



THE UNIVERSITY of EDINBURGH
informatics



Microsoft

DIY Model for Mobile Network Deployment: A Step Towards 5G for All

Mohamed M. Kassem^{*}, Mahesh K. Marina^{*} and Bozidar Radunovic^{**}

^{*} The University of Edinburgh, UK

^{**} Microsoft Research, Cambridge

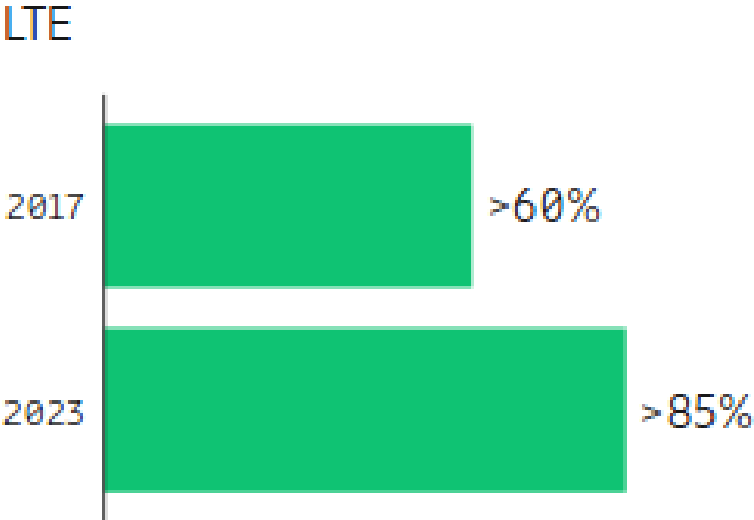
Long way to go for universal mobile Internet connectivity

4.3 Billion \approx 57%^{*}

Lack mobile broadband connections

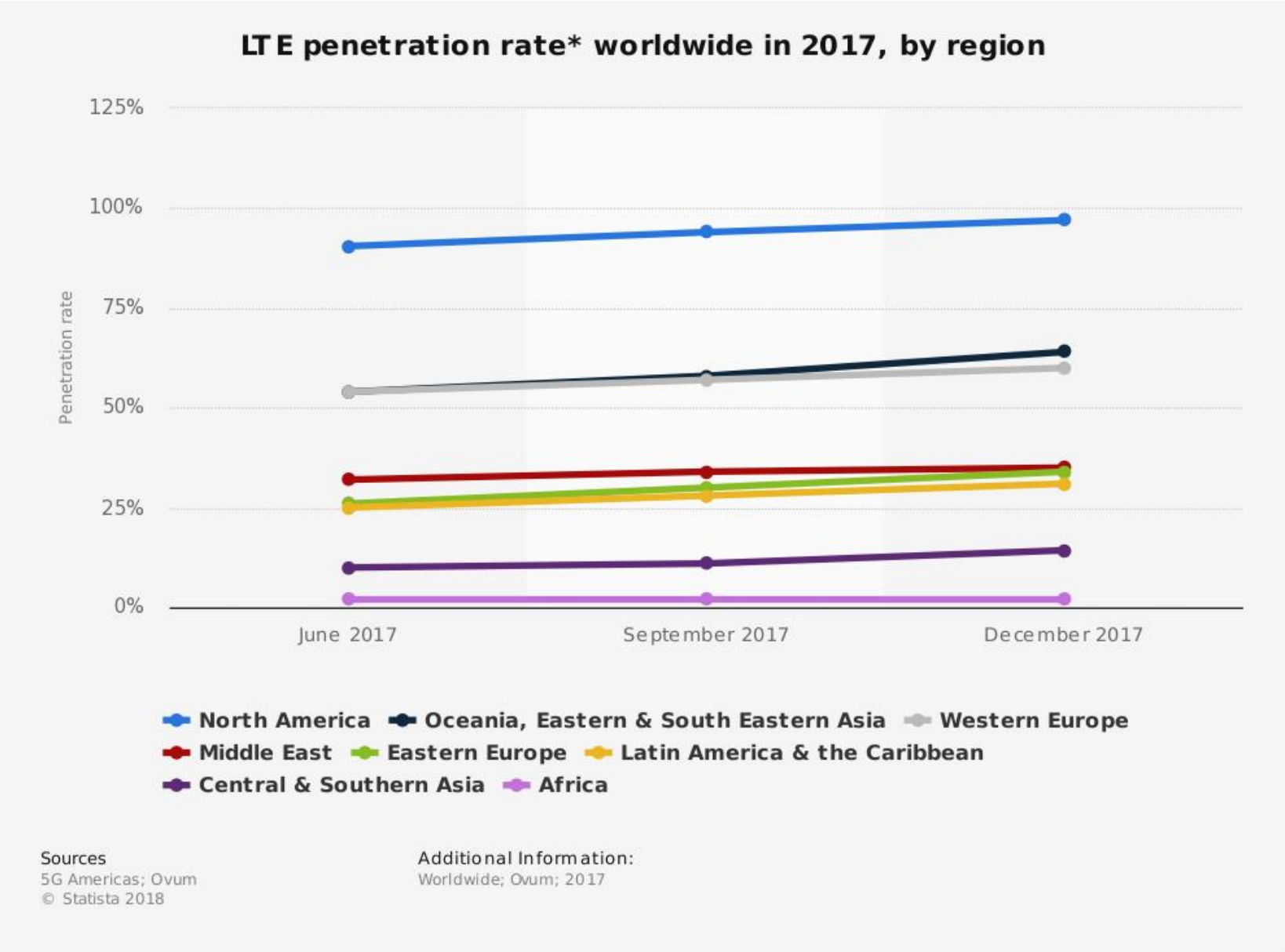
* Source: GSMA - The mobile
Economy Report, 2018

The State of LTE (4G)

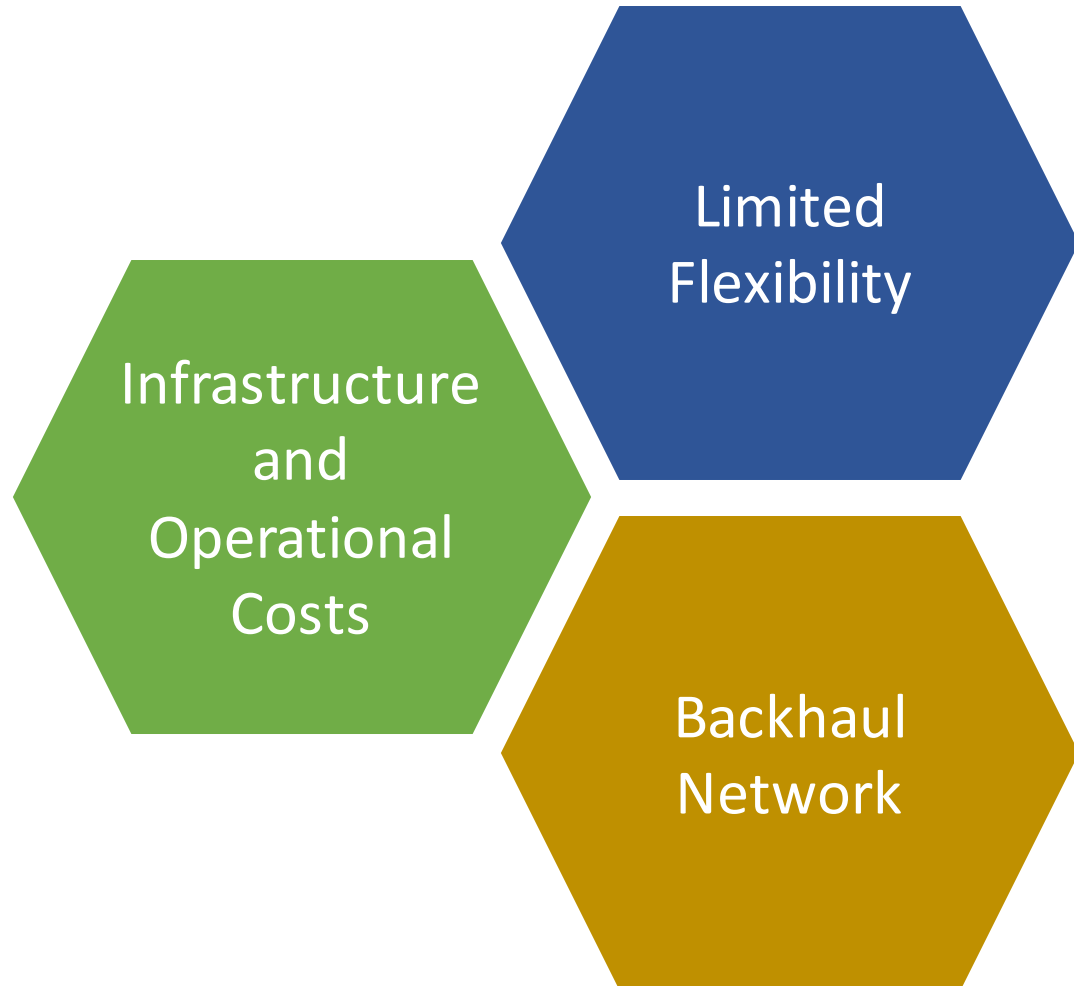


Source: Ericsson Mobility Report, 2018

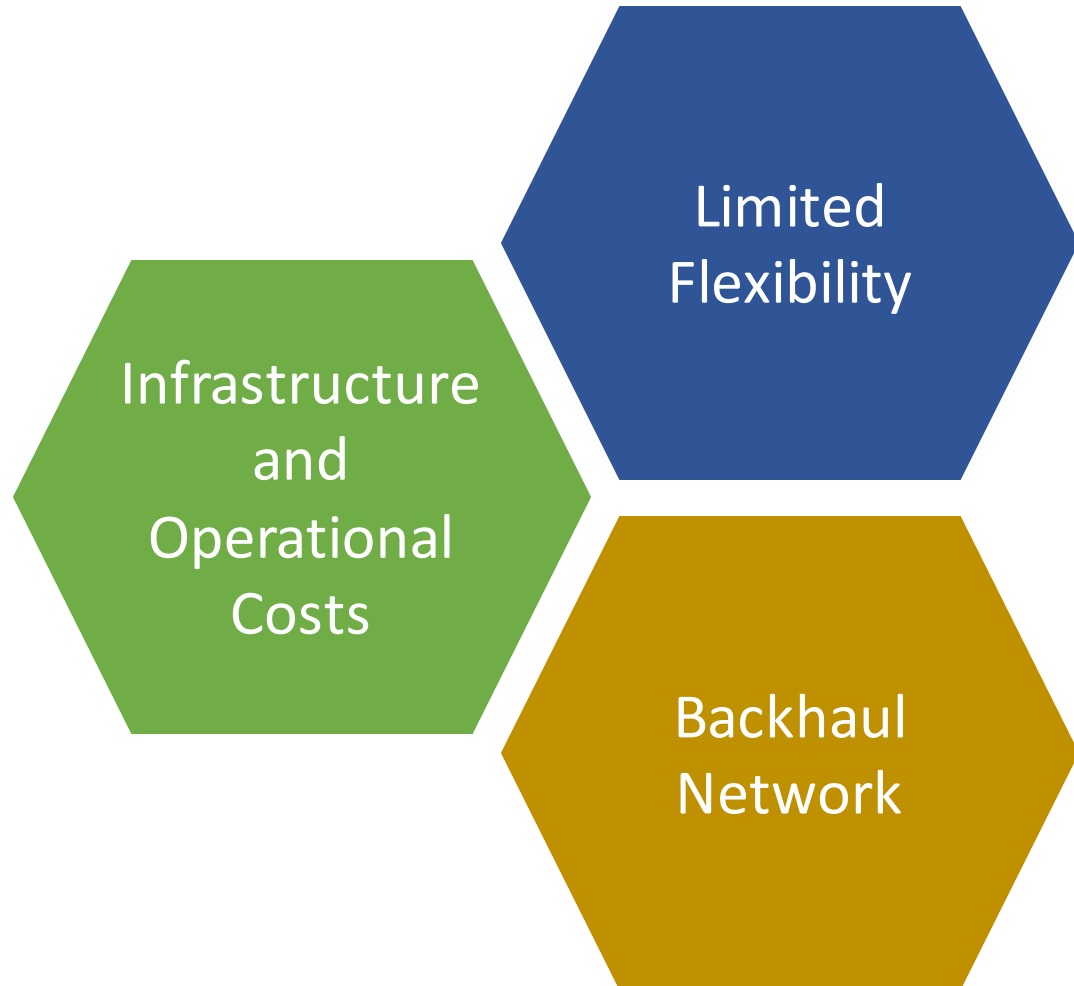
Around 60% of the world's population covered by LTE network. Most of the unconnected population lives in rural and low income areas



Mobile network deployment challenges



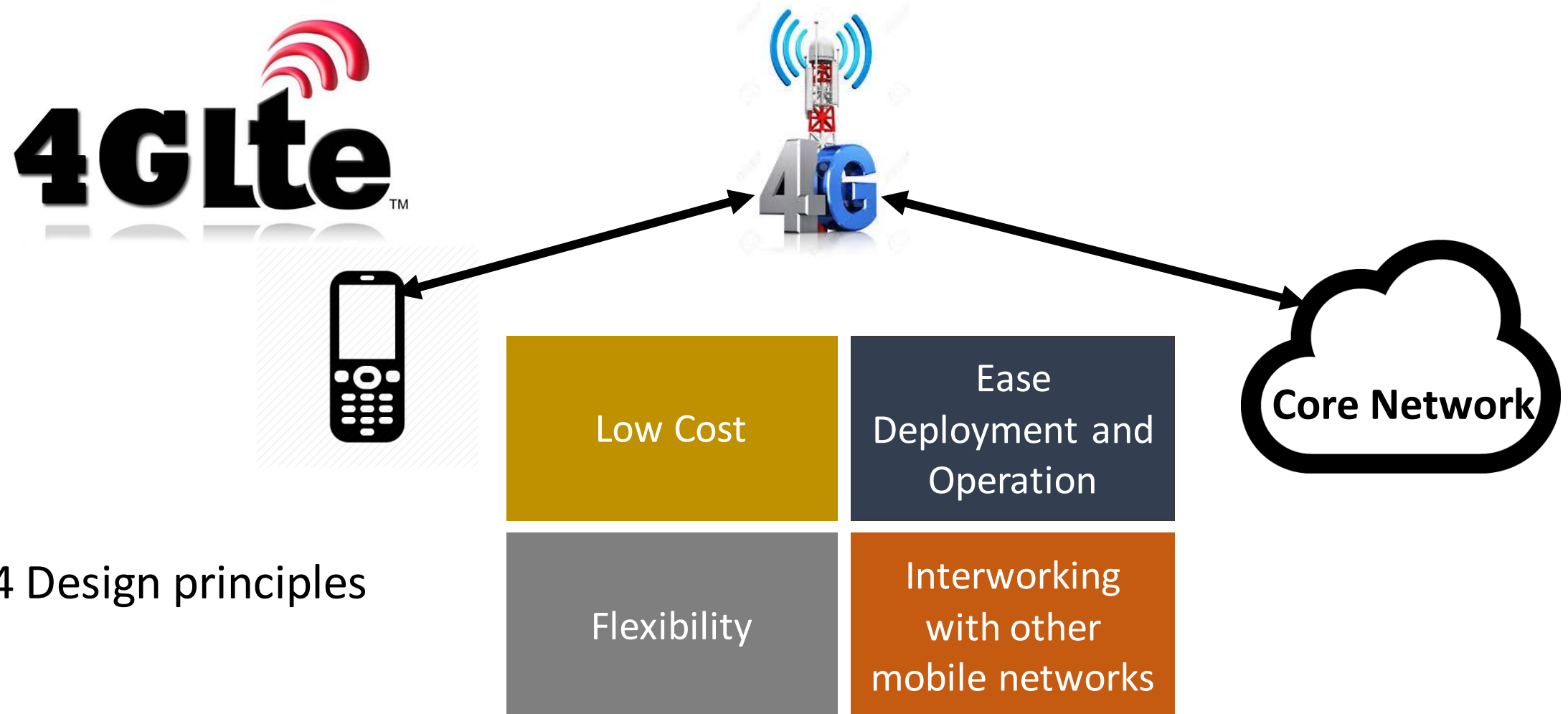
Mobile network deployment challenges



Current Approaches

1. Traditional market-driven mobile network deployment model proven to be ineffective for rural and low-income regions
2. Community cellular networks are promising but limited only to voice and SMS (GSM services)

DIY Model for mobile network deployment



- 4 Design principles

Proposed DIY network deployment model

Access Network Layer

- Commercial LTE small cells
 - Plug and play
 - IP backhauling
- Open-source platforms (e.g., OpenAirInterface, srsLTE) with software radios
 - Cost reduction

Proposed DIY network deployment model

Access Network Layer

- Commercial LTE small cells
 - Plug and play
 - IP backhauling
- Open-source platforms (e.g., OpenAirInterface, srsLTE) with software radios
 - Cost reduction
- Spectrum (unlicensed or shared spectrum)
- Commodity mobile devices (MiFis and smartphones)

Proposed DIY network deployment model

Backhaul Network Layer

- TV White space
Spectrum:
 - Superior propagation characteristics
 - Practically unlicensed spectrum
 - Large availability in rural areas

Proposed DIY network deployment model

Backhaul Network Layer

- TV White space
Spectrum:
 - Superior propagation characteristics
 - Practically unlicensed spectrum
 - Large availability in rural areas
- Configuration Types:
 - PtP
 - PtMP

Proposed DIY network deployment model

Core Network Layer

- Core-in-the-cloud:
 - Core as a service on public clouds
 - Benefits in terms of cost, scalability and flexibility

Proposed DIY network deployment model

Core Network Layer

- Core-in-the-cloud:
 - Core as a service on public clouds
 - Benefits in terms of cost, scalability and flexibility
- Two types of functions
 - Core network functions
 - Orchestration functions

Proposed DIY network deployment model

Access Network Layer

- Commercial LTE small cells
 - Plug and play
 - IP backhauling
- Open-source platforms (e.g., OpenAirInterface, srsLTE) with software radios
 - Cost reduction
- Spectrum (unlicensed or shared spectrum)
- Commodity mobile devices (MiFis and smartphones)

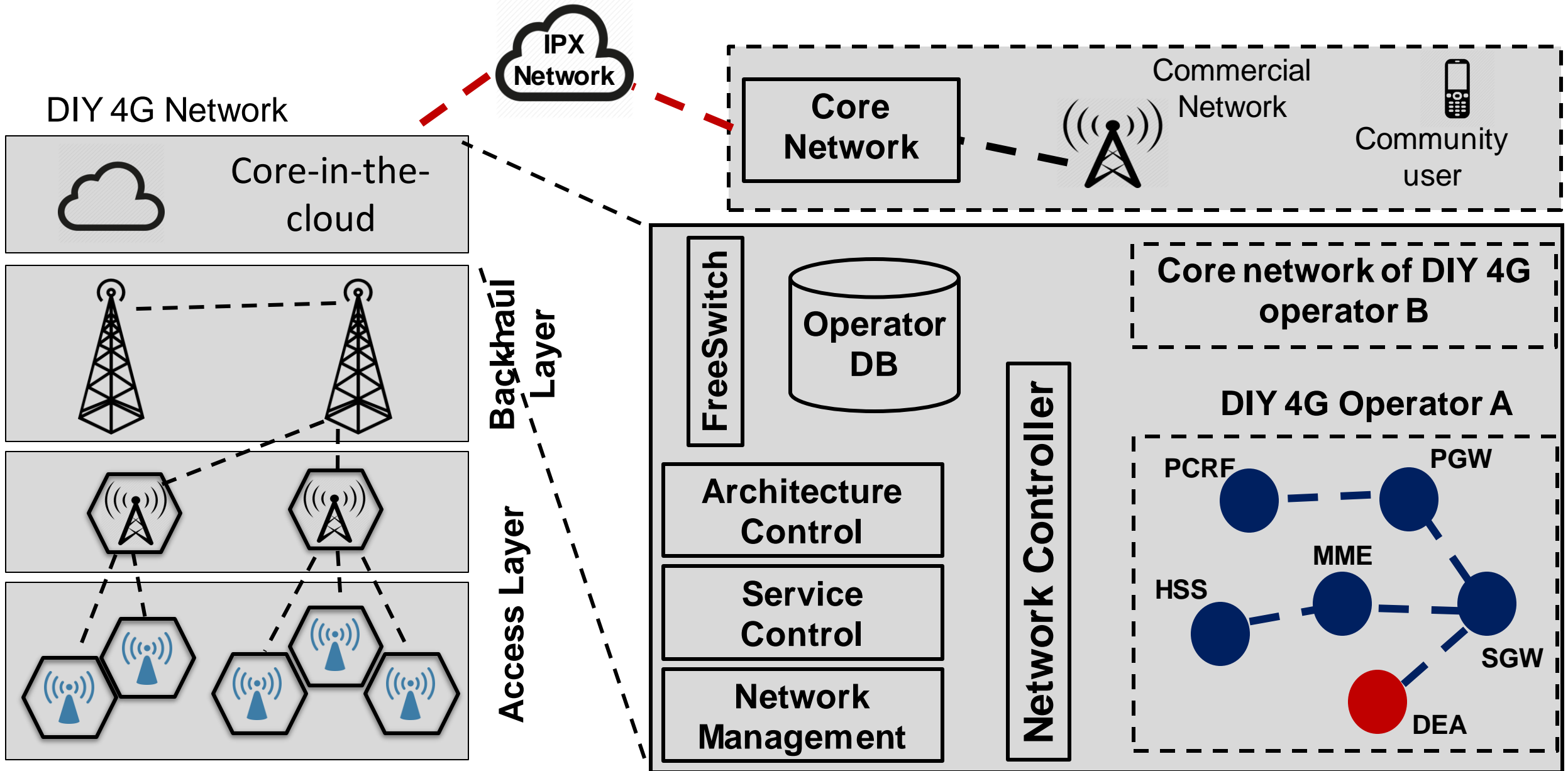
Backhaul Network Layer

- TV White space
 - Spectrum:
 - Superior propagation characteristics
 - Practically unlicensed spectrum
 - Large availability in rural areas
- Configuration Types:
 - PtP
 - PtMP

Core Network Layer

- Core-in-the-cloud:
 - Core as a service on public clouds
 - Benefits in terms of cost, scalability and flexibility
- Two types of functions
 - Core network functions
 - Orchestration functions

DIY 4G mobile network architecture



Balquhiddel



Trial Deployment: Access Network



Trial Deployment: Access Network

IP Access E40 small cell with IP backhaul



Trial Deployment: Access Network

IP Access E40 small cell with IP backhaul



Novatel MiFi 6620

Lochside Cottages

Tom na Voil

Rob Roy's Grave

Cnoc Farnh
Holiday Cottage

Stronvar

Molmeg Bed & Breakfast

Loch Moy

Trial Deployment: Access Network

IP Access E40 small cell with IP backhaul



Novatel MiFi 6620

Spectrum: 5MHz channel in 700 MHz band (TVWS in the UK)



Trial Deployment: Backhaul and core networks

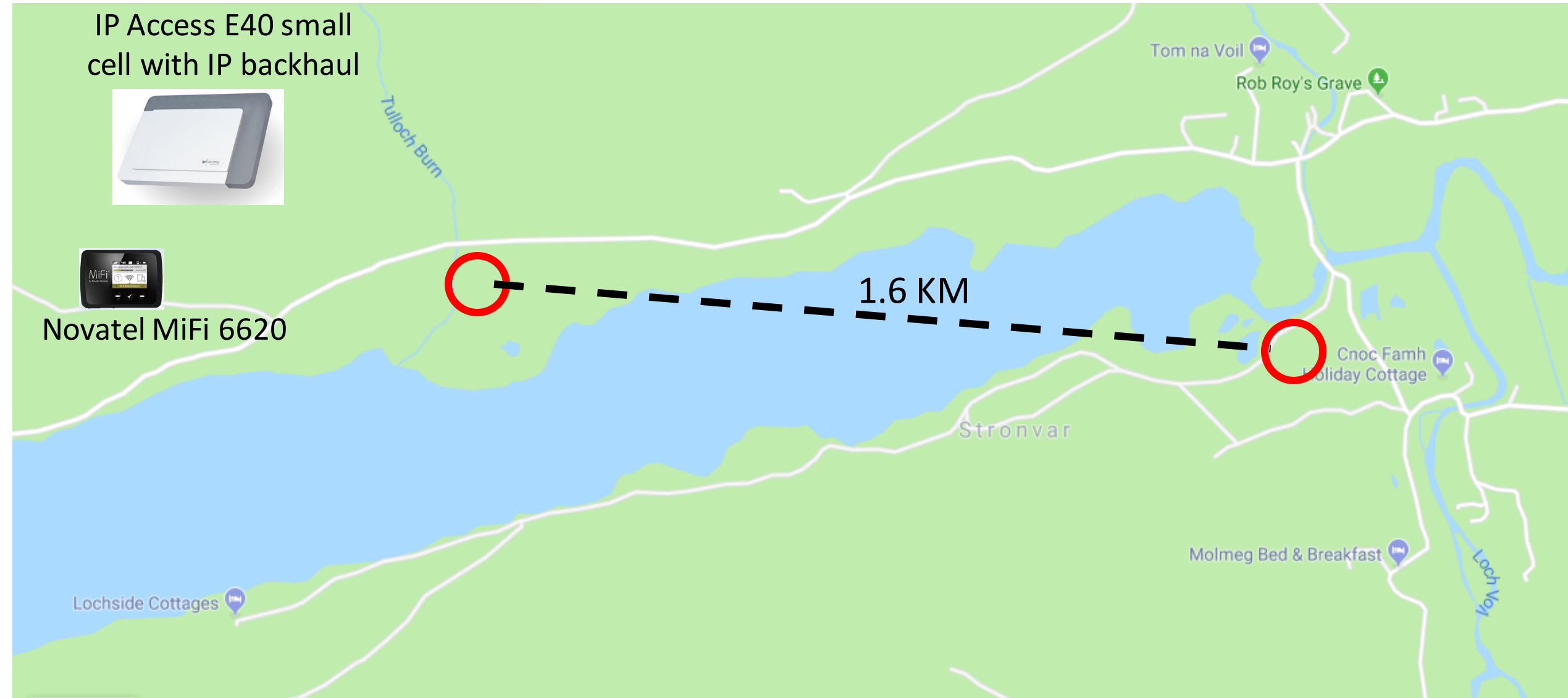
IP Access E40 small cell with IP backhaul



Novatel MiFi 6620



1.6 KM



Trial Deployment: Backhaul and core networks

IP Access E40 small cell with IP backhaul



Novatel MiFi 6620



1.6 KM



Optical Fiber cabinet

Lochside Cottages

Stronvar

Molmeg Bed & Breakfast

Cnoc Famh Holiday Cottage

Loch Moy

Tulloch Burn

Trial Deployment: Backhaul and core networks

IP Access E40 small cell with IP backhaul



Adaptrum TVWS client



Novatel MiFi 6620



1.6 KM



Optical Fiber cabinet

Spectrum: 8MHz channel with 506 MHz central frequency

Data Rate: 12 Mbps

Adaptrum TVWS Base



Lochside Cottages

Stronvar

Molmeg Bed & Breakfast

Cnoc Farn Holiday Cottage

Loch Mor

Trial Deployment: Backhaul and core networks

IP Access E40 small cell with IP backhaul



Adaptrum TVWS client



Novatel MiFi 6620



1.6 KM

Spectrum: 8MHz channel with 506 MHz central frequency

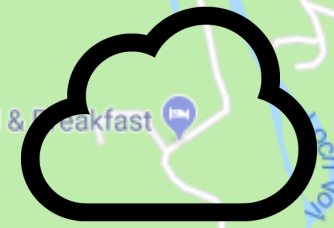
Data Rate: 12 Mbps

Optical Fiber cabinet

Adaptrum TVWS Base



ECHO: core in the cloud



Lochside Cottages

Stronvar

Molmeg Bed & Breakfast

Cnoc Farnh Holiday Cottage

Deployment cost

- Dependent on:
 - Deployment settings
 - Number of Users
 - Service requirements
- With some optimizations, we expect the costs can be reduced to below **1 USD** per subscriber per month
 - Local breakout for the traffic
 - Open source platforms
 - Leveraging unlicensed/shared spectrum

Summary

- 57% of the world's population does not have mobile broadband connectivity
- Market driven traditional deployment model of mobile network insufficient while community cellular networks are limited to GSM services
- We propose a DIY deployment model:
 - Access Network: leverage shared/unlicensed spectrum and open source platforms
 - Backhaul Network: TVWS links
 - Core-in-the-cloud
- The trial deployment in rural UK shows the feasibility of the proposed deployment model