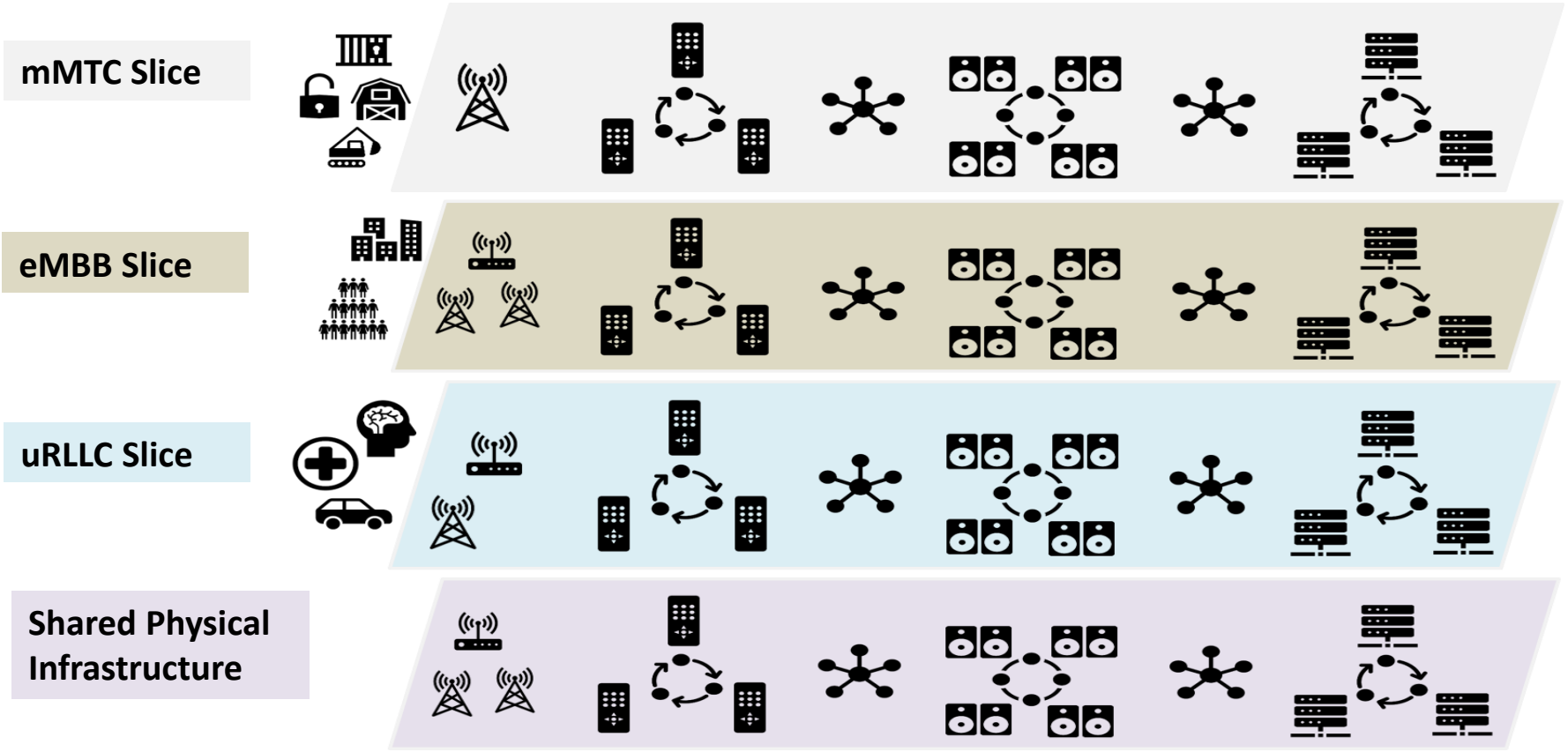
- SDN and 3GPP 5G Architecture
- IEEE 5G SDN Standardization
- IEEE P1930.1 - MultiRAT SDN Controller Architecture
- IEEE P2061 - Frugal 5G and Novel Use case of SDN in Broadband Network

# 3GPP 5G standardization

- SDN and NFV
  - Key technologies for 3GPP 5G standards
- Specifies components as Network Functions
- Data Plane and Control Plane Functions separated thru standardized interface
  - Both in Core and Radio Access Network (RAN)
- Control Plane Functions in Core Network (CN)
  - Access & Mobility Management Function (AMF)
  - Session Management Function (SMF)
  - …
- Forwarding Plane Function in Core Network
  - User Plane Function (UPF)

# 5G Network Slicing

- Network Slicing
  - Multiple Virtual Networks over shared infrastructure
- Different Slice - Different Service



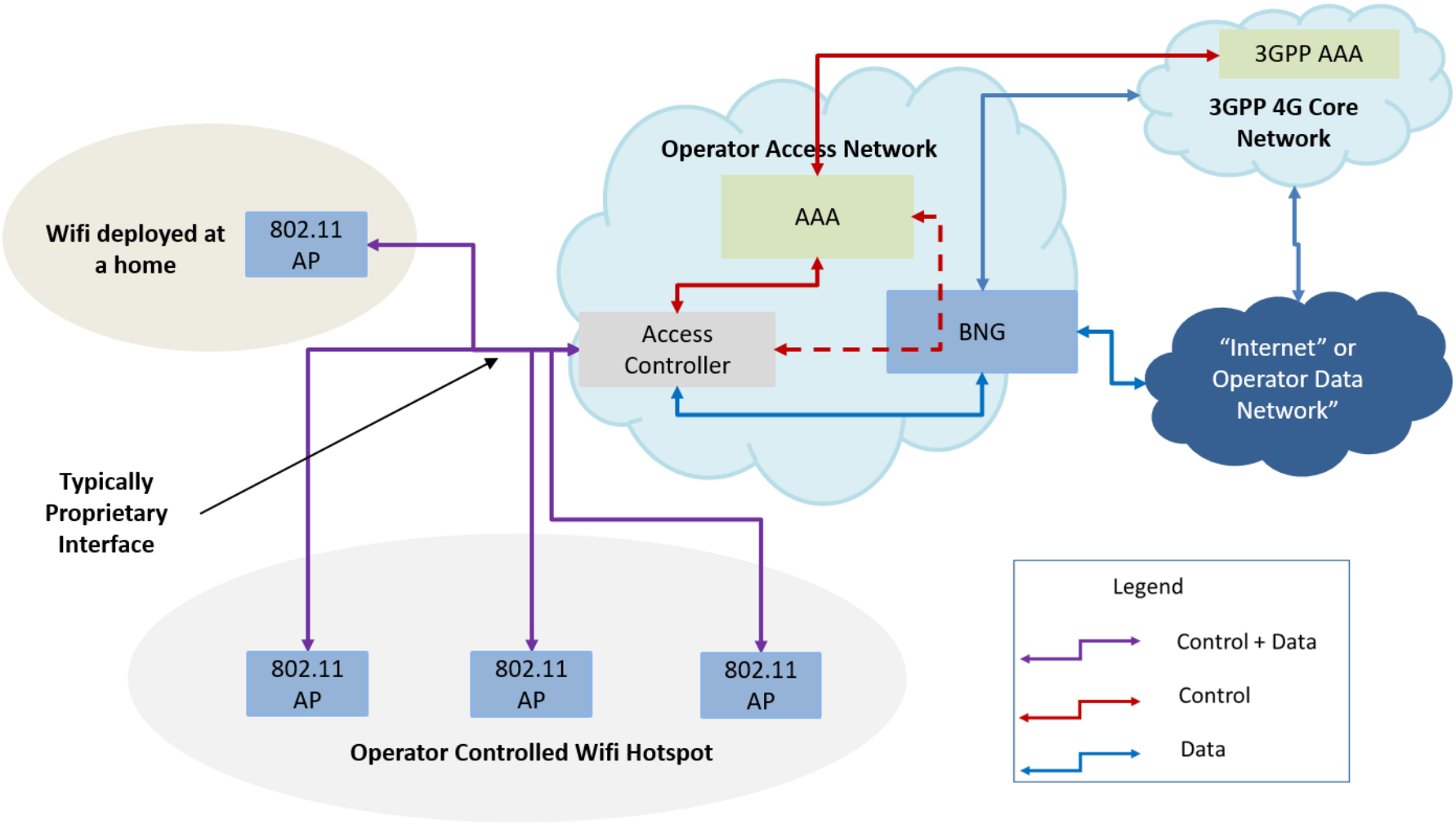
# IEEE - Standardization Activities for 5G SDN

| Project No. | Name | Scope |
|---|---|---|
| P1915.1 | SDN and NFV Security | Specifies security framework, models, analytics, and requirements for SDN and NFV based environment |
| P1916.1 | SDN and NFV Performance | Specifies performance framework including models, terminology and analytics for optimized system operations |
| P1917.1 | SDN and NFV Reliability | Specifies a framework to build and operate SDN/NFV service delivery infrastructure that satisfies reliability expectations of operators, content providers etc. |
| P1921.1 | Bootstrapping Procedures | Introduces automation in networking by means of an SDN bootstrapping procedure |

# Mobile Network Landscape today

- Increased Network Densification
  - Heterogeneous Networks – Coexistence of Small and Large Cells
- Multi-RAT Networks
  - Different Radio Access Technologies exist together
- Fragmented Decision Making in RAN
  - Suboptimal Resource Utilization
- Need for Unified Control of RAN

# WLAN Deployments Today

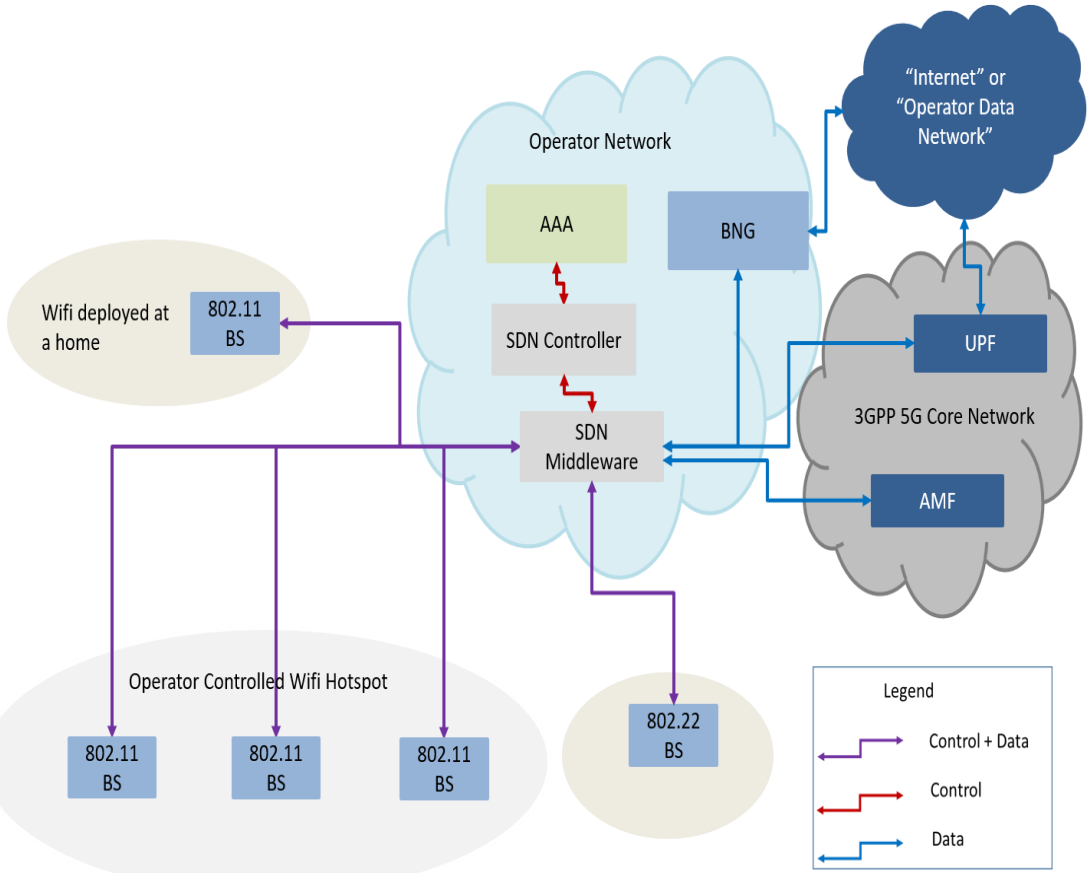



Issues of Interoperability and Vendor Lock-in

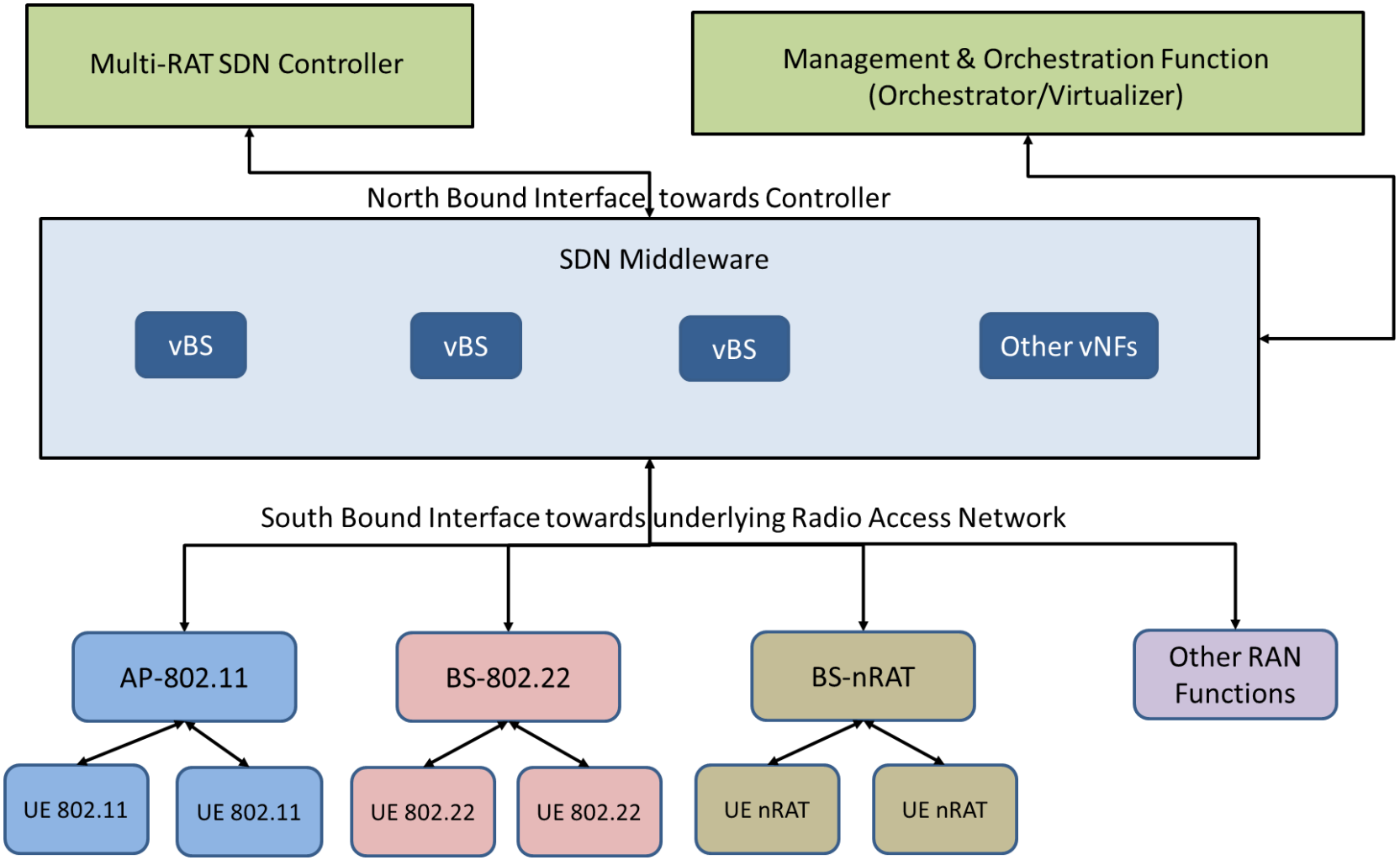
No clean separation of data and control

# Proposed Solution - P1930.1 Standard

- Replace Access Controllers with two entities
  - SDN Controller
  - SDN Middleware
- Interface as exposed by RAN nodes abstracted at SDN Middleware
- SDN Controller responsible for Control of Access Networks
- Standard and Open Interface between SDN Middleware and SDN Controller



# IEEE P1930.1 - Proposed Multi-RAT RAN Architecture



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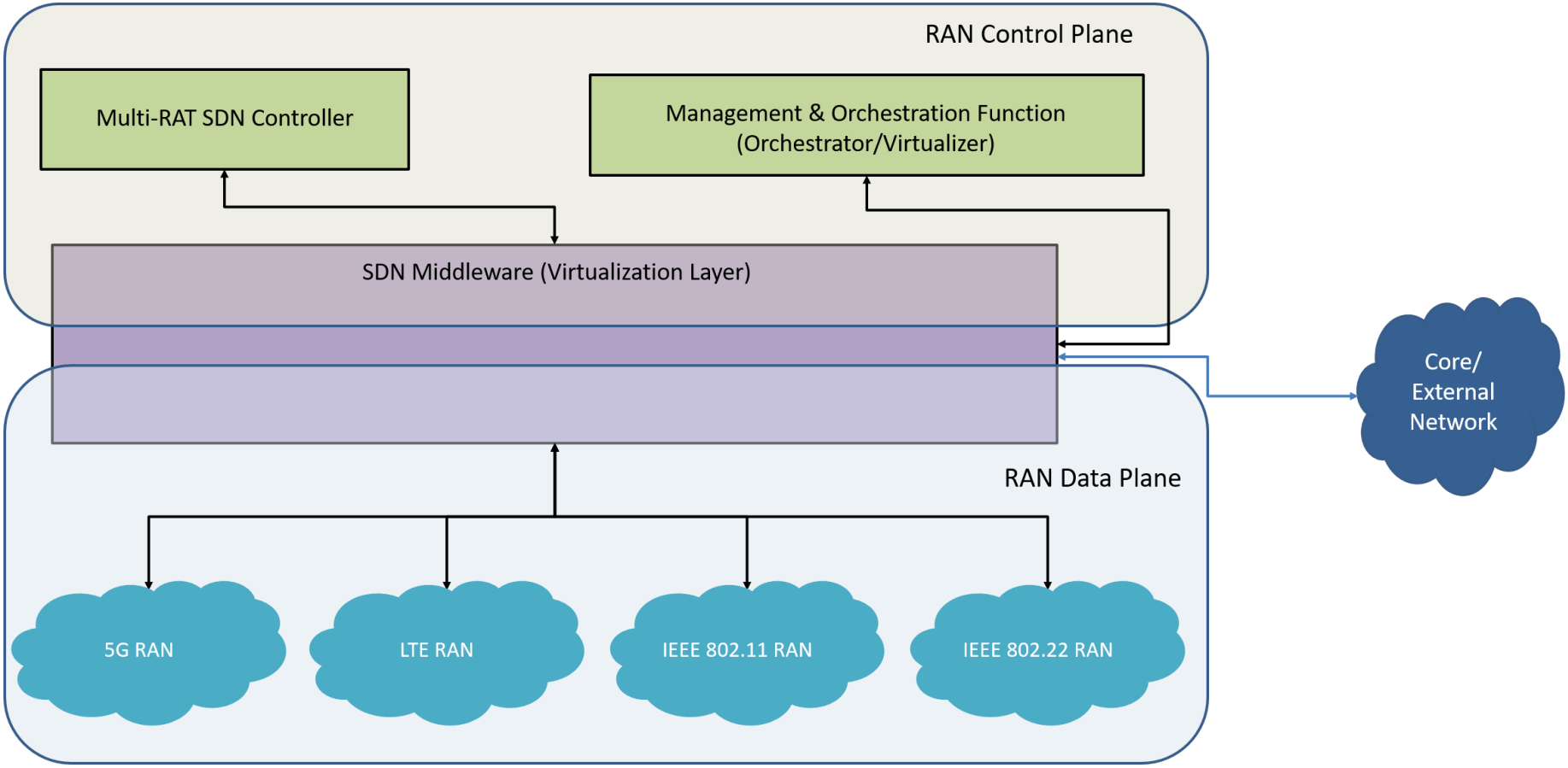


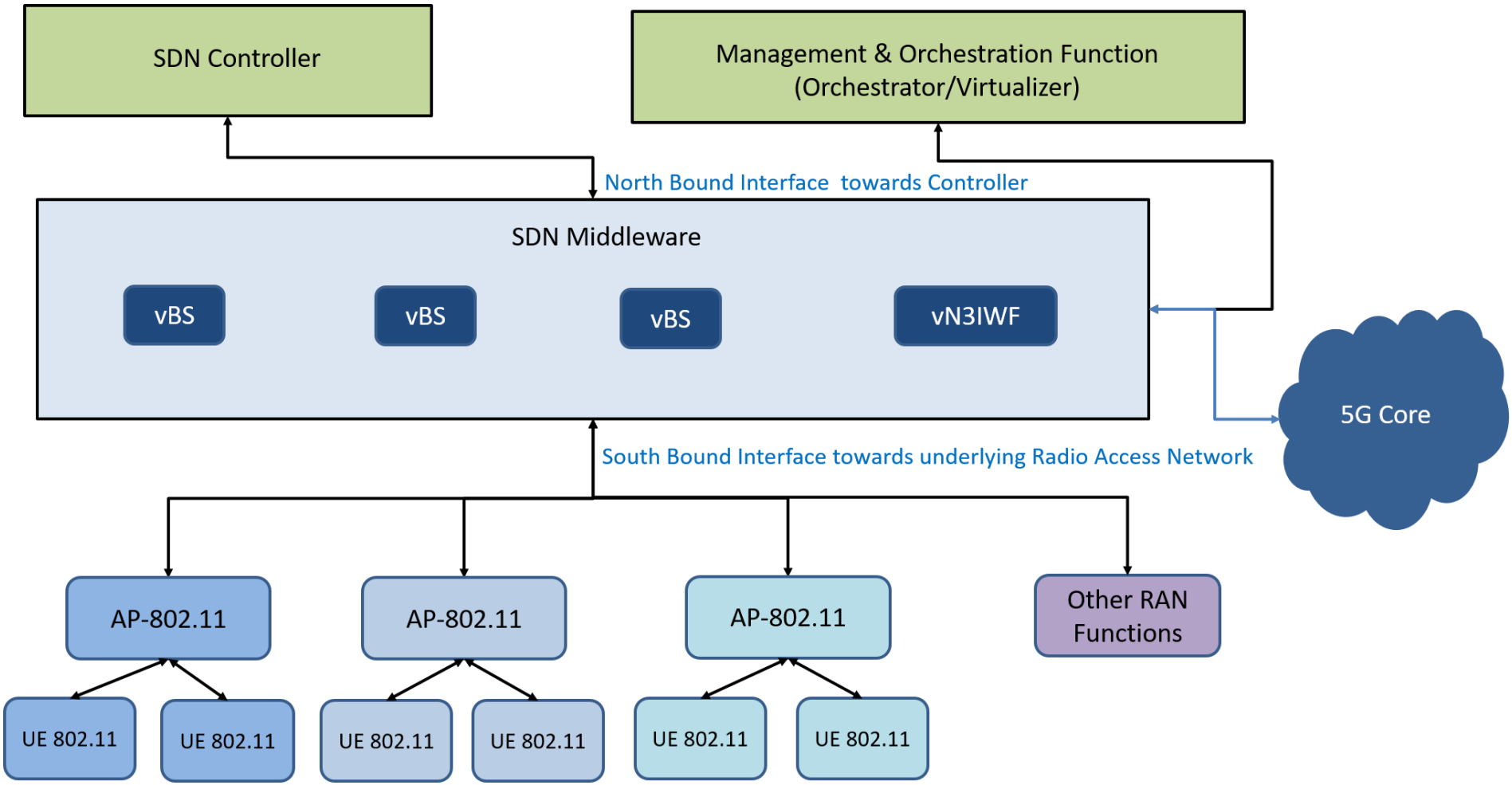
# Key Architectural Components

- SDN Middleware
  - Presents an Abstract Information Model of the underlying RAN
    - Through Virtual Network Entities
      - Virtual Base Stations(vBS) for Base Stations (BS) and APs
      - Other functions, e.g., for 3GPP 5G Core Interworking Function (N3IWF)
    - Enables features like Network Slicing in RAN
- SDN Controller
  - Responsible for Control and Management of the Access Network
- Management and Orchestration Entity
  - To orchestrate and manage the SDN Middleware (the virtualized network entities) over the RAN Infrastructure
- Radio Access Network Infrastructure
  - Access Points, Base Stations, Network Interworking Functions

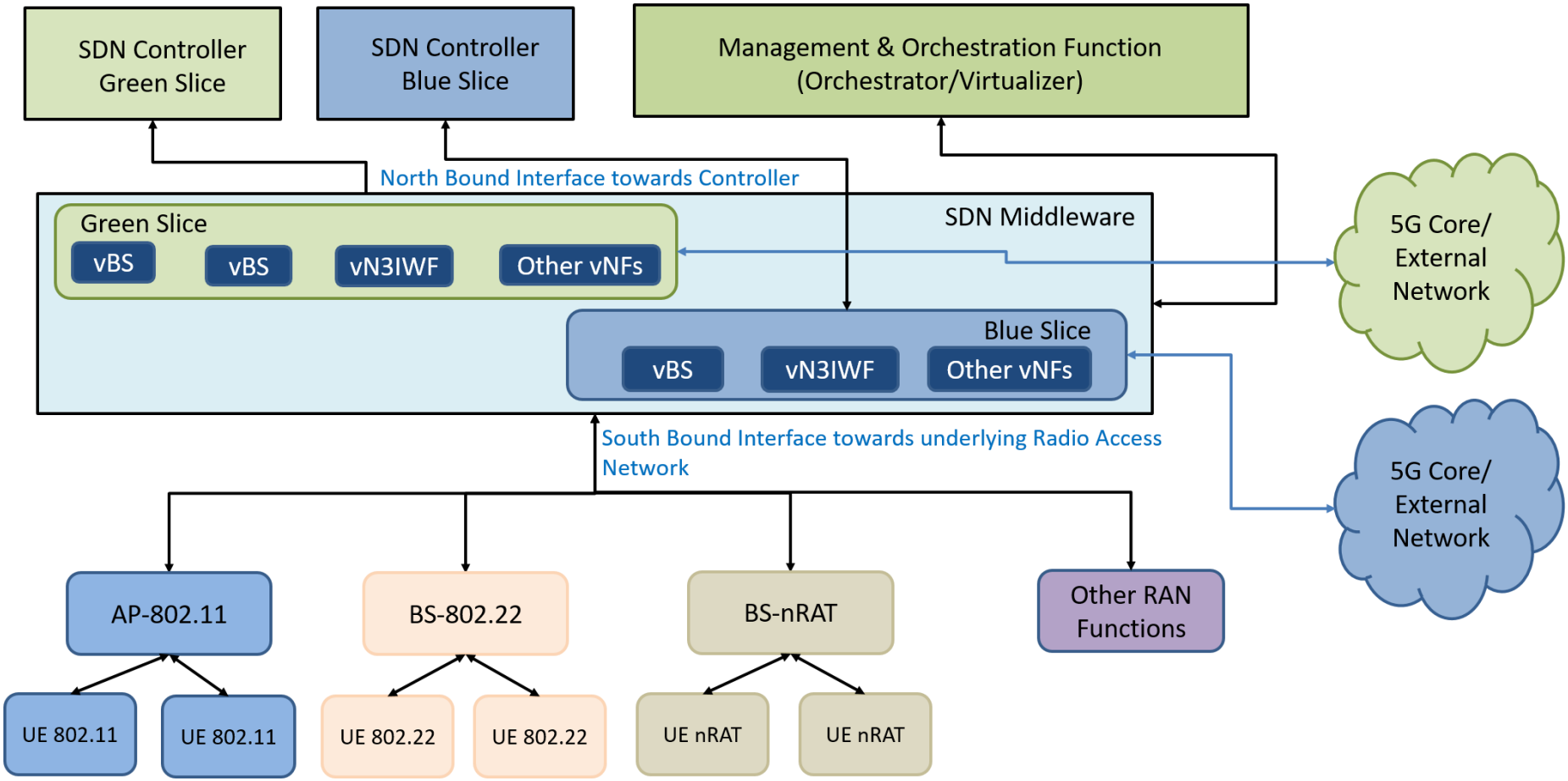
# SDN Middleware Interfaces

- Northbound Interface of the Middleware
  - Interface between the virtual entities and the Controller
  - From the Controller perspective, it appears as if it is interfacing directly with the physical BSs
  - NETCONF for Management and Openflow for Control
- Southbound Interface of the Middleware
  - Interface between the physical infrastructure, e.g., AP, BS and the Middleware
  - Can be based on vendor specific or standard protocols, e.g., LWAP, CAPWAP, TR-069, SNMP
- Middleware maps the Southbound Interface with the Northbound Interface

# IEEE P1930.1 – WLAN Interworking with 5G Core



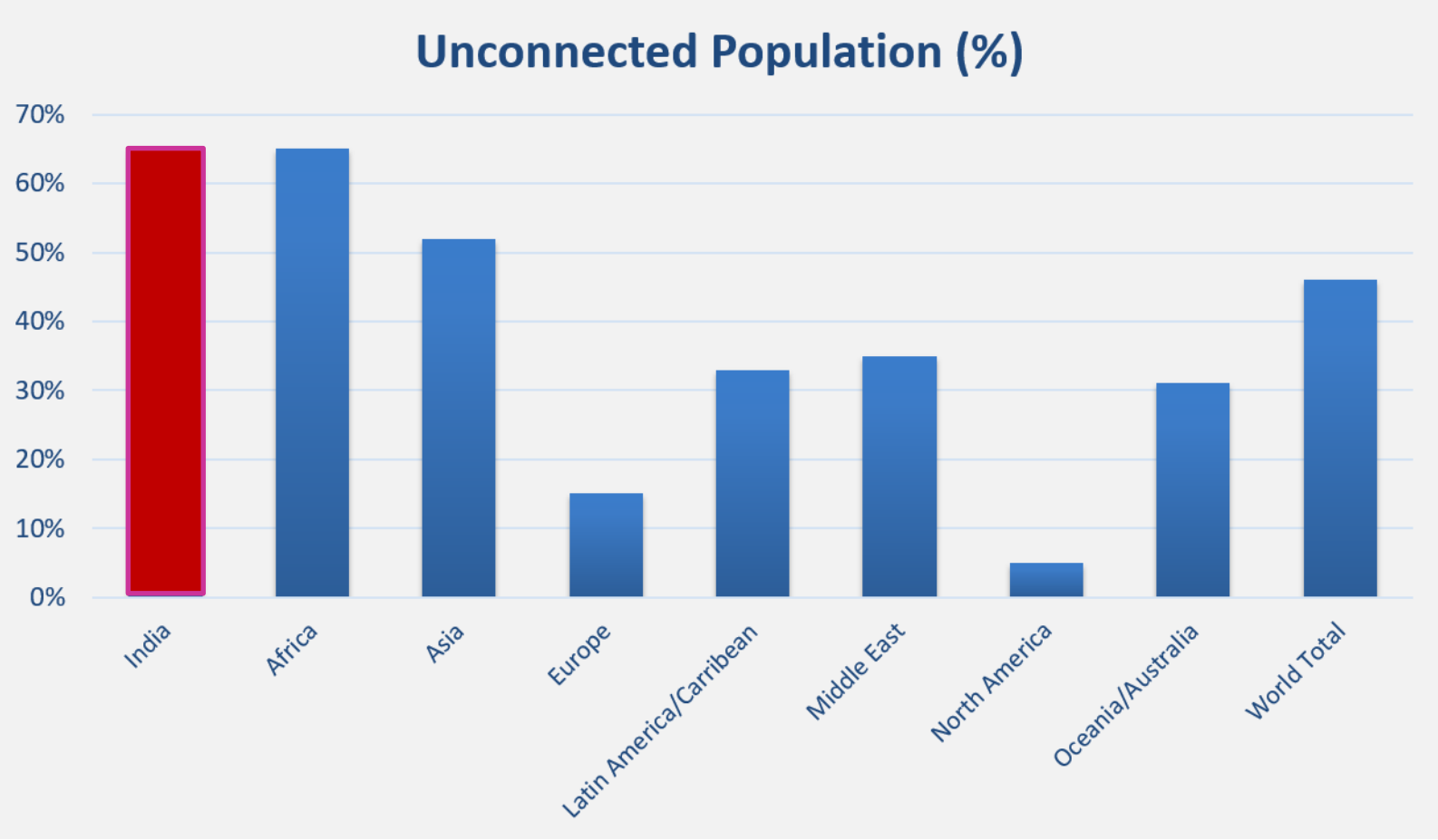
# P1930.1 based Architecture - Network Slice support



# P2061

## Frugal 5G – Affordable Rural Broadband Access

# Internet Penetration Status: Worldwide




Almost 50% of the world population is unconnected Majority in Developing World

*Source: https://www.internetworldstats.com/*

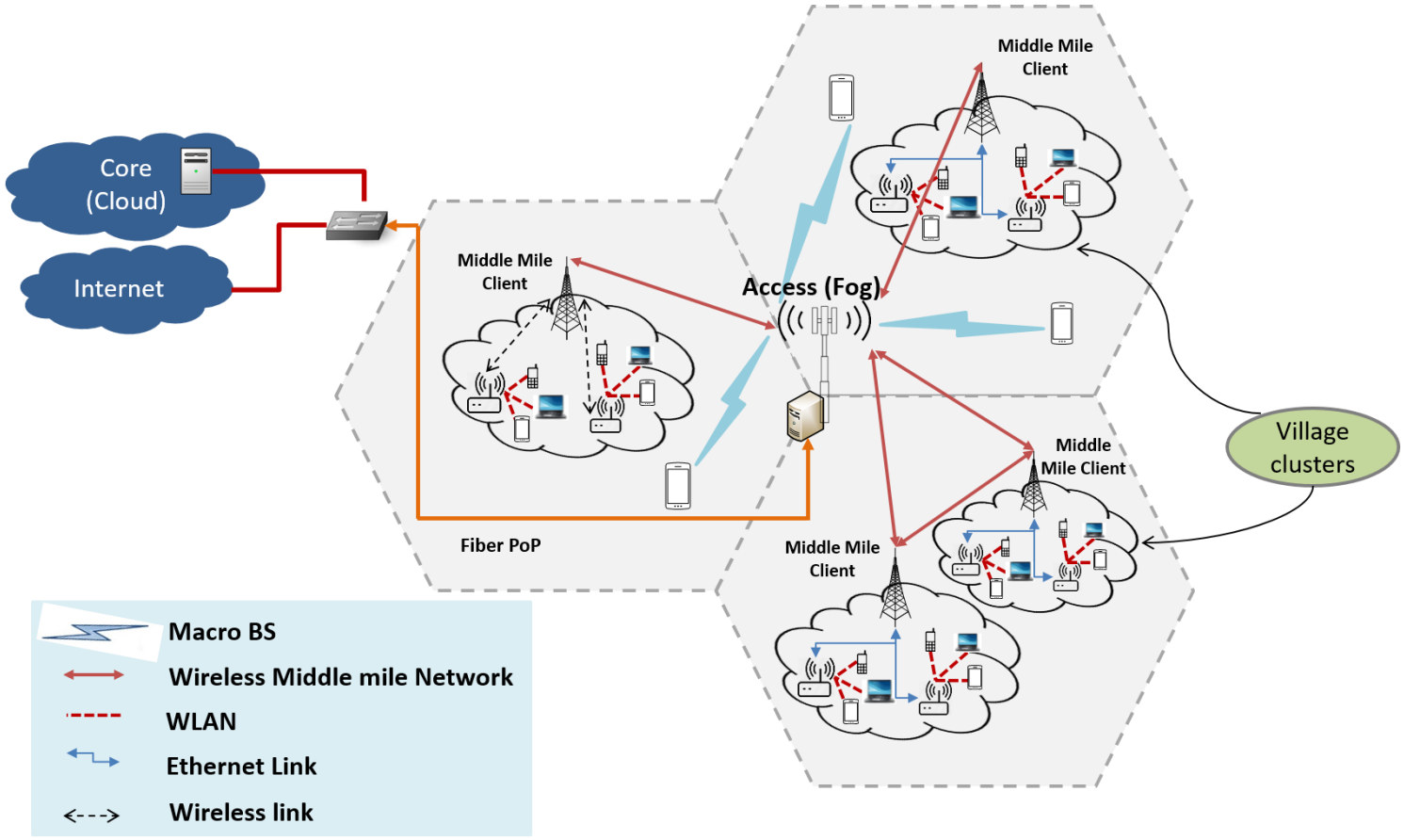
# Internet/Broadband Access – How is it enabled?

- Developed countries
  - Typically enabled through wired communication infrastructure - Fiber and DSL
- Developing countries
  - Fiber/DSL Infrastructure - Inadequate
  - Cellular Technology - Primary broadband access mechanism

# Rural Connectivity Requirements

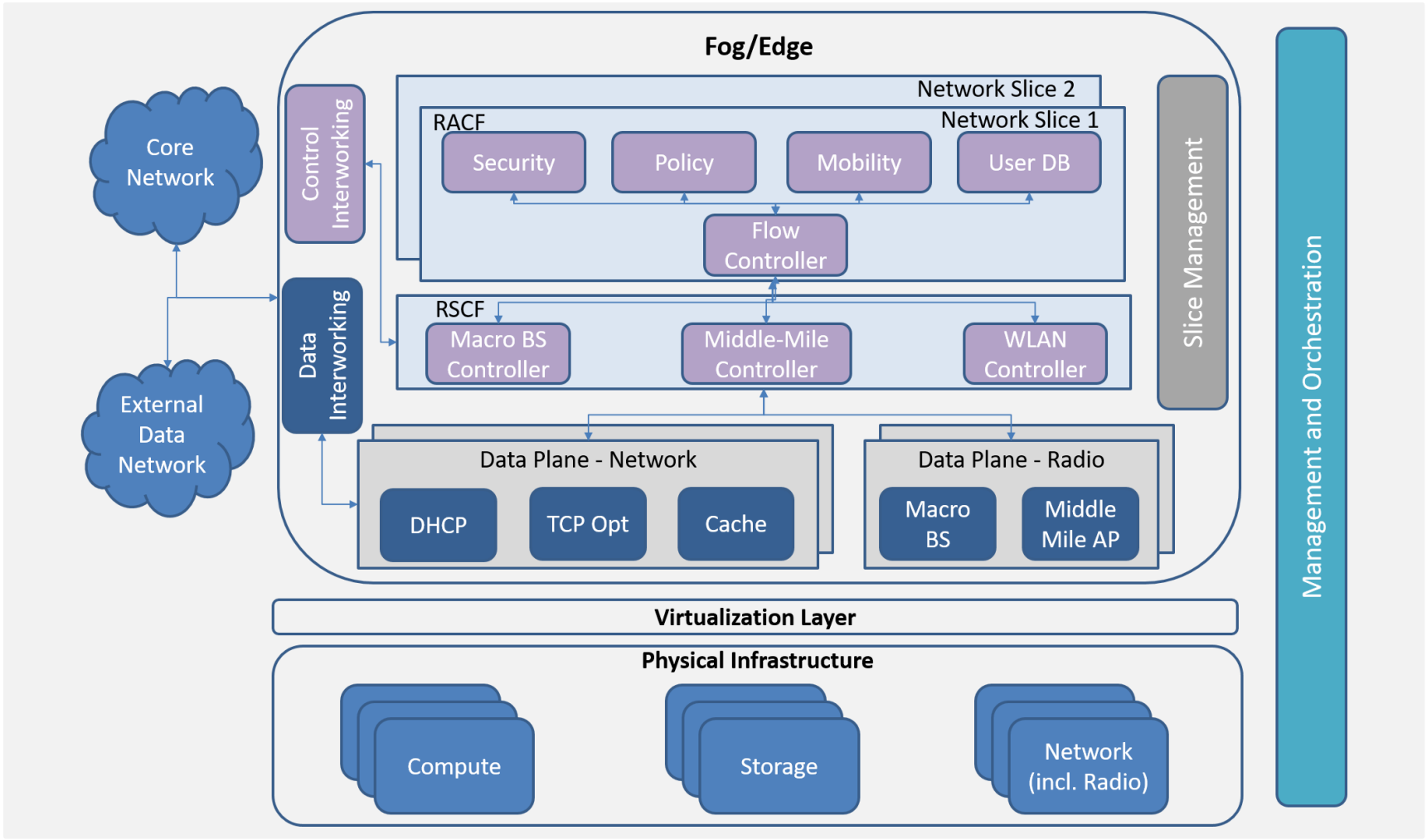
Frugal 5G refers to the vision of providing broadband access to rural areas by addressing these requirements and challenges

# IEEE P2061 - Low Mobility Energy Efficient Network for Affordable Broadband Access - Architecture




| | |
|---|---|
| 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 Frugal 5G Network Architecture – Fog Components

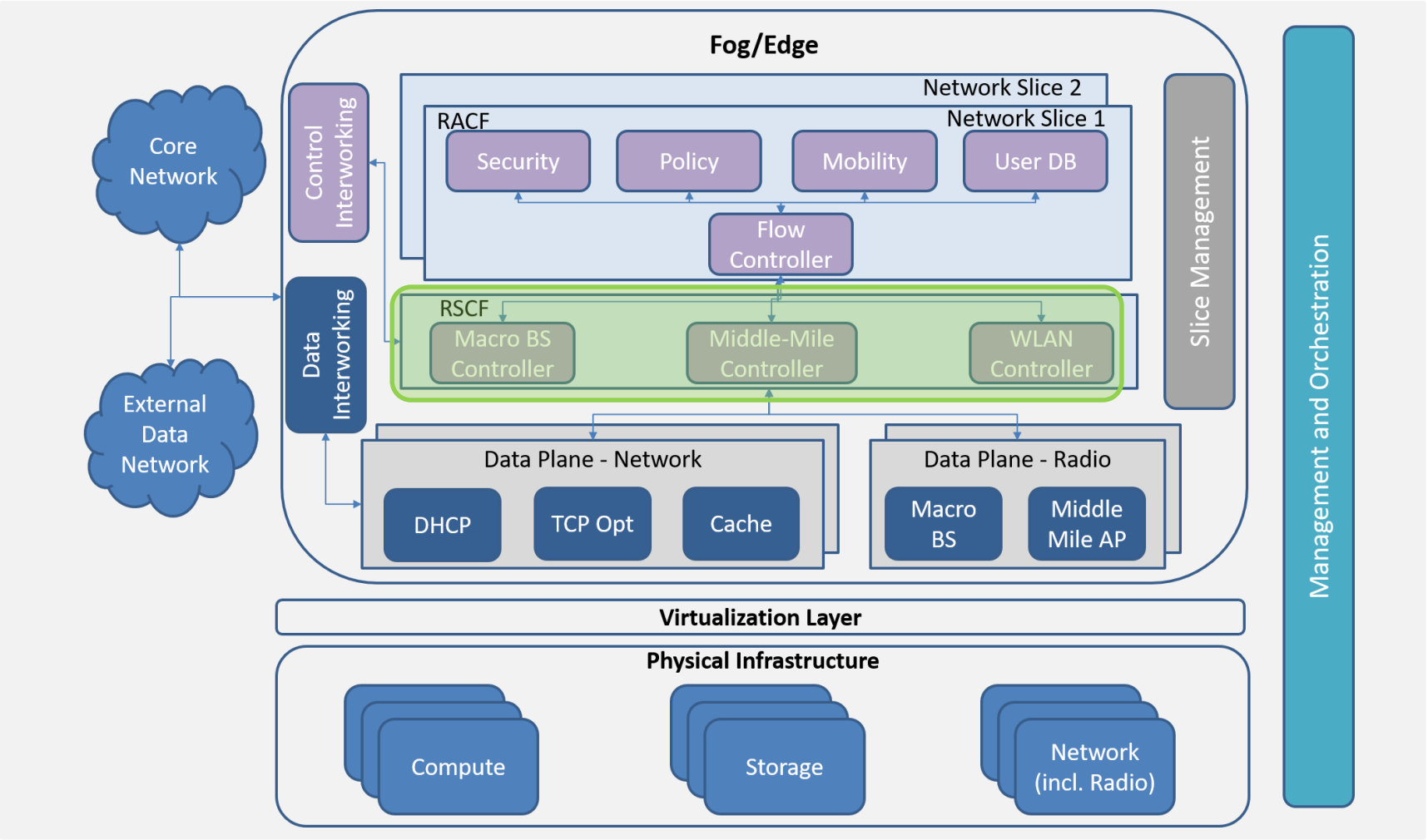



Core Network (CN): Responsible for overall control of the complete network

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

Synchronization of network functions over fog & cloud to avoid inconsistencies

# Fog – RAT Specific Control Functions (RSCFs)

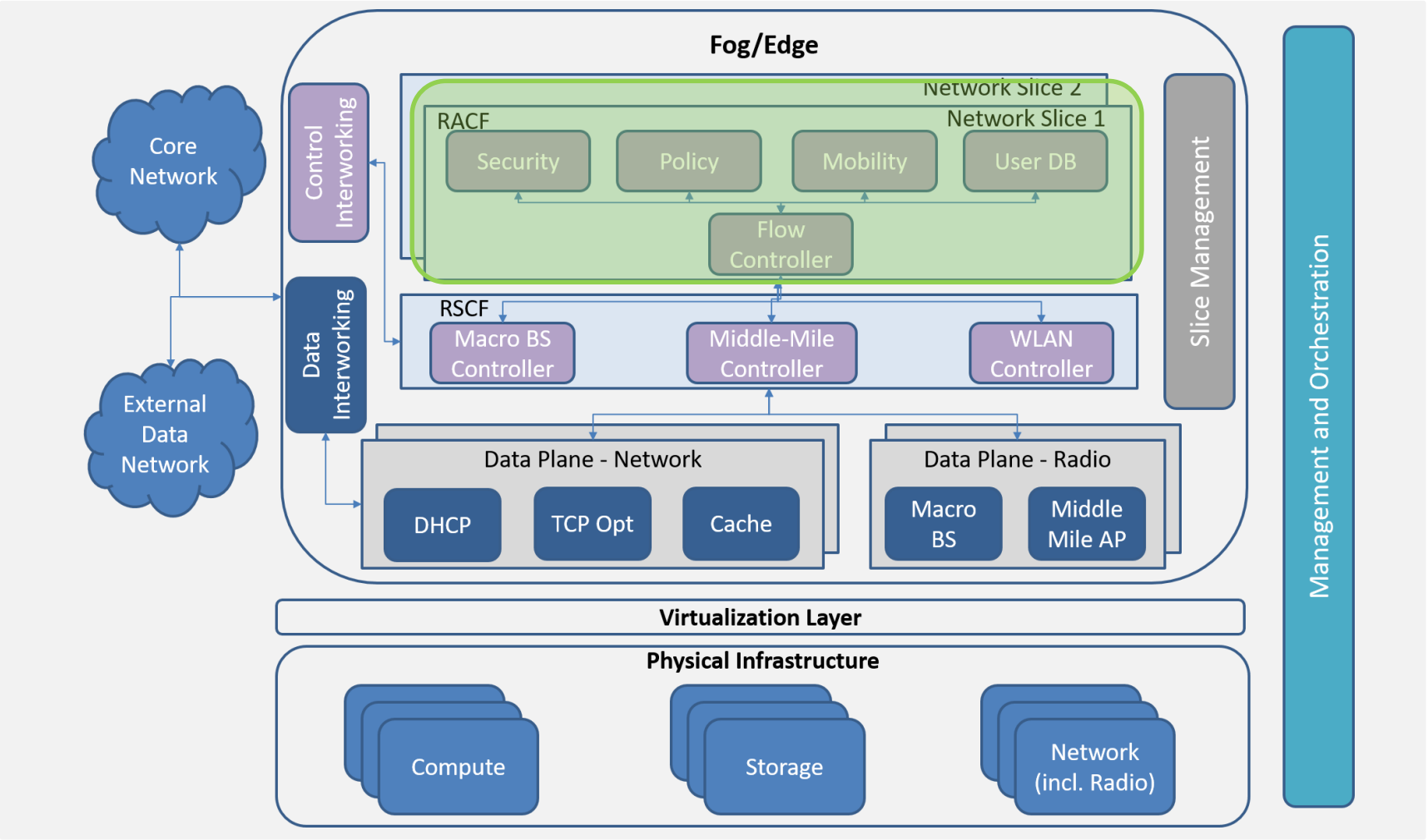



Provides an abstract view of underlying RAN to higher level control entities

Enables unified control of multi-RAT network

Enables RAN virtualization and Network Slicing

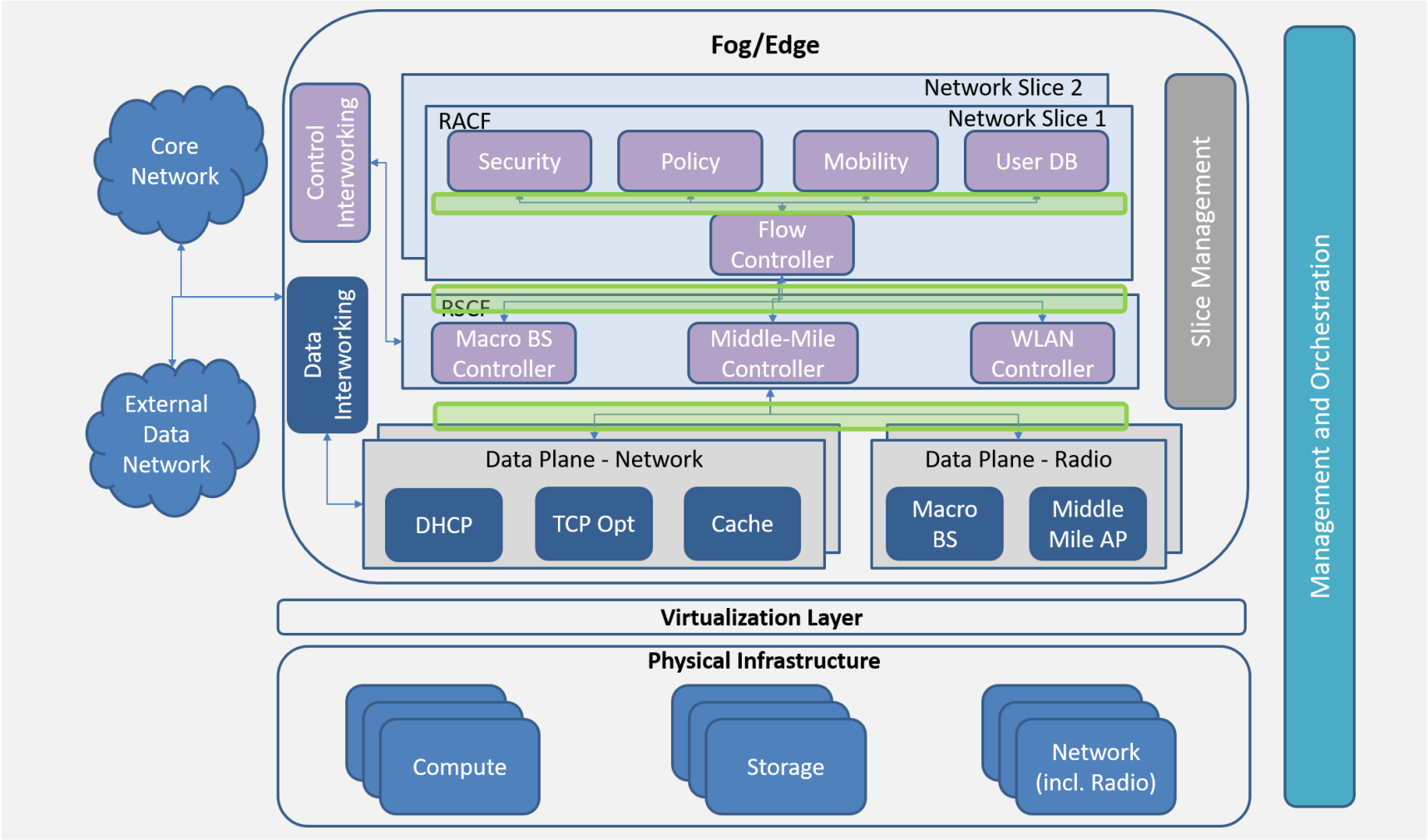
# Fog – RAT Agnostic Control Functions (RACFs)




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

# Frugal 5G Network Architecture – Interfaces




Interactions between RACFs : Service based Interface

Flow controller & RSCFs : OpenFlow (Modified)

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

# Frugal 5G Network Architecture – Key Working Principles (1/2)

- Wireless Backhaul Integration
  - Flow Controller gives the required instructions to both WLAN and Middle-mile controllers
  - Path set up through Middle-Mile and WLAN for data/control transfer
- Multi-Operator Resource Sharing
  - Individual slices can be allocated to an operator
  - Depending on parameters like subscriber base, an operator needs certain amount of network resources
  - RSCFs provide abstract view of network resources to Slice Management Function
  - Slice Management Function splits virtual network resources into multiple network slices  allocated to individual operators

# Frugal 5G Network Architecture – Key Working Principles (2/2)

- Flexible Fog Control
  - Flexible Instantiation of Network Functions across fog and cloud
  - Dependent on the availability of Resources
    - Network, Compute and Storage
- Localized Communication Support
  - SDN controllers sets up data path through the network
  - End-to-end data path may be fully contained within a single fog element
    - Reduces end-to-end latency of data transfer
    - Optimizes Resource Utilization
    - Improves Network Resilience

# Thank you

# P1930.1 - Summary

- SDN based Architecture for RAN
- Unified Control of Multi-RAT RAN
- Vendor Interoperability for different RATs
- Unified Interface to RAN Resource Management Applications, e.g., Mobility Control, Admission Control, Load Balancing
- Facilitates Optimal Decision making in RAN
- Supports Features like Network Slicing

# Wireless Technology for Rural Broadband Connectivity

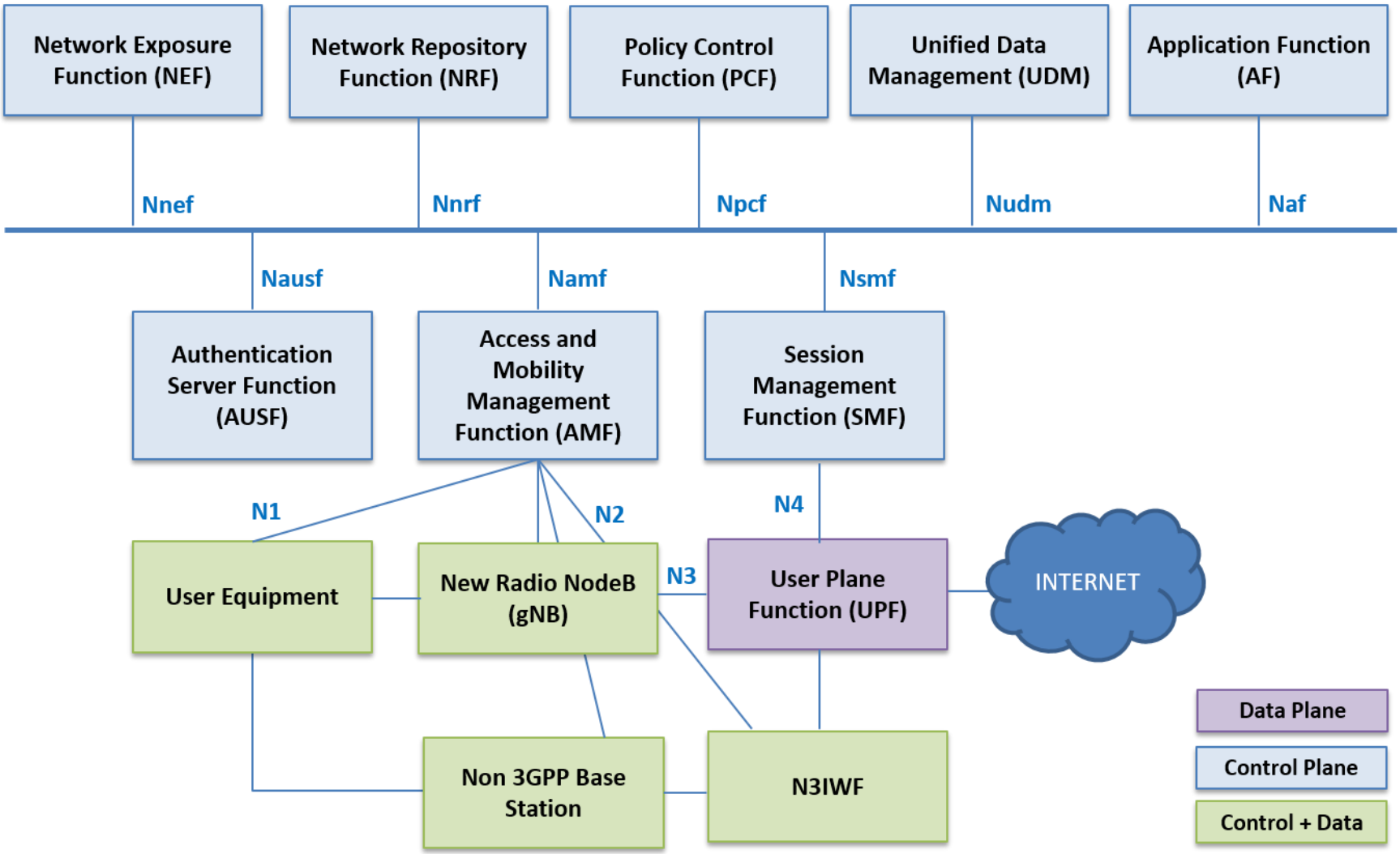
## Existing and Emerging Wireless Cellular Standards

- Typically focussed on urban usage scenarios
  - 5G technology targets - 10 Gbps data rate, 1 ms latency, 500 km/h mobility
- **Challenges and Characteristics of Rural Connectivity not factored into specification and design**
- Variations in use cases across regions, countries, continents ignored

## Operators

- Roll out networks in urban/semi-urban areas
- No compelling commercial reason for them to target rural areas

# 3GPP 5G Network Architecture – Impact of SDN and NFV




*3GPP System Architecture: Courtesy TS 23.501*