Fog and SDN paradigms in 5th Generation Wireless Communication Networks

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Agenda

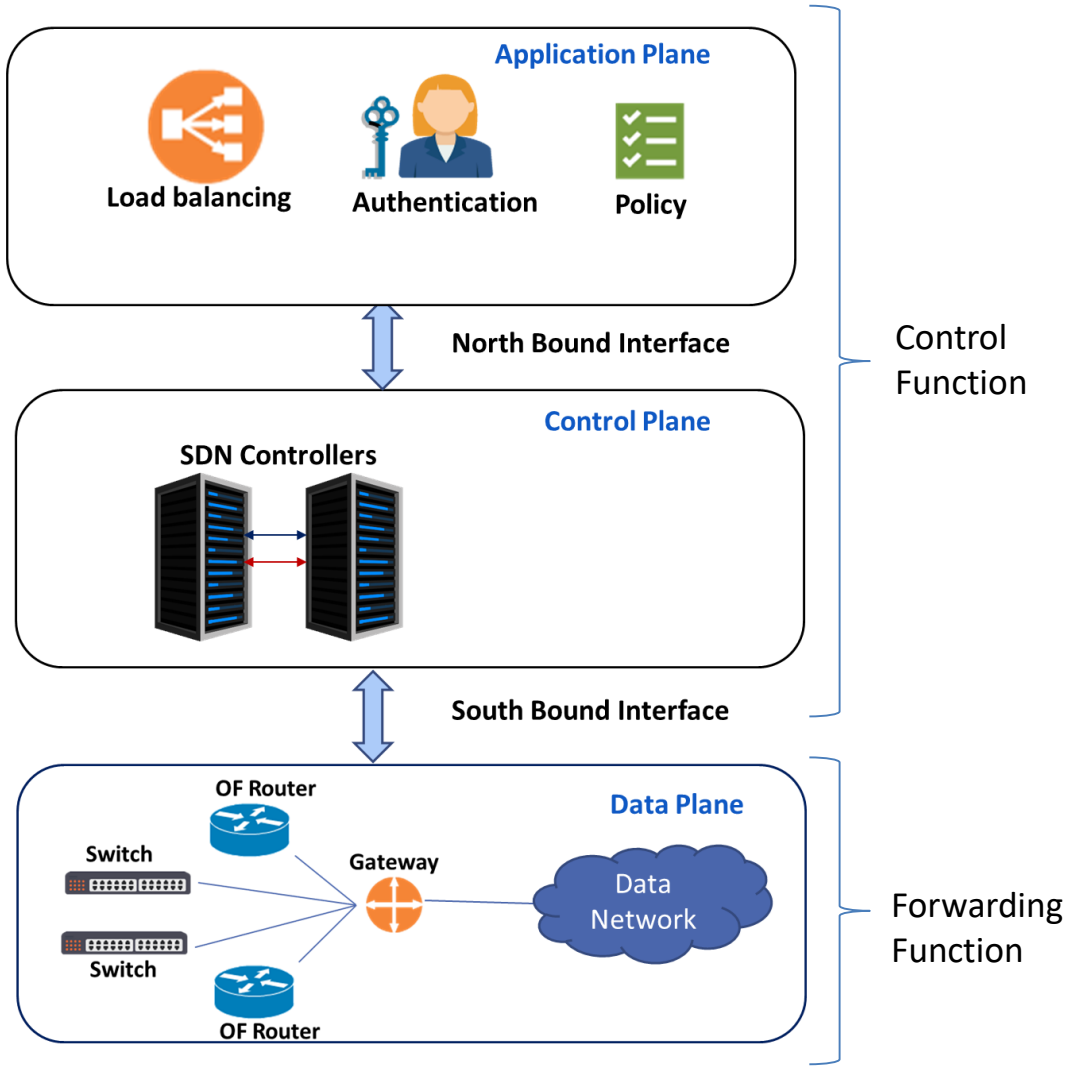
- Fog and Cloud Computing
- Software Defined Networking (SDN)
- Emerging Mobile Network Architecture
  - Impact of SDN and Fog Computing
- Mobile Networks - Use Cases
  - Broadband Public Safety Communication
  - Rural Broadband Communication

Fog and Cloud Computing

- Fog Computing
  - Nearer to the Edge Computation & Communication
  - Lower Latency Applications
  - Reduced Backhaul Bandwidth usage
  - Possibility of a hierarchical organization – Multiple fog levels
- Cloud Computing
  - Centralized Resource Pooling - typically in data centres
  - Efficient Resource Utilization through pooling
  - Management and Control - located in Data Centres
- Not this or that
  - Form a continuum, complement each other

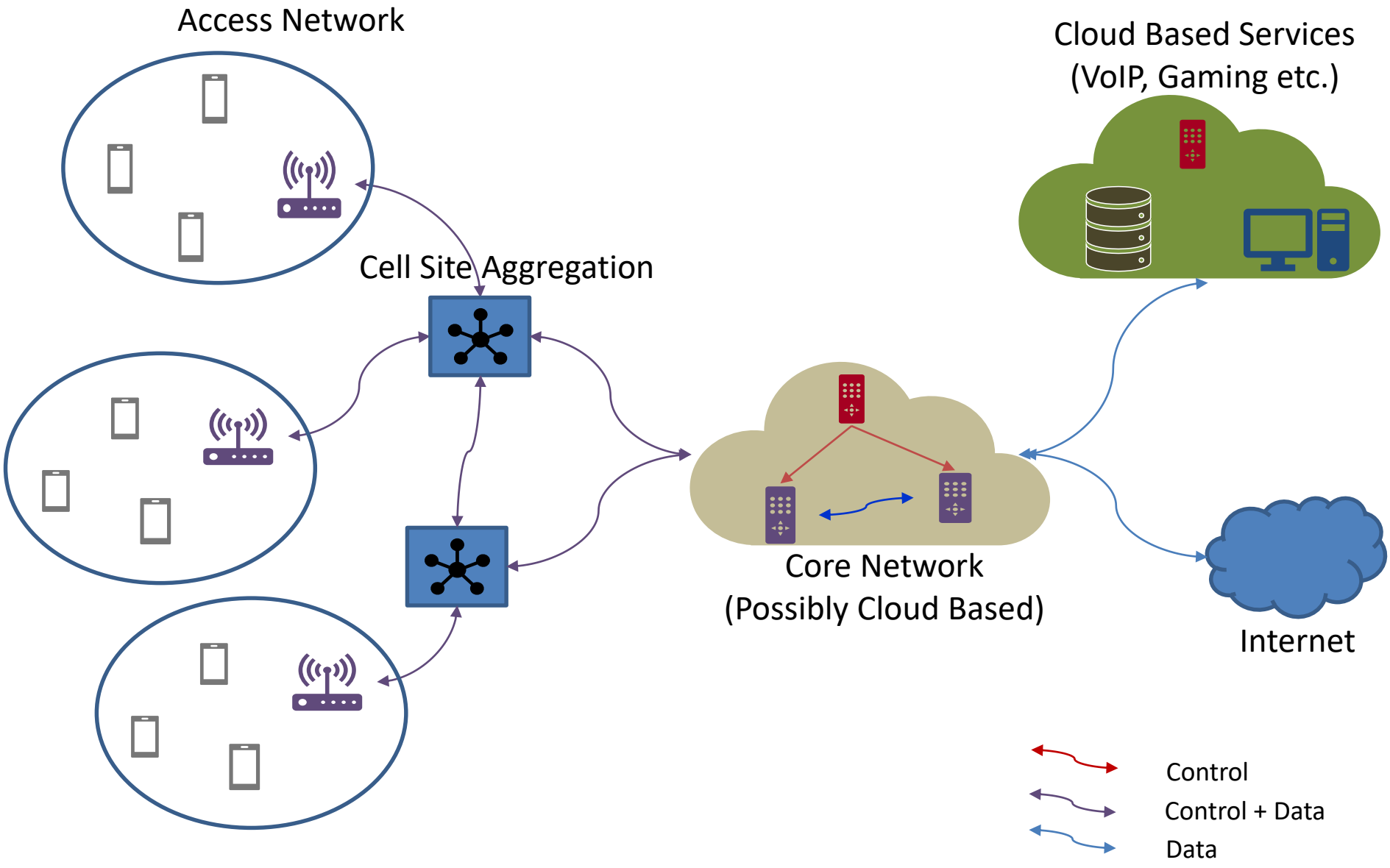
Software Defined Networking (SDN)

- Network divided into three planes
  - Forwarding/Data Plane
    - Forwarding Elements
  - Control Plane
    - Configures Forwarding Elements
  - Applications Plane
    - Deals with Policies, Algorithms
    - Uniform Policy Enforcement
    - Control over network resources
- Control and Forwarding functions
  - Separated through Open, Standardized interface



SDN Architecture

Existing Mobile Network Architecture

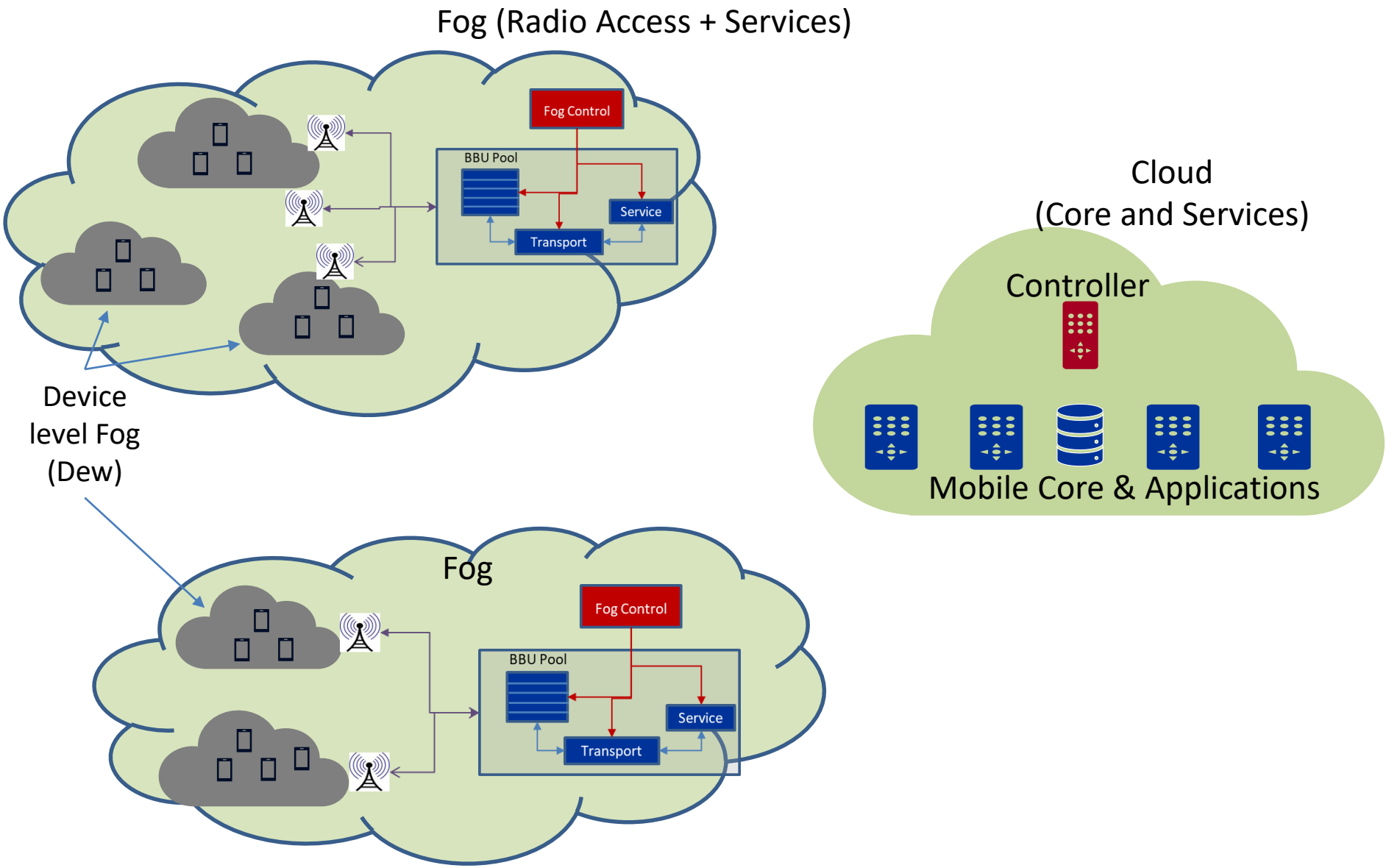


Existing Mobile Network Architecture – Salient Points

- A data pipe between a User and the Cloud is created
  - Data Bearer - to handle User Mobility
- Data Flow always routed via the Cloud
  - Higher Latency
  - Higher Backhaul Utilization
- Service deployments in cloud only
  - Application Servers in Cloud, e.g., IMS based services
  - No service deployments near the user (edge)
- Tightly Coupled Control and Data Plane
- Distributed Intelligence and State in RAN
  - Suboptimal decisions due to fragmented view

Architecture may not be suitable for certain Use Cases!!!

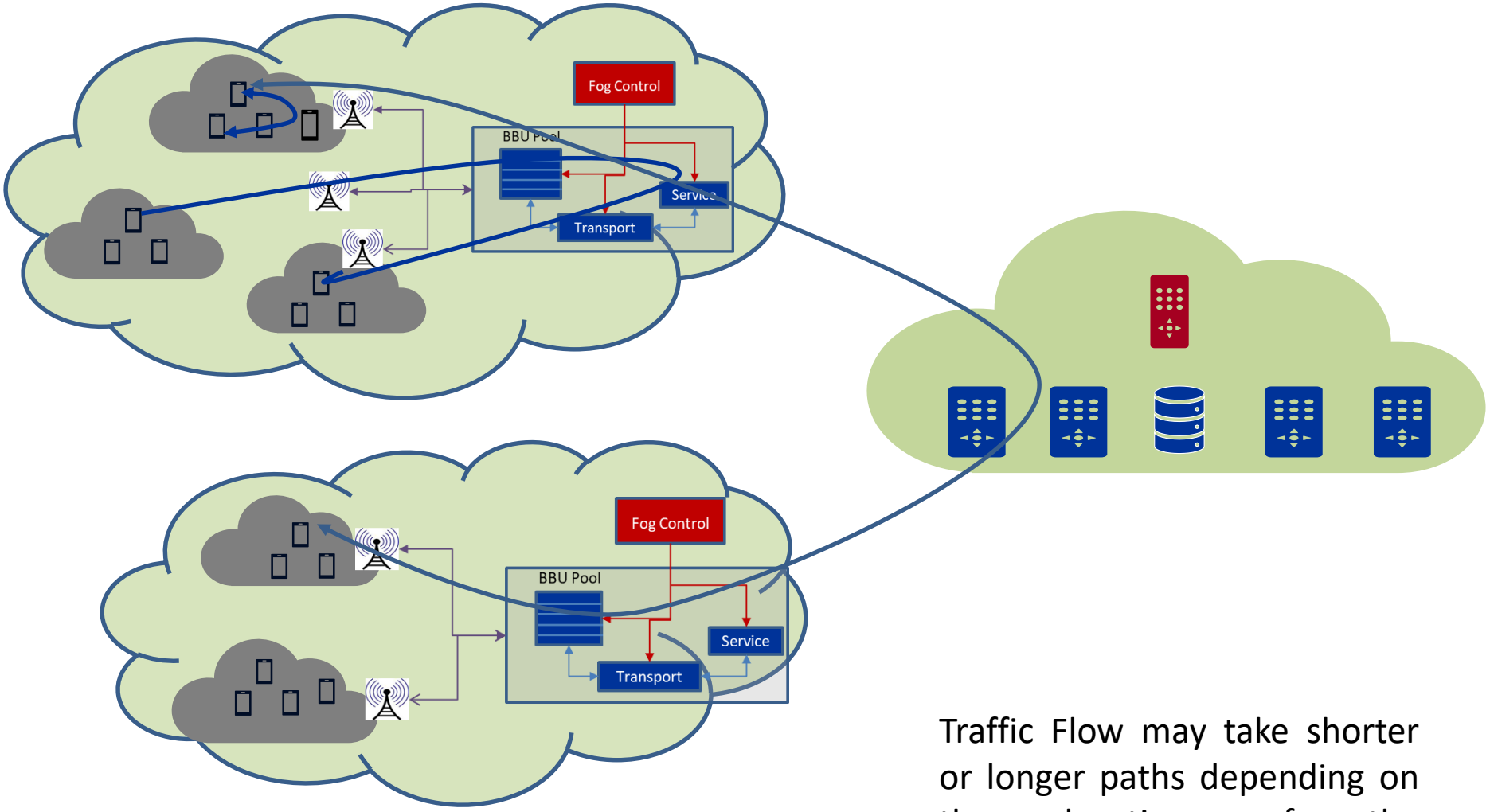
Emerging Mobile Network Architecture



Emerging Mobile Network Architecture

- Network Split into Fog and Cloud Components
- Hierarchical Structure
  - Multiple Levels of Fog Components
- Components typically follow SDN paradigm
- Each Fog/Cloud Component may have
  - Control Function
    - Controller
    - Control Applications
  - Forwarding Function
    - Forwarding Elements
    - Services – Application Servers, e.g., VoIP
- Migration of Application level Intelligence from Cloud to Fog and vice versa

Emerging Mobile Network Architecture
Data Flow Paths



Traffic Flow may take shorter or longer paths depending on the location of the communication end points

Mobile Networks – Let us see some use cases

- Rural Broadband Communication
- Broadband Public Safety Communication

Rural Broadband Connectivity

- India suffers from low Rural Tele-density
- One-fourth of the unconnected population globally, lives in India
- Rural Broadband Connectivity
  - Abysmally low in India

Challenges in Connecting Rural India

Low Average Revenue Per User

Unavailability of Fiber Backhaul

Intermitant Availability of Electricity

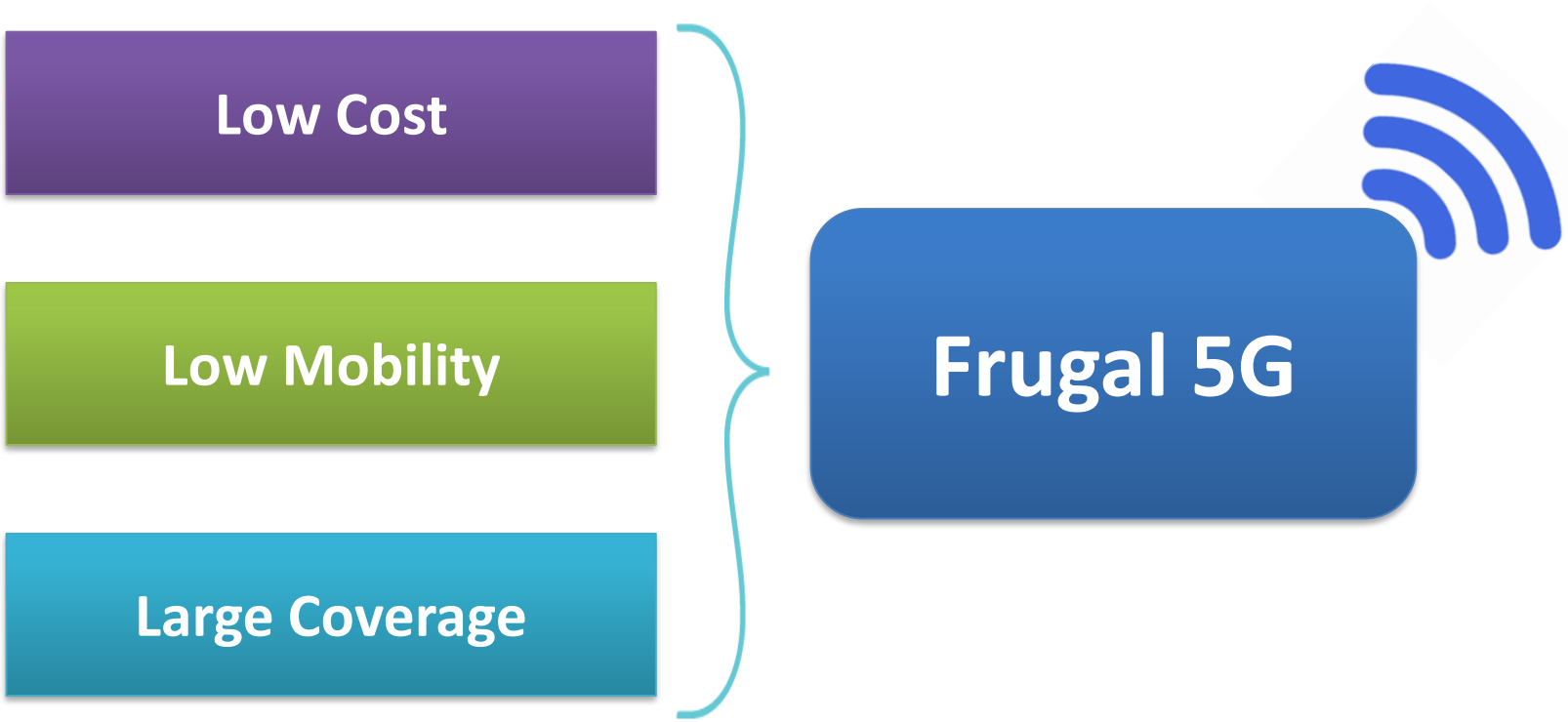
Rural Broadband Connectivity - Requirements

- Low cost solution
  - Low Device cost
    - Simpler Hardware and RF Design reducing the device costs
  - Low cost Connectivity/backhaul solution
    - Using wireless backhaul/middle mile instead of fiber
  - Lower spectrum cost
    - Efficient usage of spectrum
      - For Access as well as Middle Mile Network
- Limited mobility support
  - Fixed primary access is the key

Rural Broadband Connectivity – Requirements contd.

- Energy efficient solution
  - Lower system energy consumption
  - Support for operation in power saving mode
  - Usage of non-conventional energy sources
- Large coverage area support
  - Support for large cells to reduce CAPEX and OPEX
- Our study also shows
  - Significant % of Communication Needs – Local
    - Peer-to-peer communication
    - People who know each other typically live in a small geographical area

Is the existing Mobile Network Architecture an appropriate one for this use case?


Low Cost
Low Mobility
Large Coverage
Frugal 5G

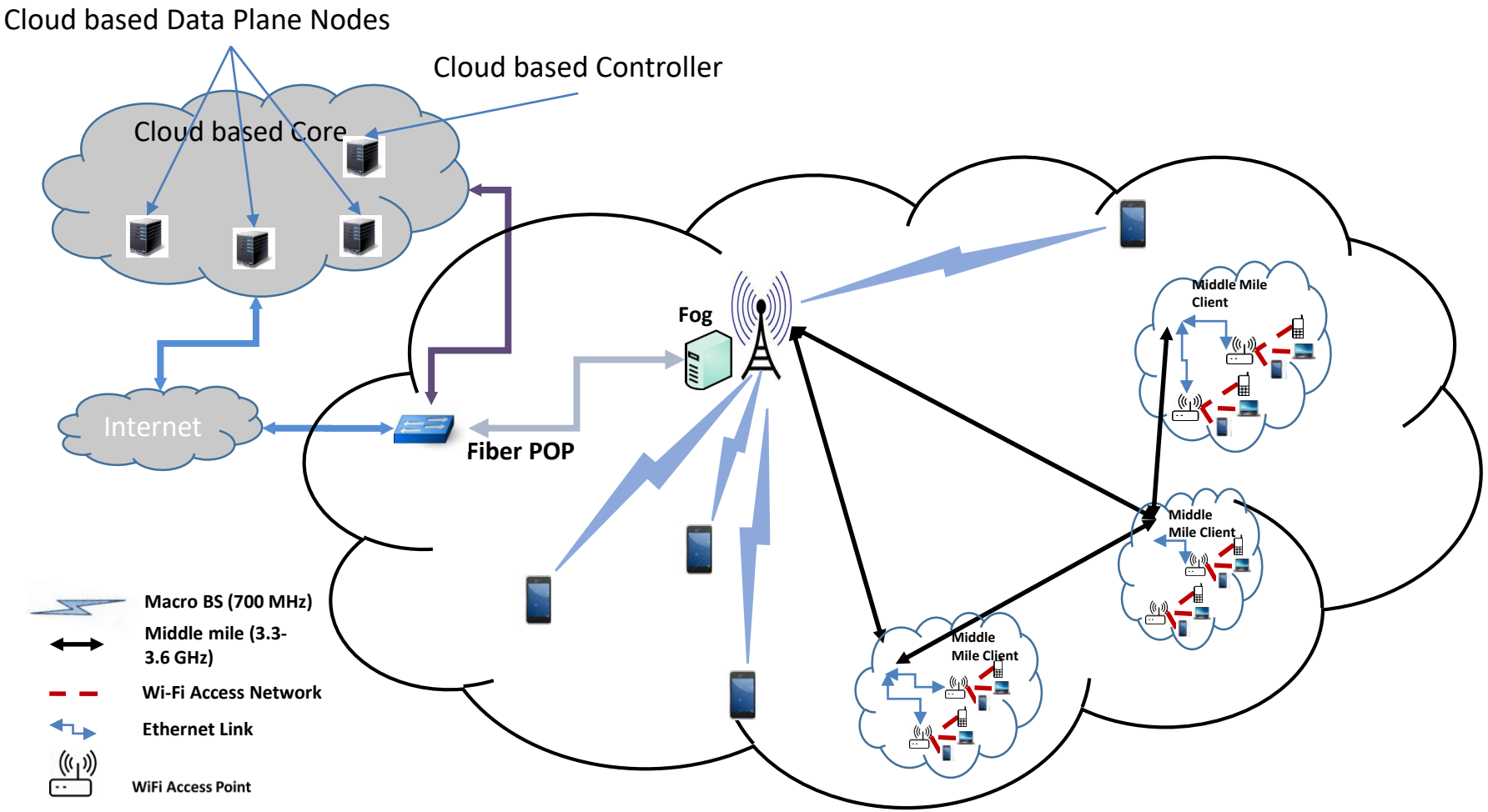
Frugal 5G –IEEE P2061

- Standardization activity initiated to
  - Define an architecture for low mobility energy efficient network for affordable broadband access
  - Also specify the interfaces between the architectural components
- Result of an earlier RRSA study by IEEE Communication Society for
  - Low cost solution for providing 5G connectivity to un-connected
- The proposed network architecture comprises of a
    - An Access Network
    - A Wireless Middle-mile Network
    - Associated control and management functions

SDN and Fog based Mobile Network for Rural Connectivity – IEEE P2061

- Large Coverage Area Cells to provide ubiquitous connectivity
- Small Cells (WiFi Hotspots) as access points for high speed data connectivity
  - 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
- Usage of Fog and Cloud Computing/Networking Paradigm
- SDN based control and management of the network
  - Local (Fog/Edge) as well as Global (Cloud-based) Controllers
  - Multi-RAT Control

Frugal 5G - System Architecture



Frugal 5G – System Architecture – Fog & Cloud

Cloud

- Cloud based SDN controller
  - Control and Management of complete Network
    - Policy Based Control
  - User Authentication
  - Mobility Management
  - Network Slicing
- Core Network Data (Forwarding) Plane Entities
- Can be a standard Core Network like 3GPP 5G Core

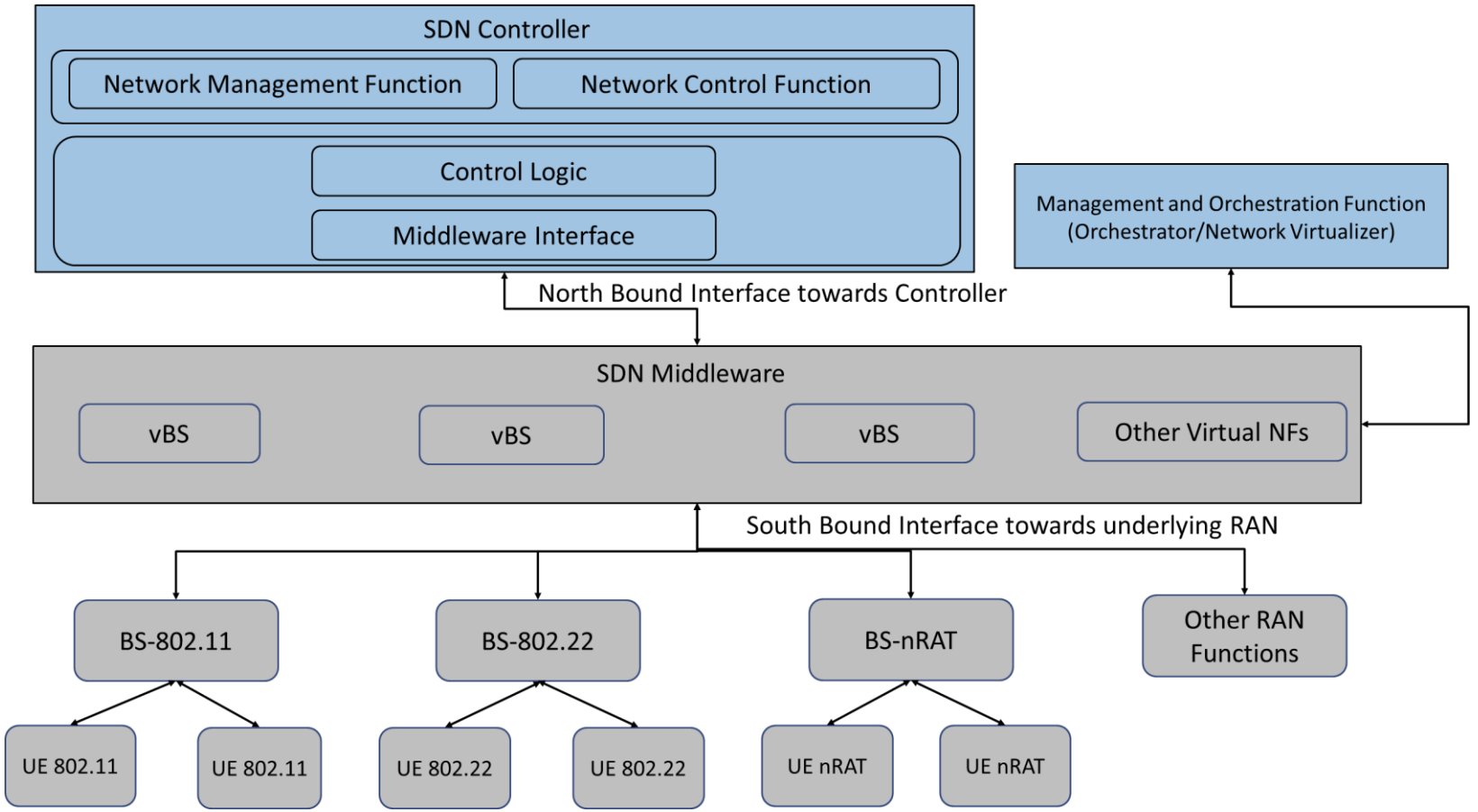
Fog

- Fog/Edge based SDN Controller
  - Mobility and Load Management
  - Macro Cell (BS) Control
  - Small Cell (WLAN) Control
  - Middle Mile Control
- Access and Middle Mile Data Plane Entities
  - Forwarding Function
  - Core Network Interworking Function
  - Caching and Optimization Function

IEEE P1930.1 - A Related Standard

- Recommended Practice for Software Defined Networking (SDN) based Middleware for Control and Management of Wireless Networks
- It Specifies
  - An SDN based Architecture for control and management of Multi-RAT Radio Access Network
  - An SDN based Middleware
    - For vendor independent management and control of Wireless Networks
      - especially IEEE 802.11 APs and IEEE 802.22 Base Stations
    - Aims to achieve interoperability across equipment from diverse vendors
    - Supports a unified interface with the 5G Core Network

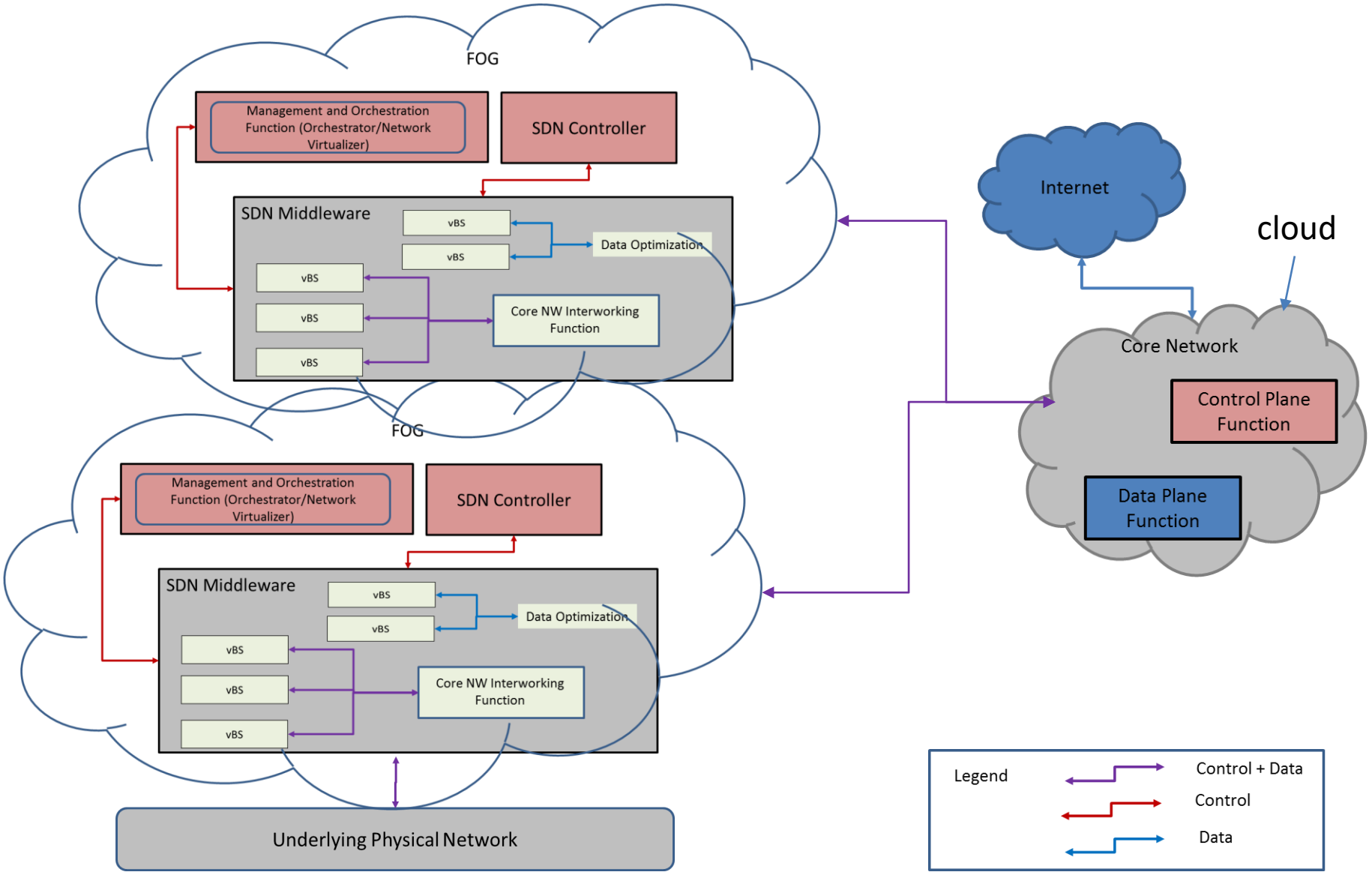
IEEE 5G P1930.1 - Proposed SDN based RAN Architecture



The SDN based RAN architecture proposed in P1930.1 can be used to develop the architecture for Frugal 5G Network

Frugal 5G - Fog/Cloud and SDN based NW Architecture

(Utilizing the concepts developed as part of IEEE P 1930.1)



Public Safety Communication

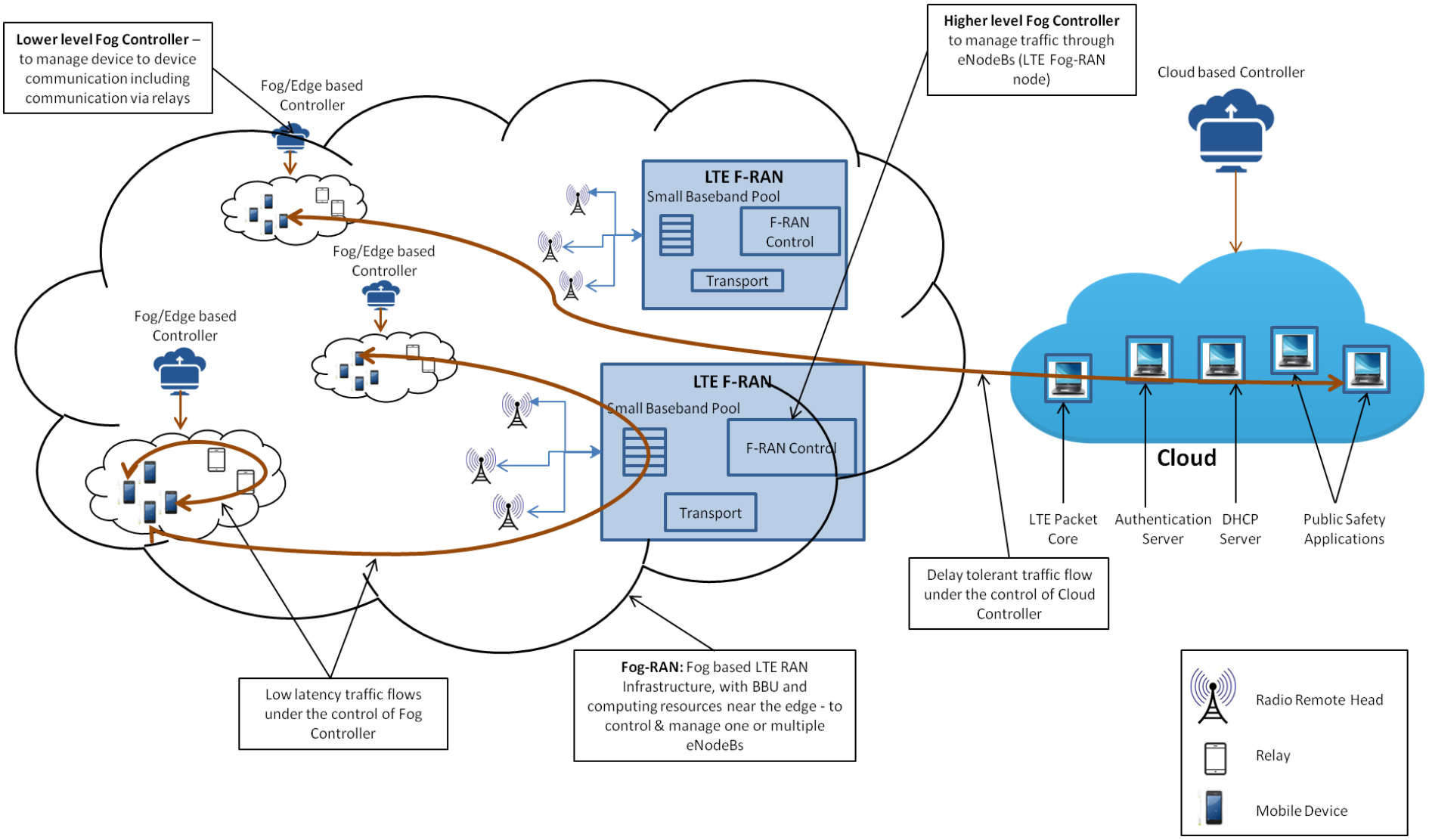
- Communication used by Law enforcement agencies, Fire Brigade, Medical Emergency teams etc.
- Emergency Warning or Public Warning Systems
- Communication to support
  - Public Safety and Disaster Recovery
- Critical Communication

Broadband Public Safety Communication - Uniqueness

- Mission Critical
- Low Latency Communication
- Group Communication
- Direct mode (peer-to-peer) communication
- Public Safety operation typically localized in a small geographical area
- Real-time voice, data and video communication
- Rapidly Deployable System

Is the existing Mobile Network Architecture an appropriate one for this use case?

Modified Mobile Network Architecture for Public safety Communication (LTE Based)



Fog and SDN based Architecture for Public safety Communication - Salient Features

- Fog/Edge SDN Controllers
  - Hierarchical Fog Controllers
  - Low Latency traffic flow paths
  - Immediate Connectivity and Communication within a group
  - Rapidly Deployable System
- Cloud based SDN Controller
  - Traffic flows routed through the Core Network, if needed
    - Between Users & Application Servers
  - User Authentication
  - Migration of Application Servers and Authentication Function to Fog, if needed

Better suited than the existing Mobile Network Architecture

Thank you