

November 2013

The 1000x Mobile Data Challenge

More Small Cells, More Spectrum, Higher Efficiency

QUALCOMM®



Mobile data traffic growth— industry preparing for 1000x

Industry preparing for
1000x
data traffic growth*

Richer content

more video

Bestseller example:



5.93 GB

Movie (High Definition)



2.49 GB

Movie (Standard Definition)



0.0014 GB

Homepage



1.8 GB

Game for Android



0.14 GB

Soundtrack



0.00091 GB

Book

More devices

everything connected

~**25**
Billion

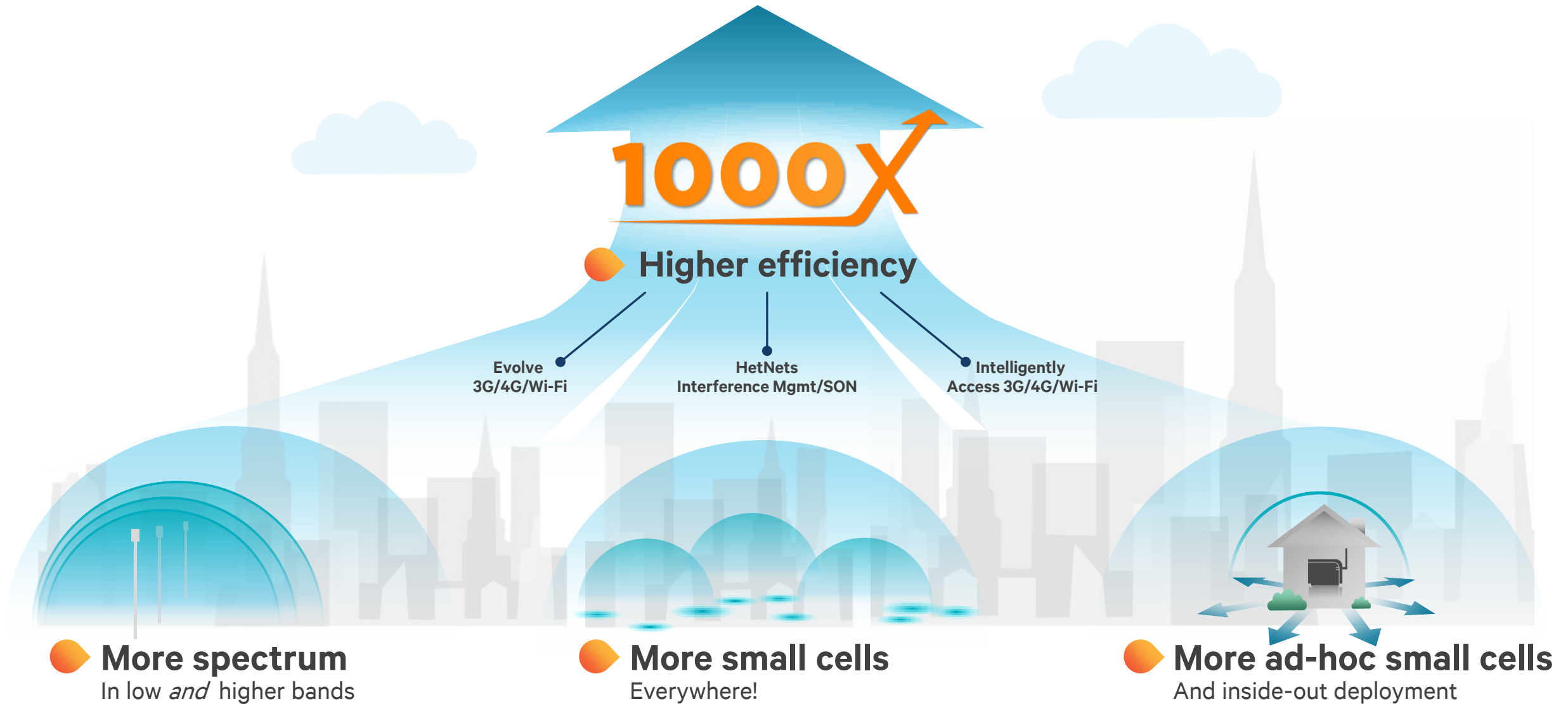
Interconnected
device forecast
in 2020²

~**7**
Billion

Cumulative smartphone
forecast between
2013-2017¹

*1000x would be e.g. reached if mobile data traffic doubled ten times, but Qualcomm does not make predictions when 1000x will happen, Qualcomm and its subsidiaries work on the solutions to enable 1000x

Rising to meet the 1000x mobile data challenge



1000X 

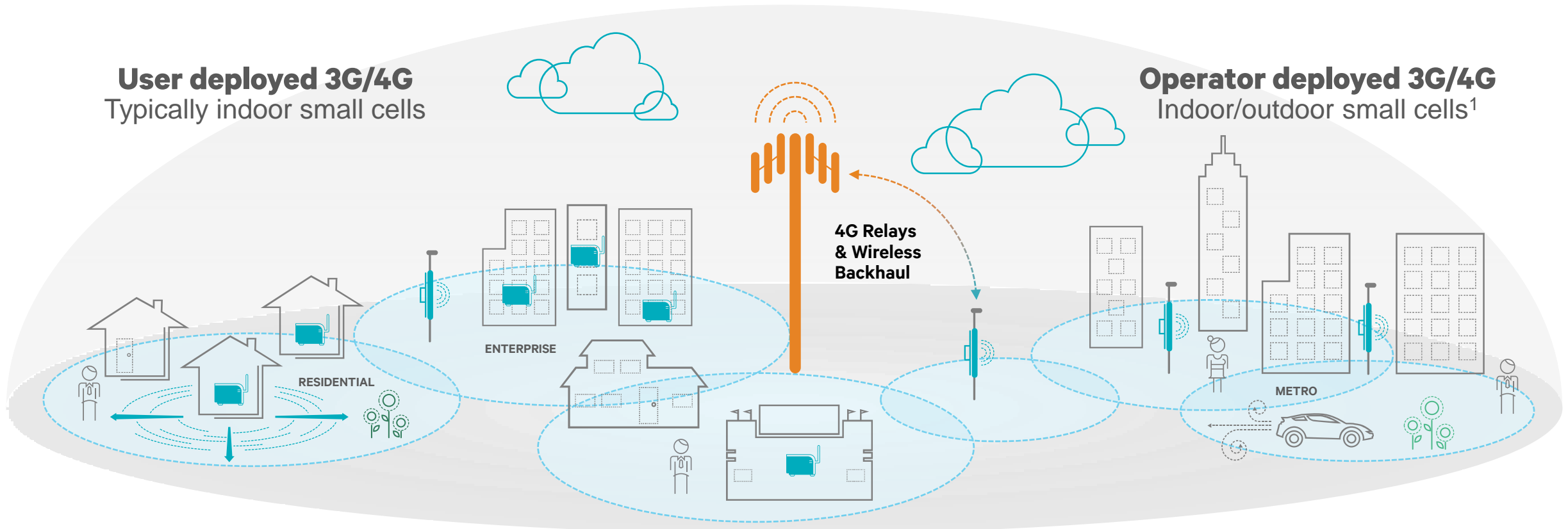


① More small cells

Taking HetNets to the next level

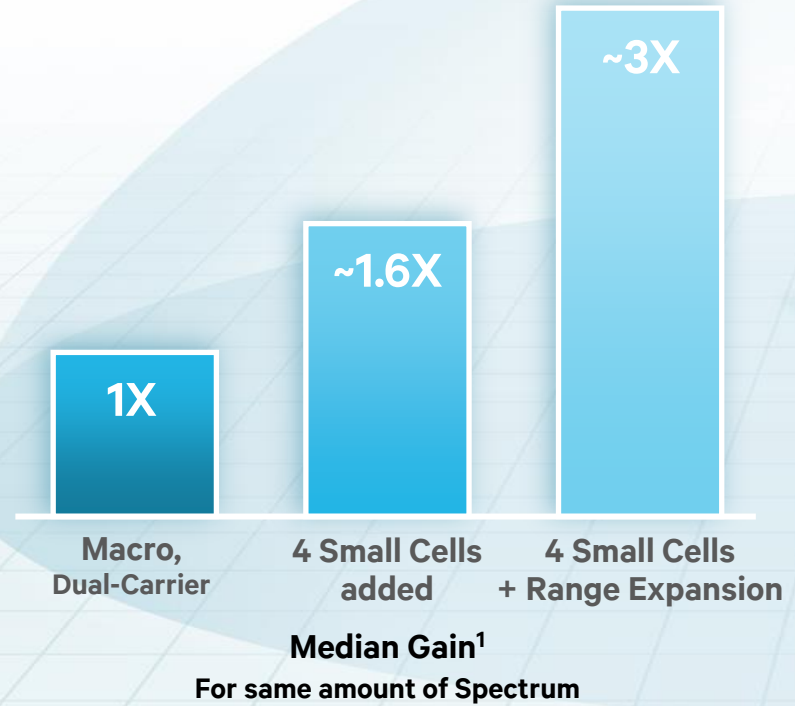
Bringing the network closer to the user is key to 1000x

Small cells everywhere—extreme densification in licensed spectrum



Leveraging unlicensed spectrum opportunistically
Unlicensed technologies integrated with 3G/4G small cells

¹ Such as relay and Pico/Metro/RRH small cells for hotspots. RRH= Remote Radio Heads, in addition Distributed Antenna Systems are used in HetNets



Range expansion possible with HSPA+ today and LTE Advanced (eICIC/IC)

HSPA+ example, Similar Gain for LTE Advanced

**1000x densification begins with existing spectrum and available techniques
—range expansion further increases capacity**

¹ Gain in median downlink data rate, 4 small cells of pico type added per macro and 50 % of users dropped in clusters closer to picos (within 40m), Model PA3 full buffer ISD 500m. Enabling range expansion features: reduced power on second macro carrier, dual carrier devices and mitigating uplink and downlink imbalance (3dB Cell-individual offset (CIO) and pico noise-figure pad)

Key enablers for small cells everywhere

HIGHLY COMPACT, LOW-COST SMALL CELL



BACKHAUL—DRIVES SMALL CELL SOLUTION

Operator Provided:
fixed, wireless, relays

User Provided:
Enables user installed
small cells¹

INTERFERENCE MANAGEMENT

So that **capacity scales**
with small cells added

Requires **device and
network features**

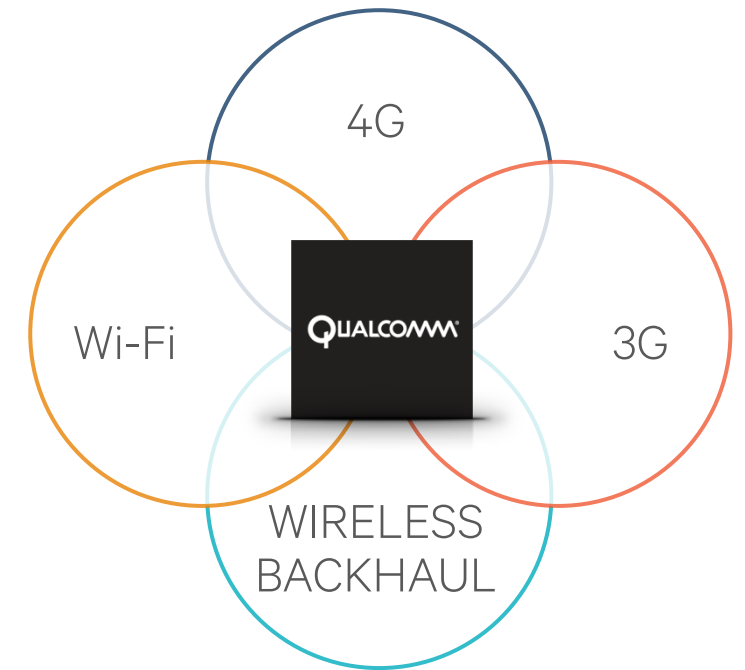
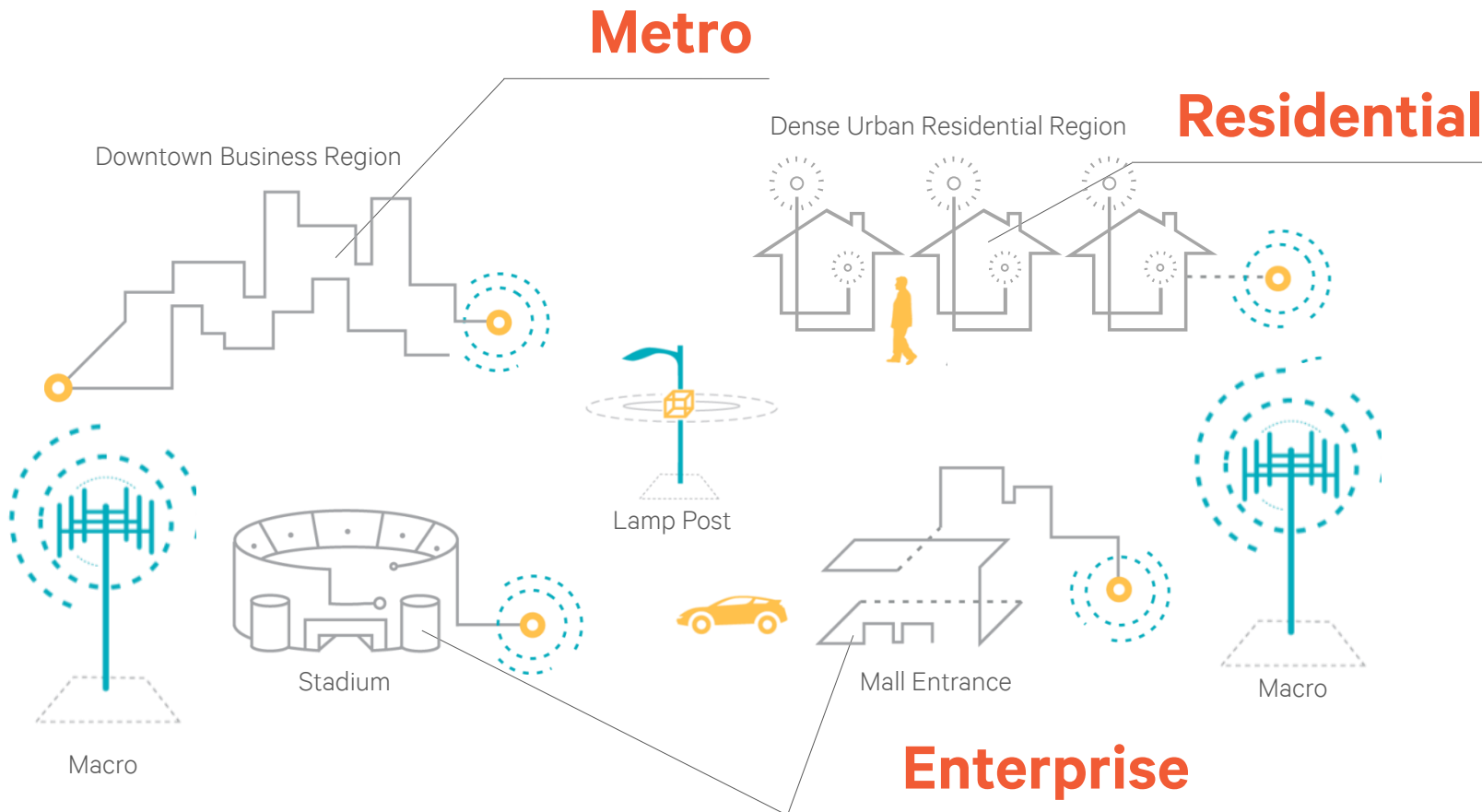
SELF ORGANIZING NETWORKS (UltraSON)

Taking **plug and play**
to the next level

Enables **hyper-dense**
small cell deployments

Qualcomm's unmatched small cell assets for all venues

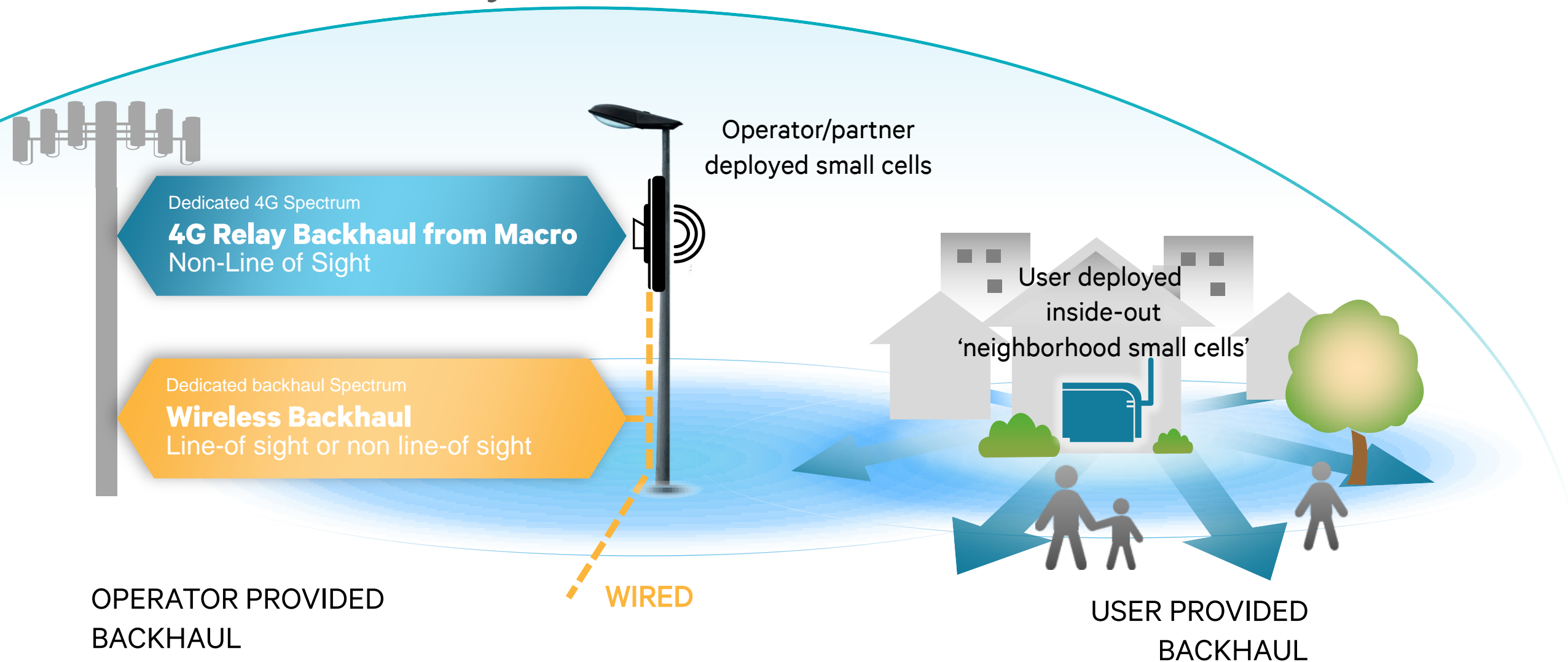
Industry's highest level of small cell technology integration



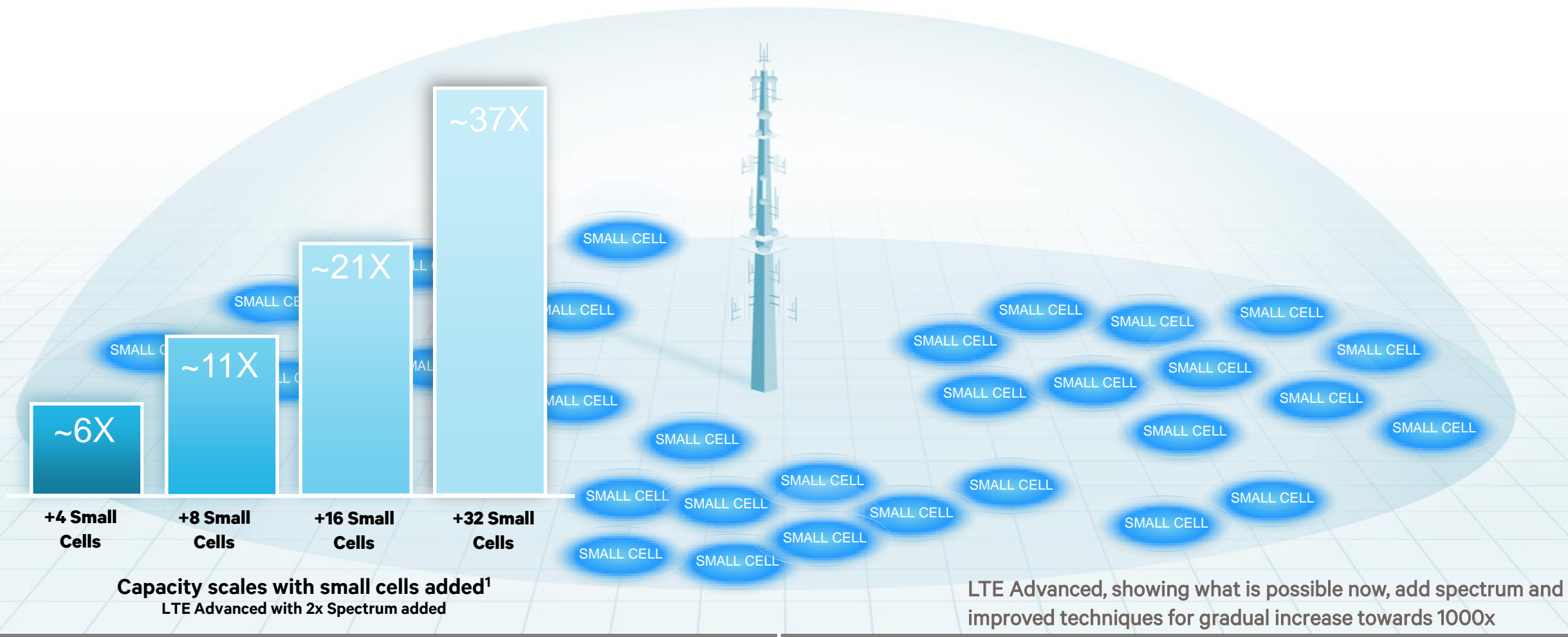
World-Class
Apps Processor

Complete RF
Solution

Backhaul availability drives small cell solution



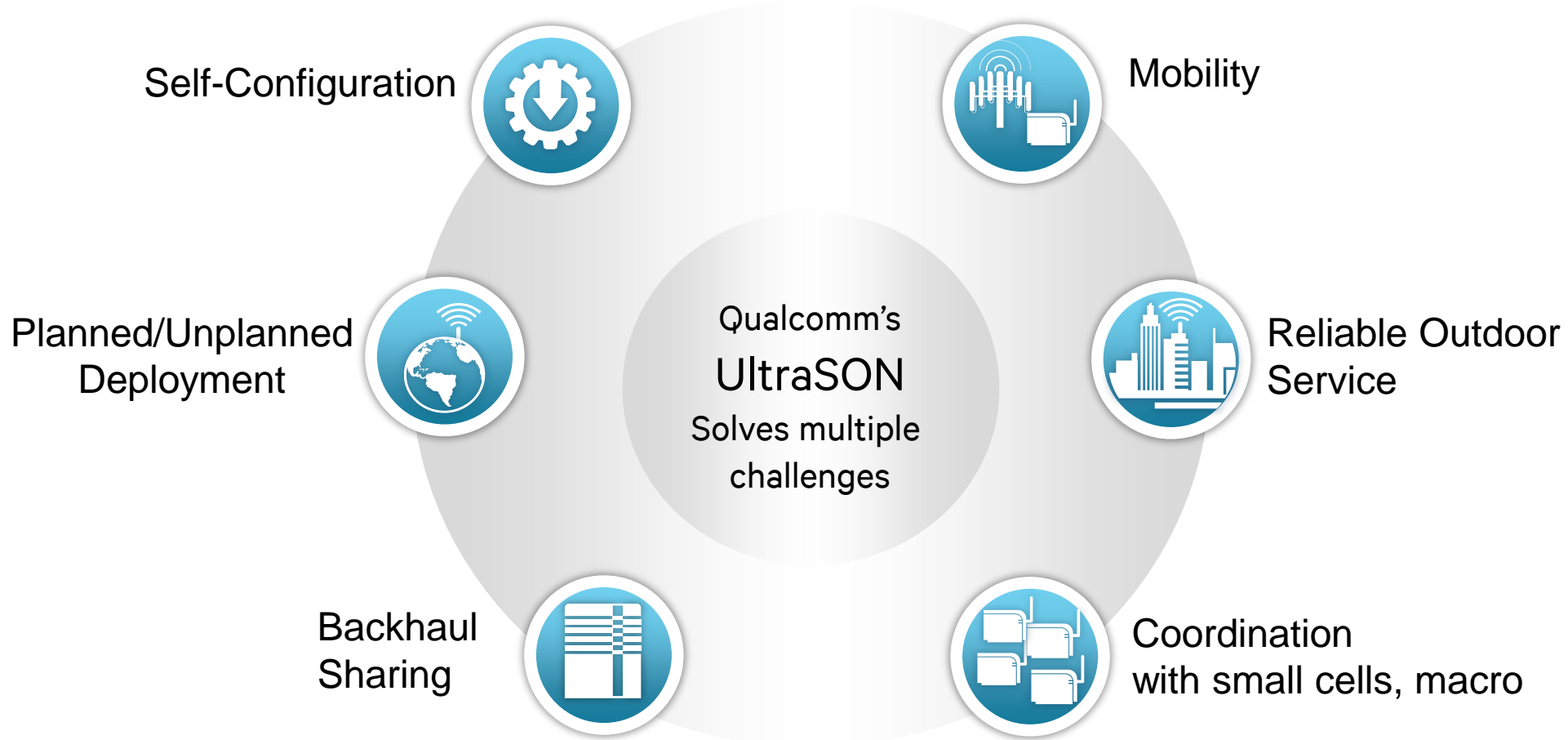
¹LTE Advanced defines relays with backhaul inbound (sharing F1) or outband spectrum (shown). A new 'velcro' type of relay would be more loosely integrated and could use different air interfaces for access, e.g. HSPA+/DO for access and LTE for backhaul



Capacity scales with small cells deployed — thanks to interference management and use of licensed spectrum

¹ Assumptions: Pico type of small cell, 10MHz@2GHz + 10MHz@3.6GHz, D1 scenario macro 500m ISD, uniform user distribution scenario. Gain is median throughput improvement, from baseline with macro only on 10MHz@2GH, part of gain is addition of 10MHz spectrum. Users uniformly distributed—a hotspot scenario could provide higher gains. Macro and outdoor small cells sharing spectrum (co-channel)

UltraSON enables hyper-dense deployments for 1000x



1000X

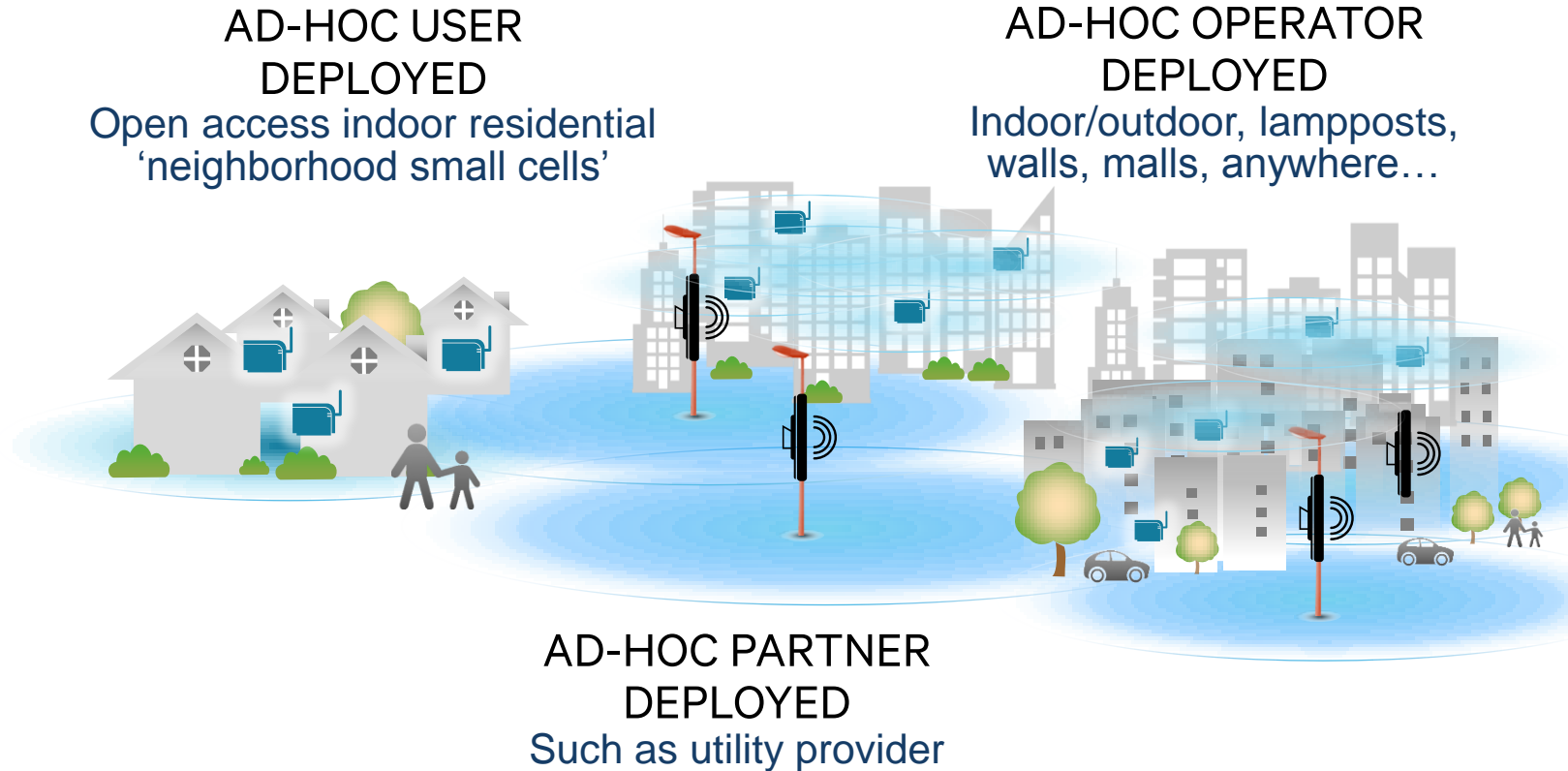


Evolution to low cost ad-hoc small cells

Viral, more unplanned deployments, licensed spectrum, managed by the operator

Extreme densification requires new ways of deploying

Evolution to lower cost ad-hoc small cell deployments



Viral, more 'unplanned', e.g. where backhaul exists—more like Wi-Fi

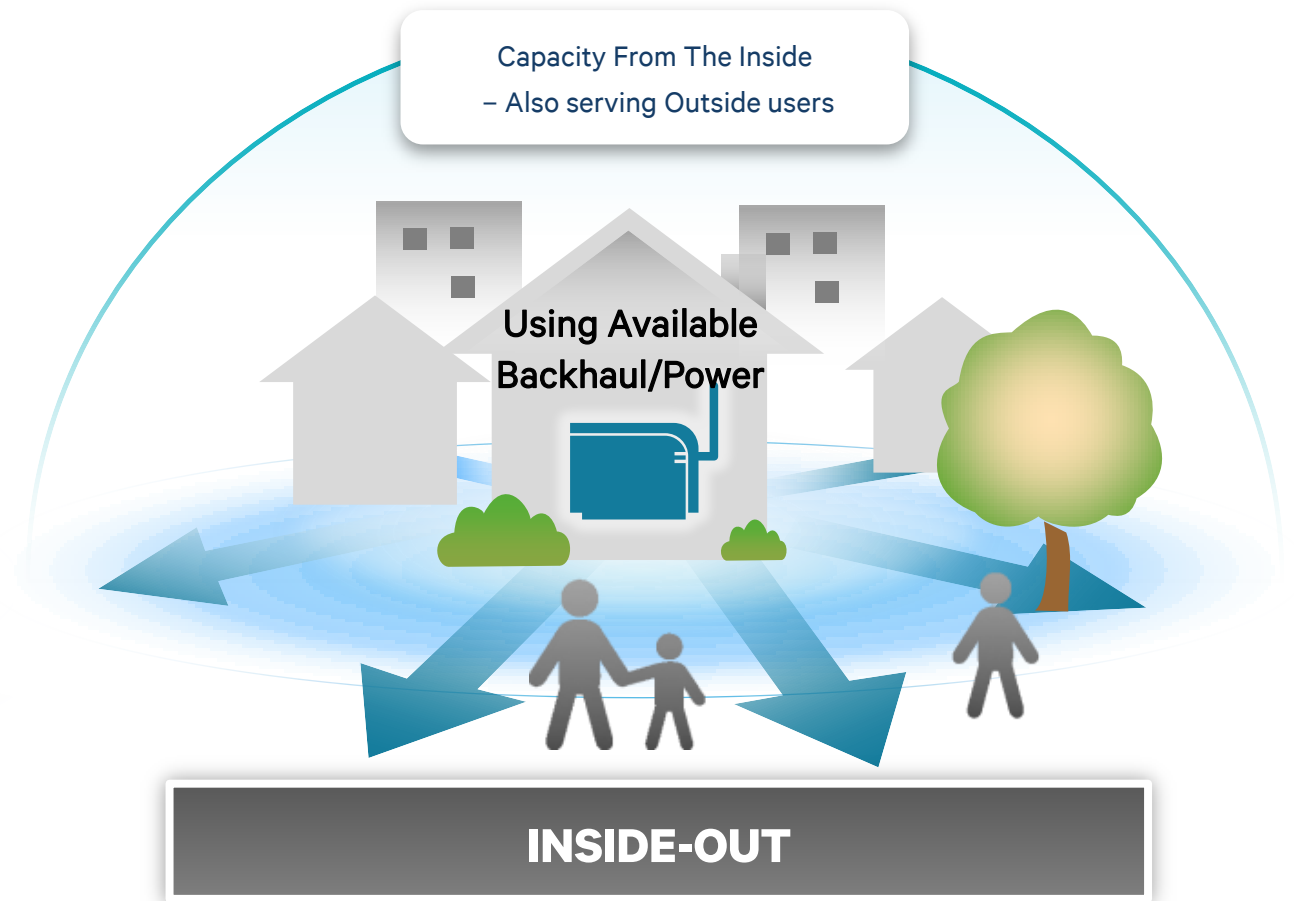
Plug & play, self organizing, coordinated small cells

Licensed spectrum ensures quality of service

Managed and controlled by the operator

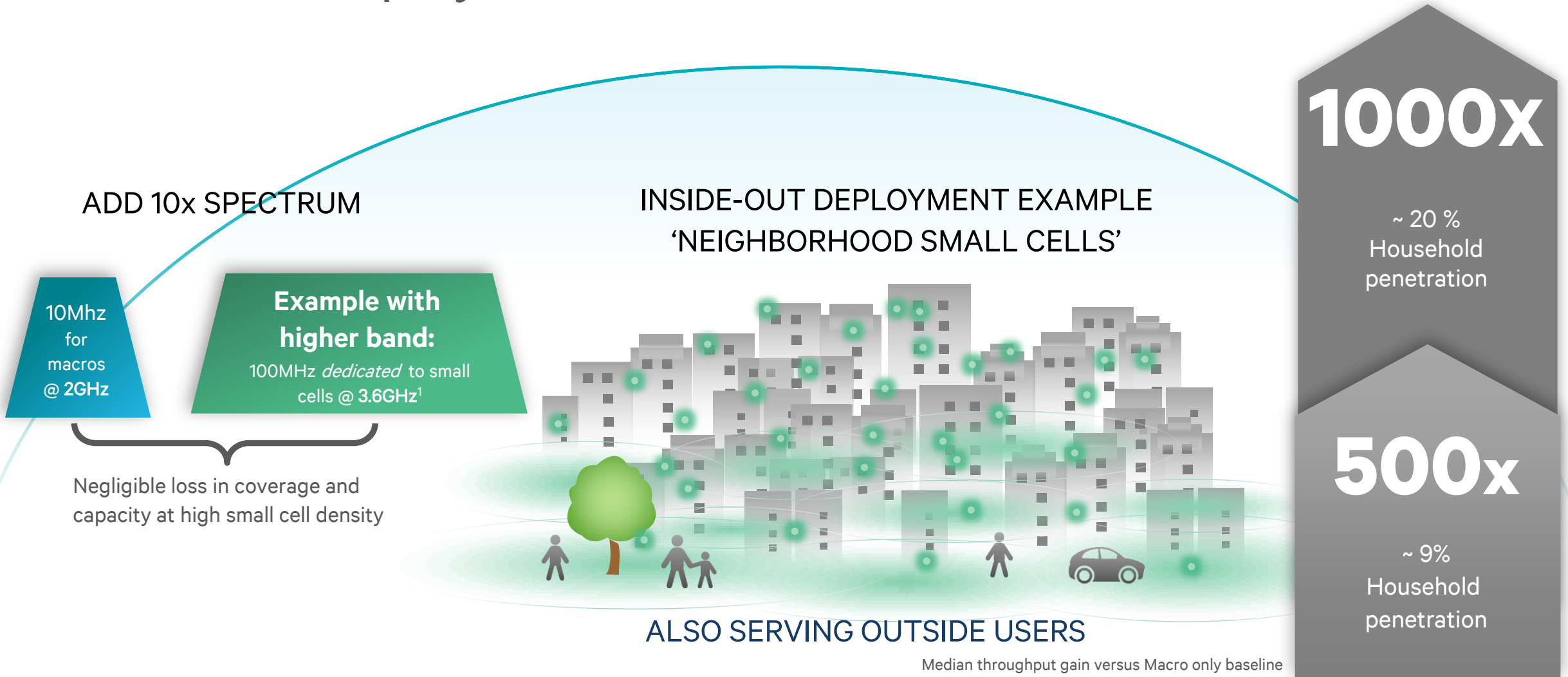
More inside-out deployments

The majority of traffic is indoors¹—why not also capture the outside?



¹>70% of mobile data traffic is consumed indoors and steadily increasing

Viral, ad-hoc deployed small cells is one enabler towards 1000x



Example for LTE FDD, 2x2 MIMO. Assumptions: 70% indoor users, 200 Active users per macrocell, small cells randomly dropped in households in a mix of 2 to 6 story apartments. ¹Small cells on dedicated spectrum used in this example, but we envision future neighborhood small cells also sharing the spectrum with macro and other small cells. 20% household penetration equals ~ 144 small cells, and 9% penetration equals ~ 65 small cells.

Neighborhood small cells opens up new opportunities

Cost-saving opportunity means that business solutions will emerge

LOWER COST FOR EXISTING OPERATOR



- ▶ Natural extension for operators offering fixed broadband
- ▶ Opportunity to partner with fixed broadband provider

NEW ENTRANTS



- ▶ Fixed broadband provider can add wireless
- ▶ New low cost broadband access networks
- ▶ Leverage lower cost ASA spectrum

NEW BUSINESS MODELS



- ▶ Wholesale small cell network
- ▶ Paid local access
- ▶ Reciprocal access

Tests show indoor small cells providing coverage outside



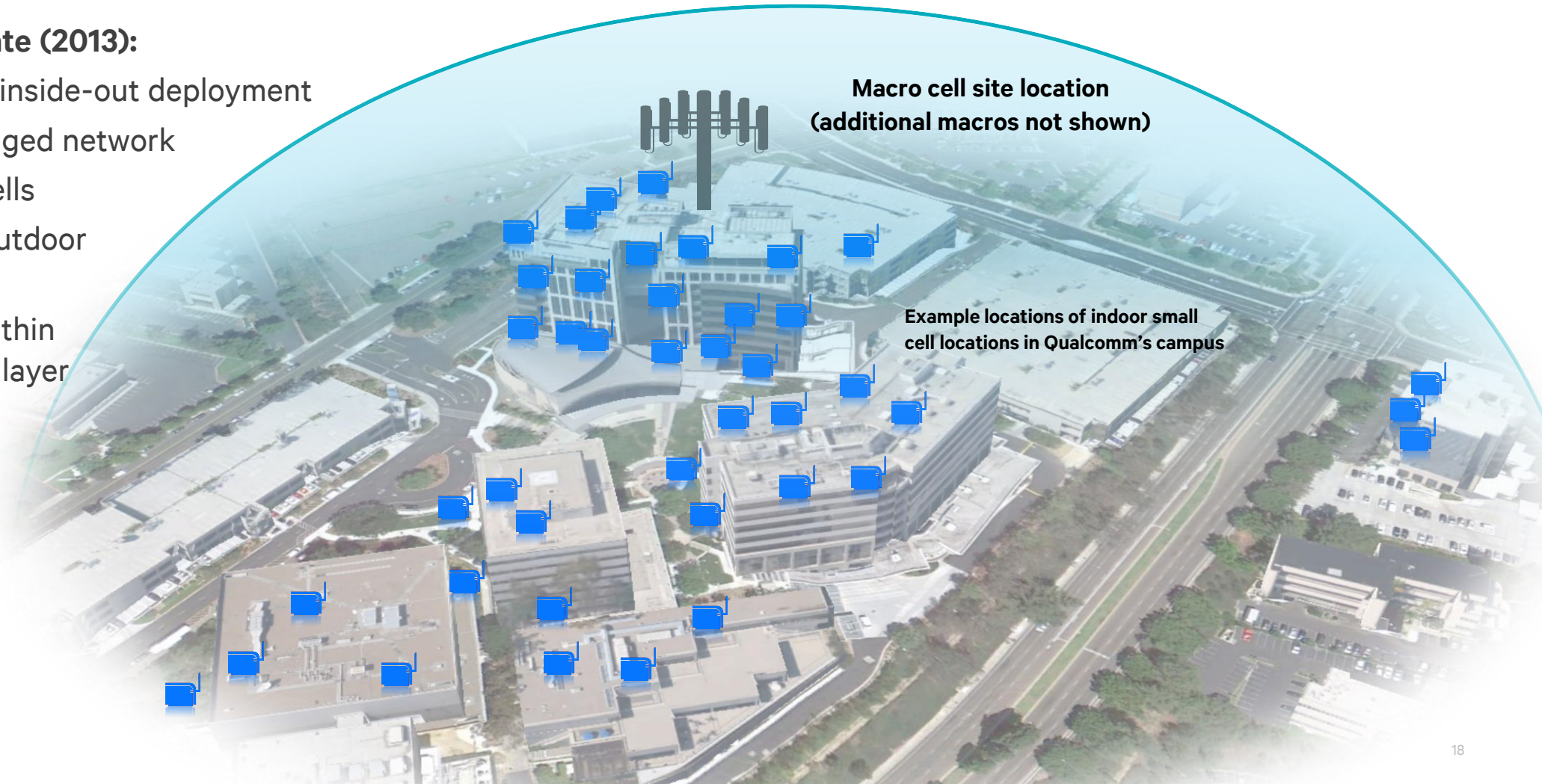
Shows actual measured received pilot strength for a small cell deployment: -115dBm results in ~700kbps for Rel-7 5MHz in thermal noise limited case; Points less than -115dBm are not shown on the plots.

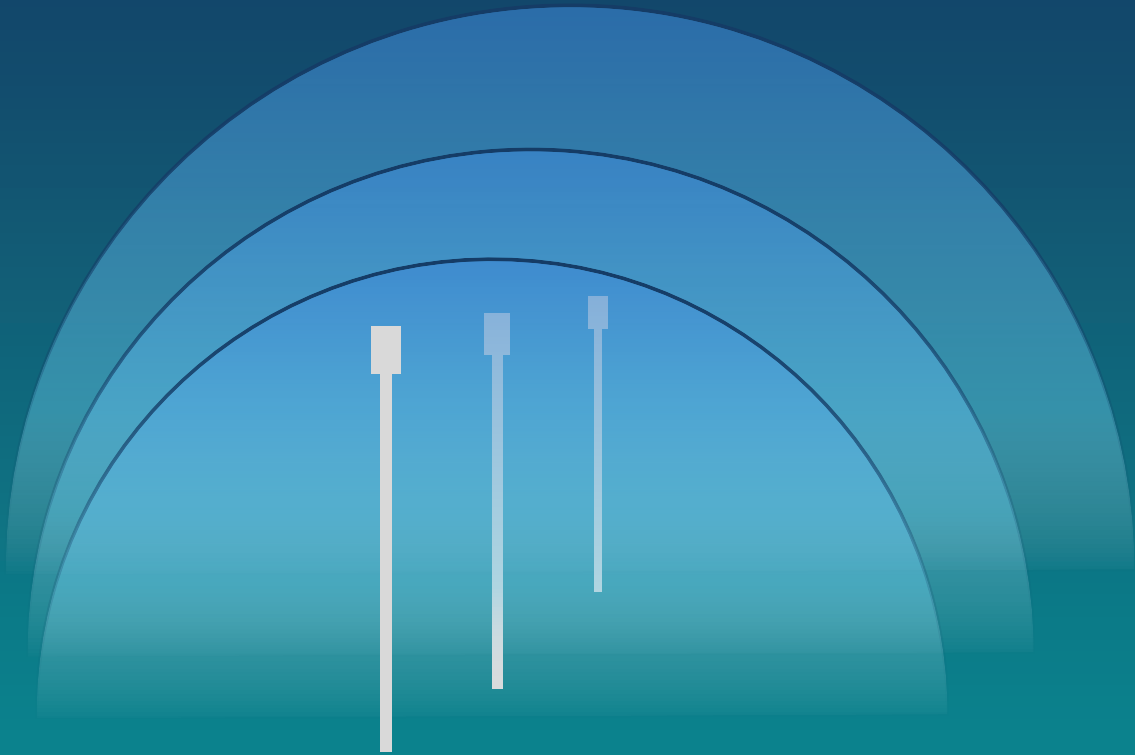
Taking viral, ad-hoc deployed small cells to the next level

Our over-the-air network will be expanded to a hyper dense network

We Plan To Demonstrate (2013):

- 'Unplanned', ad-hoc, inside-out deployment
- Controlled and managed network
- Coordinated small cells
- Robust indoor and outdoor operation
- Seamless mobility within small cell and macro layer
- Capacity gain





② More spectrum

A new way to access underutilized spectrum:
Authorized Shared Access (ASA)—suited for small cells

Current spectrum provides the foundation of 1000x – with more small cells and higher efficiency

**Harmonization and
global standards drive
economies of scale**

- North America**
- UMTS/CDMA AWS
 - UMTS/CDMA1900
 - UMTS/CDMA850
 - LTE700
 - LTE AWS
 - LTE2600 (B41)
 - LTE2000 (MSS S-Band)

- Europe**
- UMTS900/2100
 - LTE800/1800
 - LTE2600

- China**
- UMTS/CDMA2100
 - CDMA850
 - TD-SCDMA1900/2000
 - TD-SCDMA2300
 - LTE1900/2300
 - LTE2600 (B38)

- Japan**
- CDMA800/2100
 - UMTS800/900
 - UMTS1500/1700/2100
 - LTE700/800/900
 - LTE1500/1700/2500

- MENA**
- UMTS900/2100
 - LTE800/1800/2600
 - LTE2300

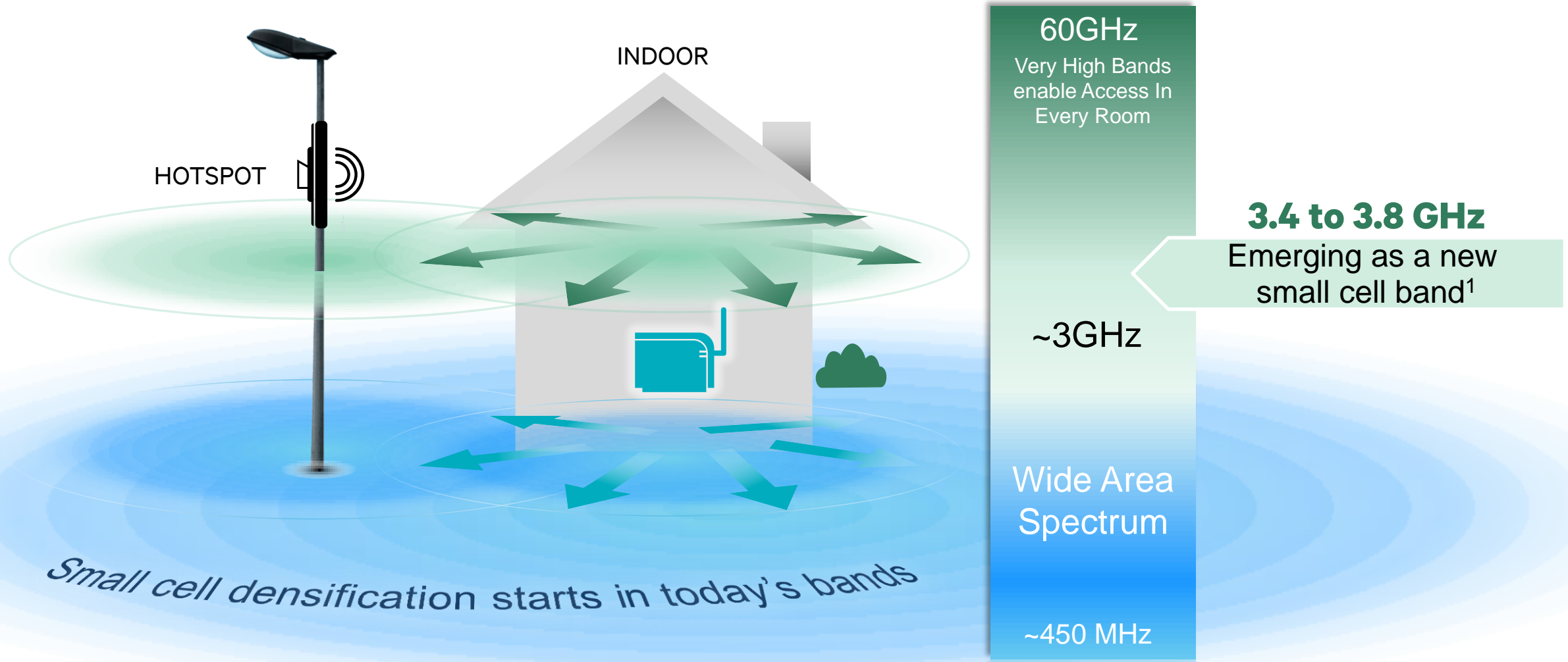
- South Korea**
- CDMA800/1800
 - LTE800/e850
 - LTE900/1800
 - UMTS2100
 - LTE2100

- India**
- CDMA850
 - UMTS900/2100
 - LTE2300

- South America**
- UMTS850/1800
 - UMTS1900/2100
 - LTE2600

- Australia**
- UMTS850/900
 - UMTS2100
 - LTE700/1800/2600
 - LTE2300

Higher spectrum bands suitable for small cells

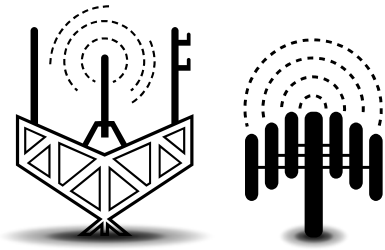


¹ Some parts can be traditionally licensed, some parts need to be **ASA licensed**, such as ~3.5GHz in the US/EU¹. 3GPP has already defined 3G/4G bands 42/43 for 3.4 GHz to 3.8 GHz, 3.5GHz in the US defined as 3550 – 3650 MHz. In addition, Wi-Fi in unlicensed such as 2.4GHz, 5GHz (802.11 ac) and 60GHz (802.11 ad).

We need to make best use of all spectrum types for 1000x

Licensed Spectrum

Auctions of cleared spectrum for 3G/4G

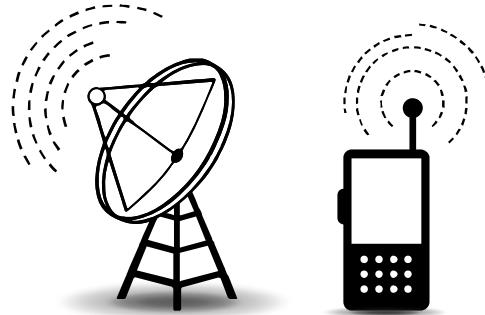


Exclusive use

Industry's top priority, ensures quality of service (QoS), mobility and control

Shared Licensed Spectrum

Complementary licensing for 3G/4G: Authorized Shared Access (ASA)

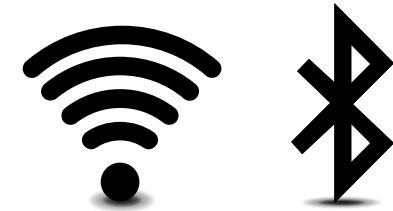


Shared exclusive use

ASA required when government spectrum cannot be cleared within a reasonable timeframe, or at all locations

Unlicensed Spectrum

Multiple technologies (Wi-Fi, LTE in unlicensed, BT & others)



Shared use

Unpredictable QoS, ideal for local area access, and opportunistic use for mobile broadband

Allocated spectrum may be underutilized

Incumbents (e.g. government) may not use spectrum at all times and locations

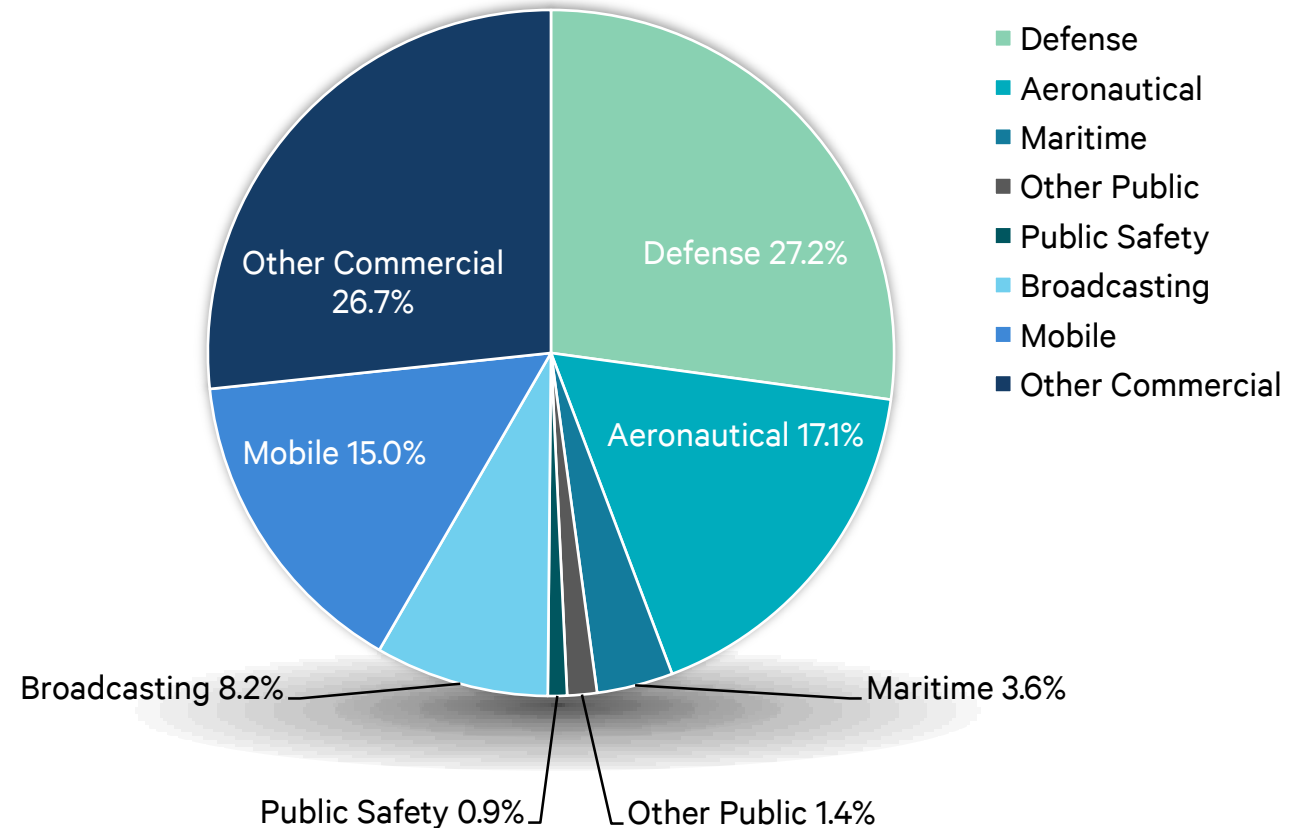
Challenge today



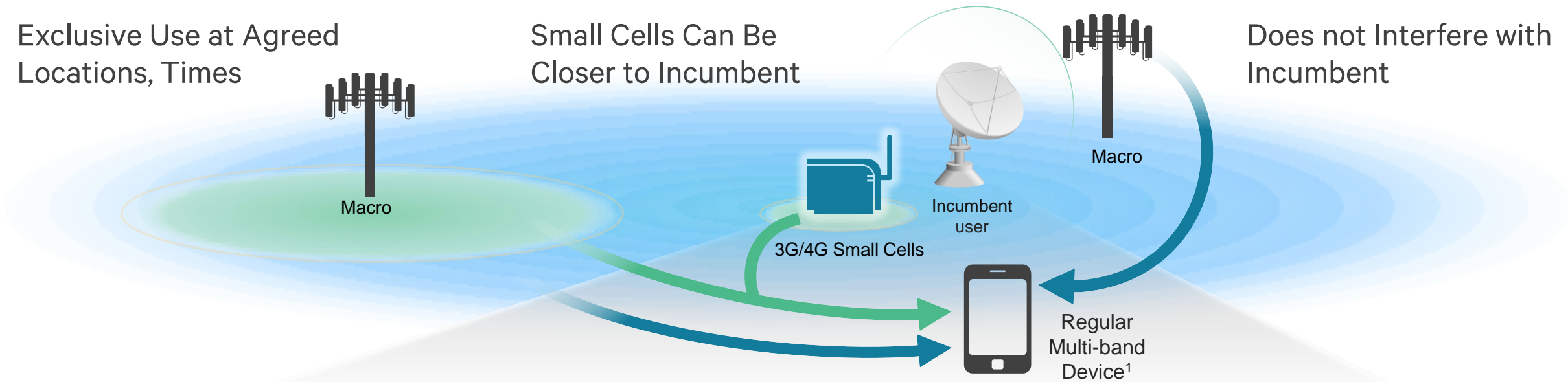
Repurposing and vacating spectrum takes longer and longer time.

ASA opportunity

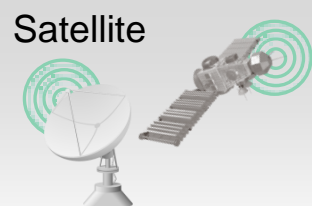
- Accelerate harmonization and potential re-farming.
- Access underutilized spectrum, which may always have incumbent spectrum holders.



Authorized shared access (ASA)—optimal for small cells



Incentive-Based Cooperation Model



Military Radar



Public Safety



¹ No device impact due to ASA, just a regular 3G/4G device supporting global harmonized bands targeted for ASA. Carrier aggregation would be beneficial to aggregate new ASA spectrum with existing spectrum, but is not required.

ASA targets harmonized spectrum—suitable for small cells

Leveraging global, available 4G technologies to ensure economies of scale

ASA CANDIDATE EXAMPLES	2.3 GHz (100 MHz)	2.6 GHz (100+ MHz)	~3.5 GHz (100-200 MHz)
Applicable Regions	EUROPE (Traditionally licensed in e.g. India)	MENA (Traditionally licensed in e.g. Europe)	USA, EU, LATAM, SEAP
Incumbent Users	Telemetry, public safety, cameras	Various	Naval Radar (US) Satellite (EU, LATAM, SEAP)
Suitable Technology	LTE TDD	LTE FDD/TDD	LTE TDD
Possible Launch	~2015		

3.4 to 3.8 GHz

Emerging as a key band for 3G/4G small cells, some parts can be traditionally licensed, but some parts need to be **ASA licensed**, such as ~3.5GHz in the US/EU¹

¹ 3GPP has already defined bands 42/43 for 3.4 GHz to 3.8 GHz, 3.5GHz in the US defined as 3550 – 3650 MHz, but up to 200MHz could be targeted for ASA in e.g. SEAP/LATAM. Note that ASA targets IMT spectrum bands, but the concept can be applied generally to all spectrum bands and other technologies

1000X

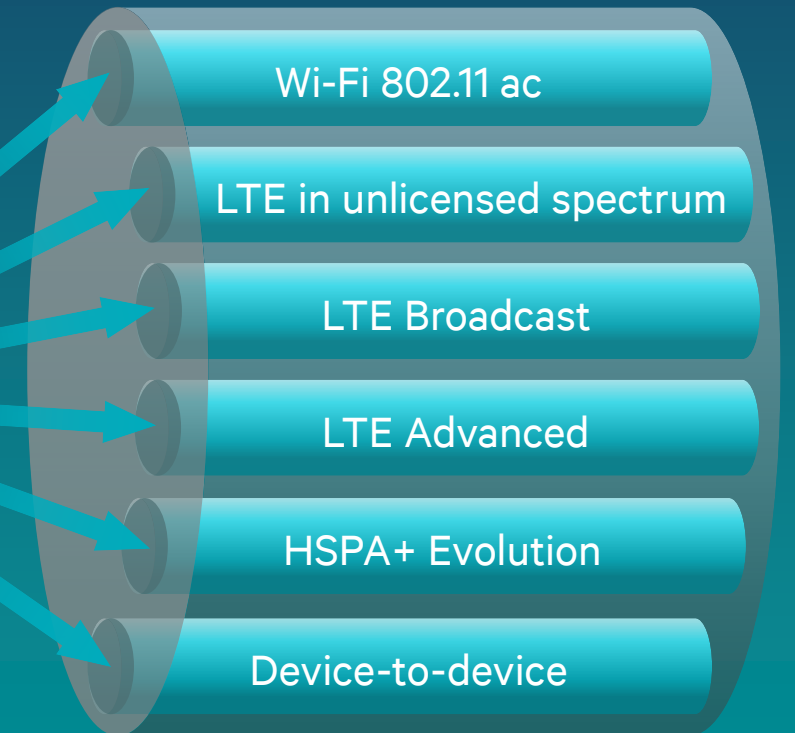
More efficient
apps & services



Intelligently
access 3G/4G/Wi-Fi

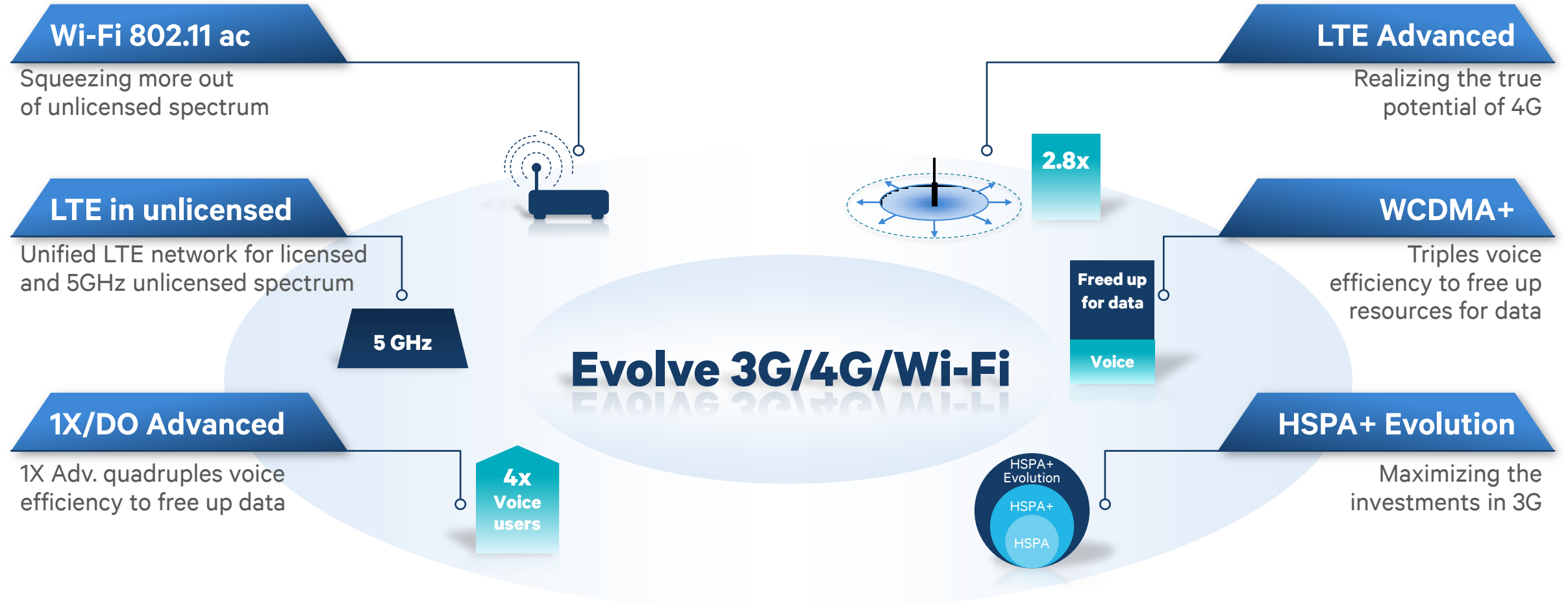


More efficient data pipe
—evolve 3G/4G/Wi-Fi



③ Higher efficiency

Utilizing finite spectrum resources better



Significant gains still possible for certain traffic

>10x

(HSPA+ Advanced example, compared to HSPA+ R7/R8)



Small Data Bursts

>10x

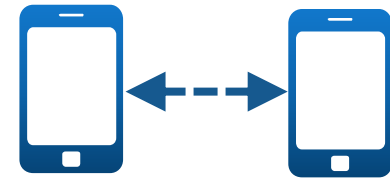
(More per 6 multicast users in a network vs. 6 unicast users in dense urban area, but ~3x gain for just two users)



LTE Broadcast

>10x

(Less resources to discover proximal devices within 20s in a cell with 800 users, vs. regular LTE. Can also discover 16x more devices than Wi-Fi Direct)



Device to Device Discovery and Communication—LTE Direct

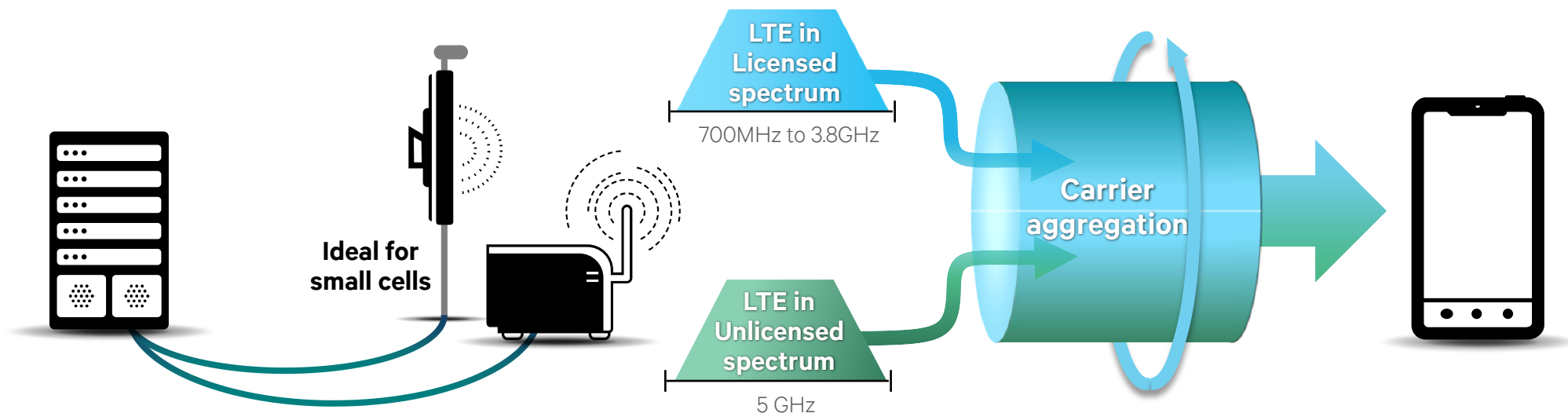
Extending the benefits of LTE Advanced to unlicensed spectrum

Better performance

Longer range and increased capacity

Enhanced user experience

Thanks to LTE Advanced anchor in licensed spectrum with robust mobility



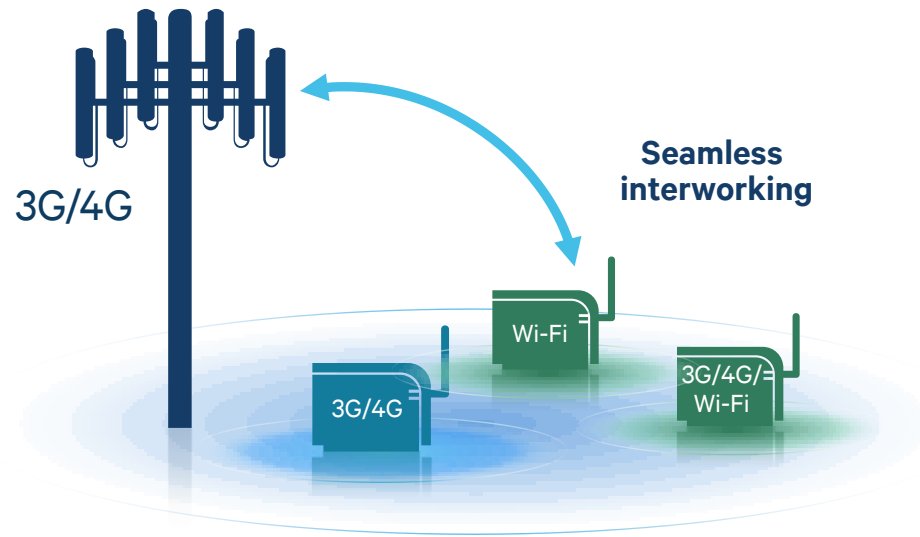
Unified LTE Network

Common LTE network with common authentication, security and management.

Coexists with Wi-Fi

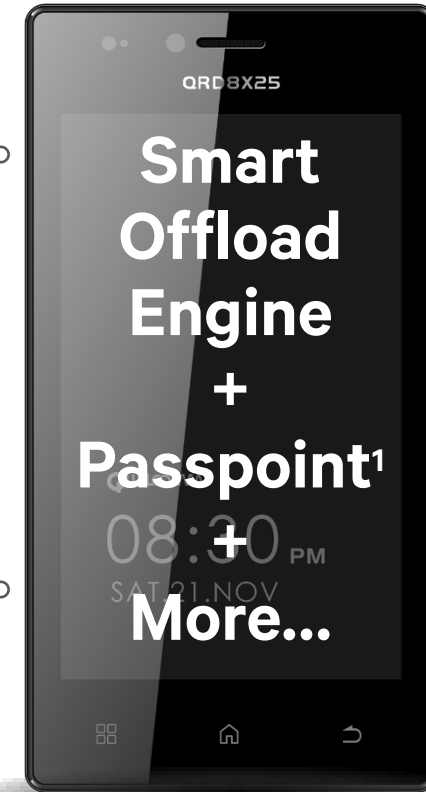
Features to protect Wi-Fi neighbors

Intelligently utilize best and multiple accesses— 3G/4G Small Cell/Macro, Wi-Fi



3G/4G Quality

Operator preferences



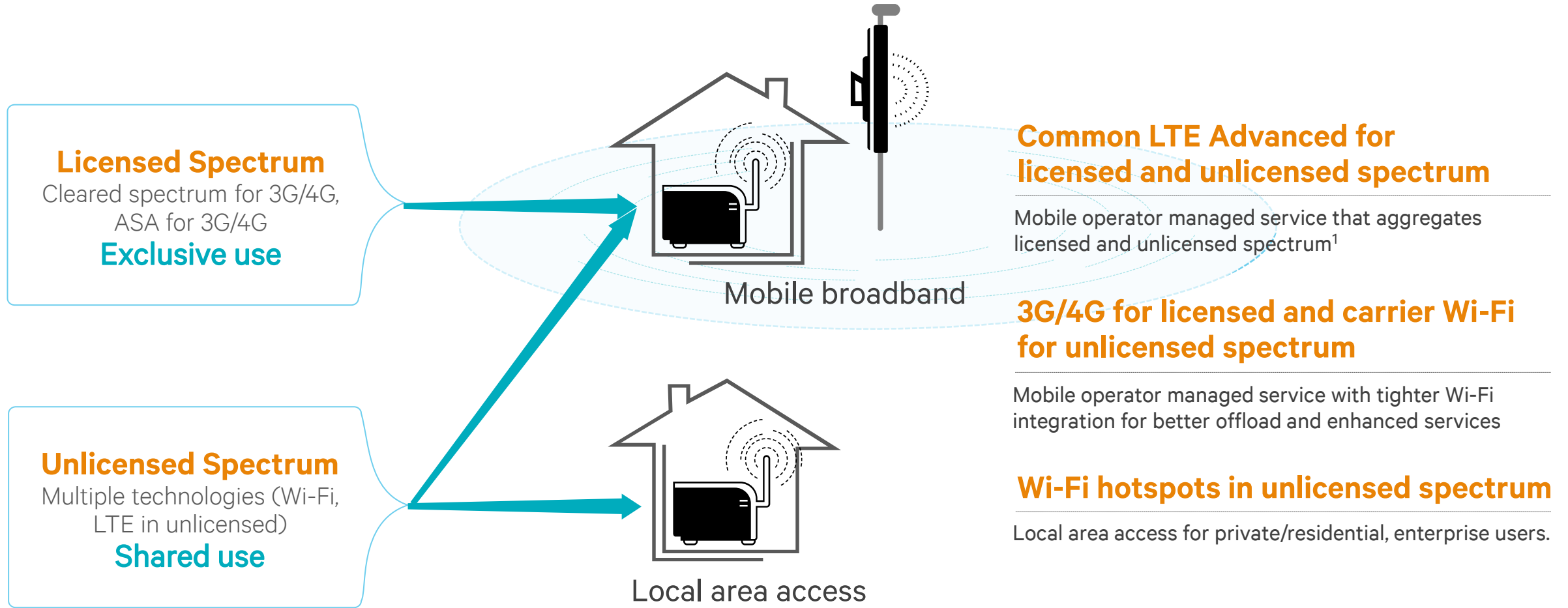
Wi-Fi Quality

Traffic/App Characteristics

(e.g. different traffic on different access)

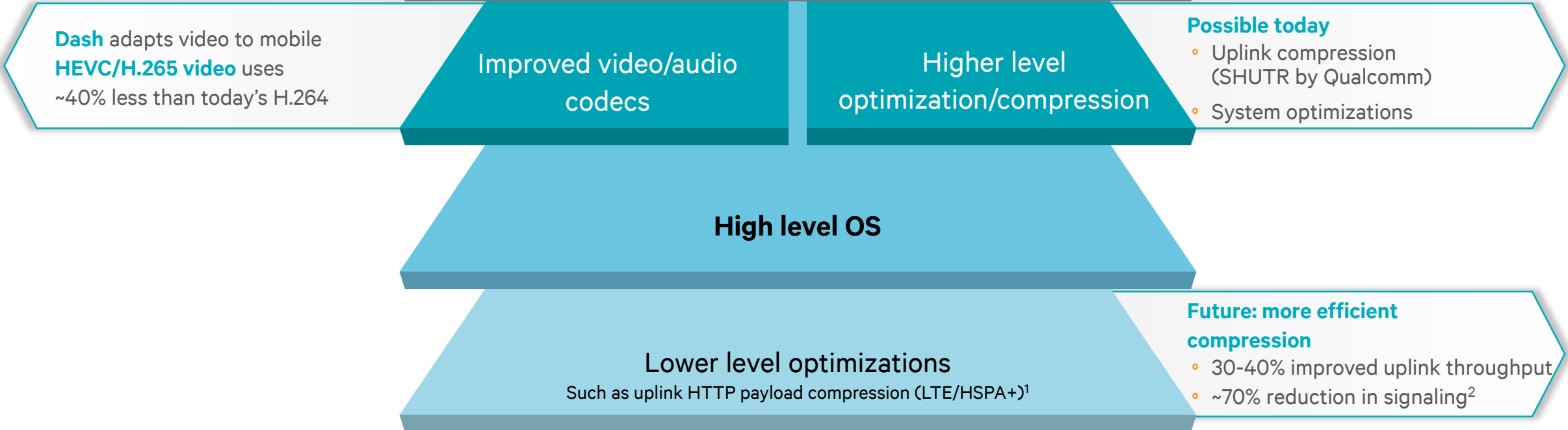
A leader in all solutions to best leverage unlicensed spectrum

Committed to end-to-end Wi-Fi, carrier Wi-Fi, bringing LTE Advanced to unlicensed spectrum



¹With Wi-Fi for backward compatibility

More efficient apps. & services: optimizations on multiple levels

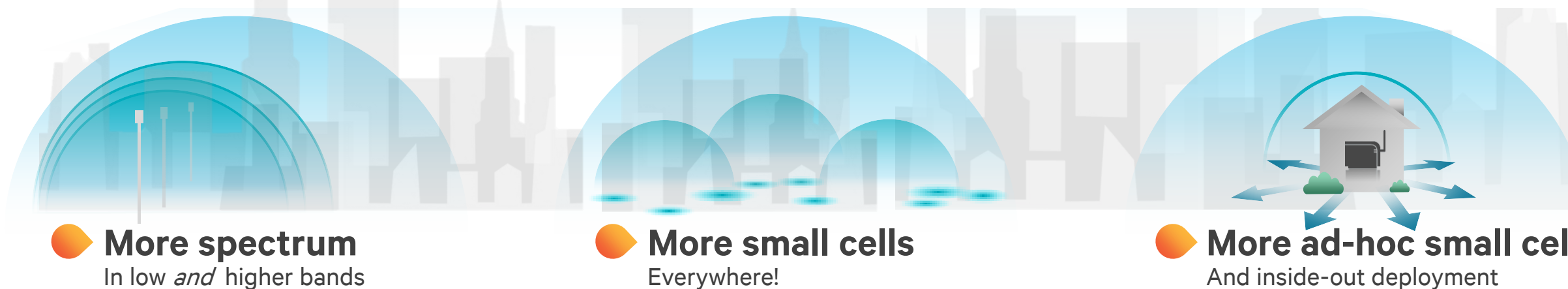


¹3GPP R12 proposal: Add payload (e.g. HTTP GET & POST packets) compression to the PDCP layer, header (RoHC/IPHC) compression already resides in PDCP. Uplink compression is suitable since highly compressible HTTP packets are ~70% of uplink smartphone data volume (based on Qualcomm logs). ²Reduction in Radio Resource Control (RRC) transitions, which drives network signaling, frees up resources for more data capacity

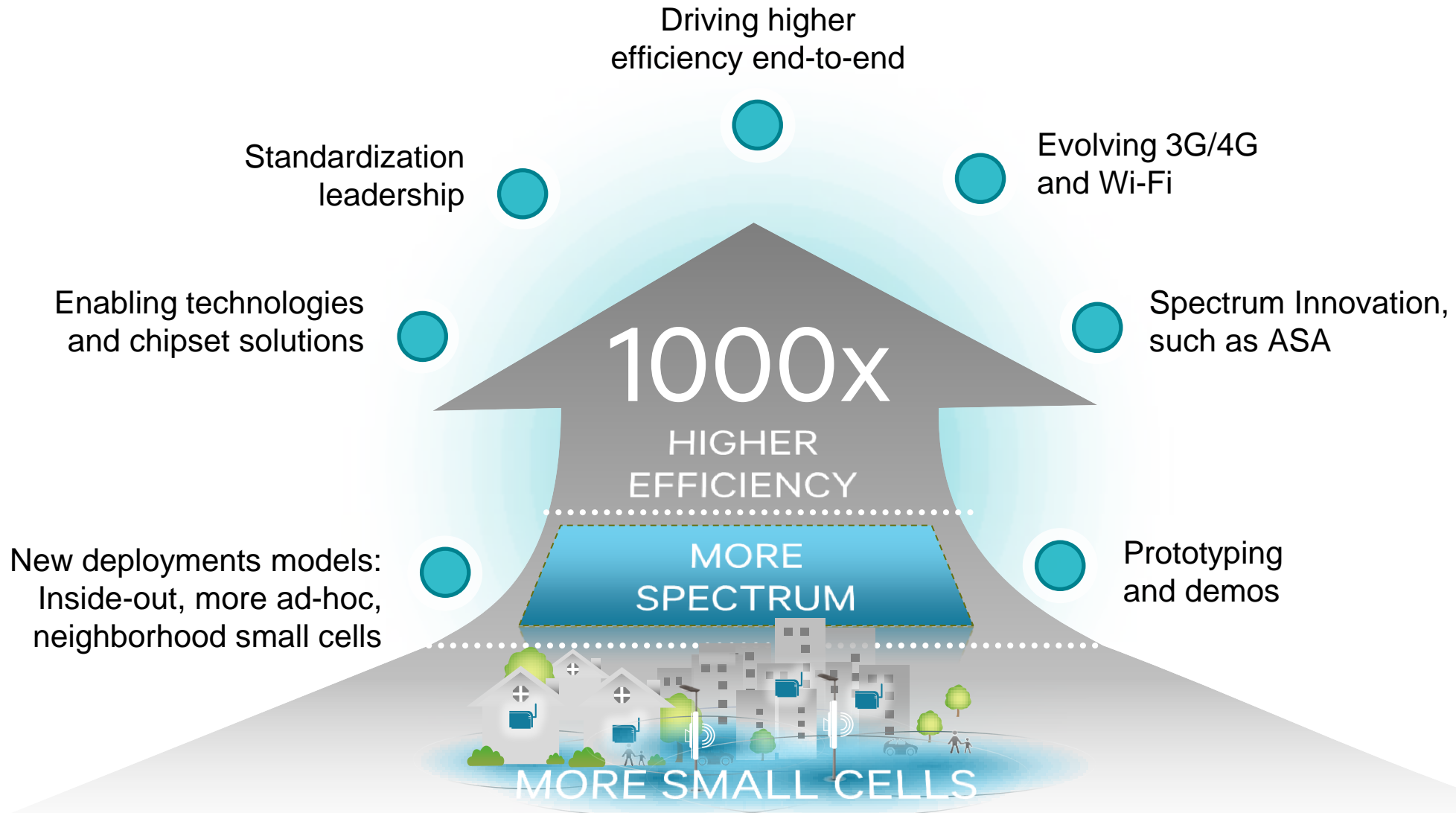
There are multiple ways to reach 1000x



Different mixes of Spectrum, Small Cell Types, Indoor, Outdoor to Reach 1000x



Qualcomm at the forefront to enable 1000x



**Will There Be 1000x Demand?
It's Just a Matter of Time...**

1000x 

Driving Network Evolution

to learn more, go to

www.qualcomm.com/1000x

- More details provided at:
 - 1) 1000x: More Spectrum
www.qualcomm.com/spectrum
 - 2) 1000x: More Small Cells
www.qualcomm.com/HetNets
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1000X

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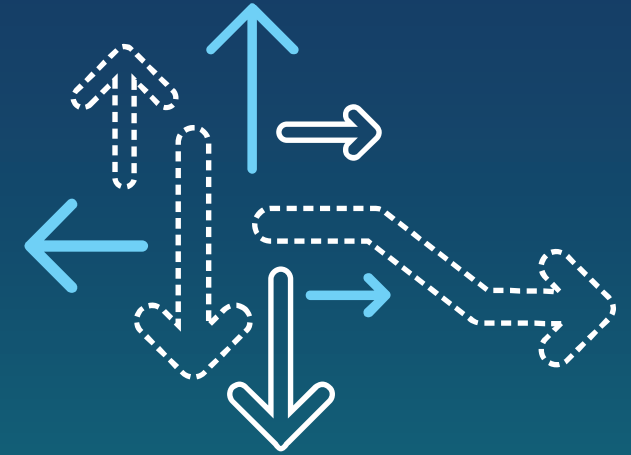
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