Contribution to Telecom Standardization

IEEE, TSDSI and 3GPP

Contributions to IEEE Standards in 5G

- Our group has initiated a new IEEE standard on Software Defined Networking in 5G

  - IEEE P1930.1: Recommended Practice for Software Defined Networking (SDN) based Middleware for Control and Management of Wireless Networks

- We have also pioneered the concept of Frugal 5G for Rural Broadband

  - IEEE P 2061: Architecture for Low Mobility Energy Efficient Network for Affordable Broadband Access

IEEE - P1930.1

Standard Development for SDN based Wireless Networks

- IEEE Project 1930.1 (IEEE P1930.1)
  - Standard Development Project initiated under IEEE Communications Society by our group @ IIT Bombay

- IEEE Working Group
  - SDN-MCM - SDN based Middleware for Control and Management of Networks

- Project : Recommended Practice for Software Defined Networking based Middleware for Control & Management of Wireless Networks

- Project Goal : To define an SDN based Middleware for Management & Control of Wireless Access Networks
  - IEEE 802.11 based Wireless Local Area Networks
  - IEEE 802.22 based Wireless Regional Area Networks
  - 3GPP Access Networks

- *IIT Bombay playing a very active role in standard development*
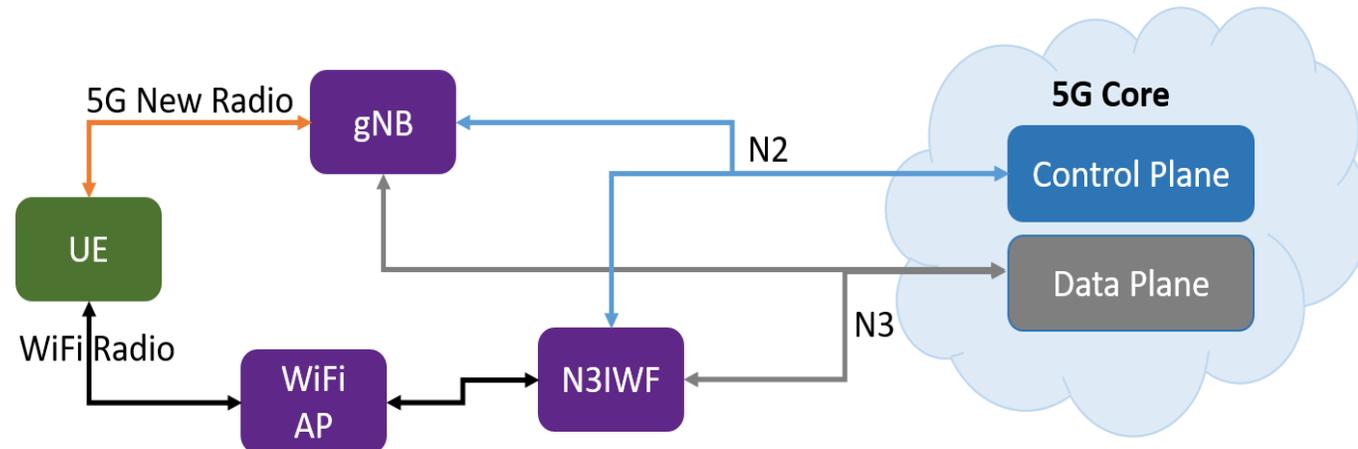
Emerging Mobile Network Architecture

Increased Network Densification

Multi-RAT Networks - Presence of 3GPP & Non-3GPP Access (e.g. Wi-Fi)

Unified 5G Core

Common Interface towards Core for Access Networks

Wi-Fi an Important Access Technology for 5G

5G New Radio — gNB — N2

UE

WiFi Radio

WiFi AP — N3IWF — N3

5G Core

Control Plane

Data Plane

**Fragmented Decision Making in RAN
Need for Unified Control of Multi-RAT RAN**

Fragmented RAN Control – Increased Complexity

- Dual Connectivity
  - UE Connects to two BSs (eNB/gNB/AP)
- UE's Primary Signalling Connection with a single eNB/gNB
- Radio resources in each BS under the control of RRC at each eNB/gNB
  - Extensive coordination between eNBs/gNBs
- Subtle differences in DC mechanism across RATs
  - LTE-LTE DC, MR-DC, LTE-WLAN Aggregation (LWA)
  - Brings higher complexity
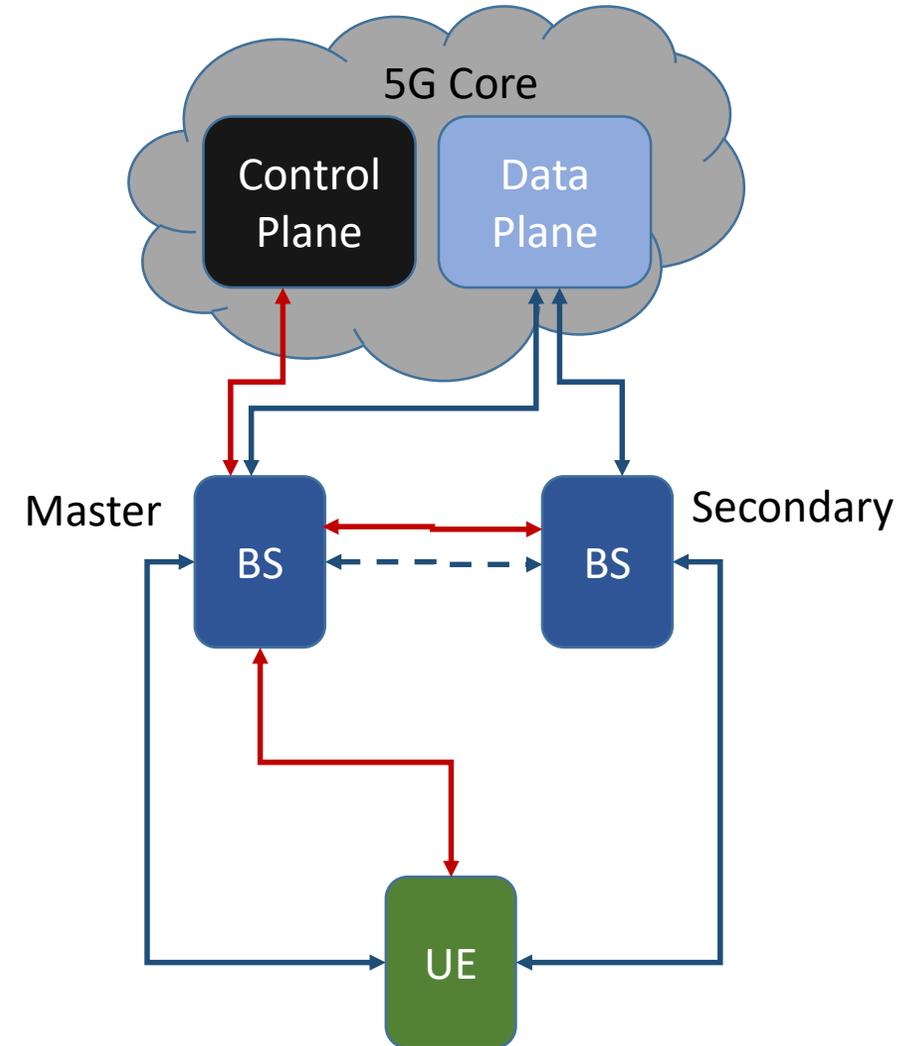
IEEE P1930.1 – Unified Multi-RAT RAN

SDN Middleware

- Abstract Information Model of underlying RAN
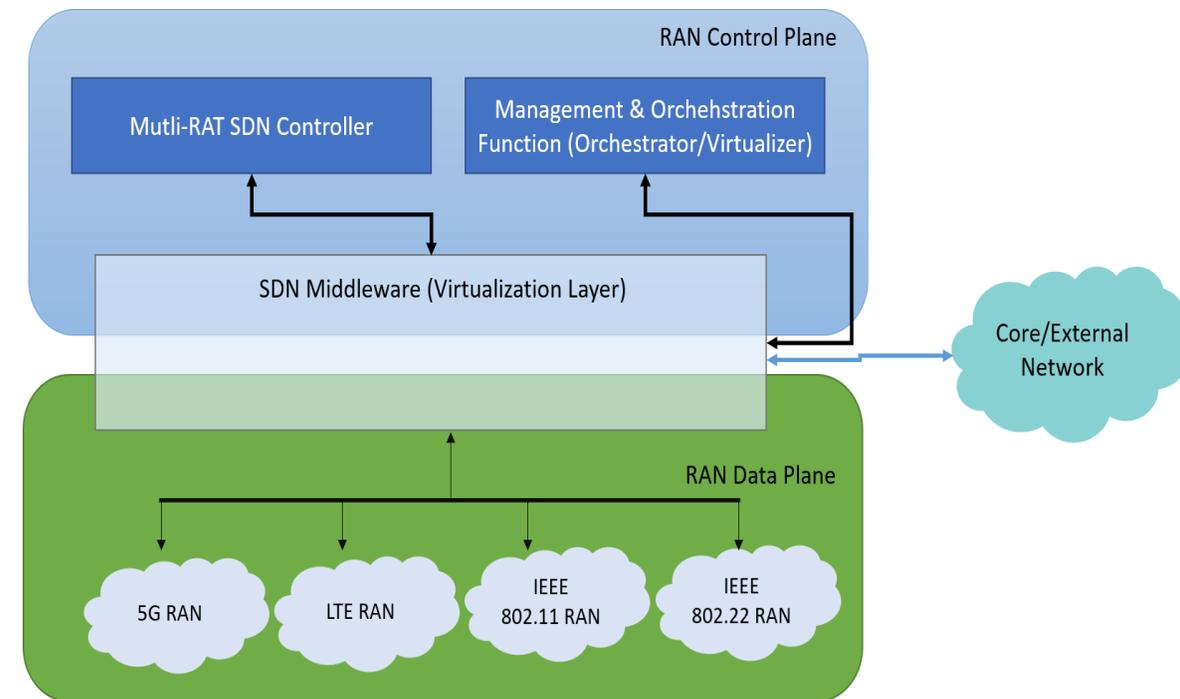- Through Virtual Network Entities

SDN Controller

- Control and Management of the Access Network

Management and Orchestration Entity

- To Orchestrate & Manage the SDN Middleware over RAN Infrastructure

Radio Access Network Infrastructure

- Access Points, Base Stations, Network Interworking Functions

RAN Control Plane

Mutli-RAT SDN Controller

Management & Orchehstration Function (Orchestrator/Virtualizer)

SDN Middleware (Virtualization Layer)

Core/External Network

RAN Data Plane

5G RAN

LTE RAN

IEEE 802.11 RAN

IEEE 802.22 RAN

IEEE P1930.1 - SDN Middleware Interfaces

- **Northbound Interface of the Middleware**
  - Interface between the virtual entities and the Controller
  - NETCONF for Management (Configuration) and Openflow for Control
- **Southbound Interface of the Middleware**
  - Interface between the physical infrastructure, e.g., AP and the Middleware
  - Can be based on vendor specific or standard protocols
    - Control And Provisioning of Wireless Access Points (CAPWAP)
    - Lightweight Access Point Protocol (LWAPP)
    - SNMP
    - OpenFlow
    - NETCONF
- **Middleware maps the Southbound Interface with the Northbound Interface**

IEEE P1930.1 – Key Principles

- Unified Controller

- Modular, Re-usable Multiple Data Plane Functions
  - Managed/Controlled by Controller

- Virtualization of Data Plane through SDN Middleware
  - Abstract Information Model for the Controller

- Unified Interworking with Core Network
  - RAT Agnostic Interworking with Core
  - In case of 5G - Comprise of N2/N3 Interface Functions

- Separation of UE Control from Network Control
  - UE Control
    - Responsible for UE Management/Control
    - Uses RRC Protocol in LTE/5G NR RAN
  - Network Control
    - Control/Management of RAN Data Plane

IEEE P1930.1 – Modular Data Plane

- Modular Data Plane Functions, Examples

- …

- Radio Tx/Rx Function (BS)
  - May Include Physical Layer, MAC Layer etc.

- Security Function (SF)
  - Encryption and Integrity Protection

- Optimization Function (OptF)
  - IP Header Compression etc.

- RAN Adaptation Function (AdpF)
  - Link Control, ARQ etc.

- Interworking Function (IWF)
  - Interworking with Core
  - In case of 5G - Comprise of N2/N3 Interface Functions

- …

IEEE P1930.1 - Unified Control and Management
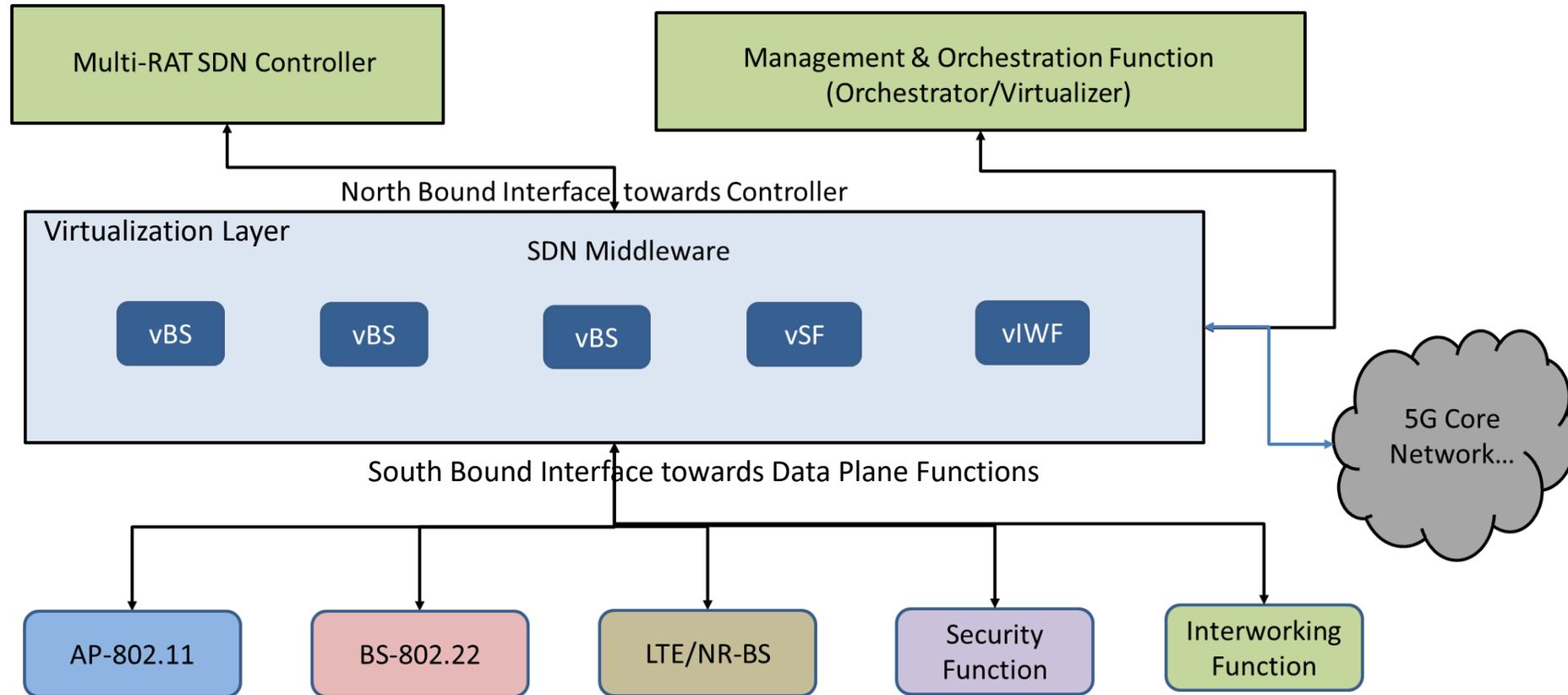
- There may be additional RAN Functions, not shown here
- Virtual Functions may be used for only control and management purposes by the unified Multi-RAT Controller
- VFs may have some data processing functionality also

Frugal 5G Networks - IEEE P2061

Standard Development for Rural Broadband Connectivity

- **IEEE Project 2061 (IEEE P2061)**
  - Standard Development Project initiated under IEEE Communications Society by our group @ IIT Bombay
- **IEEE Working Group**
  - Frugal 5G Networks
- **Project : Architecture for Low Mobility Energy Efficient Network for Affordable Broadband Access**
- **Project Goal : To specify**
  - An Architecture for a Low Mobility and Energy Efficient Network for Affordable Broadband Access to be referred as the "Frugal 5G Network"
  - The "Frugal 5G Network" comprises of
    - A Wireless Middle-mile Network
    - An Access Network
    - The Associated Control and Management Functions
- ***IIT Bombay playing a very active role in standard development***
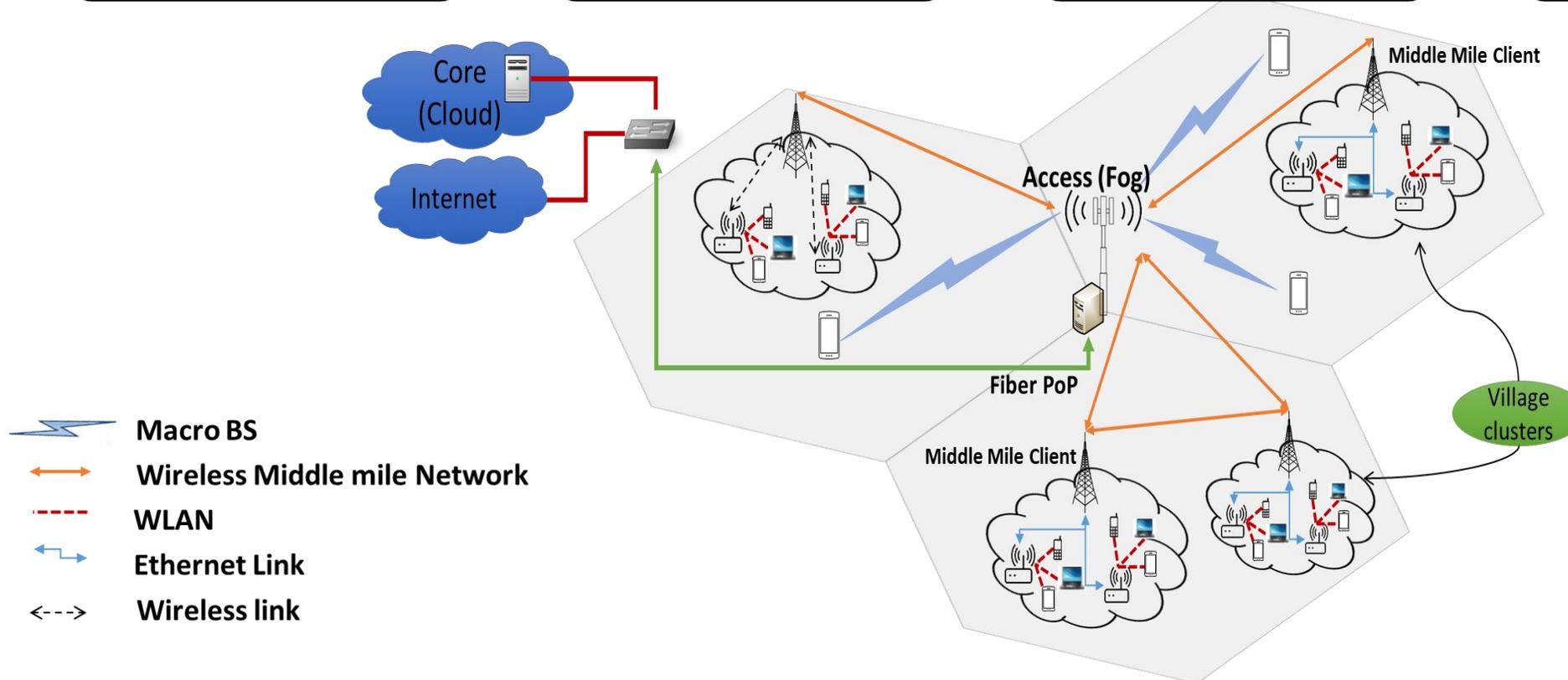
Frugal 5G Networks (IEEE P2061)

IEEE P2061 Network Architecture - Features

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

Core (Cloud)

Internet

Access (Fog)

Middle Mile Client

Fiber PoP

Middle Mile Client

Village clusters

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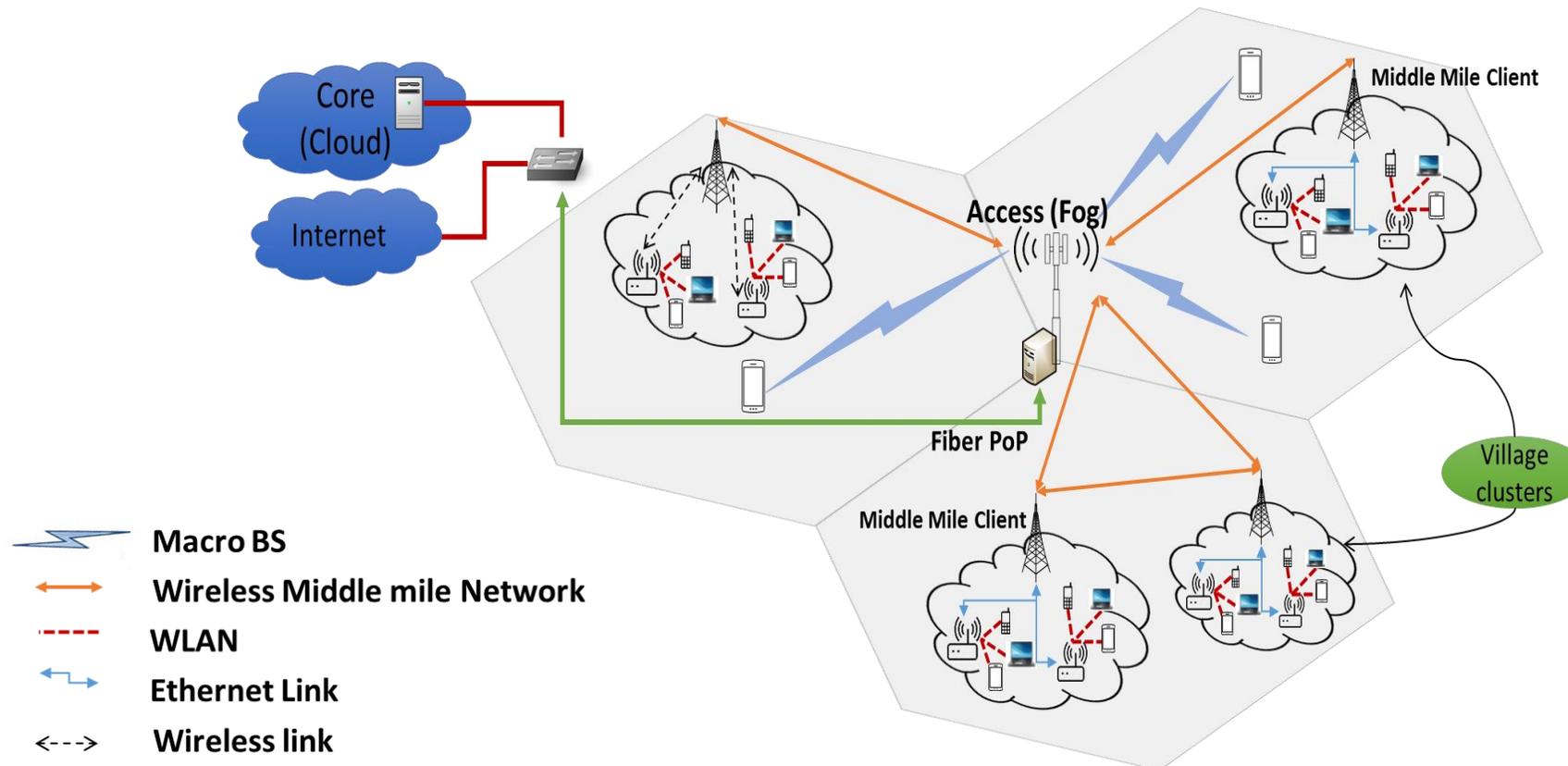- WLAN
- Ethernet Link
- Wireless link

IEEE P2061 Network Architecture- Features

SDN based unified control - Efficient service delivery, Independent Evolution and Development of control/data plane entities

Usage of Virtual Network Functions - makes the system cost-effective

Intelligence at the edge - Enables local communication & reduces resource usage

Other Contributions

Contribution to Other Standards – TSDSI and 3GPP

- TSDSI
  - Enhanced Relay Architecture for 4G/5G Networks

- 3GPP
  - Mission Critical Communication

THANK YOU