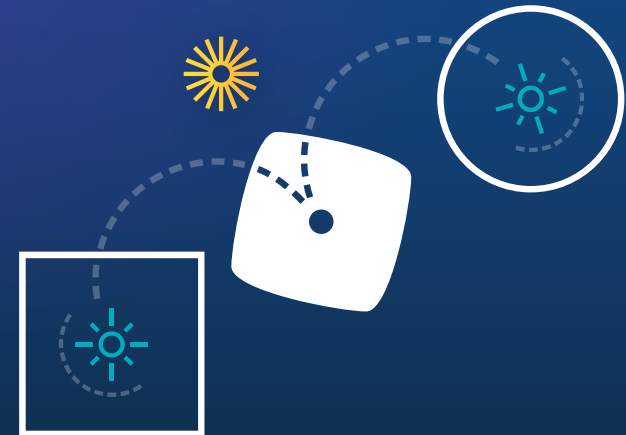November, 2014

Qualcomm's 5G vision

QUALCOMM®

Mobile is the largest technology platform in history

~7 billion connections, almost as many as people on earth[1]

Evolving into Internet of Everything: cars, meters, sensors, health devices, etc.

More prevalent than electricity or running water in some regions

At the center of breakthrough experiences like 4K UHD video

[1] ~7B connections (~3.5B subs) — GSMA Intelligence, Apr. '14.

Mobile has made a leap every ~10 years

1G
Analog
voice

AMPS, NMT, TACS

2G
Digital voice

D-AMPS, GSM,
IS-95 (CDMA)

3G
Mobile broadband

WCDMA/HSPA+,
CDMA2000/EV-DO

4G
Faster and
better MBB

LTE,
LTE Advanced

1980s

1990s

2000s

2010s

Mobile surpassed fixed-line, then PC
Human communication

Era of mobile phones
Primary communication device

Era of Smartphones
Center of new experiences and services

2002
Surpassed fixed voice

2010
Surpassed fixed BB

2013
Surpassed PC

5G to meet needs beyond today's trends

Mainly addressed by 3G/4G/Wi-Fi and its evolution

More video

Richer content like 4K Video

~2/3

of mobile traffic will be video by 2017[3]

More devices

Smartphones

~8B

Cumulative smartphone shipments forecast between 2014-2018[1]

More things

Connected

~ 25B

Interconnected device forecast in 2020[2]

More data

Small cells

1,000x

from ~2010 to the 2020'ies

[1]Gartner Mar'14 [2]Machina Research/GSMA, Dec. '12. [3]Cisco, Feb. '13

Can we predict the world in 2025?

To maximize the opportunity, we need a user-centric approach—around human, thing, machine

Communication	>	Also to control and discover
Best effort data	>	Also ultra reliable and aware services
Device as end-points	>	Also new ways of connecting everything

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Scalability and adaptability

To connect everything, across an extreme variation of types of services and use cases

User-centric design

To scale for billions of connected things, provide new ways of connecting, and to improve cost and energy efficiency

Unified platform

Unifying platform for all spectrum, new deployment/business models, and a wide range of new services for the next decade

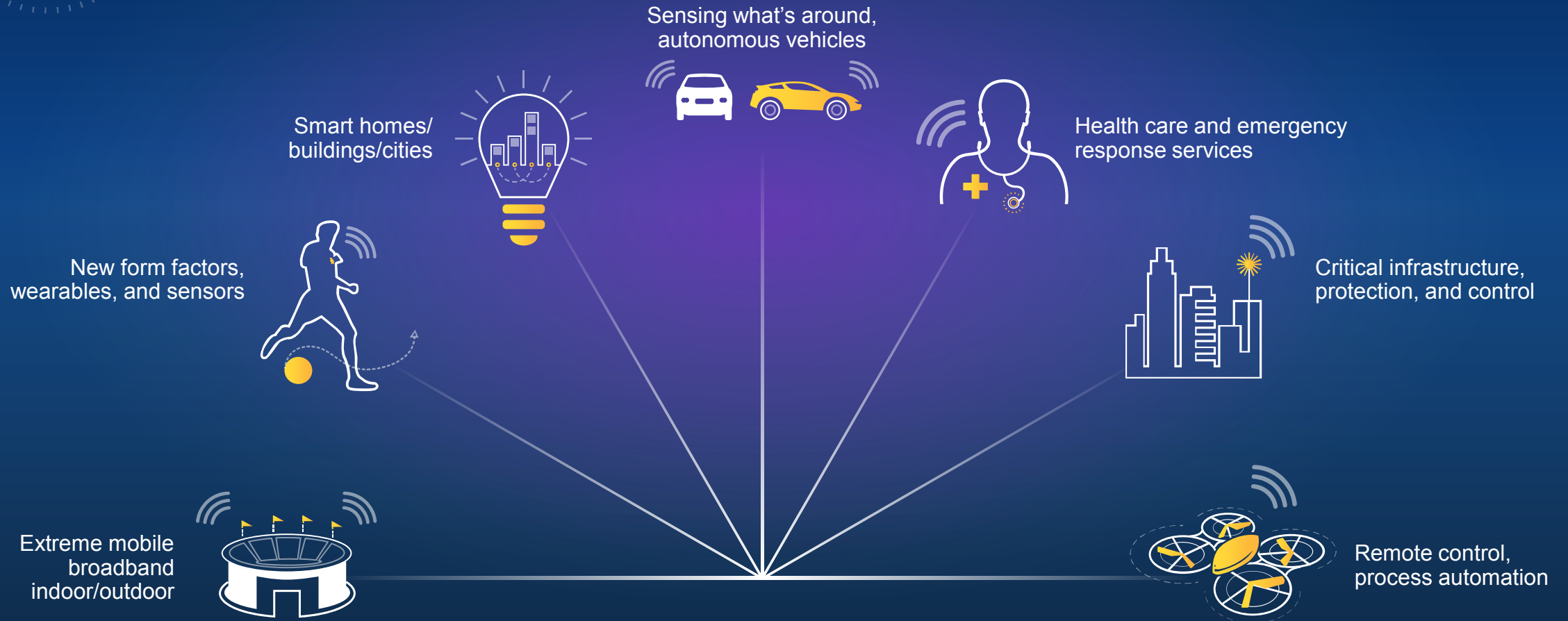# In parallel: driving 4G and 5G to their fullest potential

5G

Fully leverage 4G investments
Improve cost and energy efficiency
Enable a wide range of new services
A unified, much more capable platform

Further backwards-compatible enhancements

Flat architecture
CoMP   FeICIC   Unlicensed spectrum
Carrier aggregation   MTC   Massive/3D MIMO
TDD/FDD
Broadcast   Device-to-device

LTE   LTE Advanced

4G   SON   Relays   Dual connectivity   256QAM   Enhanced CA
SIPTO   SON+   Lower latency

2010   ~2020   2030

Scalability and adaptability to **connect everything**

Support current and emerging services

Sensing what's around, autonomous vehicles

Smart homes/ buildings/cities

Health care and emergency response services

New form factors, wearables, and sensors

Critical infrastructure, protection, and control

Extreme mobile broadband indoor/outdoor

Remote control, process automation

Support current and emerging services

Massive number of things
Connect everything

Proximal and aware services
New ways of interacting

Sensing what's around, autonomous vehicles

Smart homes/ buildings/cities

Health services and emergency response

Mobile broadband
Enhancing the foundation

New form factors, wearables and sensors

Critical infrastructure, protection and control

Mission-critical services
Failure is not an option

Extreme mobile broadband indoor/outdoor

Remote control, process automation

Support extreme variation in requirements

Ultra-high reliability

Ultra-low energy

High security

Ultra-low cost

Massive Number of Things

Mission Critical Services

Flawless mobility

Deep coverage

Enhanced Mobile Broadband

Extreme broadband

Ultra-low latency

Deep awareness
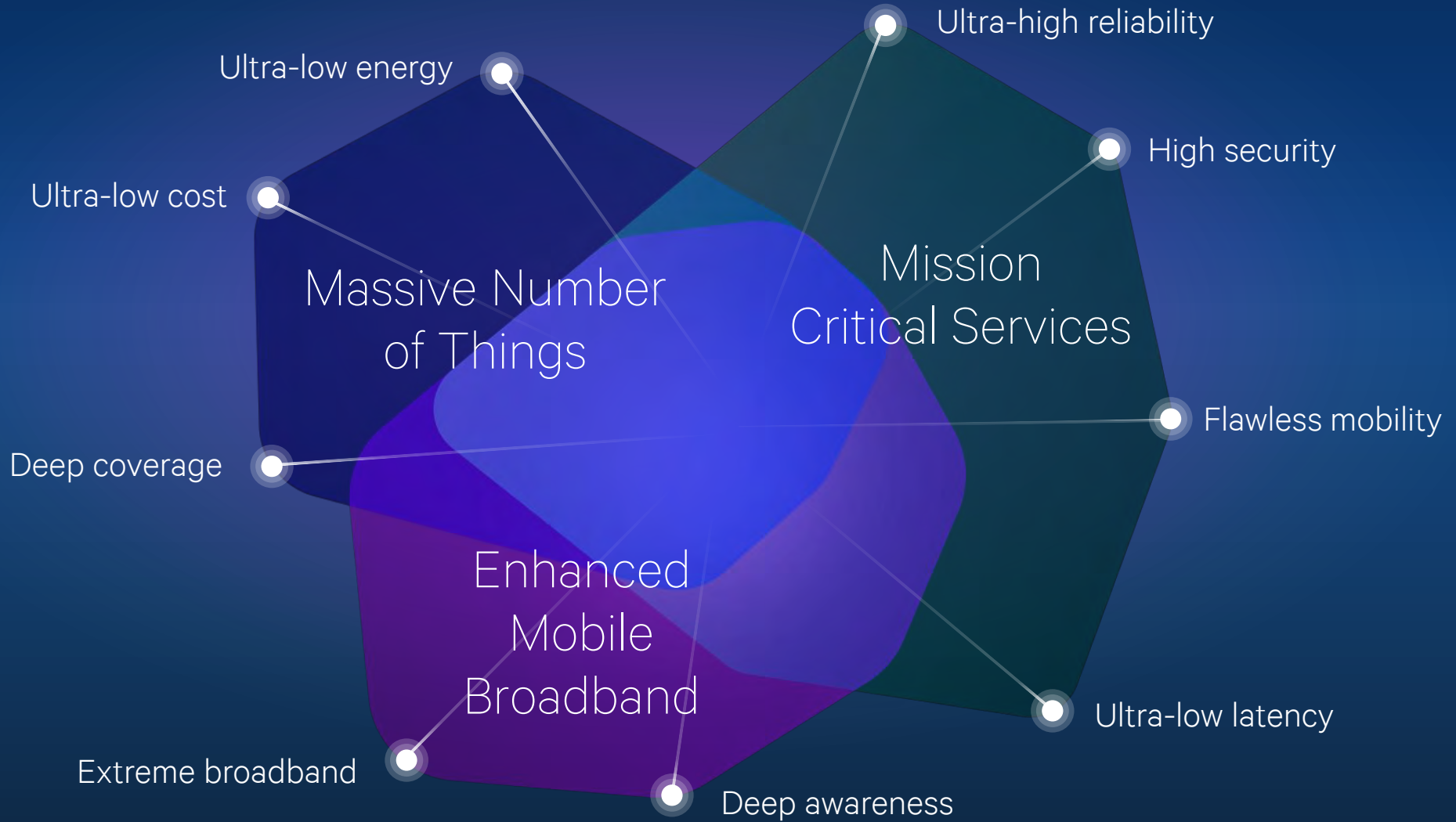
A **user-centric** design

User-centric
Bring connectivity, computing and content close user

Computing

Connectivity

Content/data
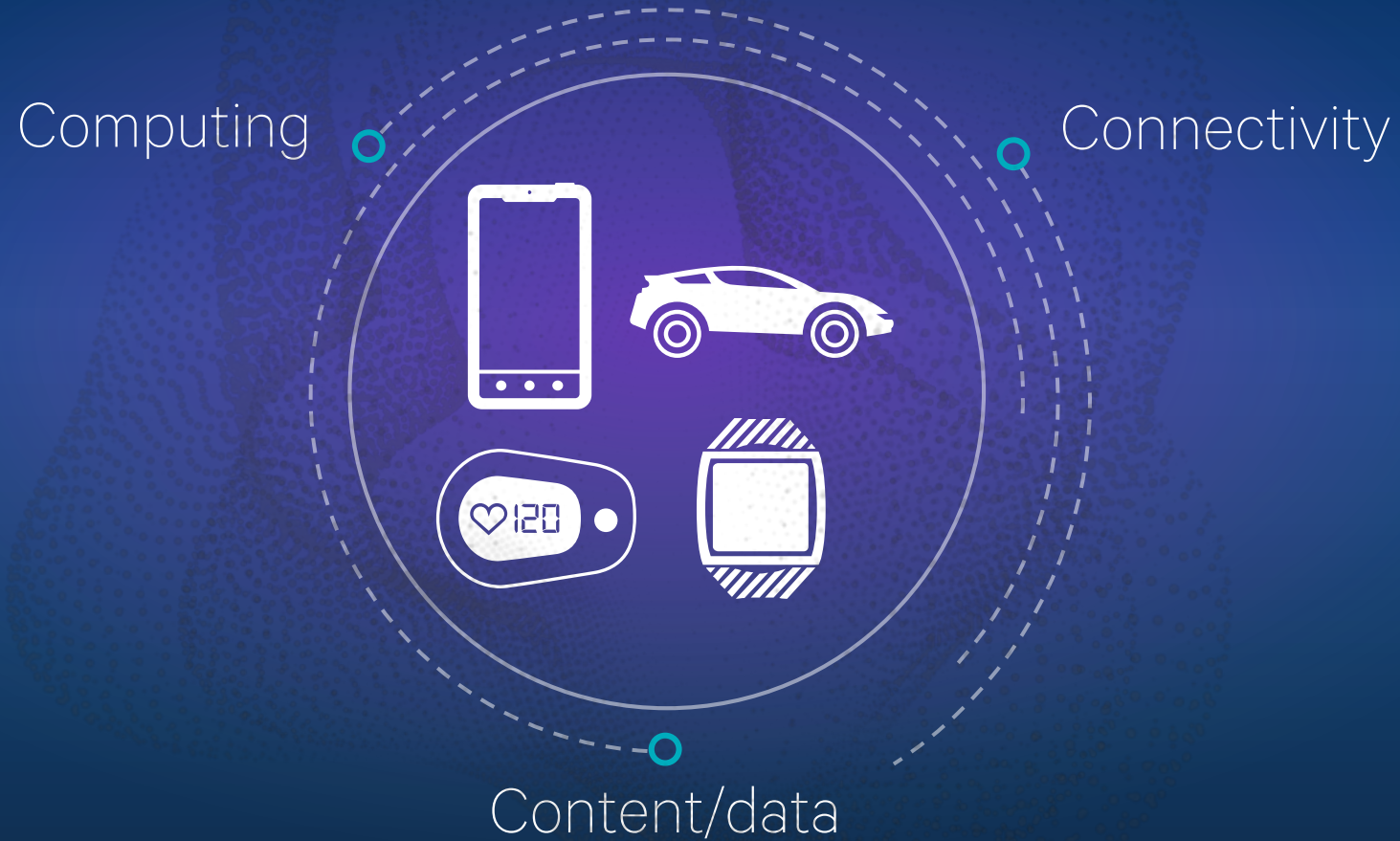
User-centric connectivity
Device is not just an end-point—integral part of the network

User-centric connectivity
Achieving truly edgeless connectivity with 5G

Multi-hop to
extend coverage

Device-to-device discovery
and communications

Integrated access and
backhaul, relays
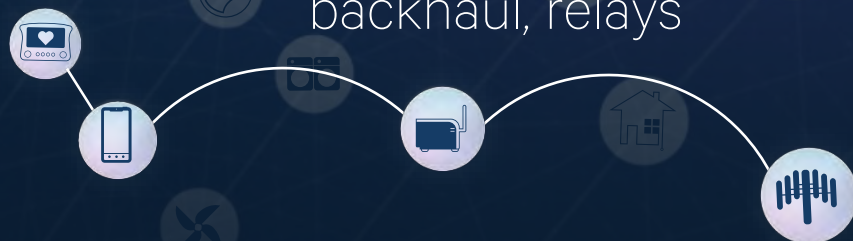
User-centric computing—on devices, things
Continuing today's trend, and more cognitive technologies

Reasoning
such as learn and adapt

Perception
such as see and hear

Actions
such as act intuitively

Expanded human abilities   Contextual personalization   Human-like interactions

And multiple enablers for uniform user experiences and more capacity

Context and service awareness | **Full Self-Configuration** | **Truly unplanned deployments** | **Hyper dense deployments**

Backhaul

Interference Coordination

Beam forming

Coordinated Spatial Techniques

Advanced Receivers

Massive Spatial Processing
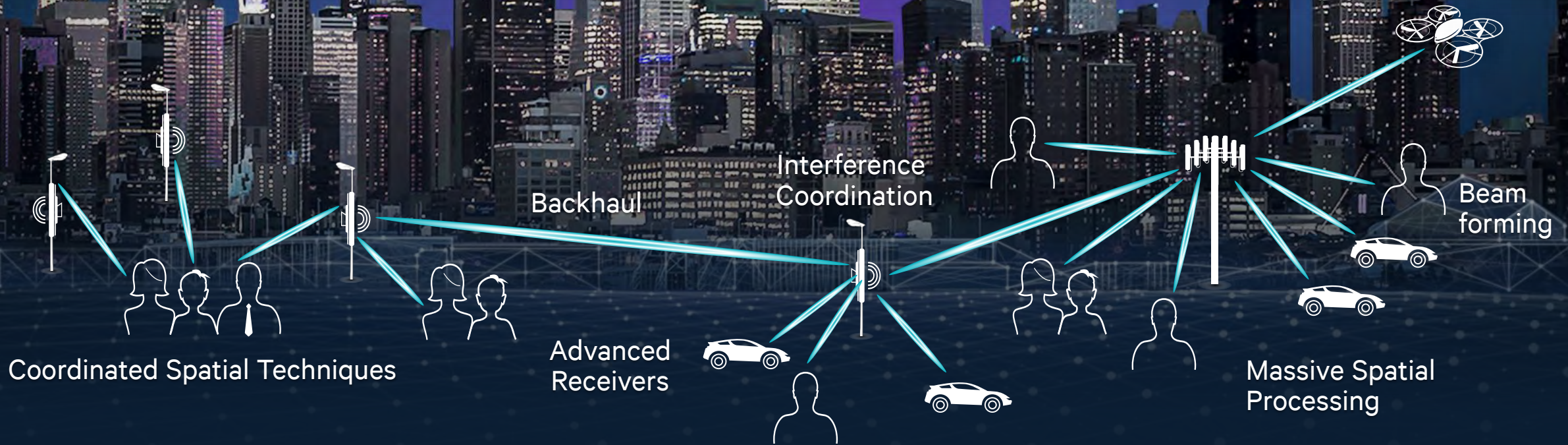
A **unified** connectivity platform for the next decade and beyond

Unified 5G design across spectrum types and bands

Licensed Spectrum	Shared Licensed Spectrum	Unlicensed Spectrum
Cleared spectrum	Complementary licensing	Multiple technologies
EXCLUSIVE USE	SHARED EXCLUSIVE USE	SHARED USE

Below 1 GHz: longer range, massive number of things

Below 6 GHz: mobile broadband, mission critical

Above 6 GHz including mmWave: for both access and backhaul, shorter range

User-centric, flexible and scalable network

WI-FI

4G
RAN

5G
ACCESS

Multi access to a single core network
And simultaneous connectivity

Distributed Architecture
Reduced overall cost, reduced backhaul and lower energy

Virtualized network functions
Dynamically distributed based on mobility

Modular core network
Scale from wide area deployments to hotspot nodes

Flexible business models
Deployment, subscription, charging

Lower latency
Such as control and user plane closer to edge

Edge security
Design for less-trusted nodes

Simultaneous connectivity to leverage 4G investments

Small cell

Macro

5G/4G/3G/Wi-Fi multimode device

5G Carrier Aggregation[1]

| 5G above 6Ghz |
| 5G below 6GHz |
| 4G and Wi-Fi |

| 5G below 6GHz |
| 4G |

Simultaneous connectivity across 5G, 4G and Wi-Fi

5G coverage

4G coverage

[1]Thanks to integrated MAC across sub 6 GHz and above 6 GHz
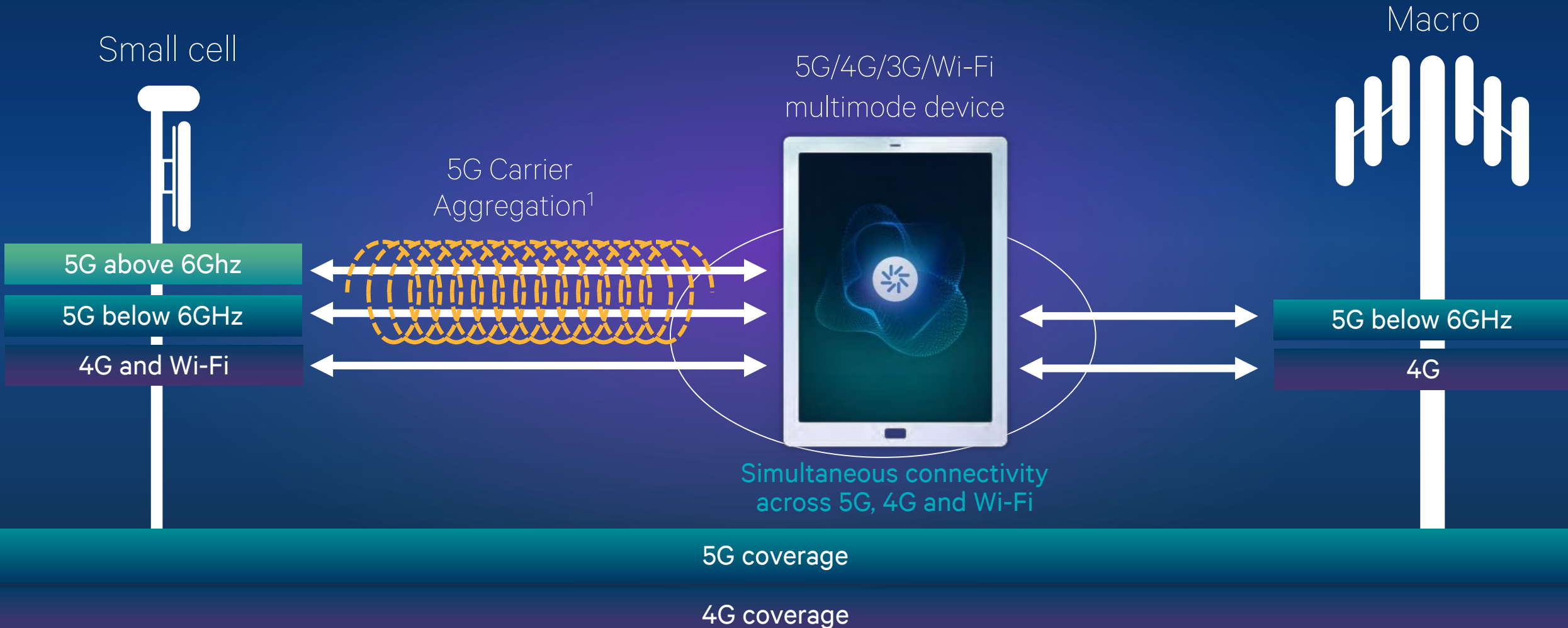
Scalable from wide area to local area deployments

Wide area network
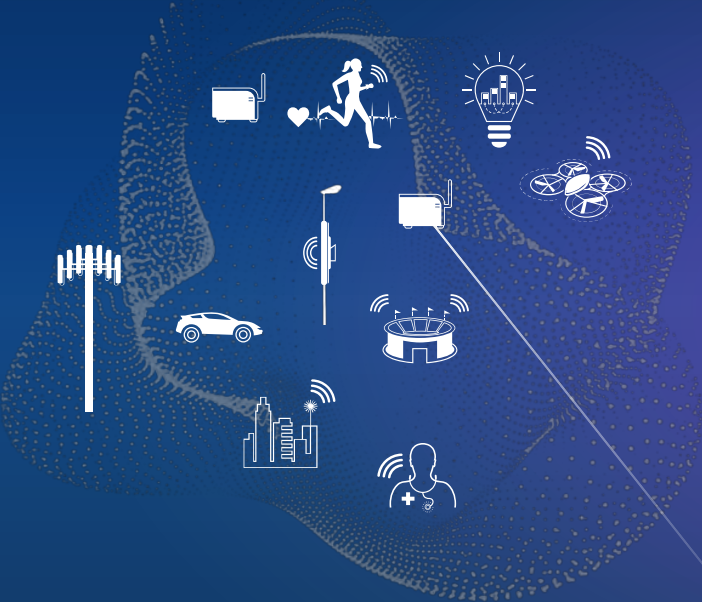
Local area network

Hotspot/residential

Operators

MVNOs   Enterprises   Consumers

Network sharing & hosting
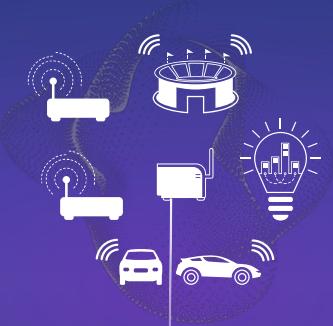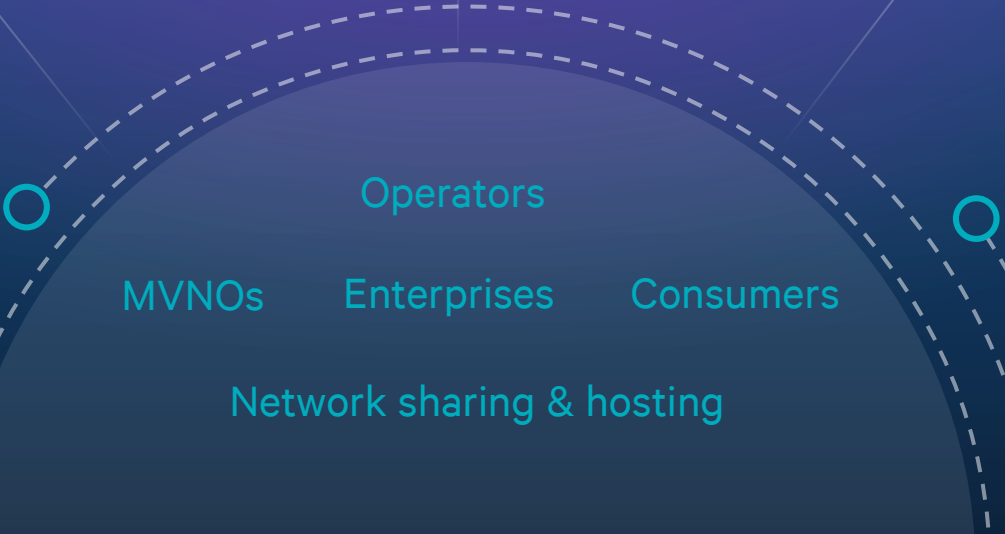
A unified platform for expanded connectivity needs for the next decade and beyond

Unknown new service

Mission-critical services

Proximal/aware services

Massive # of things

Mobile broadband

New services & devices

New business models

Wide to local area deployments
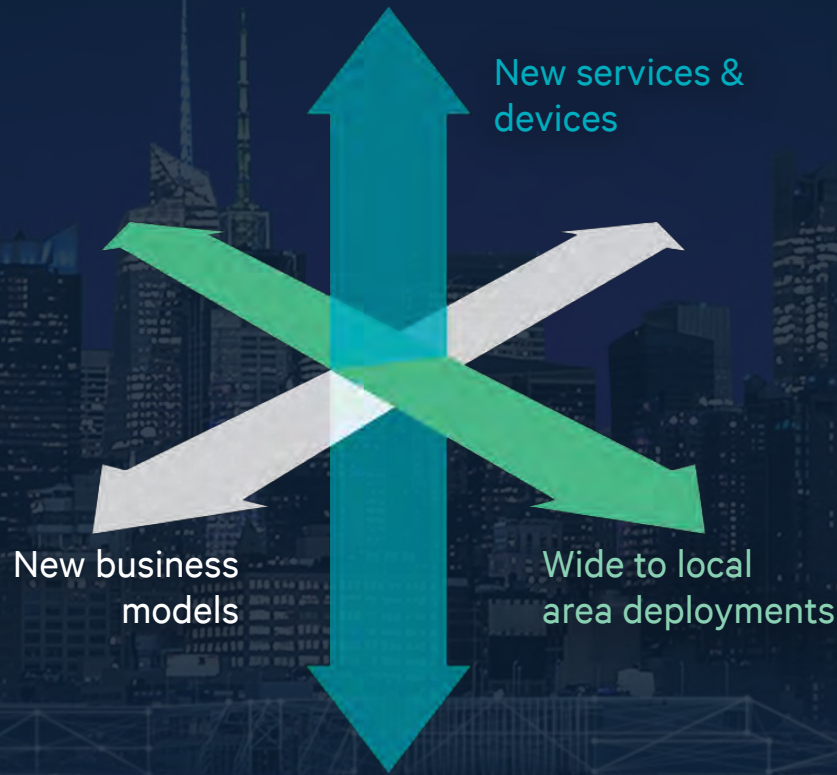
Thanks to a user-centric, distributed design

New services, unify all spectrum

Scalability across broader dimensions

Cost and power efficiency

Meeting new connectivity needs for the next decade

Uniform fiber-like mobile broadband with deep awareness

New services like mission critical remote surgery

Connecting everything from simple sensors to complex robots
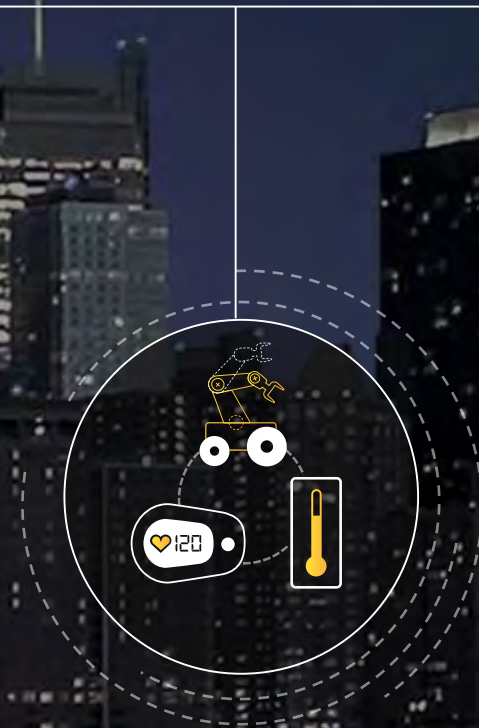
5G: not just a new generation, but a new kind of network

Connectivity

Computing

Content/data

Enabling | **Connecting** | **Empowering**
new services | new industries and devices | new user experiences

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BLOG

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http://storify.com/qualcomm_tech
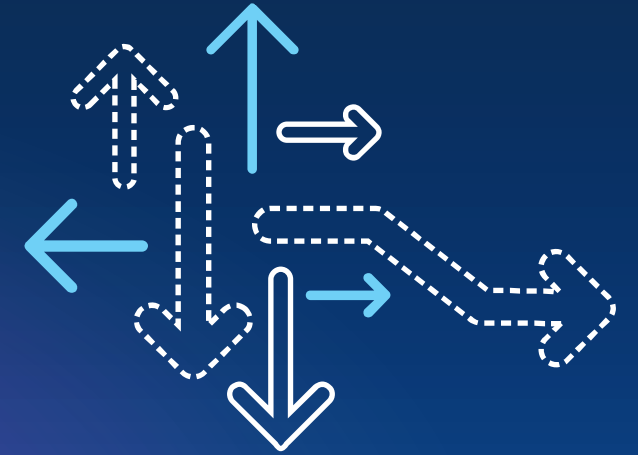
Thank you

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