Fog Computing

Public Safety & Rural Broadband Communication Scenarios in Emerging markets

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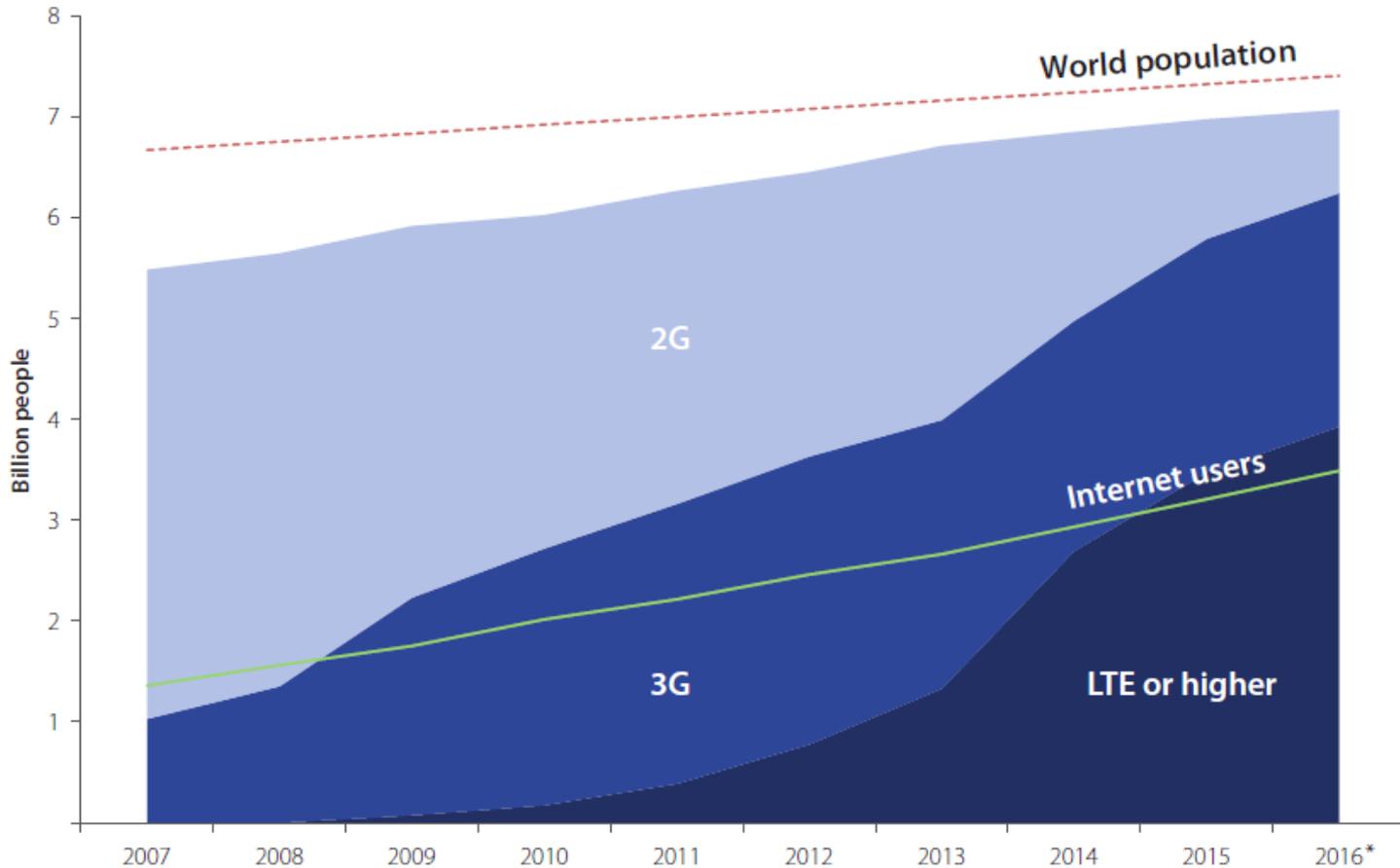Dean (Faculty Affairs) and Institute Chair Professor
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Broadband Penetration Status: Worldwide

Around half of the global population is unconnected

Source: International Telecommunication Union

Around 84% of global population lives in regions covered by wireless broadband (3G/4G) but the adoption rate is only 47%

Rethinking 5G Requirements

- Low cost solutions

- Limited mobility support
  - Mobility is required but not very high speed
  - Fixed primary access is the key

- Energy efficient solutions
  - Lowering system energy consumption
  - Support for operation in power saving mode
  - To enable working off non-conventional energy sources

- Large coverage area support
  - Support for large cells to reduce CAPEX and OPEX

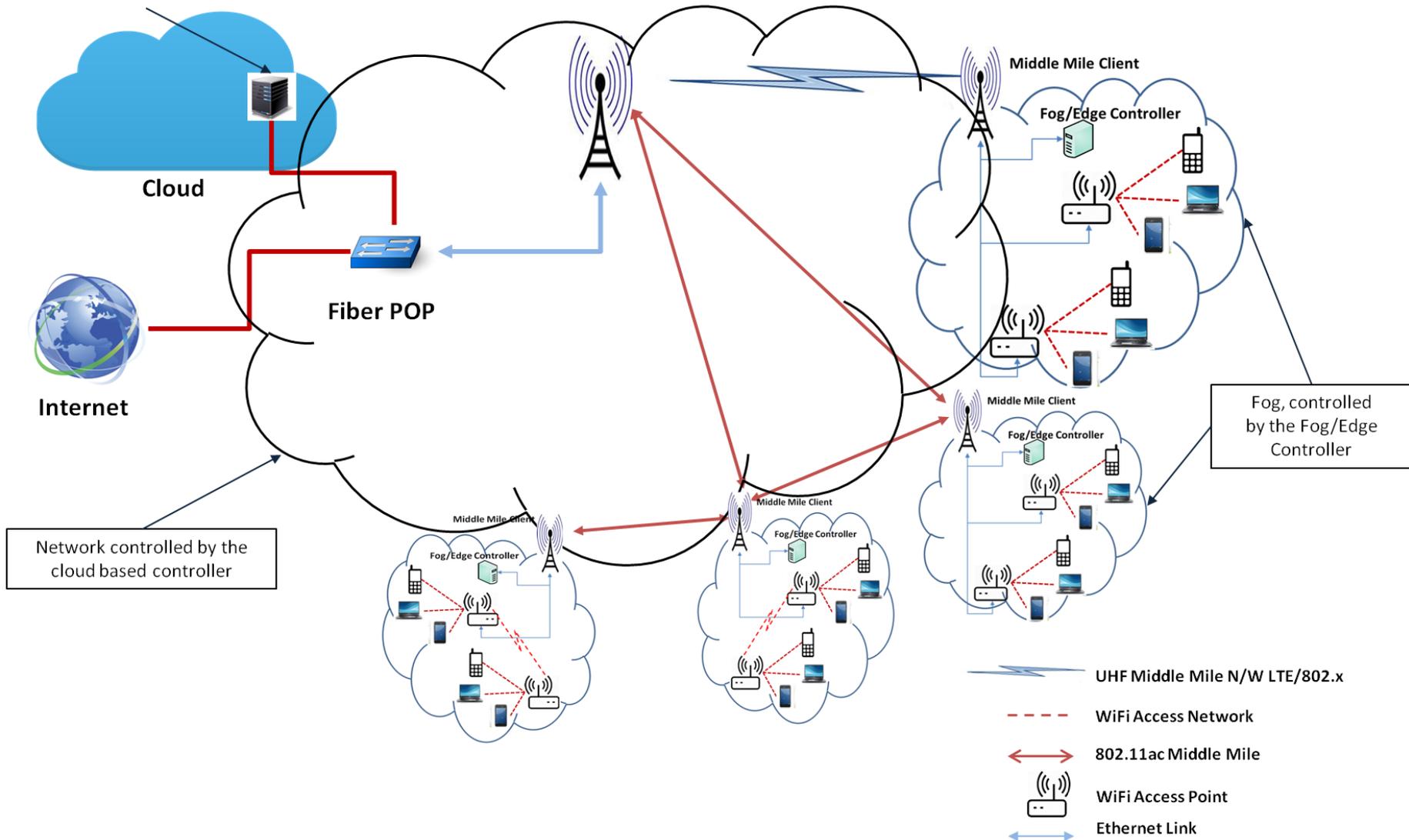- Less stringent availability requirements

Frugal 5G – System Architecture

- A promising approach to provide Rural Broadband Connectivity

- Small Cells based Solution
    - Ultra dense deployment of WiFi Hotspots/LTE small cells
    - Backhauled using fiber or TV UHF band or unlicensed radio

- Fog and Cloud Computing/Networking Paradigm for system design
    - It is Fog **&** Cloud here

- SDN based control and management of the network
    - Local (Fog/Edge) as well as Global (Cloud-based) Controllers

Rural Broadband Communication System Architecture

Cloud based Global Controller

Cloud

Internet

Fiber POP

Network controlled by the cloud based controller

Middle Mile Client

Fog/Edge Controller

Fog, controlled by the Fog/Edge Controller

UHF Middle Mile N/W LTE/802.x

WiFi Access Network

802.11ac Middle Mile

WiFi Access Point

Ethernet Link

Frugal 5G System Architecture – Fog & Cloud

- Cloud based SDN controller
  - Control and Management of complete Middle Mile Network
    - Policy Based Radio Control
    - Efficient & Fair allocation of UHF spectrum resources
    - Control of Mesh Network
  - Traffic flows routed through Middle Mile Network (backhaul) to cloud/Internet
  - User Authentication

Frugal 5G System Architecture- Fog & Cloud

- Fog/Edge based SDN Controller
  - Local Controller at Middle Mile Client site
    - Management of Wifi Access Points in a village cluster including their Radio Resource Management
    - User Admission and traffic flow configuration
  - Backhaul Bandwidth Optimization
    - Peer-to-peer communication: Traffic flows inside a village cluster
    - Streaming content, to be distributed to multiple users, received through a single common traffic flow over backhaul
  - Serving locally stored data w/o fetching from the cloud, when possible

Technology Evolution for Public Safety communication

3GPP LTE for Public Safety Communications

LTE capability, reach and costs attractive to Public Safety users
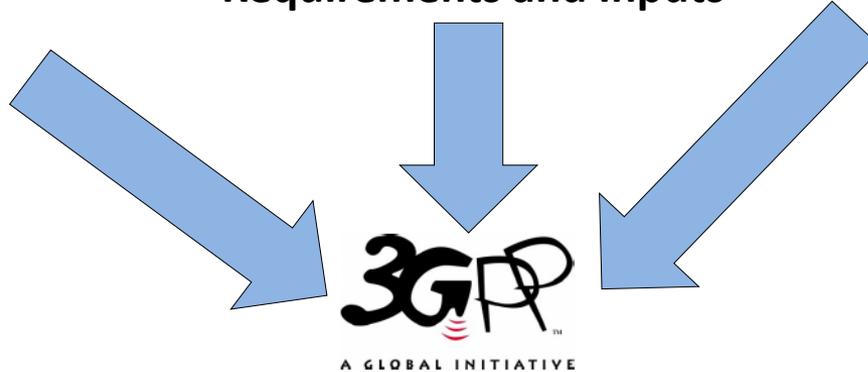

National Public Safety Telecommunications Council

TETRA and Critical Communications Association

ETSI Technical Committee on TETRA

Requirements and Inputs

Maximize commonality between commercial and public safety aspects

Public Safety Communication – Fog vs Cloud

- It is not Fog vs Cloud
  - It is Fog **and** Cloud
- Fog/Edge SDN Controllers
  - Hierarchical Fog Controllers
  - Low latency data flows
  - Immediate Connectivity and Communication within a group
  - Rapidly Deployable System
- Cloud based SDN Controller
  - Traffic flows routed through the backhaul/Core Network
    - Between Users & Mission Critical Application Servers
  - Authentication of devices, to ensure secure communication

Public Safety Communication System Architecture Hierarchical Fog Controllers

Lower level Fog Controller – to manage device to device communication including communication via relays

Fog/Edge based Controller

Fog/Edge based Controller

Fog/Edge based Controller

Higher level Fog Controller to manage traffic through eNodeBs (LTE Fog-RAN node)

Cloud based Controller

LTE F-RAN
Small Baseband Pool
F-RAN Control
Transport

LTE F-RAN
Small Baseband Pool
F-RAN Control
Transport

Cloud

LTE Packet Core

Authentication Server

DHCP Server

Public Safety Applications

Delay tolerant traffic flow under the control of Cloud Controller

Low latency traffic flows under the control of Fog Controller

Fog-RAN: Fog based LTE RAN Infrastructure, with BBU and computing resources near the edge - to control & manage one or multiple eNodeBs

Radio Remote Head

Relay

Mobile Device