



Harvesting Unlicensed & Shared Spectrum with 5G: Opportunities and Challenges

Narayan Menon, CTO & EVP
Engineering

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Demand for Wireless Capacity Ever Increasing

Supply Struggles to Keep Pace with Demand

BETTER EXPERIENCE



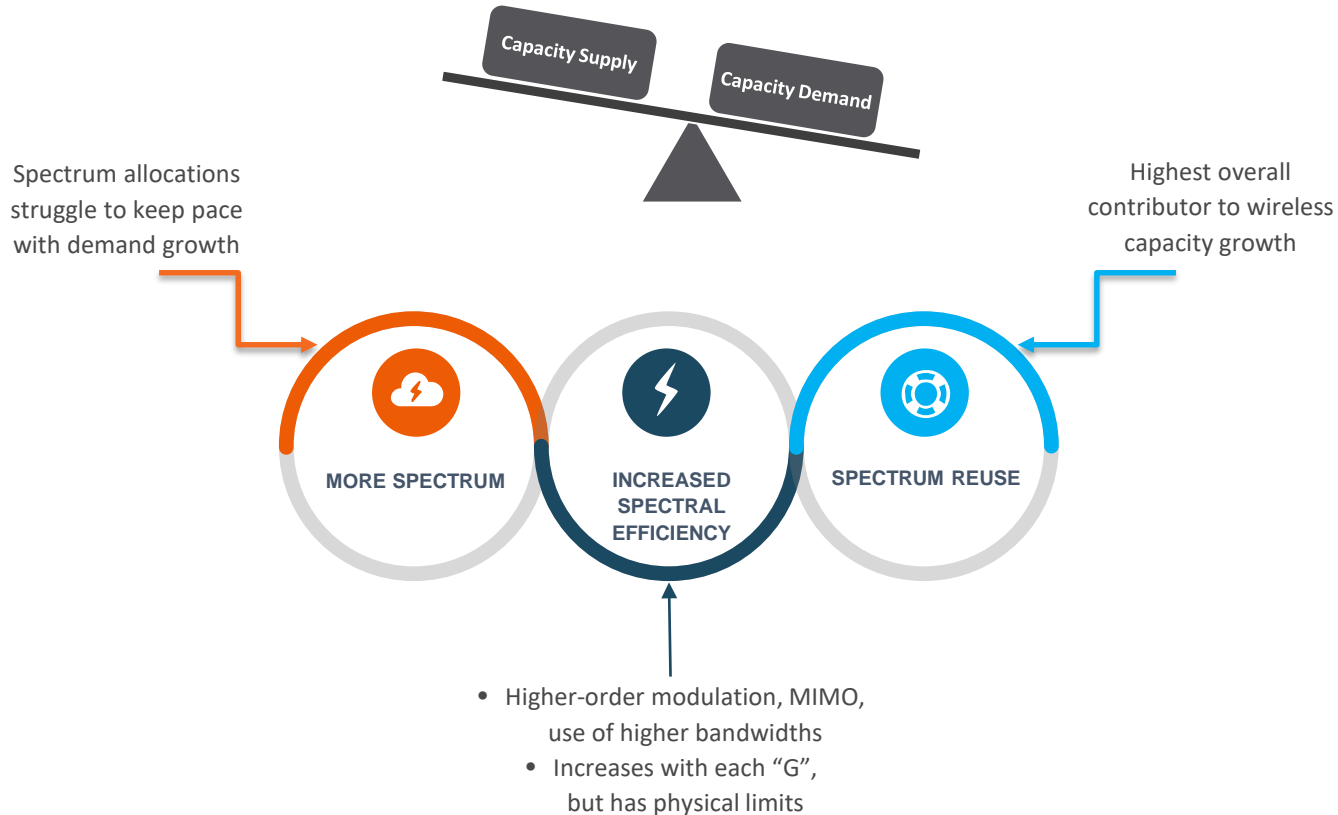
MORE SERVICES AND APPLICATIONS

Education Augmented Reality
Medical Sensor Fusion
Social and Gaming 4K Video
Social Media Context Aware
3D Imaging Advertising

MORE DEVICES



Traditional Capacity Improvement Strategies

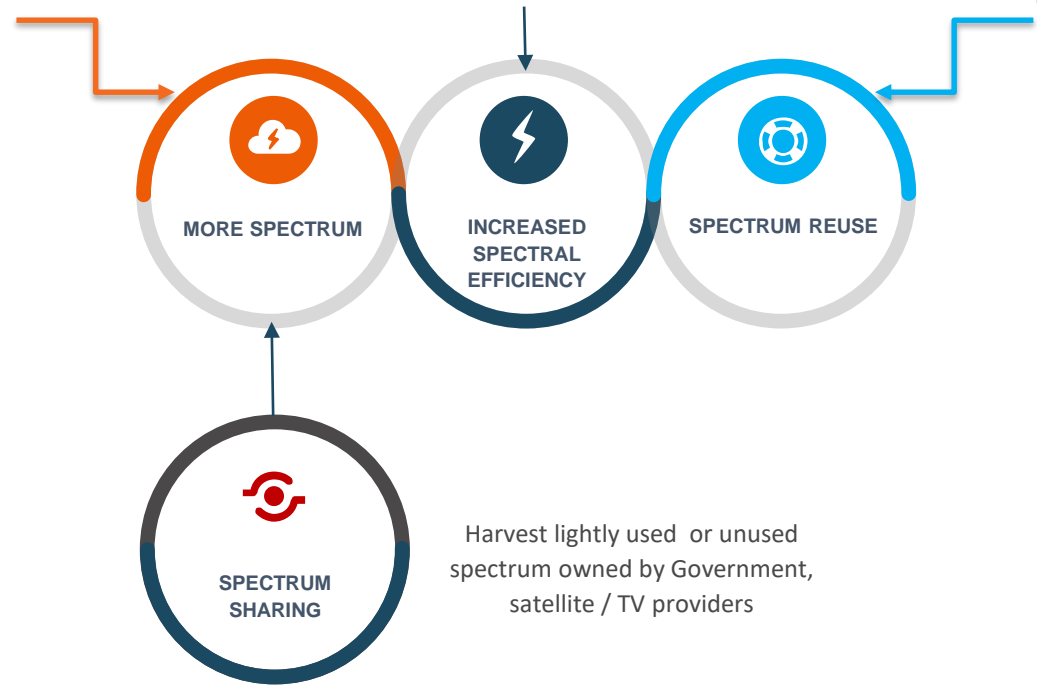


Capacity Drivers in a 5G World

New spectrum bands – licensed, unlicensed and shared

Higher-order modulation, MIMO, use of higher bandwidths

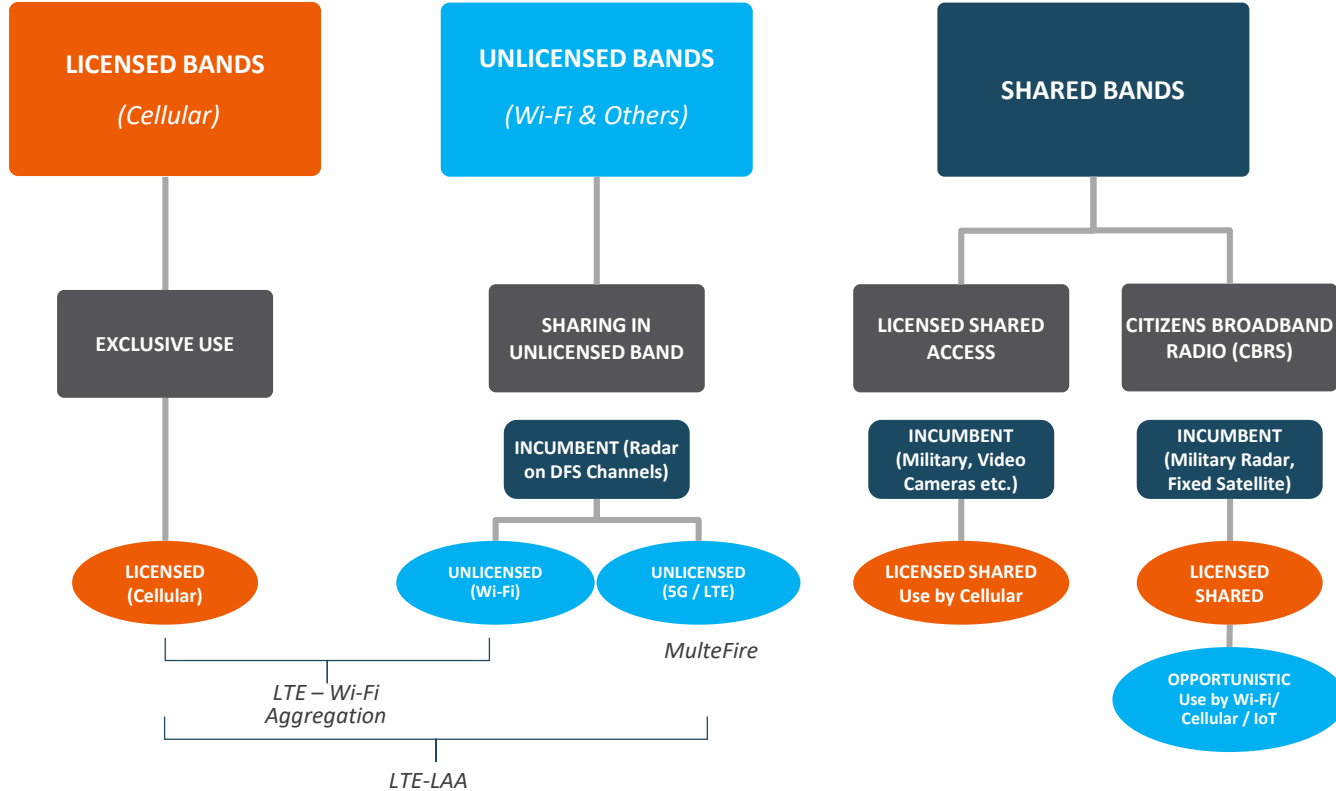
Increased reuse via operation in mmwave bands



Harvest lightly used or unused spectrum owned by Government, satellite / TV providers



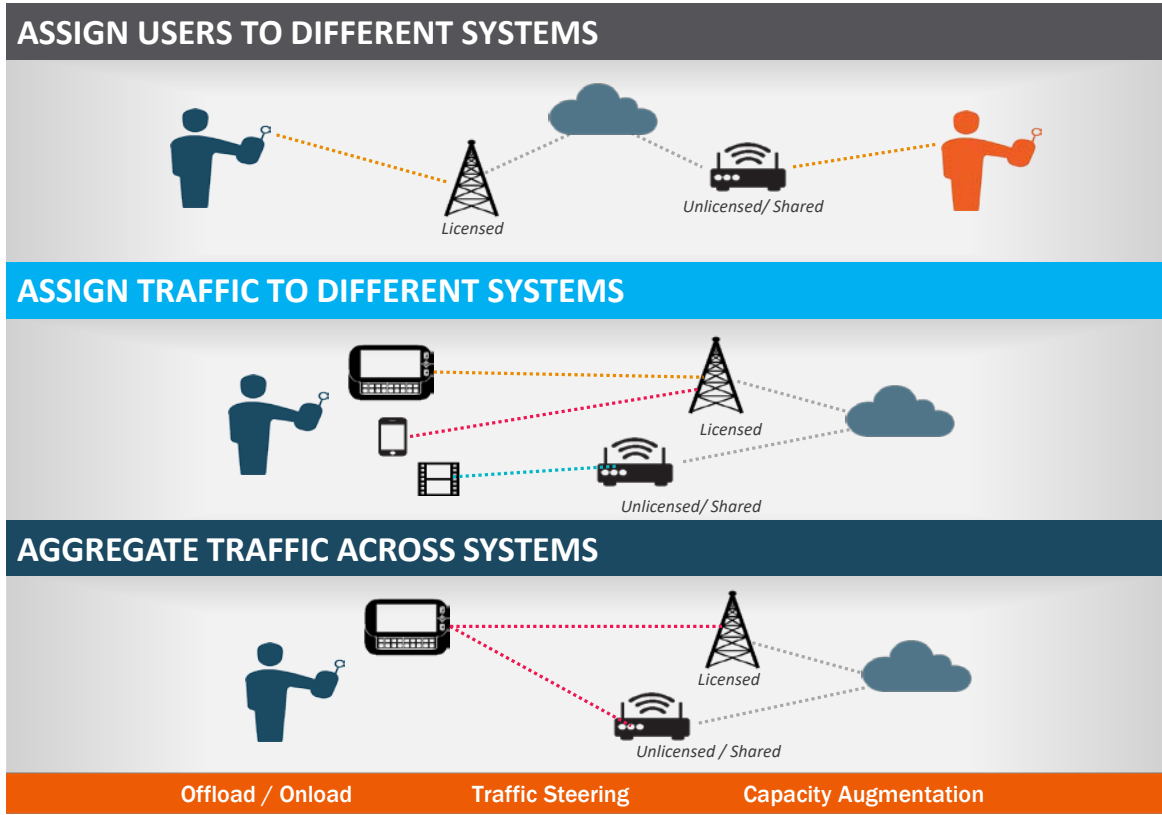
Spectrum Sharing Regimes



Opportunities for Holistic Capacity Management Using Multiple Systems

Driven by Policy

Driven by Network Conditions



Example of Multi-Tier Spectrum Sharing Framework

Citizens Broadband Radio Service (CBRS)

Designed to Encourage Innovation, Competition, Smaller Players



Protected Tier 1 player (Incumbent)



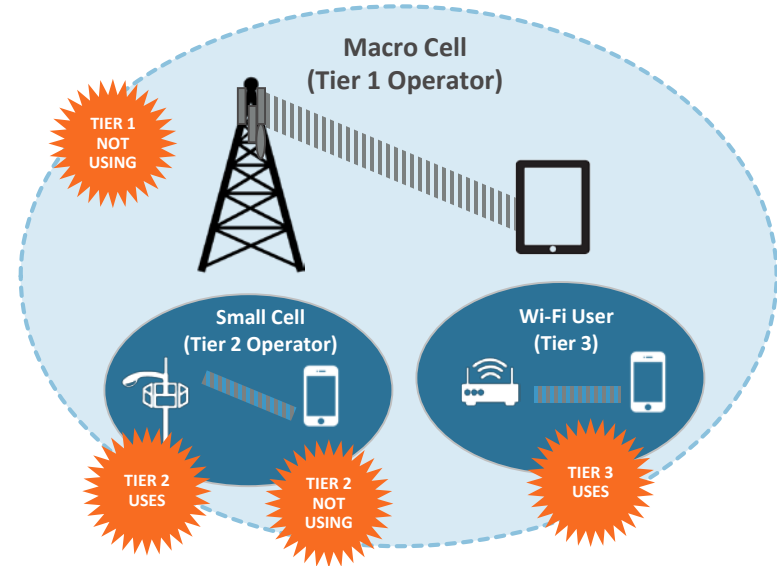
Lightly licensed Tier 2 uses spectrum when incumbent isn't using



Unlicensed Tier 3 players use spectrum opportunistically when Tiers 1 and 2 are not using the band

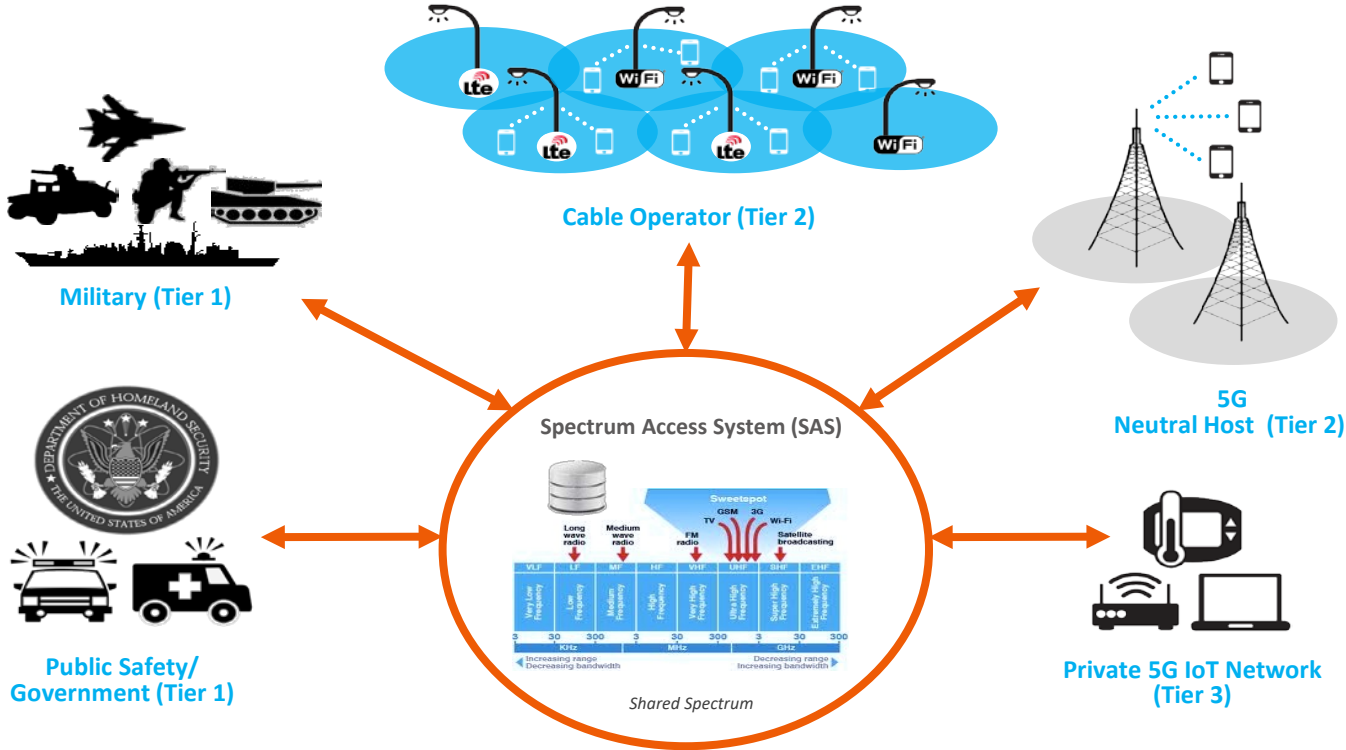


Affordable Tier 2 licenses, allocated per census tract for 3-year periods

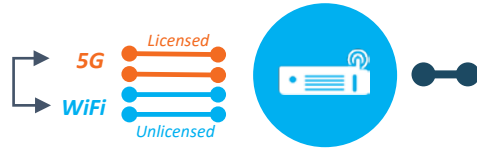


Multi-Tier Model, Enabling Spectrum Sharing Across Incumbent, Licensed and Opportunistic Layers of Users

CBRS: Spectrum Sharing Use Cases

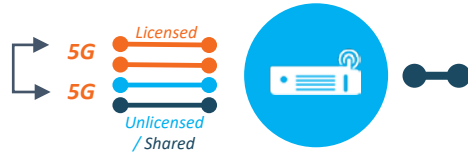


Strategies for Leveraging Unlicensed & Shared Spectrum with 5G



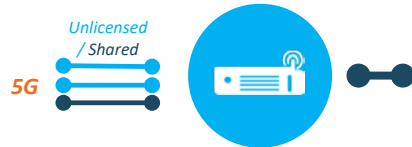
Bandwidth Augmentation or Offload: 5G + WiFi

- 5G in licensed spectrum, Wi-Fi in unlicensed spectrum
- Aggregation or Offload scenarios



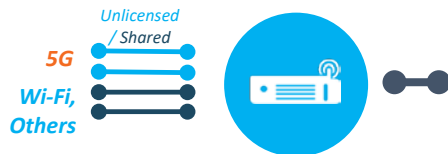
Bandwidth Augmentation – 5G in Licensed + Unlicensed / Shared

- 5G operates in unlicensed band
- Carrier Aggregation – licensed + unlicensed bands



New Entrants – Cable MVNO, IoT:

- 5G operates solely in unlicensed or shared band
- Usable by cable operators with no licensed spectrum
- Industrial IoT deployments



Private 5G Networks & Neutral Host Models:

- 5G operates solely in unlicensed or shared spectrum
- Neutral Host provides access to enterprises, venues, high-rise buildings

Bandwidth Augmentation, Offload, Private Networks

5G New Radio (NR) Designed for Spectrum Sharing

Designed from the Outset for Unlicensed & Shared Spectrum Operation

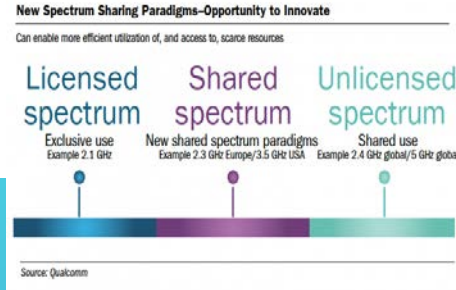
Supports Diverse Bands

Sub 1GHz Bands:
Longer-range
communications

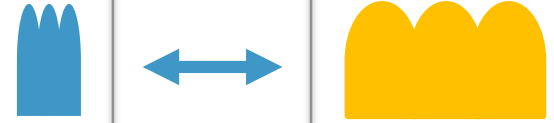
Mid bands (1 – 6GHz):
Wider bandwidths

Bands above 24GHz
(mmWave):
Extreme bandwidths,
short range

Works in All Spectrum Types



Highly Band-Agile



- Highly band-flexible
- Can switch bands nimbly
- Can operate simultaneously in multiple bands

5G Radio – Optimizable for Different Bands, Deployments, Services

Flexible Numerology Enables Optimal Operation in Diverse Scenarios

Flexible, Dynamically Variable Physical Layer Configurations – Optimizable for Different Scenarios

Band-Optimized

- Optimizable for every band
- Simultaneous operation in multiple bands
- Aggregation across multiple bands
- Multiplexing across time, frequency

Deployment-Optimized

- Optimal indoor operation
- Optimal outdoor operation
- Short vs. long range

Service-Optimized

- Latency-critical
- High throughput
- Mission-critical / high reliability
- Can be multiplexed within one carrier

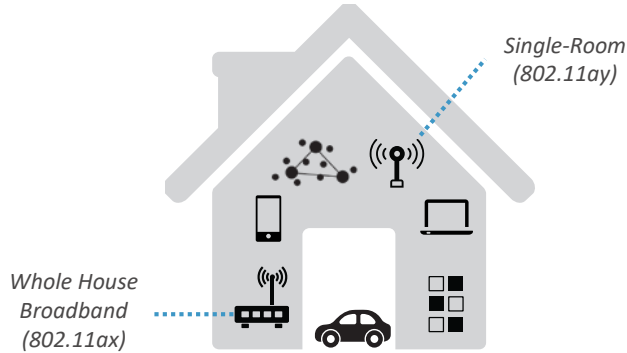
802.11ax & ay – WiFi's Own 5G...

Incorporates Cellular-Like Capabilities & Band Flexibility

- Offering Gigabit Bandwidths - at least 4x current WiFi speeds
- Bandwidth usage efficiency – larger # of simultaneous users, increased capacity
- Optimizable for multiple deployment types – dense, outdoor, indoor
- Knobs for bandwidth management, QoS
- Multiple bands – 2.4GHz, 5GHz, mmWave
- Mobility between bands, power management



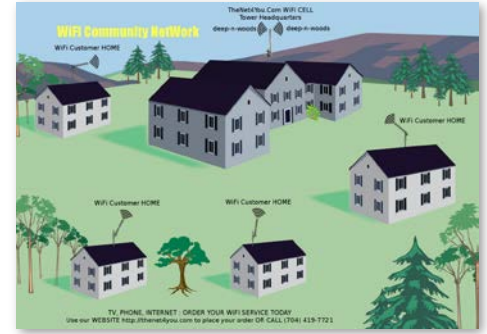
Supporting an Increasingly Diverse Array of WiFi Use Cases



Single Family Home



Multi-Dwelling Unit



Community WiFi & Neutral Host



Enterprise



Venue

Coexistence Challenge in Unlicensed & Shared Bands

Diverse Technologies Sharing the Same Bands

CELLULAR



Longer-range, high-speed, mobility

MEDIUM-RANGE/ LAN



Medium-range, high-speed, indoor

SHORT-RANGE/ PAN



Short-range, battery-operated, power-sensitive, low-speed

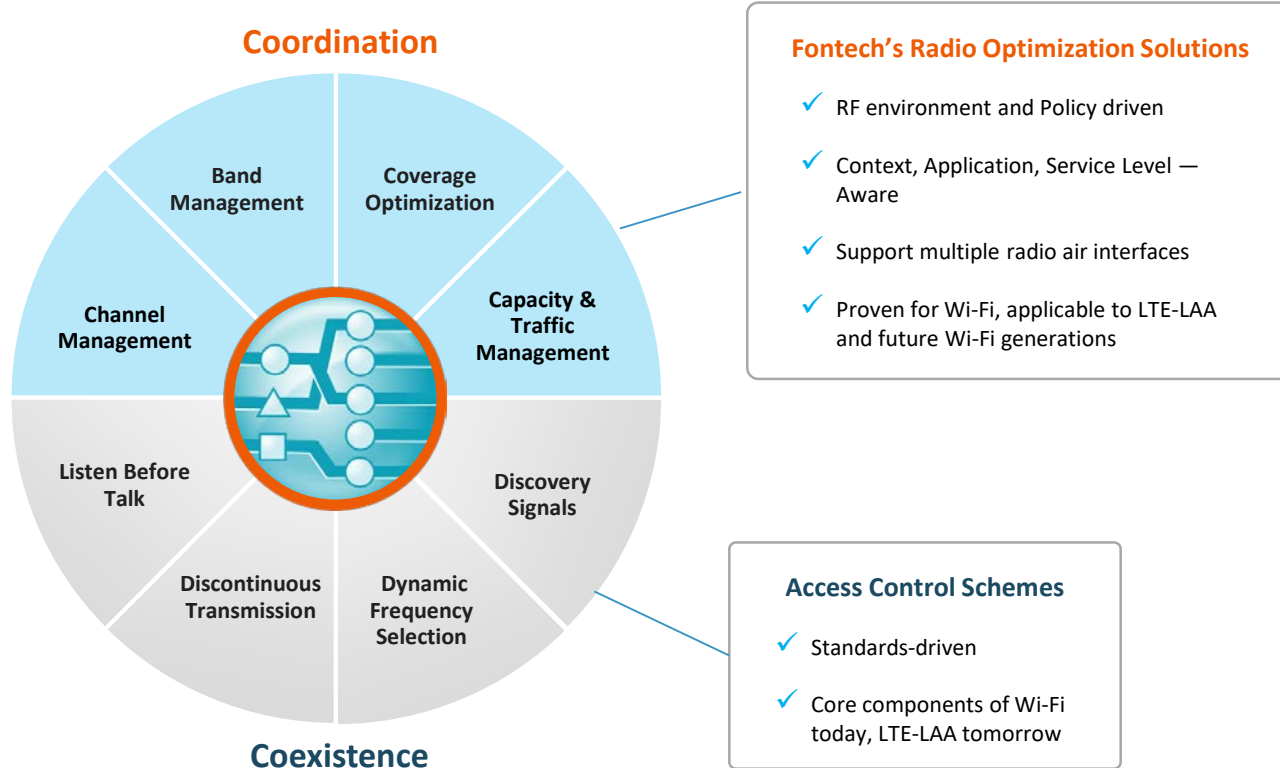


Creates Congestion & Interference – Compromising Performance

- Dense Deployments – large numbers of devices, access points contending for bandwidth
- Multiple technologies coexisting
- Multiple service providers
- Resulting congestion, interference issues affect performance – latency, throughput, QoS

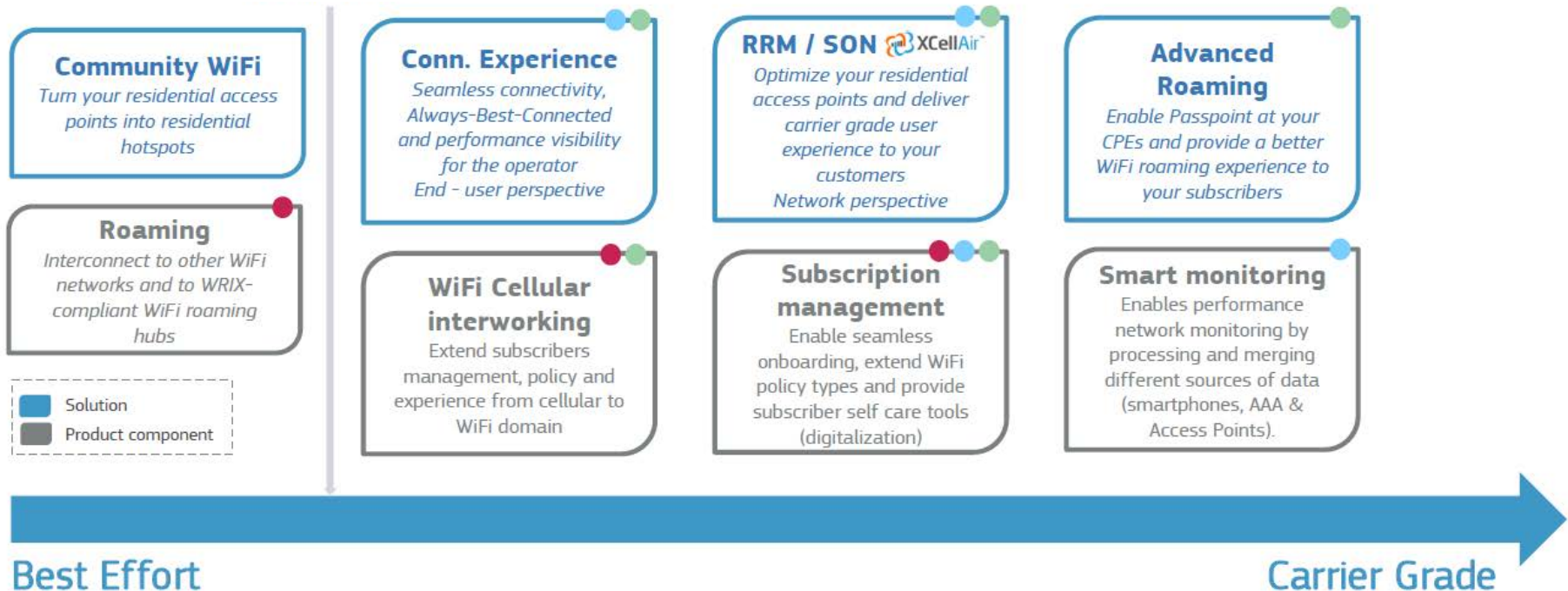


Solutions Must Address the Problem at Two Levels



Fontech's Suite of Unlicensed Spectrum Solutions

The path from best effort to carrier grade service



■ Solution
■ Product component

fontech 