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# Hup-2-3-4... Do we stop at Four?

A perspective on the wireless industry

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QUALCOMM®



1

The technology today

2

The challenges

3

**Some new  
Technology  
Directions**

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# Agenda



# MOBILE

WORLD'S LARGEST TECHNOLOGY PLATFORM



# Smartphone: our most personal device

# ~80B

DOWNLOADED  
APPS in 2013

## ~106

Avg. number of daily  
app launches by US  
Android users

## ~64%

In Brazil used them  
to watch video in  
a web browser



## ~80%

Chinese users  
sleep with them  
at arm's reach

## ~78%

On global basis use  
them to play games

Percentages of smartphone users / owners.

Sources: comScore custom research avg. over Q3'13, GroupM, Jul. '13, Nielsen, Feb. '13, Strategy Analytics, Q2 '12

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# Mobile is redefining computing

PC Era



Mobile Era



CPU-centric  
(Gigahertz race)



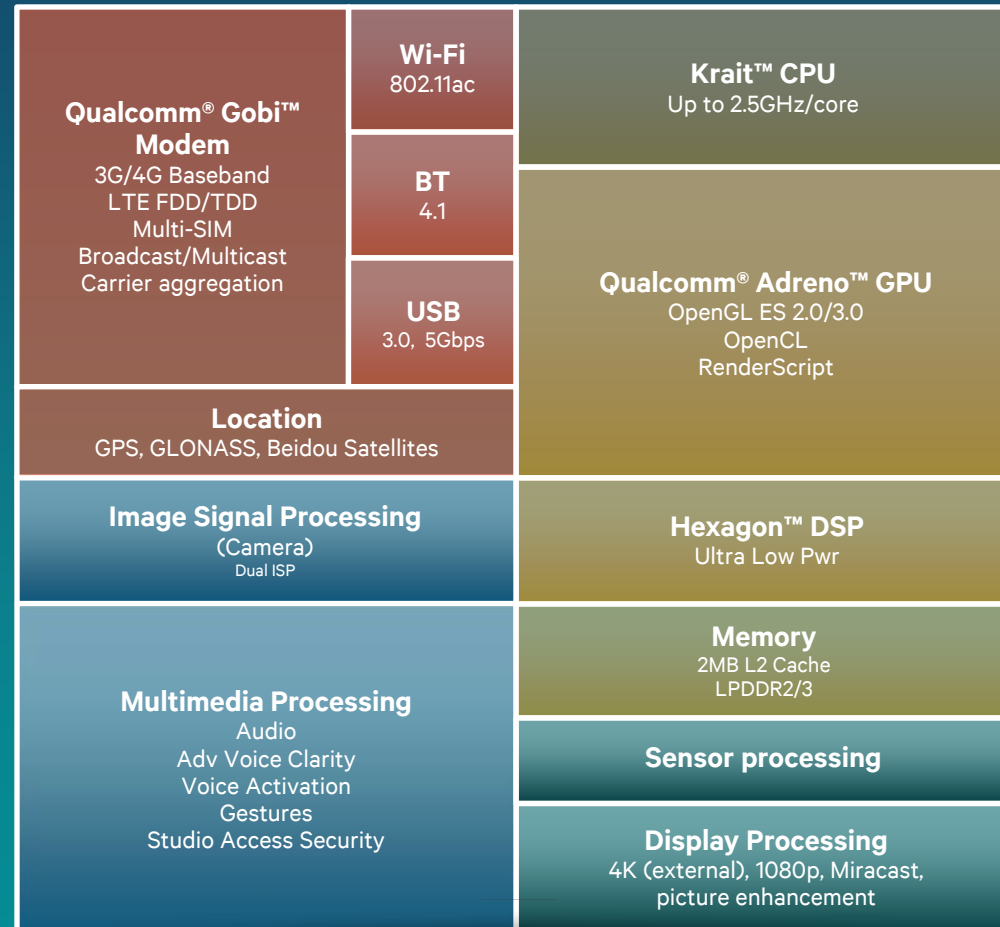
User experience oriented  
(System level innovation)

Always on  
Always connected  
Always with you

**~7 BILLION**  
cumulative smartphone unit sales forecast between 2013–2017

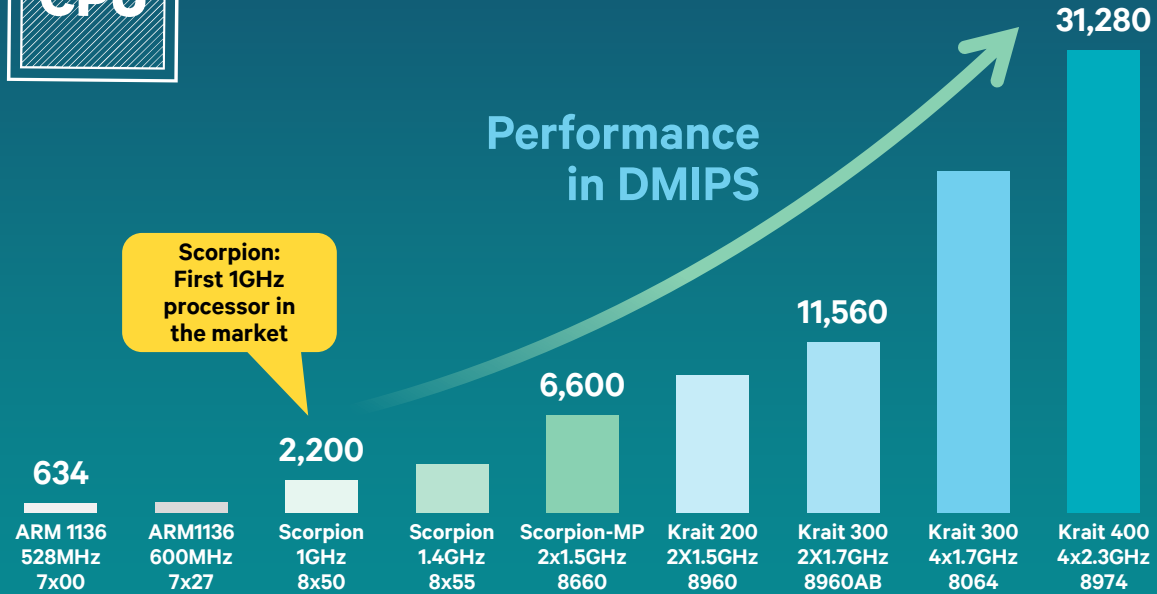
# Comprehensive platforms at the heart of mobile computing

## Integration of multiple specialized cores on a single-die SoC

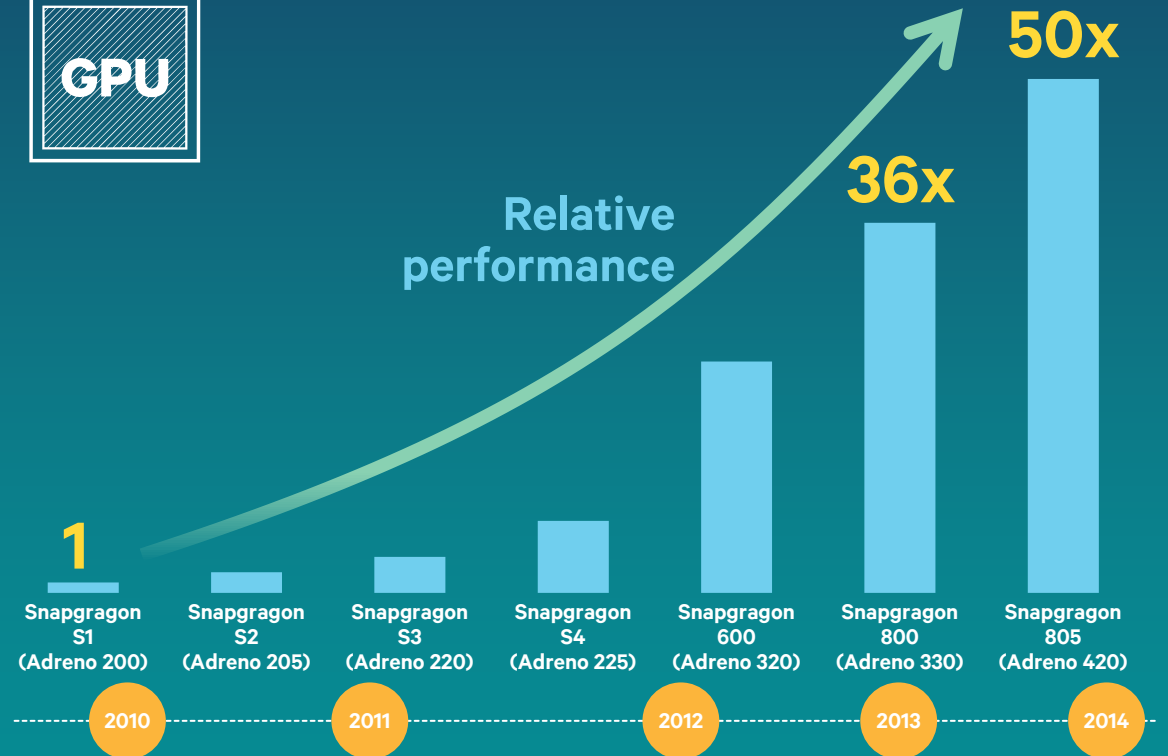
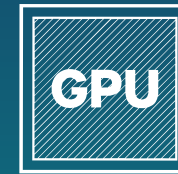


# Mobile devices getting more powerful

Faster processing, better graphics, longer battery life enabling breakthrough experiences



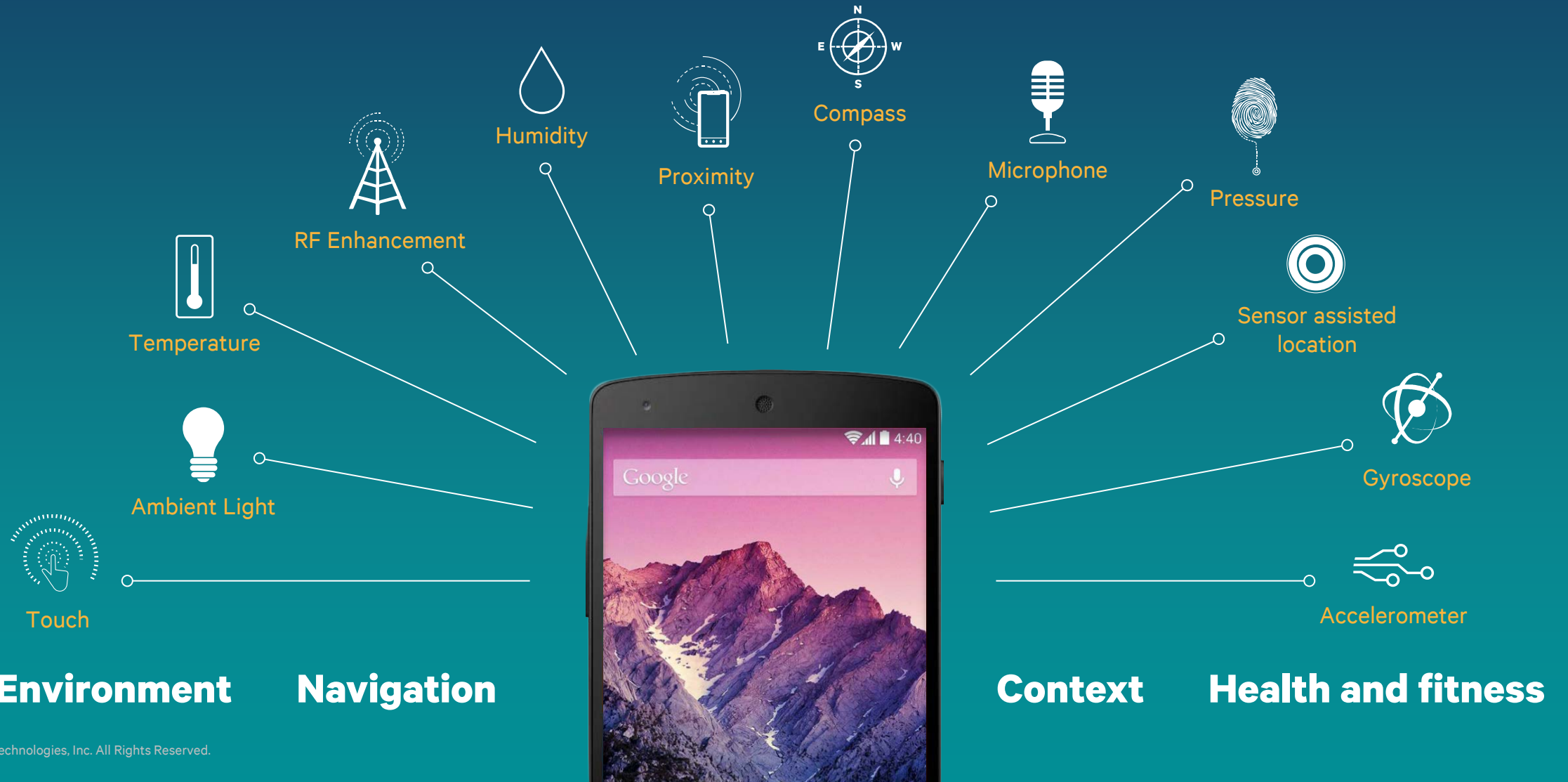
Qualcomm Technologies Flagship Processors Over Time



Qualcomm Technologies Flagship GPUs Over Time

# Evolution of integrated sensors

Technologies enabling the “Digital 6<sup>th</sup> Sense”





# 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

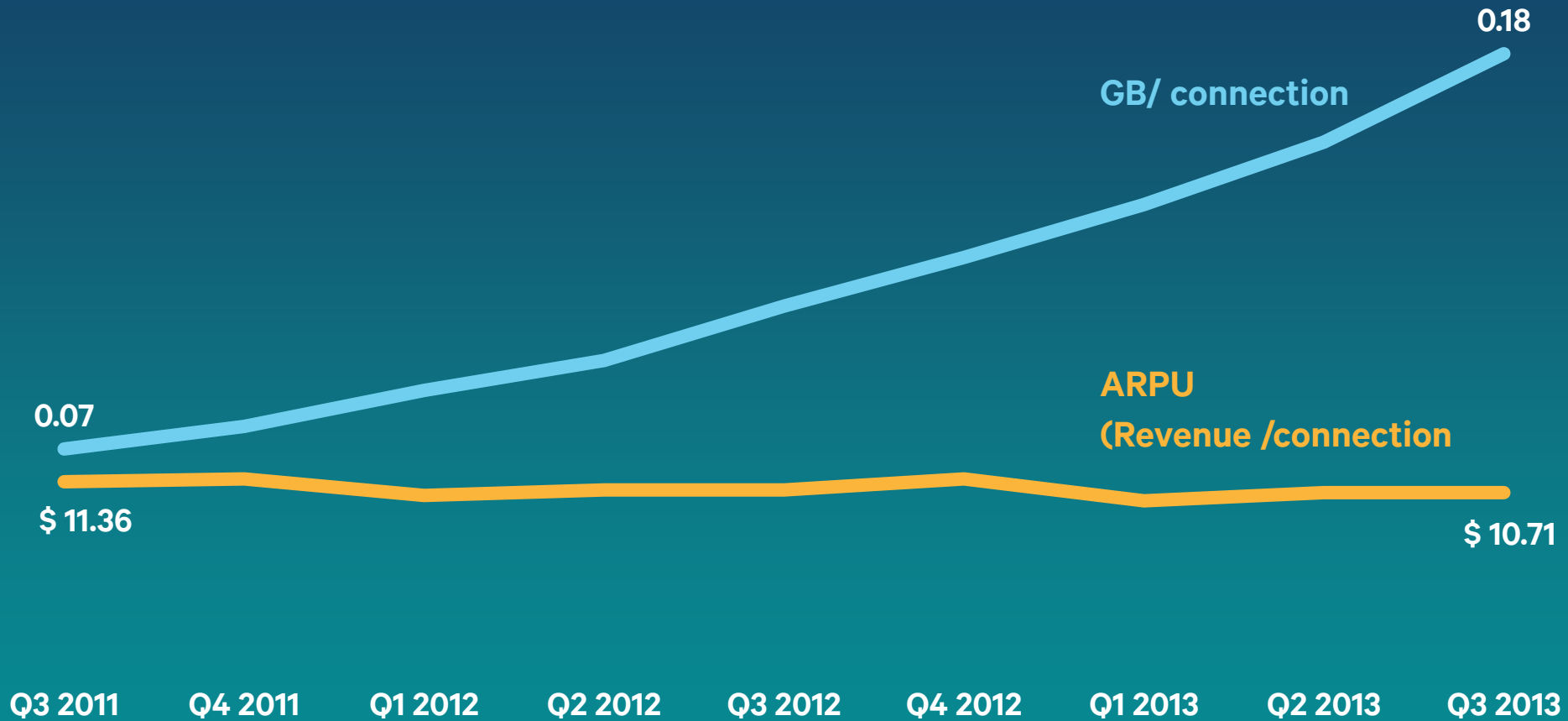
Interconnected  
device forecast  
in 2020<sup>2</sup>

**~7**  
Billion

Cumulative smartphone  
forecast between  
2013-2017<sup>1</sup>

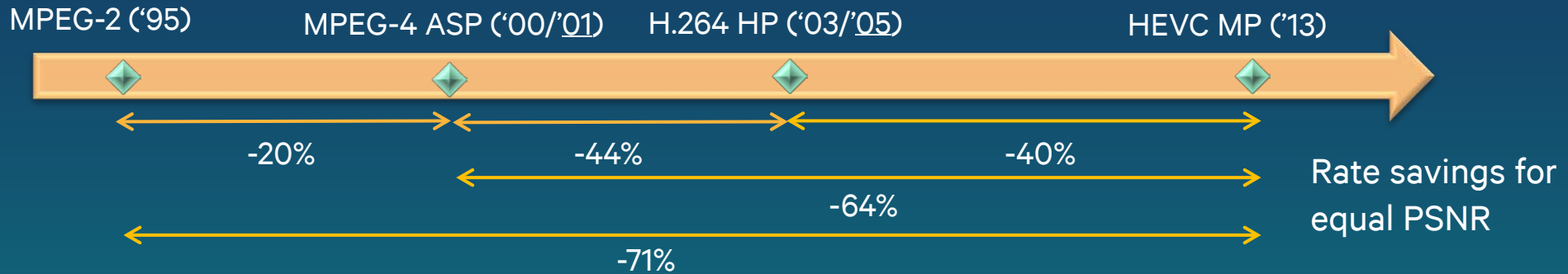
\*1000x would be e.g. reached if mobile data traffic doubled ten times, but Qualcomm does not make predictions when 1000x will happen, Qualcomm and its subsidiaries work on the solutions to enable 1000x

# Traffic growth outpacing operator revenue



Example of ARPU and traffic for a major asian operator  
Sources: GSMA Intelligence, Feb. '14

# HEVC (H.265) Performance

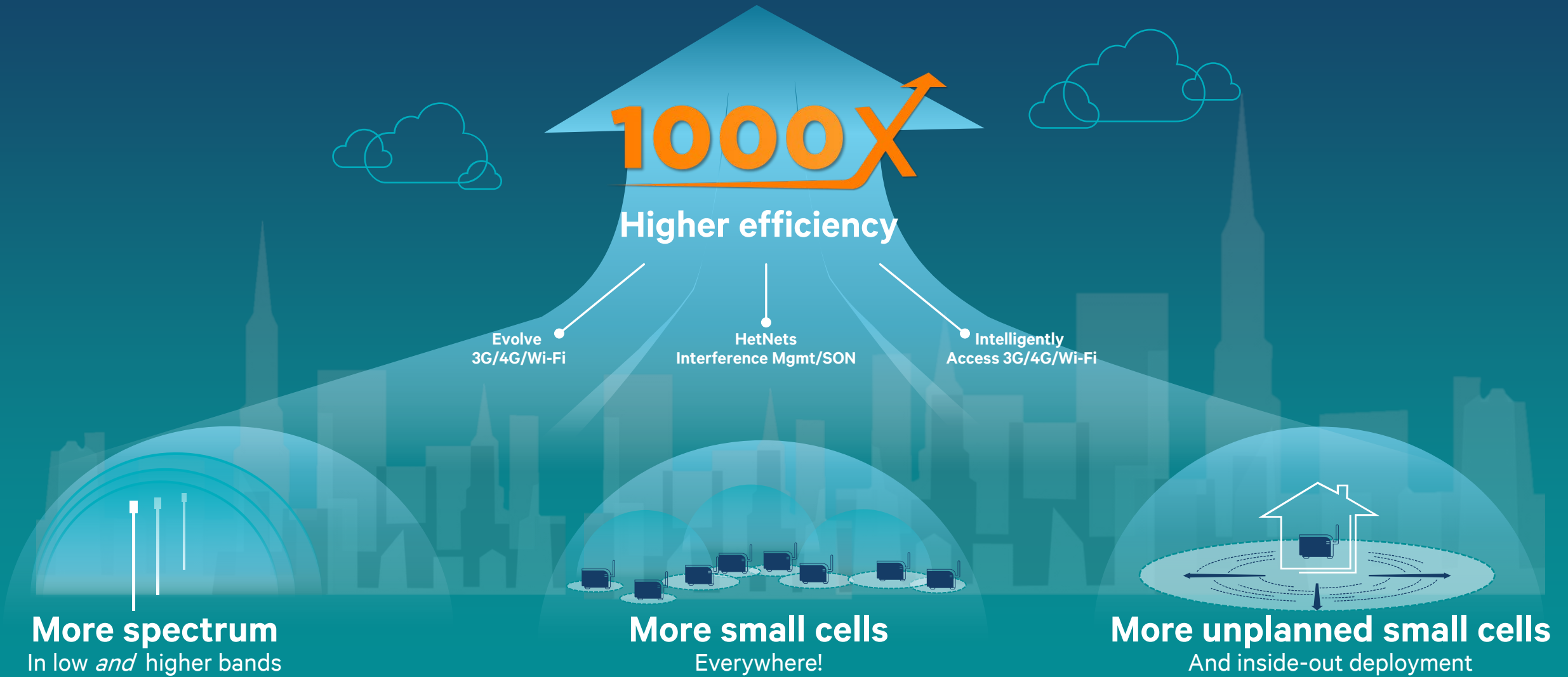


- HEVC gains over H.264 are on average higher for higher resolutions and for low delay configuration.

Content	HEVC vs. H.264 - Rate Savings for Equal PSNR		
	Random Access	Low Delay (B)	Low Delay (P)
4k x 2k @ 30 fps	-43%		
1080p @ 24 fps	-44%	-50%	-49%
WVGA @ 30 & 60 fps	-34%	-40%	-43%
WQVGA @ 30 & 60 fps	-31%	-35%	-38%
720p @ 60 fps (Video Telephony)		-49%	-56%
<b>Average</b>	<b>-38%</b>	<b>-43%</b>	<b>-46%</b>

- Subjective gains (measured by MOS score) higher than objectives gains measured traditionally by PSNR, average reduction over 50% over H.264.

# Rising to meet the 1000x mobile data challenge



# Technologies for small cells everywhere

All venues; residential, enterprise, metro, indoor, outdoor and multiple deployment models

## Highly compact, low-cost Small Cells

To enable densification  
& ease of deployment

## Self-organizing networks (UltraSON)

To enable low cost  
hyper-dense deployments



## Interference Management

So that capacity scales  
with small cells added

## Backhaul Solutions

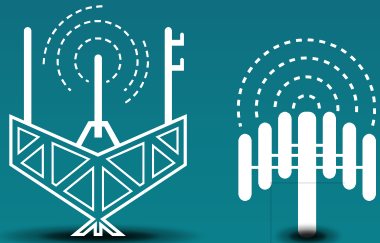
Fixed, wireless, relays  
User provided

UltraSON is Qualcomm's suite of Self Organizing features for small cells.

# 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/Licensed Shared Access (ASA/LSA)



### Shared exclusive use

ASA/LSA 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

# Towards WRC-15

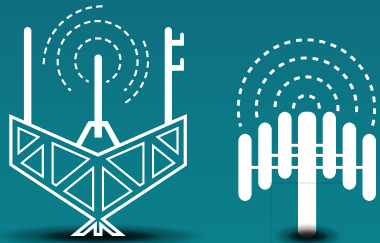


- WRC-15 – November 2015
- JTG 4-5-6-7
  - Goal is to complete the CPM-15 report by June 2014
  - Agenda item 1.1: considering additional spectrum in support of IMT and other mobile broadband services
  - Agenda item 1.2: usage of the 694-790 MHz band in Region 1 for IMT
- Bands in Discussion for Agenda Item 1.1
  - 470-806 MHz – currently broadcast (some has been assigned for mobile)
  - L –band 1300-1400/1427-1530 MHz – currently earth exploration satellite, aeronautical mobile telemetry (AMT), digital sound broadcasting, and fixed services
  - 2025-2110 MHz and 2200-2290 MHz – currently co-primary basis to space services
  - 2.7-2.9 GHz - currently used by aeronautical radio navigation, maritime navigation and radiodetermination services
  - 3.4-4.2 GHz – currently satellite C-band
  - 5 GHz RLAN bands - 5350-5460 MHz and 5460-5470 MHz – currently satellite, space and radio navigation

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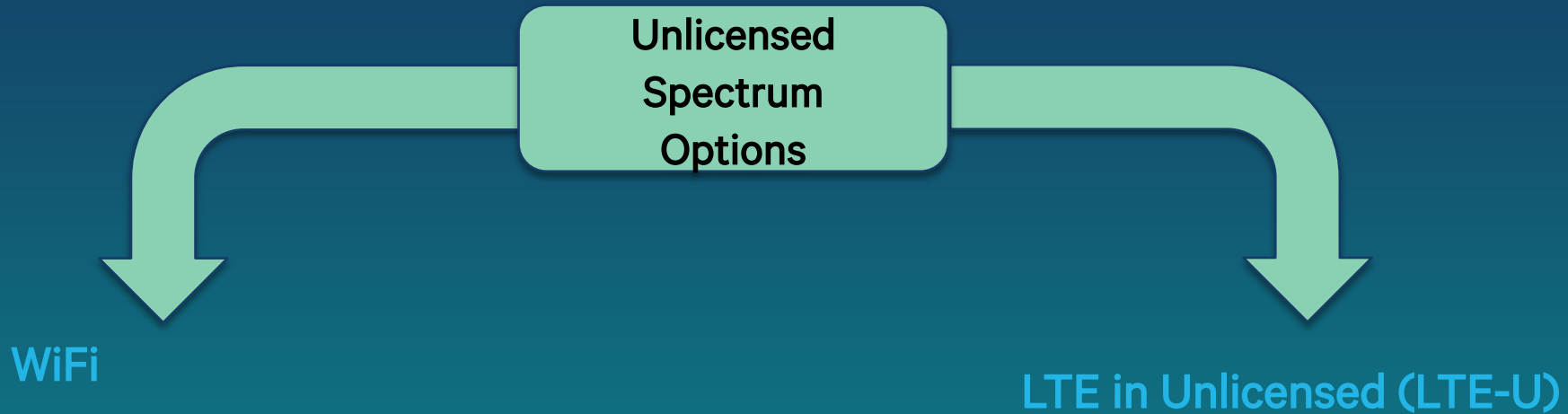


# Near-Term Solutions to Wi-Fi Network Issues

## Getting to Carrier Grade WiFi

- Some of the field-issues in current Wi-Fi networks currently could addressed in the WFA
  - Using selected features from existing IEEE addendums
    - 11ai (Faster connection and handoff signaling, reduction in probe storms)
    - 11k (Efficient measurement & management of radio resources)
    - 11v (Improved network management)
  - Agreeing on best practices and testing to prevent poorly behaving devices
    - More airtime for user traffic by reducing Probe request/response traffic
    - More consistent AP return codes and resulting STA behaviour to prevent “association storms”
    - Efficient use of airtime by managing low data rate users.

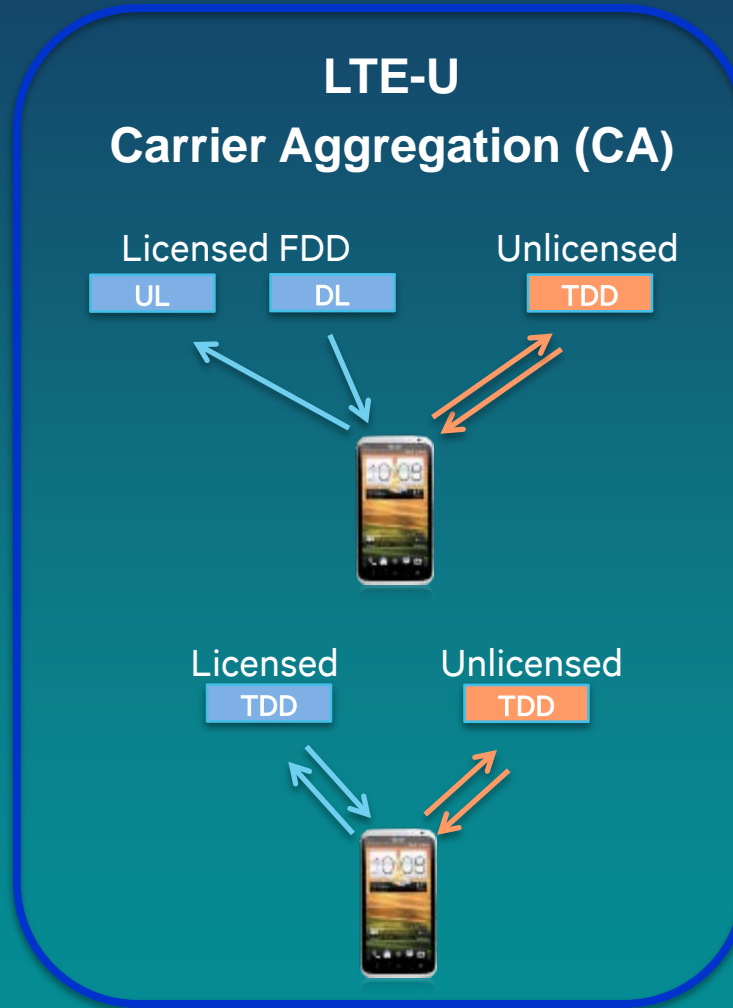
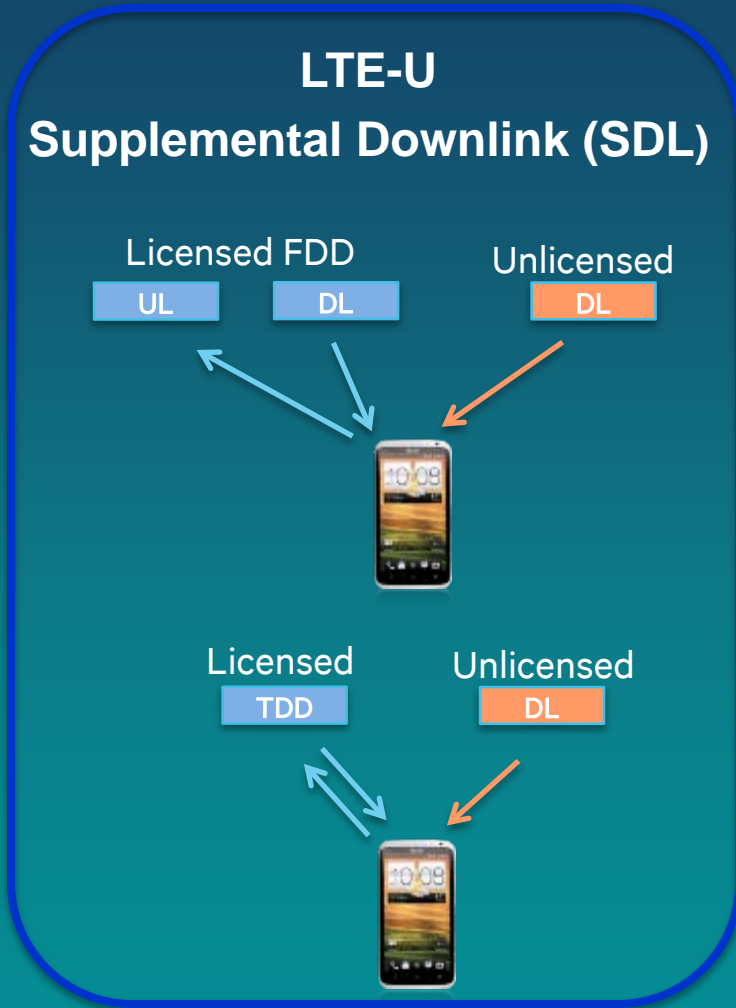
# Extending LTE to Unlicensed Spectrums Helps Mobile Operators



- High penetration in smartphones
- Good opportunistic offload tool used by many wireless operators
- Evolving towards 802.11ax (HEW) for higher efficiency

- Optimized offload performance with tighter integration with LTE network
- Provides greater range and capacity compared to 802.11n/ac
- Builds on LTE scale and ecosystem which addresses entire system
- LTE carrier transmitted according to unlicensed spectrum regulations

# LTE-U\* Carrier Aggregation Modes



- Anchor carrier is on licensed spectrum
  - Acquisition, access, registration, paging and mobility performed on anchor
  - Control plane signaling, control channels (grants, acknowledgments) and QoS sensitive data sent on anchor
- Secondary carrier uses unlicensed spectrum
  - Opportunistic data offload.

\*3GPP is currently using LAA (License Assisted Access)

3GPP has a workshop in June, expect Study Items and then Work Items for Release 13

# 802.11ah Value Proposition – 3rd Band Wi-Fi

## Internet of Things & Extended Range Applications

802.11g  
2.4 GHz

802.11n  
2.4 & 5 GHz

802.11ac  
5 GHz

802.11ah  
(sub 1 GHz)

### Rich Data Rates

150Kbit/s ~ 78 Mbits/s per spatial stream (sensor, audio, security camera, internet)  
1,2,4,8,16 MHz bandwidths

### Improved Range

10 dB link budget advantage over 2.4 GHz technologies, 1 MHz & 2 MHz mandatory modes

### Low Power

Whole home sensor coverage without power amplifier

### Scalable

Support thousands of nodes

### IP connectivity

Same as Wi-Fi

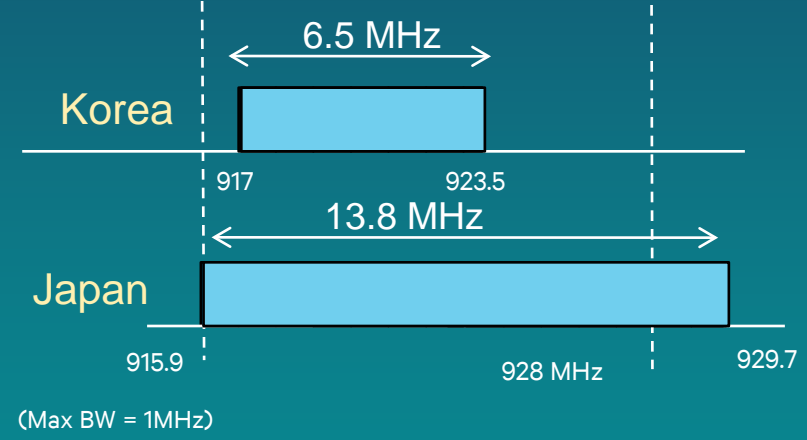
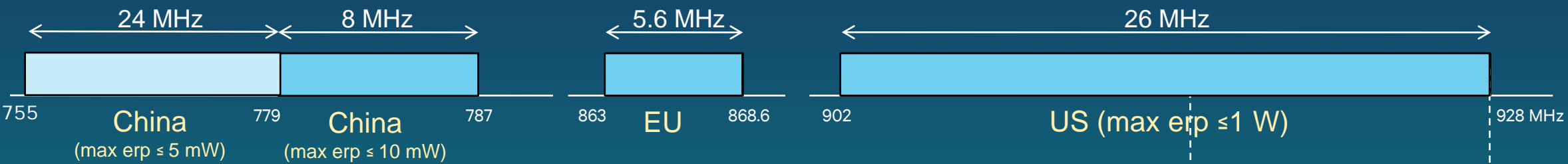
### Outdoor Coverage

Support for larger delay and doppler spreads, support for relays

### Wi-Fi ecosystem

WFA certified interoperability and Wi-Fi user experience

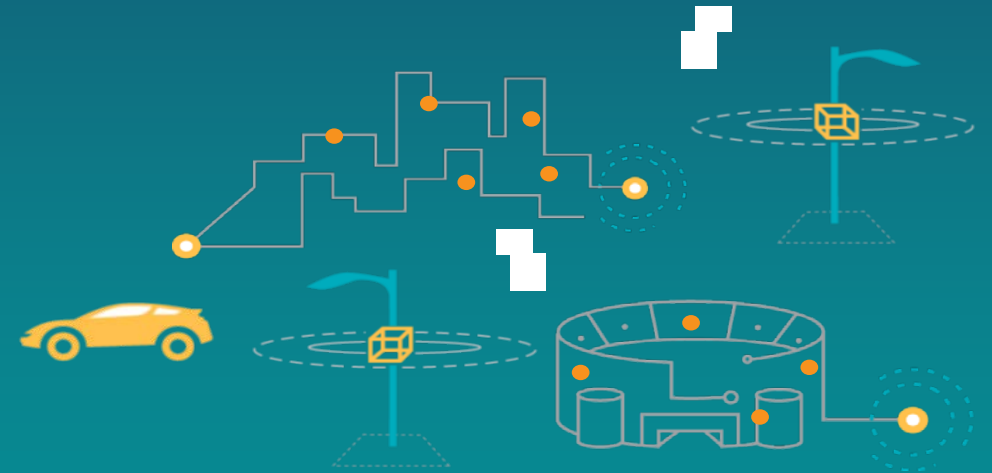
# Tentative Spectrum Availability in Key Geographies



Region	Tx power regulations
US	Max e.r.p. ≤ 1 W
EU	max erp ≤ 14 dBm PSD ≤ -4.5 dBm/100KHz (863~868.6MHz) PSD ≤ 6.2 dBm/100KHz (865~868MHz)
Korea	3 mW or 10 mW (920.6~923.5MHz and six 200 KHz channels below 920.6 MHz)
China	Max e.r.p. ≤ 5 mW (755 – 779 MHz) Max e.r.p. ≤ 10 mW (779 – 787 MHz)
Japan	1mW , 20 mW or 250 mW (915.9~929.7MHz) Max BW ≤ 1 MHz

# 802.11ax High Efficiency WLAN (HEW)

- Next major IEEE 802.11 standard with a goal of improving Wi-Fi network throughputs in 2.4/5 GHz bands (.11 -> .11b -> .11a/g -> .11n -> .11ac -> .11ax)
  - Study group completed work in March
  - 802.11ax task group expected to begin in May
- Targets and scope
  - PAR: Four times improvement in the average throughput per station in a dense deployment scenario
  - Throughput is measured at the MAC data service access point
  - “Expected to provide improvements of 5 – 10x”
  - Maintaining or improving the power efficiency per station
  - Enabling backward compatibility and coexistence with legacy IEEE 802.11 devices operating in the same band

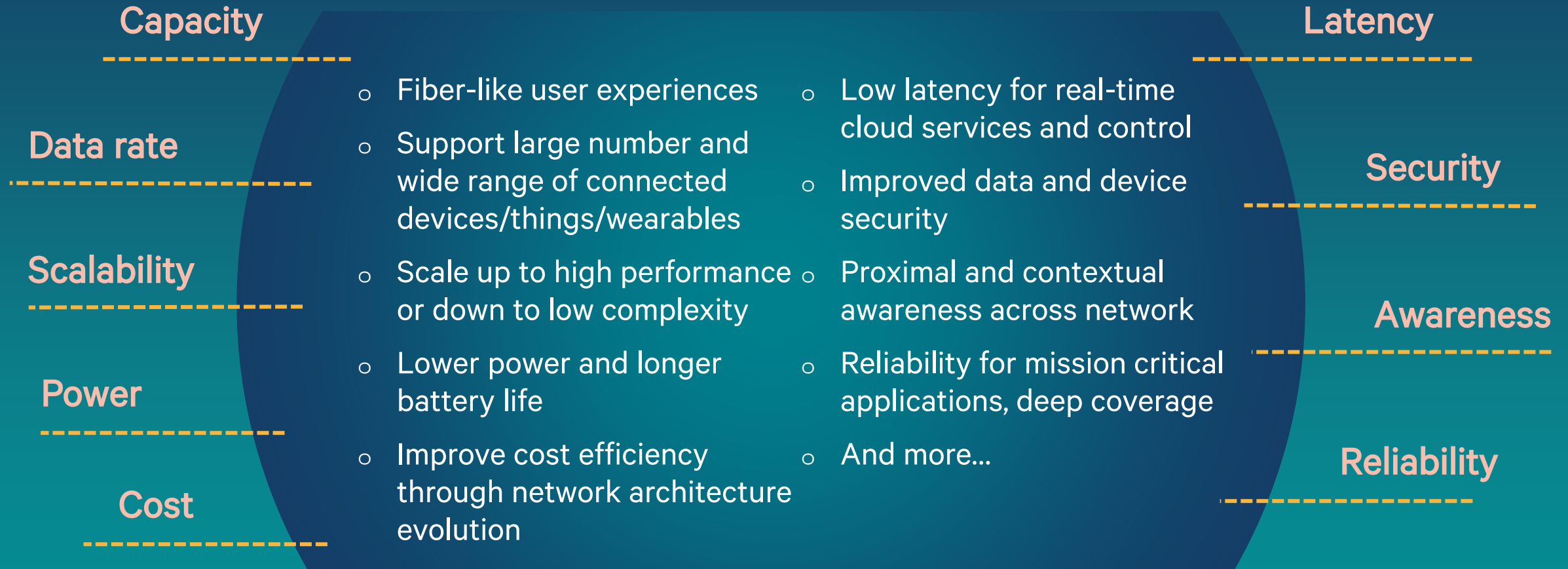


**5G** is about enabling **new services and devices**, connecting **new industries**, and empowering **new user experiences**

Qualcomm aims to be a leading force in bringing 5G to life



# Broader dimensions of improvements will drive new 5G services



**A unified 5G design that is scalable and adaptable across extreme variation of use cases**



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**Hup-2-3-4... Do we stop at  
Four?**

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**NO!**



IEEE  
**GLOBECOM**<sup>2015</sup>  
Global Communications Conference,  
EXHIBITION & INDUSTRY FORUM

**6-10 DECEMBER 2015**  
**SAN DIEGO, CA, USA**  
**CONNECTING ALL THROUGH COMMUNICATIONS**



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# Thank you

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