LTE

Network Design Suggestions for Developing Countries and Case Studies

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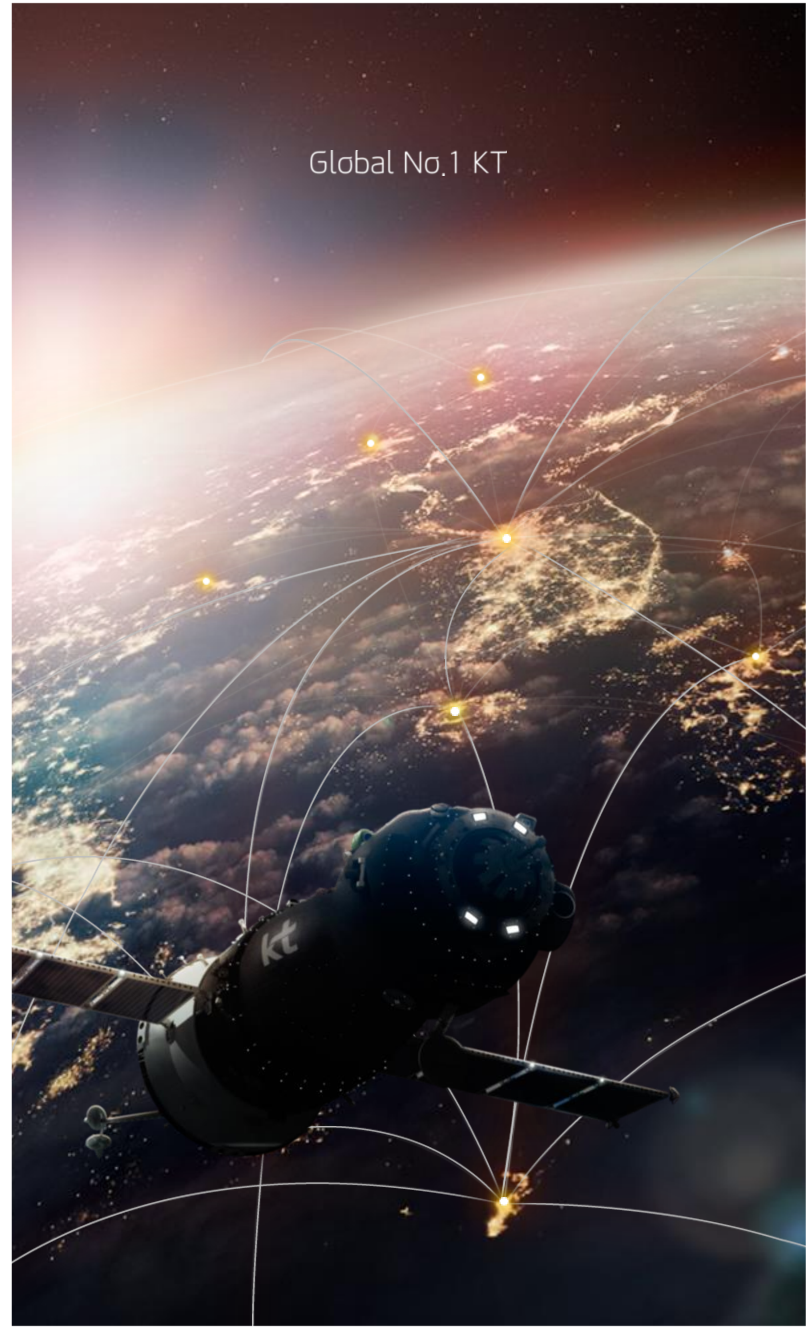
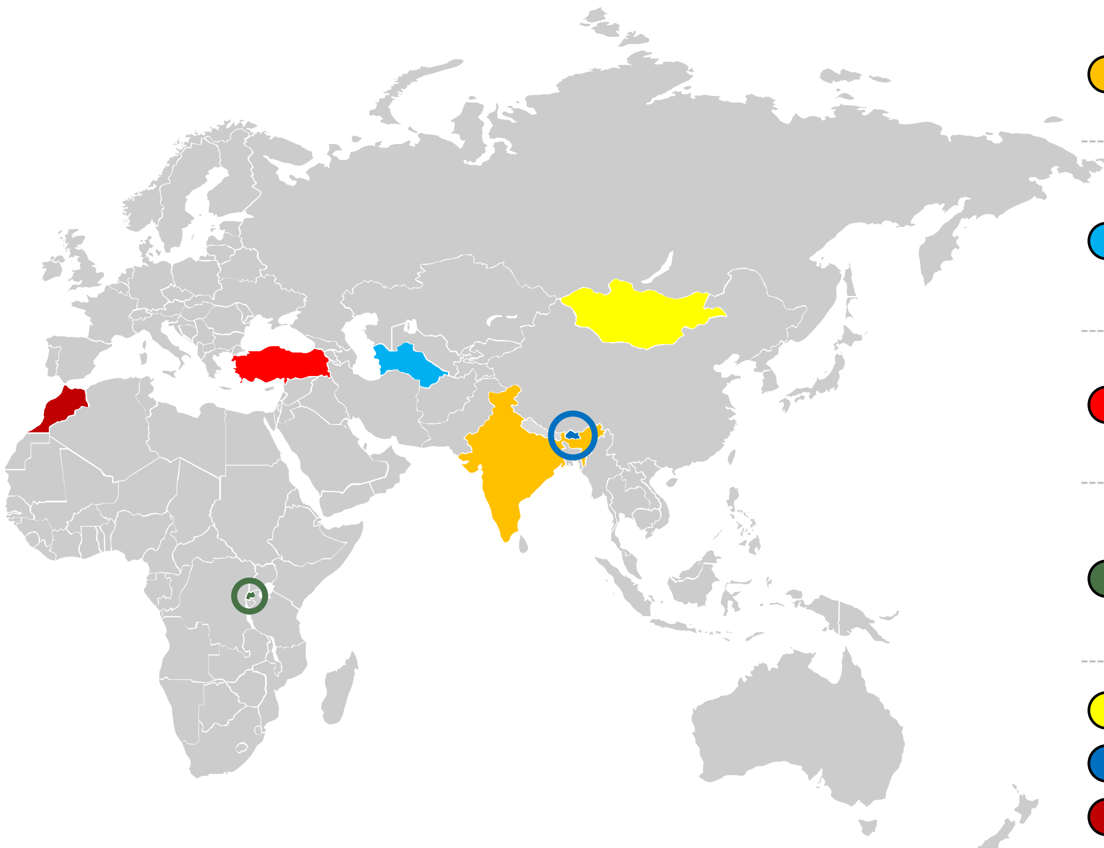


LTE Consulting

KT has provided LTE network design, implementation and strategy for emerging markets with field-proven know-hows



India	Network Quality Improvement RF Optimization
Uzbekistan	Mobile Network Strategy GiGA LTE Design & Deployment NOC Operation
Turkey	LTE Strategy GiGA LTE Deployment LTE Operation
Rwanda	LTE Network Strategy Design and Deployment Commercialization NOC operation
Mongolia Bhutan Morocco	Feasibility Study on LTE Implementation

LTE Design & Implementation for Developing Countries

- Need for a cost effective and futuristic **TOOL** for economic development
- The **Economic impact of ICT** technology in developing countries is greater
  ➔ Rationale to strengthen ICT infrastructure, especially **Mobile Broadband**
- Growing demand for **a cost effective LTE network**

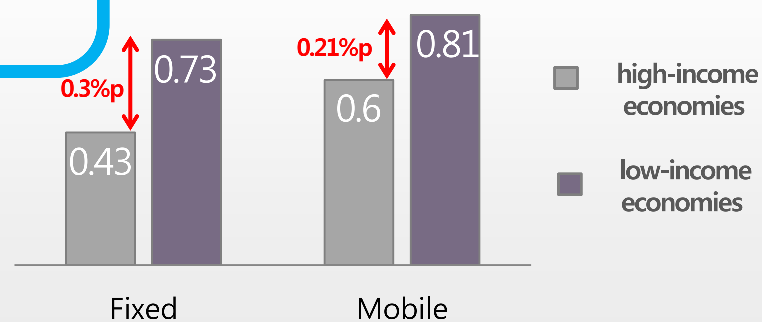
Economic Impacts of Broadband (World Bank 2013)

High Income Economies < Low Income Economies

"The Impact of Telecoms on Economic Growth in Developing Countries," by Waverman

Fixed Broadband < Mobile Broadband

- Economic growth per 10% increase in telecom penetration



General LTE Design Criteria

CAPEX & OPEX ↓ Simpler & Robust Network ↑

Design Criteria		
1. Frequency Selection	Mobile Ecosystem	Device Availability
	Frequency Characteristics	Lower bands vs. Higher Bands
	Existence of Interference	Risk Management
2. Type of Technology		FDD vs. TDD
3. Service Coverage Design		Considering Terrain and Morphology
4. RAN Architecture		S-RAN vs. C-RAN
5. Core Architecture		Complementing Coverage and Service Quality
6. Infrastructure Sharing		Passive vs. Active

Factors to Consider for Developing Countries

Factors

1 **Not enough** Fixed Network Infrastructure

2 **Insufficient** Electric Power Supply

3 **Open** Device Market

4 **Limited** Service Coverage in Rural Areas

5 **Low** Technology Maturity

Methodology

1 **Identify Specific** requirements for LTE design criteria

2 **Evaluate and Suggest** appropriate technology or methods

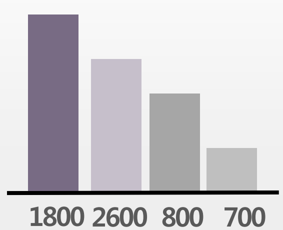
3 **Prove our suggestions with** real life cases

1. Frequency Selection Strategy

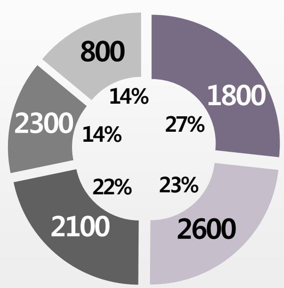
Requirements	Suggestions
1. Maximizing Accessibility	To adopt the most widely used frequency band
2. Minimizing CAPEX	To use lower frequency band if available
3. Minimizing Risk of Interference	To pre-investigate / band shifting or clearing source

Global Ecosystem

Top 4 most widely used frequency bands by operators

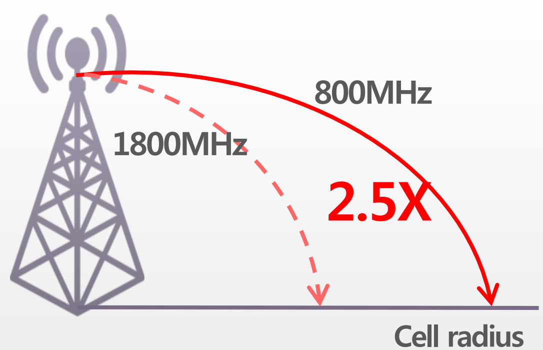


Top 5 Global Device Availability



※ source: GSA report Feb, 2016

Frequency characteristics



※ source: "LTE performance analysis on 800 and 1800 bands, master of science thesis" - prabhat man sainju

Interference

Service Quality Degradation

Delay in Commercial Launch

Solution!

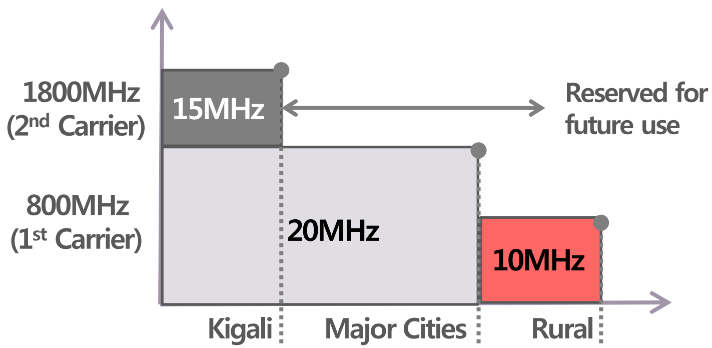
- Band shifting
- Clearing interference source

1. Frequency Selection Strategy: Rwanda Case

Frequency Utilization Plan

Available Bandwidth

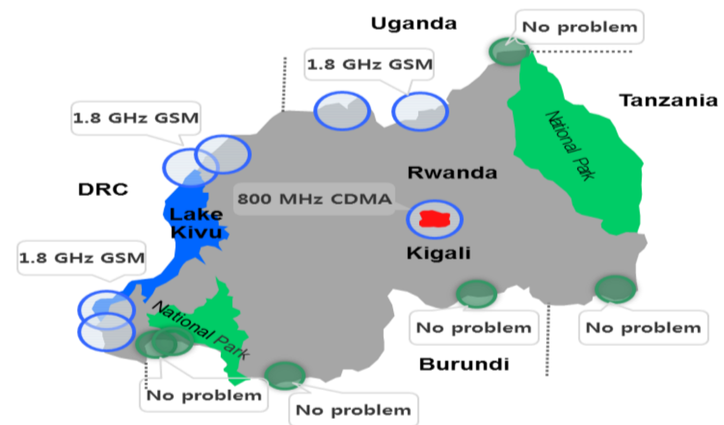
- 800 : 30MHz
- 1800: 15MHz



Selected 800 MHz as 1st Carrier for nationwide LTE deployment and reserved 1,800 MHz for capacity expansion in the future.

- Both frequency bands were globally used and supported by most devices.
- 800MHz was advantageous for service coverage.

Interference Avoidance



※ DRC: Democratic Republic of the Congo

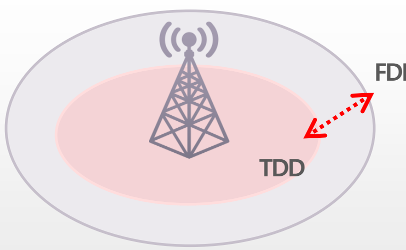
Avoided interference by the other operator's CDMA MiFi in the capital city by shifting frequency band.

- Only used 20MHz out of 30MHz from 800MHz band.
- Postponed 1,800 MHz launch till clearing interference sources at the border.

2. Type of Technology (FDD vs. TDD)

1. Eco-system+Coverage-focused deployment	FDD
2. Few technical challenges/ easy optimization	FDD (TDD has potential self-inference issue)

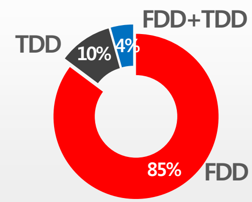
Coverage



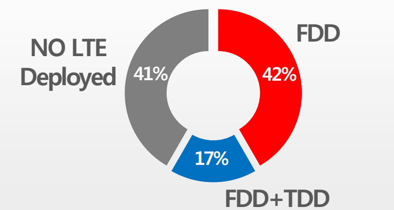
※ source: Qualcomm, "LTE-TDD-the global solution for unpaired spectrum" 2014

Global Ecosystem

- FDD/TDD use by operators worldwide



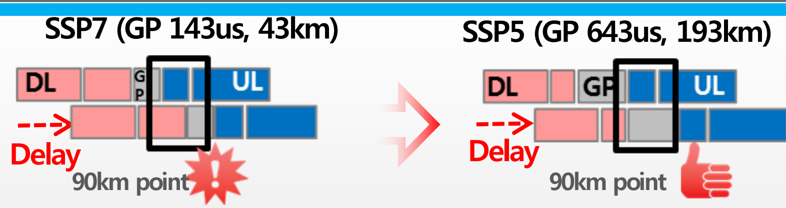
- FDD/TDD use by operators in 48 least developed countries.



※ source: GSA report Feb, 2016

Mitigating Self-Interference by TDD Transmission: India Case

Widening Buffer btw. DL and UL (SSP* Re-configuration)

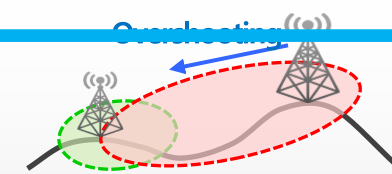


- Compensated propagation delay by re-configuring SSP with longer guard period.
- Trade-off: DL throughput degraded 29%.

※ SSP: Special Sub-frame

Adjusting Over-shooting Cells without field tests

- Calculated distance btw. serving & neighbor cells using ANR and located overshooting cells.
- In one of the major cities, cells with more than 10km RF transmission, were defined as overshooting cells and down-tilted.



- **NRT* Counts in city X**

(Distance unit: km)

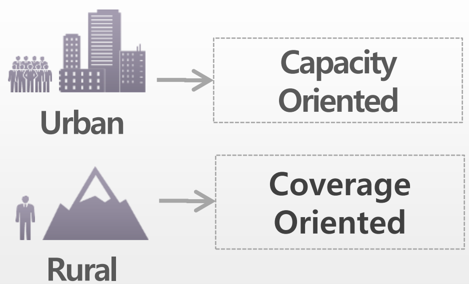
Distance	<3	3~6	6~10	10~50	50~100
Count	20180	2571	626	332	2

※ ANR: Automatic Neighbor List, NRT: Neighbor Relation Table

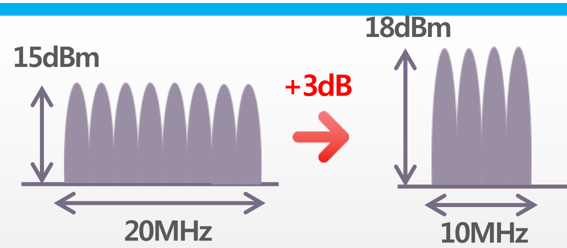
3. Service Coverage Design

Coverage-focused deployment → To maximize cell coverage in rural areas

Classification of Morphology

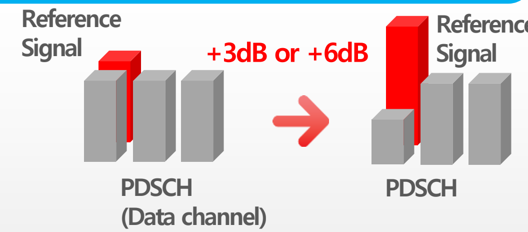


Adjusting Service Bandwidth



+3dB Coverage achievable
by adjusting bandwidth
at same amplifier power (40W).

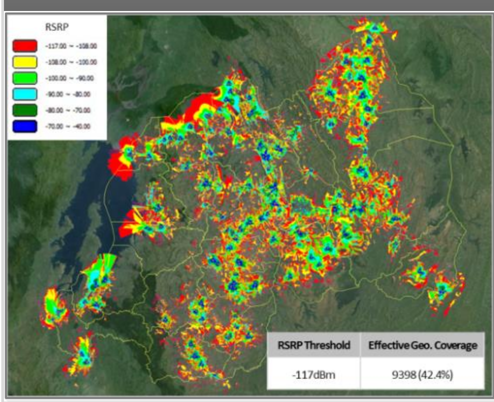
RS Power Boosting



+3dB or +6dB Coverage achievable
by using RS power boosting feature.

Maximizing Single Cell Coverage: Rwanda Case

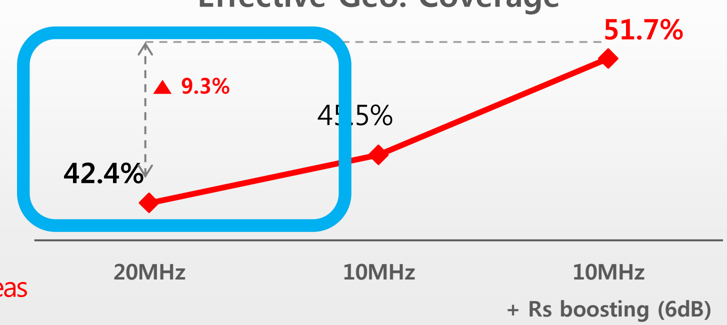
Service Coverage Simulation: Bandwidth adjustment & RS Boosting



Simulation Condition

- Frequency band: 800MHz (Band20)
- Bandwidth: 20MHz → 10MHz
- Number of sites: 239
- Amplifier power: 40W
- RS power: 15dBm → 21dBm
- Sites with RS boosting: 100 sites in rural areas

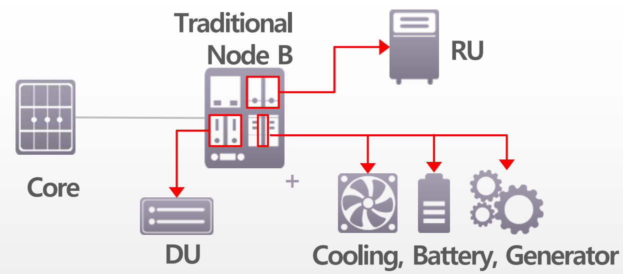
Effective Geo. Coverage



4. RAN Architecture

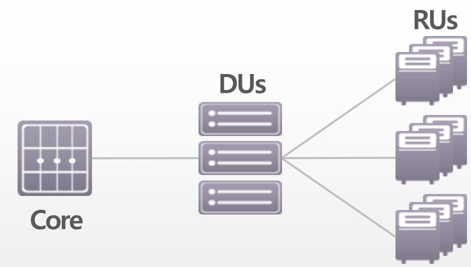
Minimizing CAPEX/OPEX	→	Hybrid architecture, C-RAN (Centralized)+ S-RAN (Stand-alone)

S-RAN: 1 DU and 1 RU at one site



- Cooling system, Cabinet, Generator, Battery and Electricity needed for each site.

C-RAN: Centralized DUs and RUs at each site



- Cooling system, Cabinet and Generator are NOT NECESSARY at each site

Korea Case

Nationwide C-RAN

- CAPEX Saving: equipment and facilities
- OPEX Saving: rent and electricity

	Rent	Electricity	Battery
Average saving per site	55%	66%	59%

Rwanda Case

C-RAN in major cites

- Deployment plan and expected savings

	S-RAN	C-RAN*	Total
Sites	85	467	552

	S-RAN	C-RAN	Savings
Space	RU + Battery + Generator + Cooling Sys.	RU + Battery	Rent ▼ 83%
Power	3,600W	2,100W	Electricity ▼ 42%

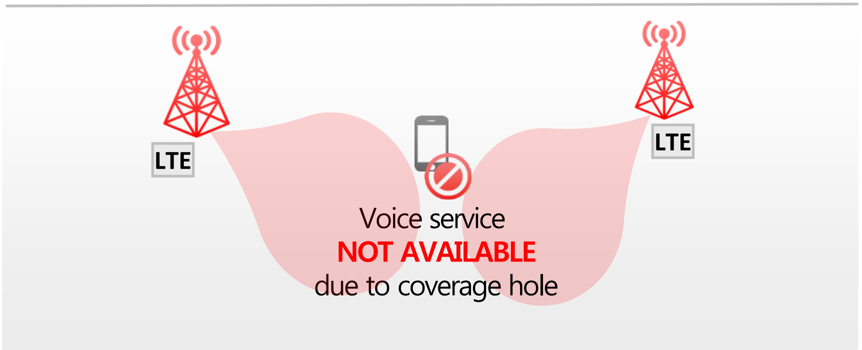
※6 DU centers in Kigali.

5. Core Architecture

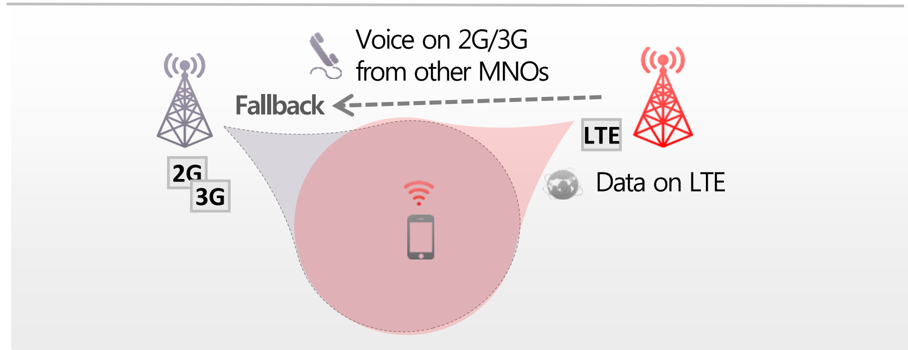
※CSFB: Circuit Switched Fall Back
※MNO: Mobile Network Operator
※SPID: Subscriber Profile ID

Voice Coverage Complementation → CSFB* with Multiple MNO*s using SPID*

VoLTE only Network

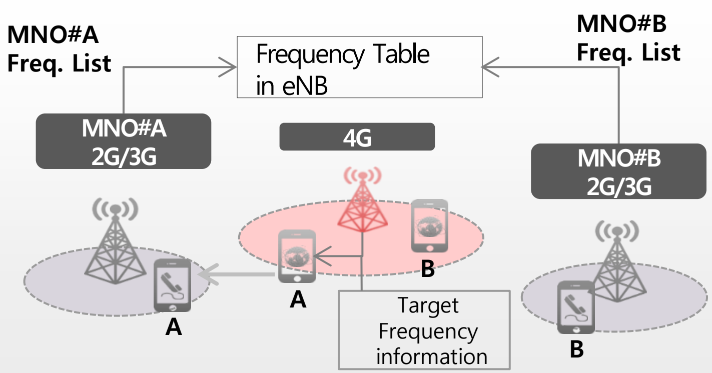


CSFB



Voice Coverage Compliment Methods: Rwanda Case

Multi-MNO CSFB using SPID (KT patent)



- **Technical Issue:** Subscriber UE doesn't know which 2G/3G network to redirect for CSFB.

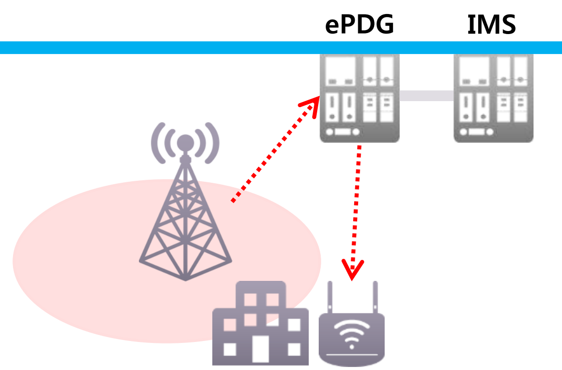
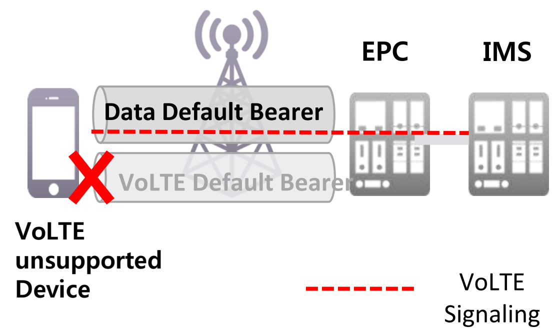
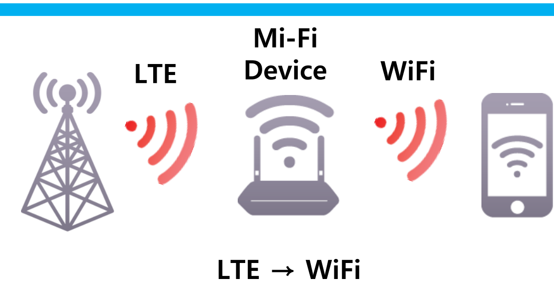
- **Solution:**

- In eNB, SPID to distinguish each MNO's frequency implemented.
- Using SPID, eNB can distinguish which MNO the UE should redirect for voice service and provides target 2G/3G frequency information to UE for successful CSFB.

Core Architecture

Supporting In-building/non-VoLTE device users ➔ Vo-WiFi / VoLTE application / Mi-Fi

In-building/Non-VoLTE user supporting methods: India Case

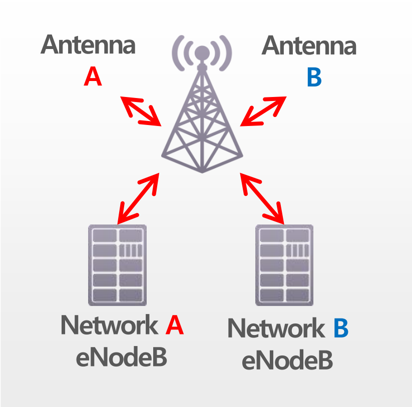
Vo-WiFi	VoLTE Application	Mi-Fi
		
• To complement coverage inside the buildings. • Enables hand over between LTE and WiFi without repeater or femto.	• Not many devices support VoLTE with open device market environment in developing countries. • Voice service can be provided via data default bearer with VoLTE application.	• Not many devices support VoLTE nor LTE with open device market environment in developing countries. • A MiFi device, cheaper than a smartphone, can convert LTE signal to WiFi signal.

6. Network Infrastructure Sharing

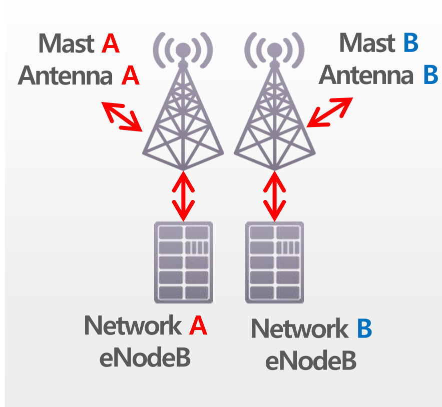
Minimizing CAPEX/OPEX → Actively Sharing Network Infrastructure (promotiion by the government)

Passive: Sites and Incidentals Sharing

Mast Sharing

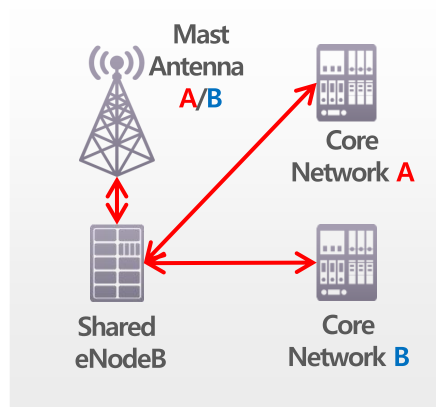


Site Sharing

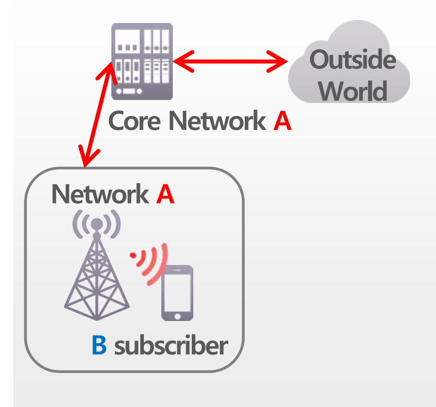


Active: Network Sharing

Full RAN Sharing



Network Roaming

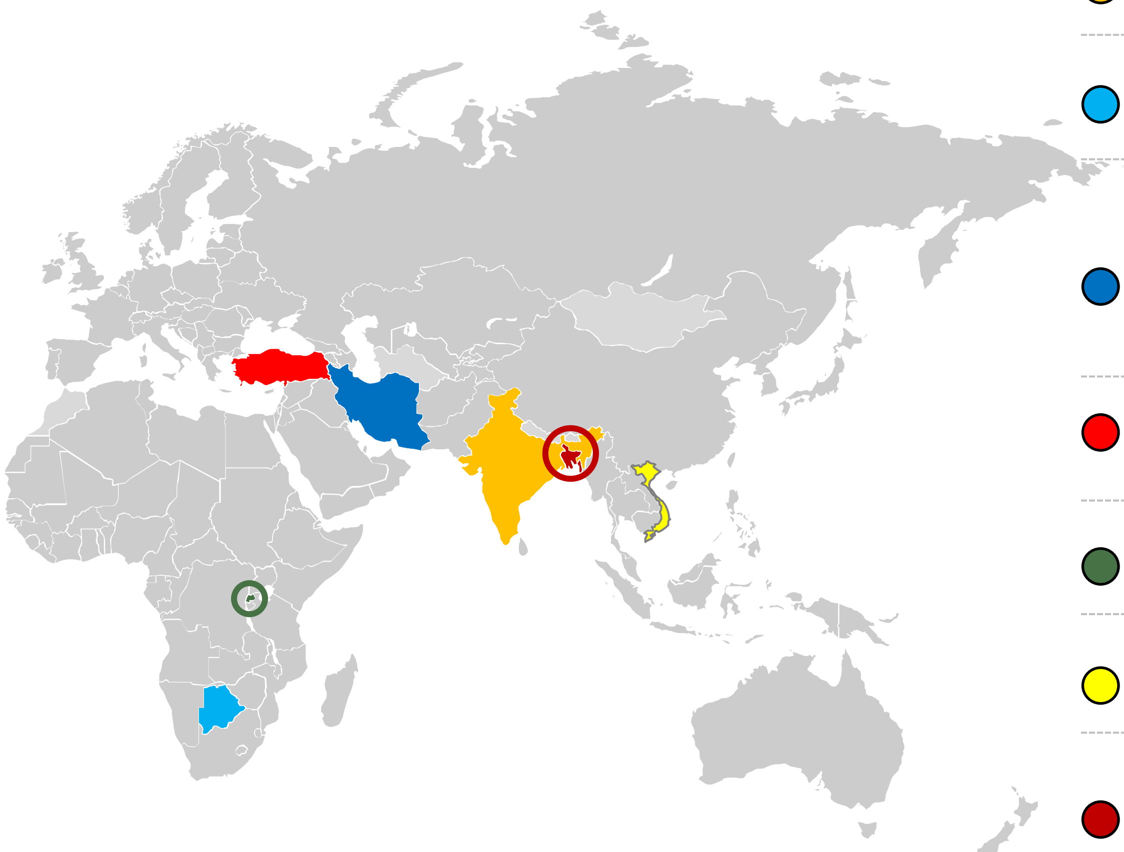


Passive Sharing : Korea Case (2015)

In-building Feeder and Antenna Sharing			
No. of sharing sites	Cost if not shared	Allotted share	Savings
3,931	US 25 million	US 15 million	▼ US 10 million (40 %)

KT's Fixed Network Consulting

KT provides optimum solution for fixed networks from strategy, establishment to operation.



India	FTTx Design & Deployment
Botswana	FTTx Strategy & Deployment
Iran	IP Network Design and Deployment Next Generation Network Strategy and Deployment
Turkey	GiGA Wire
Rwanda	Cyber Security Model
Vietnam	Internet
Bangladesh	Next Generation Network Strategy and Deployment

Thank you