August 2014

# HSPA+ Evolution: Building upon the solid foundation

QUALCOMM®

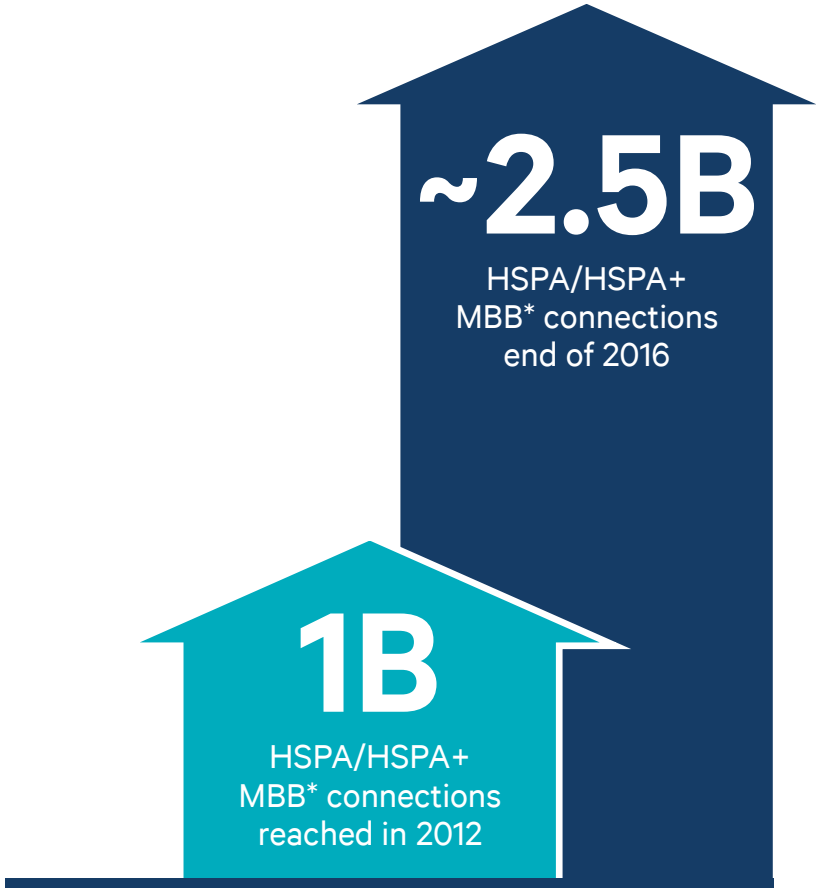
# HSPA+ continues to evolve and support billions of users

1. **Small cells with HSPA+ a key 1000x enabler**
   Cell range expansion possible today—more enhancements in the pipeline

2. **Expanded chipset support for carrier aggregation**
   Going beyond today's dual-carrier—aggregation across more carriers, bands, and uplink

3. **Continued carrier aggregation evolution**
   Such as Multiflow—carrier aggregation across cells

4. **WCDMA+ frees up capacity for HSPA+ data**
   More efficient voice frees-up resources for data




Source: Wireless Intelligence (Jan '13) . 2,437 Billion HSPA family connections expected Q4 2016

# HSPA+: Building upon the solid global foundation

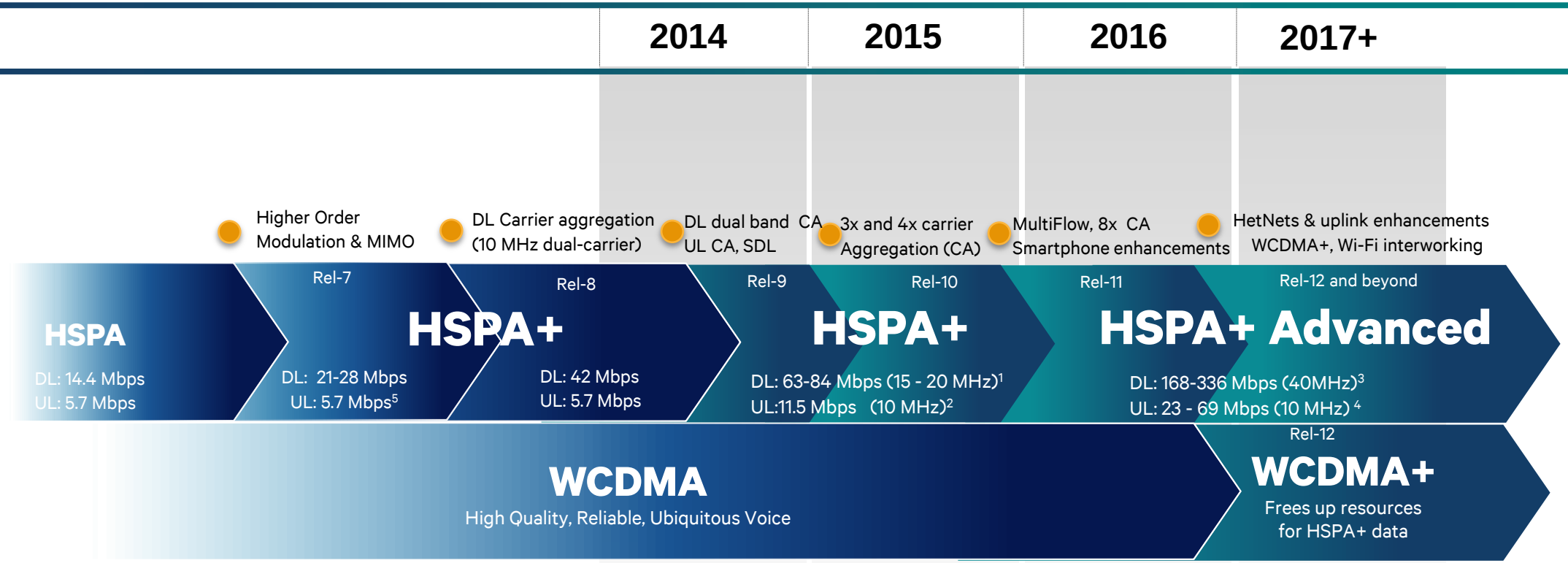
**547** HSPA NETWORKS IN **205** COUNTRIES

**363** HSPA+ NETWORKS IN **157** COUNTRIES

**160** DUAL-CARRIER NETWORKS IN **83** COUNTRIES

Source: www.gsacom.com , Feb 2014

# Strong HSPA+ Evolution




[1]Peak rate of 63 Mbps by aggregating 3 carriers, (15 MHz) and 84Mbps by 4 carriers (20 MHz), Rel. 10 standard supports up to 168 Mbps (see note 3 below), but not expected to be commercial in initial launches

[2]Uplink carrier aggregation (10 MHz) doubles uplink peak data rate to 11..5 Mbps without 16 QAM, and 23 Mbps with 16 QAM

[3]Rel 10 supports up to 186 Mbps with 20 MHz and 2x2 MIMO, Rel 11 supports 336 Mbps with 40 (4 carriers) and 2x2 MIMO,

[4] 69 Mbps Uplink rate achieved by 2x2 MIMO and 64QAM

[5] Rel. 7 supports peak rate of 11.5 Mbps, but only 5.7 Mbps commercialized

Commercial

Note: Estimated commercial dates.



Created 05/07/2014

# 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)
- **1.8 GB** Game for Android
- **0.14 GB** Soundtrack
- **0.0014 GB** Homepage
- **0.00091 GB** Book

## More devices

everything connected

**~25 Billion** Interconnected device forecast in 2020[2]

**~7 Billion** Cumulative smartphone forecast between 2013-2017[1]

[1]Gartner, Mar'13 ; [2]Machina Research/GSMA, Dec. '12

*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

# Small cells with HSPA+ a key 1000x enabler


## Continue to evolve HSPA+

- Carrier aggregation evolution and multiflow
- Smartphone signaling and IoE enhancements
- WCDMA+ to free up data

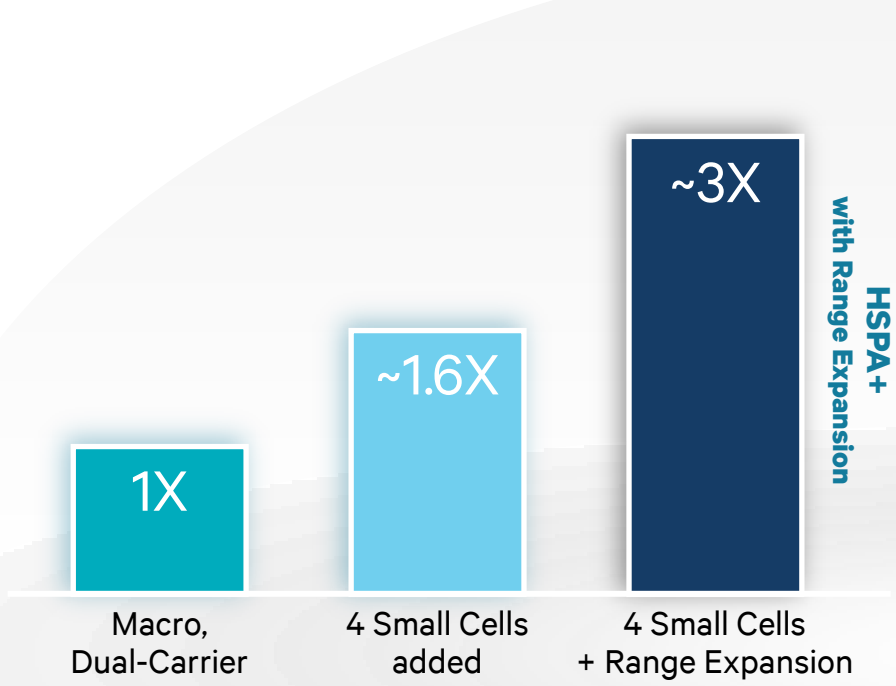
## Access to more spectrum

- Supplemental downlink (such as L-Band)
- Authorized Shared Access (ASA)

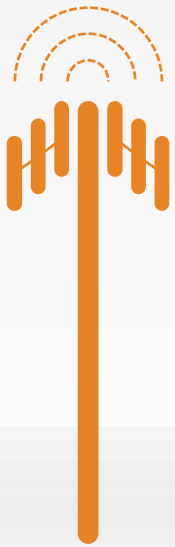
## Deploy more small cells

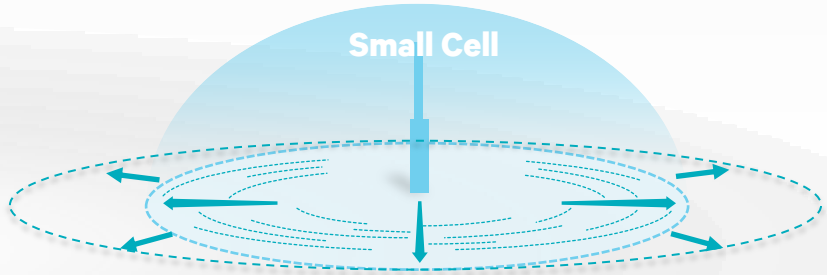
- Converged WCDMA/HSPA+, LTE and Wi-Fi
- HSPA+ small cell range expansion today
- Neighborhood small cells deployment model

# 1000x begins with HSPA+ optimizations available today
## —small cell range expansion can double capacity




Median Gain[1]
For same amount of Spectrum






Possible With HSPA+ Today

[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)

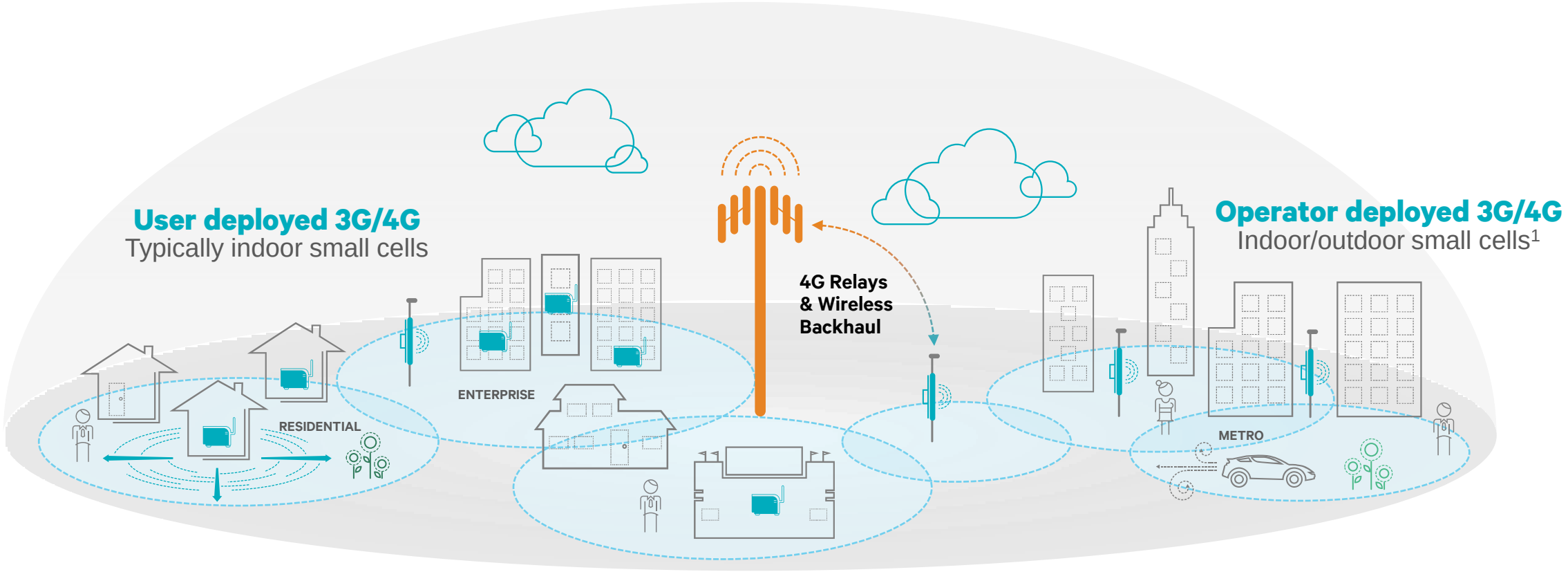
# Further HetNets enhancements for small cell densification

**Multiflow—balance load across cells**
Multiflow aggregates across cells (3GPP R11 and beyond)

**TruSignal™/Q-ICE advanced device receiver**
Interference cancellation provide even more gain

**HetNets enhancements**
Interference mitigation and mobility enhancements (3GPP R12 and beyond)

**HSPA+/LTE/Wi-Fi Converged small cells**
Tighter HSPA+ and Wi-Fi integration (3GPP R12 and beyond)

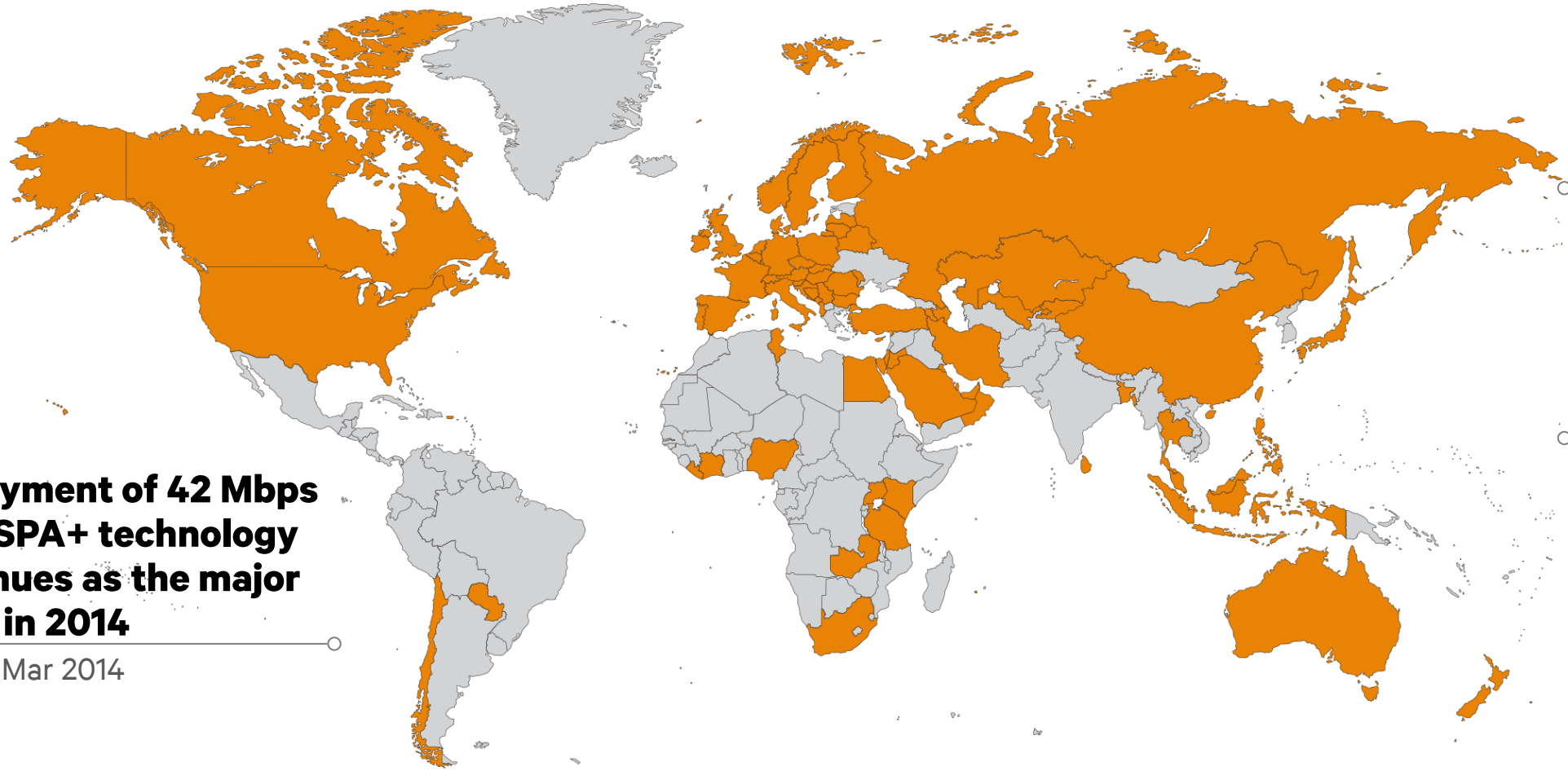



[1] Such as relay and Pico/Metro/RRH small cells for hotspots. RRH= Remote Radio Heads, in addition Distributed Antenna Systems are used in HetNets

Note: Self-Organizing Networks (SON) techniques HetNets and are standardized already in R10, such as Minimization of Drive Tests (MDT) and Automatic Neighbor Relation (ANR) with continued enhancements in R11 and beyond

# HSPA+ Dual-carrier is main-stream

## Supporting 42 Mbps downlink peak data rate



**160**
NETWORKS

**83**
COUNTRIES

**Deployment of 42 Mbps DC-HSPA+ technology continues as the major trend in 2014**

– GSA, Mar 2014

Countries launched/committed to Dual-carrier

Source: www.gsacom.com , Feb 2014

# Dual-carrier – Delivering high data rates in real networks

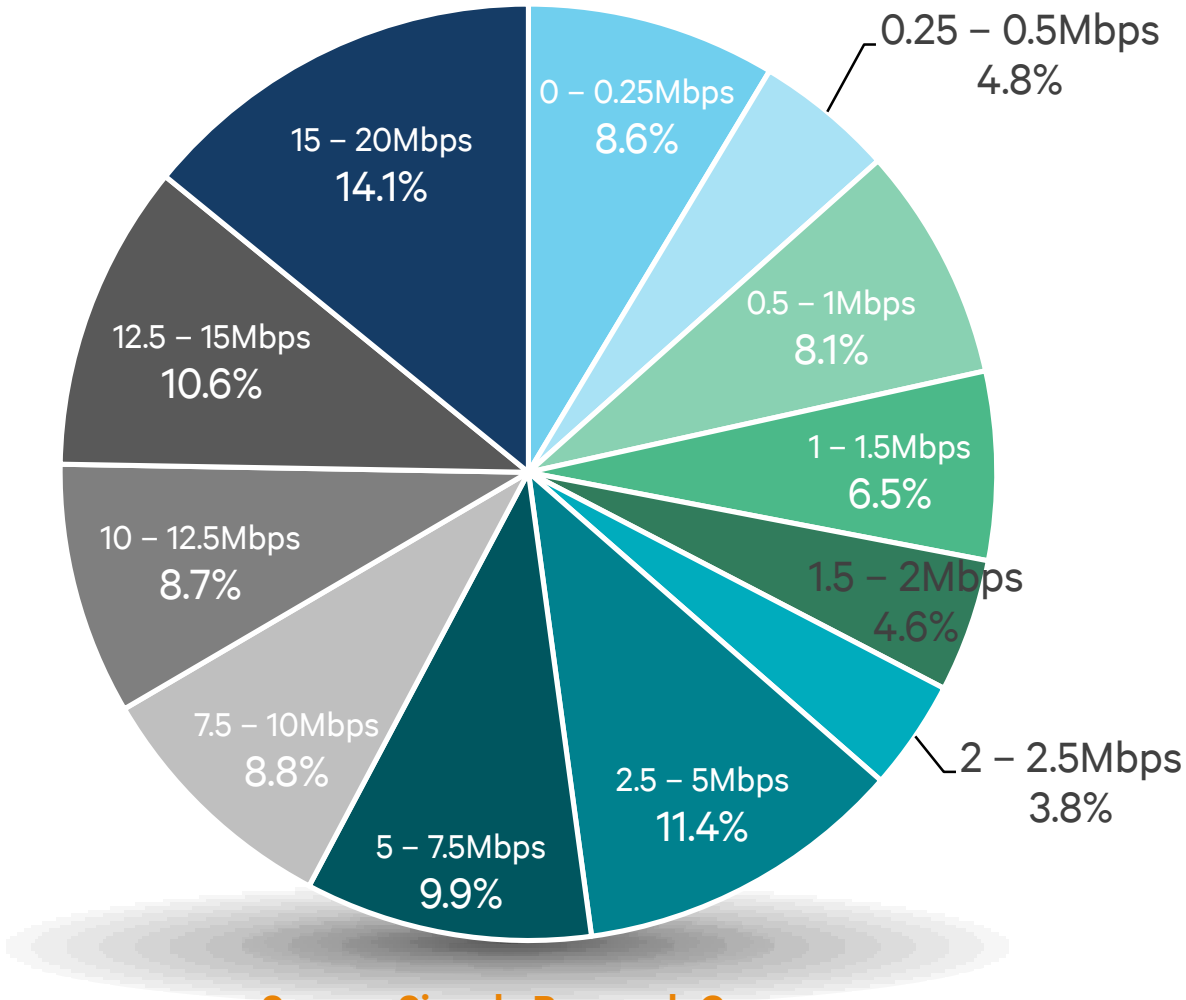
**>5Mbps >50%**

USER DATA RATE OF THE TIME

**>1Mbps ~80%**

USER DATA RATE OF THE TIME

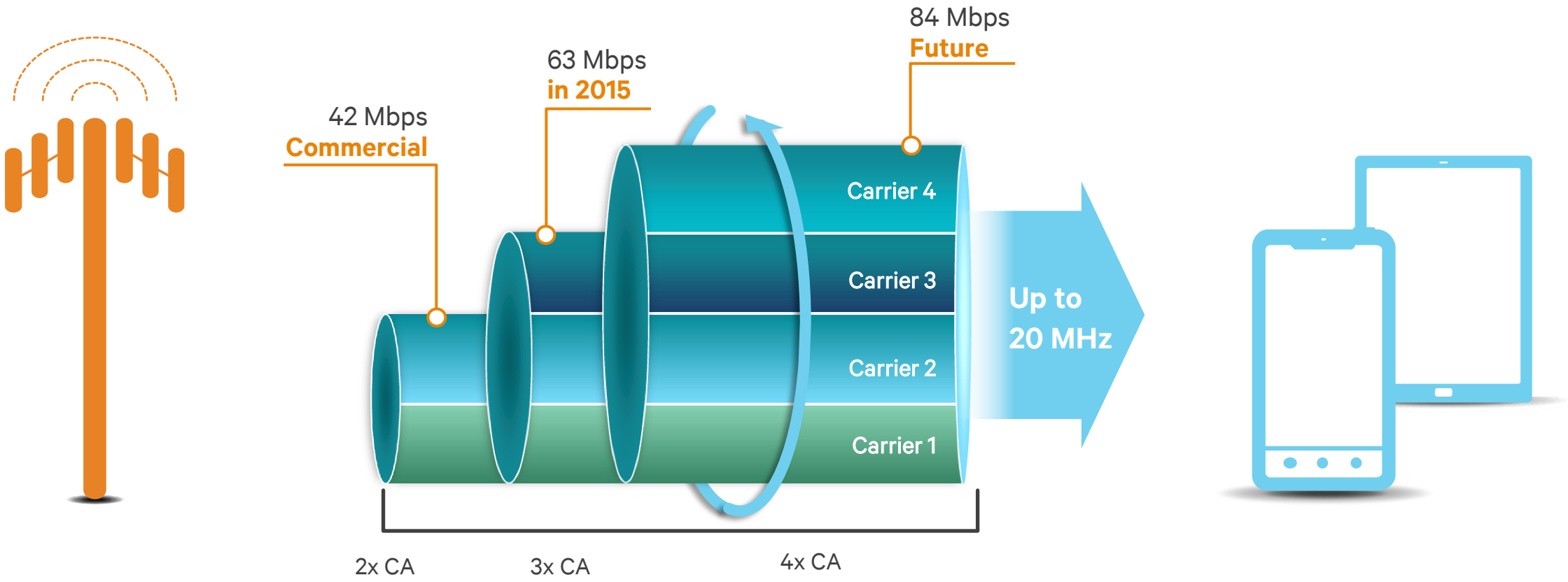
Based on comprehensive benchmarking tests conducted across two operators in greater Dallas area (Texas), covering more than 23 miles of driving, downloading nearly 7GB of data




**Source: Signals Research Group**

Signals Ahead, September 2011, "The Mother of all Network Benchmark Tests"

# Carrier aggregation enhances user experience




**Increased data rates for all users**

**Can double smartphone bursty data capacity[2]**

**Leverages all spectrum assets**

[2] For typical bursty applications and typical partial carrier load, carrier aggregation supports more bursty application users than individual single carriers.

# Expanded HSPA+ carrier aggregation support

Aggregation of 3 downlink carriers uses HSPA+ assets more efficiently

Uplink aggregation (2 carriers) improves user experience and increase network capacity for smartphone traffic

Aggregation across bands (2 carriers) takes advantage of expanding HSPA+ footprint in new bands (e.g. 900 MHz)


**Common platform for LTE and HSPA+ carrier aggregation**

**Increased data rates for all users**

**Can double smartphone bursty data capacity[2]**

**Leverages all spectrum assets**

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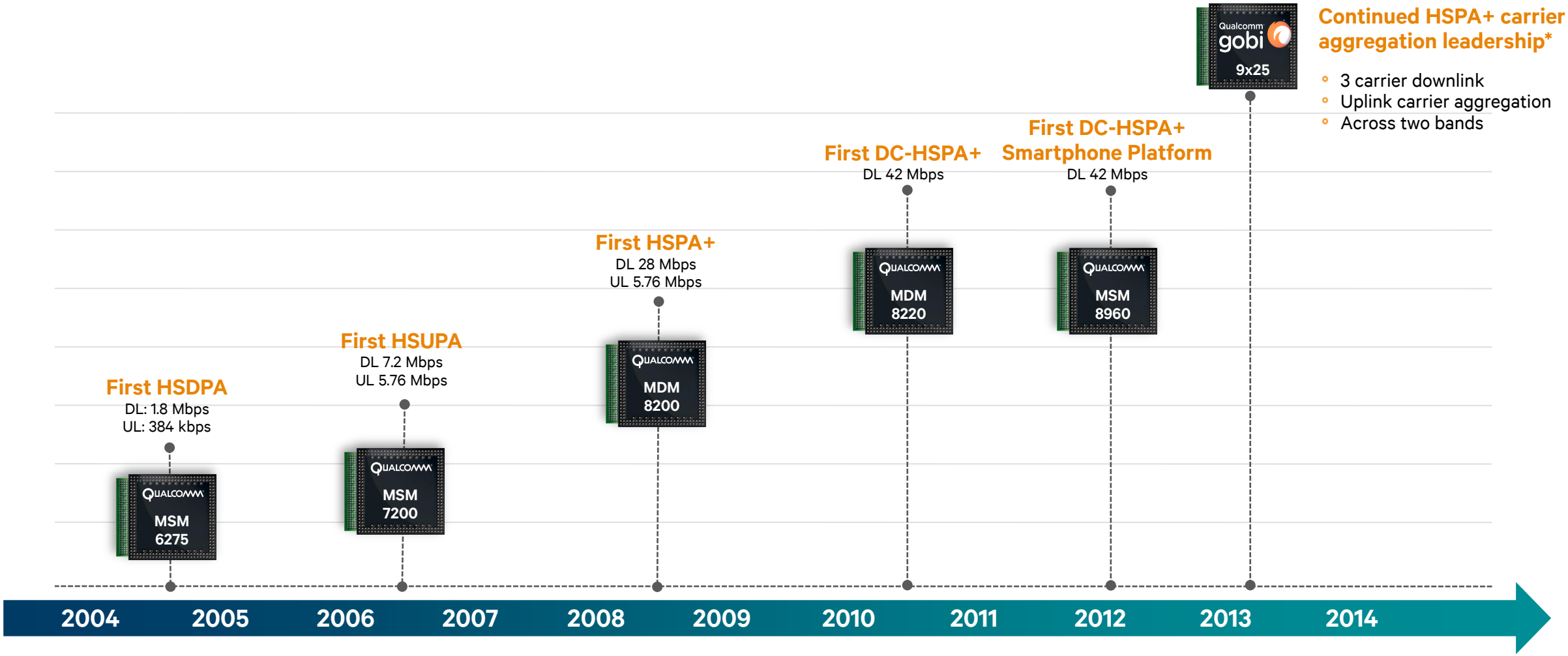
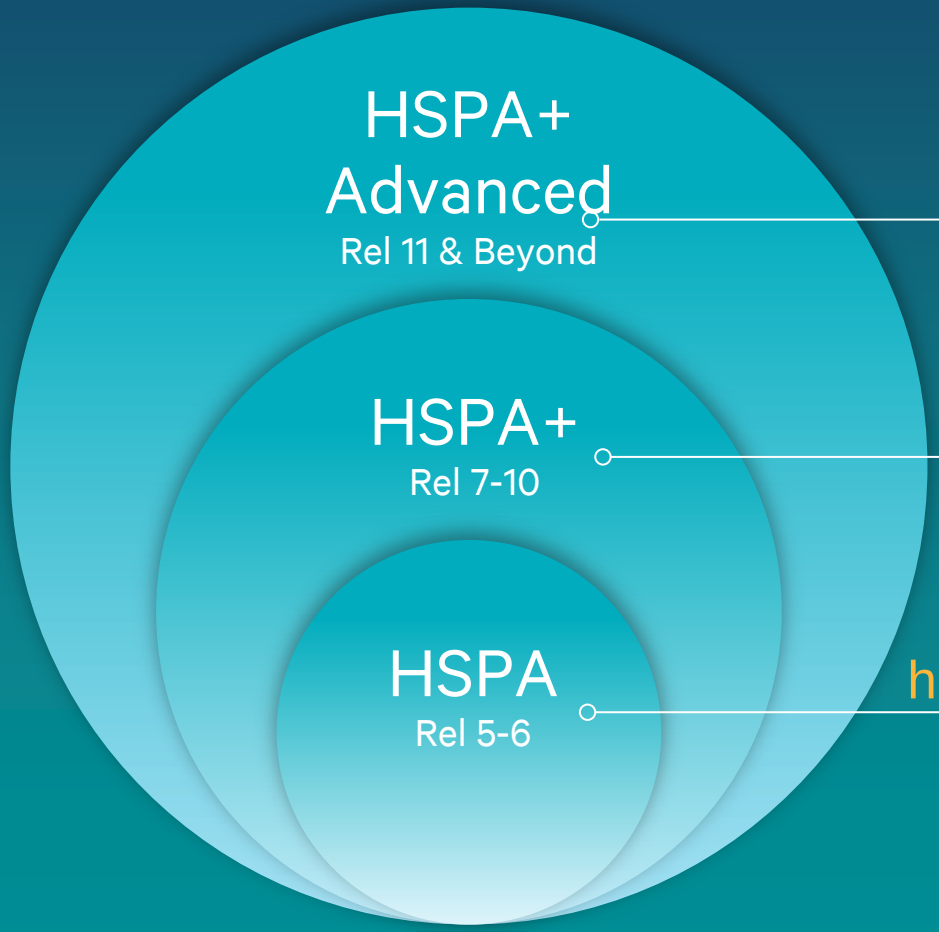
Qualcomm® Snapdragon™ and Qualcomm® Gobi™ are products of Qualcomm Technologies, Inc.; Snapdragon 800 includes 8974

# A history of time-to-market and modem technology leadership




* 9x25 - LTE-A CA was launched in 2013, HSPA+ UL-CA expected to launch in 2014; HSPA+ DL 3-carrier CA supported but not yet launched

# Continued HSPA+ evolution




Maximizing HSPA+ performance*

- **Multiflow and further carrier aggregation evolution**
- **HetNets Optimizations**
- **Smartphone/IoE Enhancements**

HSPA+ is the baseline

100% of operators have upgraded to HSPA

* Rel. 12 also includes features such as F-EUL that further increases the capacity, coverage and user experience, eBCH to make overhead channels more efficient, and IncMon that increases the number of carriers devices monitors for even better handoffs and cell reselection between HSPA+ carriers as well as with LTE

# Continued Carrier Aggregation (CA) evolution


**21-28 Mbps**
HOM (64 QAM)
or 2x2 MIMO (5MHz)

**11 Mbps**
Uplink HOM (16 QAM)

**42 Mbps**
2x CA (10MHz)
or 2x2 MIMO+64QAM (5MHz)

**42-84 Mbps**
2x CA (10MHz)
+2x2 MIMO for 84Mbps

**23 Mbps**
Uplink 2x CA
(10MHz)

**84-168 Mbps**
Up to 4x CA (20MHz)
+2x2 MIMO for 168Mbps

**34 - 69 Mbps**
UL 64 QAM
+ 2x2 MIMO for 69Mbos
Uplink Beamforming

**168-336 Mbps**
Up to 8x CA (40 MHz)
+2x2 MIMO for 336Mbps

**Multiflow** - CA across cells

Non-contiguous band CA (4 carriers)

R7 R8 R9 R10 R11 R12 and beyond

Downlink Speed  Uplink Speed

**Carrier aggregation evolution R12 and beyond**

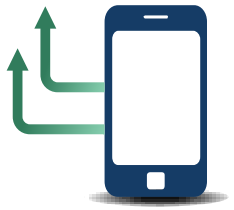
- Additional CA combinations defined (up to 4x)
- Performance definition for supplemental downlink

# HSPA+ Carrier aggregation expanding reach

## Leveraging all spectrum assets

### Uplink

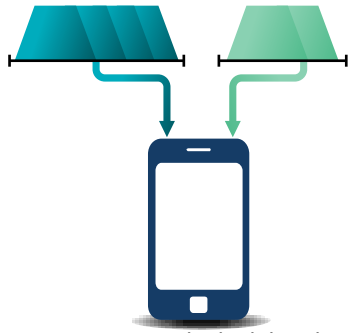
DUAL-CARRIER IN THE UPLINK[1]



### Across Bands

HIGH BAND (e.g Band I & II)

LOW BAND (e.g Band V, VII & VIII)

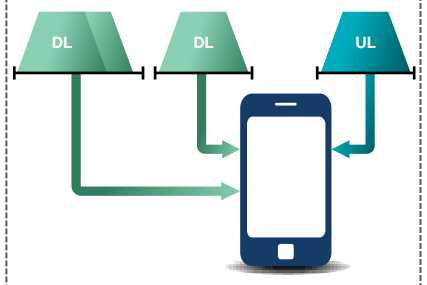


1-3 carriers in the high band, and 1-2 in the low band[2]

### Supplemental Downlink

UNPAIRED SPECTRUM

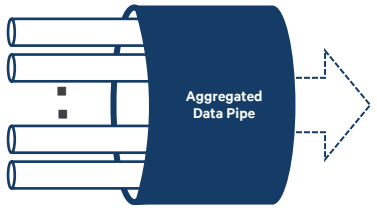
PAIRED SPECTRUM




Combining unpaired spectrum with the downlink [3]

### More Carriers

DUAL-CARRIER NOW & COUNTING[4]




### Multiflow

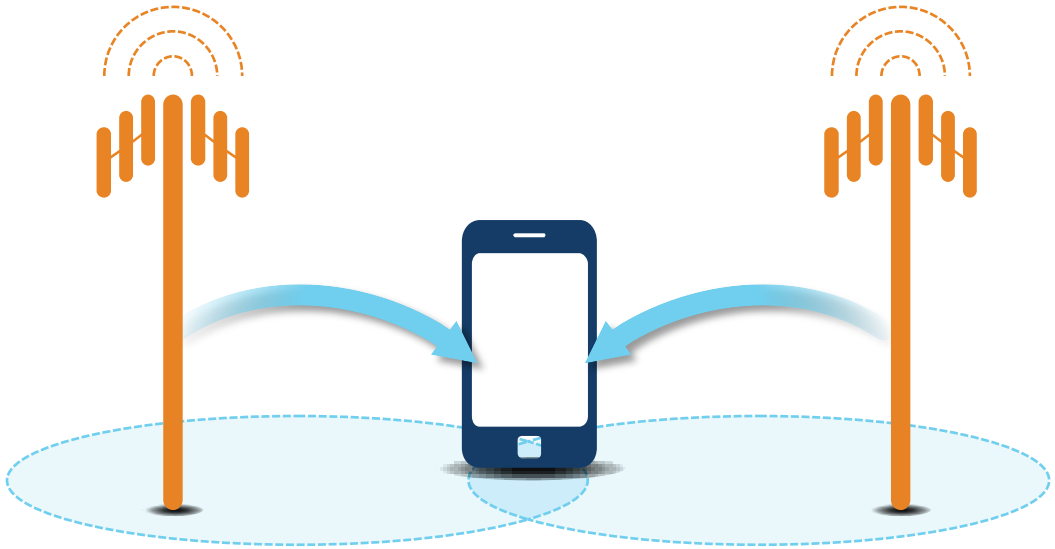
AGGREGATION ACROSS CELLS[5]

**3GPP continually defines new band combinations**

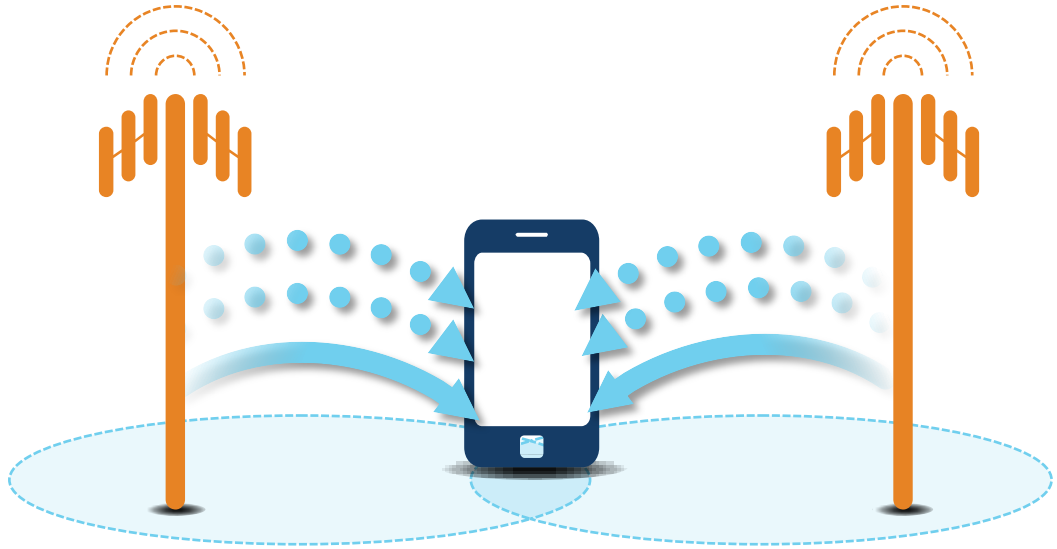
[1]Defined in Rel 9; [2] Defined in Rel 9, more carriers and combinations added in Rel 11; [3]Defined in Rel 9, band combinations being defined by 3GPP; [4]Dual-carrier in Rel 8, 4-carriers in Rel 10, and 8-carriers in Rel11; [5]Defined in Rel 11

# Multiflow - carrier aggregation across cells

## Enabling carrier aggregation in all deployments



**Bringing benefits of dual-carrier to single–frequency deployments**



**Bringing benefits of carrier aggregation to multi-frequency deployments[1]**

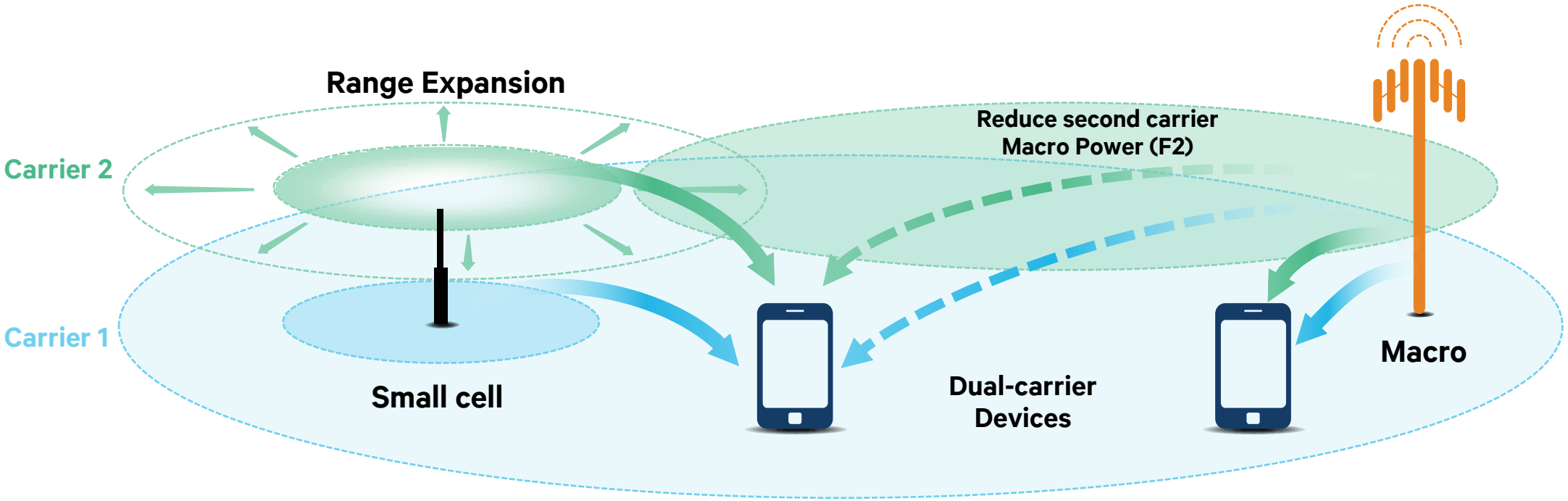
**Higher** cell-edge data rates

**Better** network load balancing

**Higher** network capacity

[1]With the evolution to supporting 4 carrier aggregation, multiflow can aggregate up to 3 carriers from one site/cell and one carrier from the other cells in the future

# Further HetNets enhancement—multiflow and more




## Further range expansion—even better small cell offload

Mitigate up/downlink imbalances—such as extended range/reconfiguring of power offsets and further enhanced advanced receivers

## Multiflow optimizations to balance load across cells

Such as mobility support to switch from dual-carrier to multiflow in the region where up/downlink are imbalanced

## Mobility enhancements between small cell & macro

Such as further enhanced serving cell change procedures, and extended neighbor list measurements

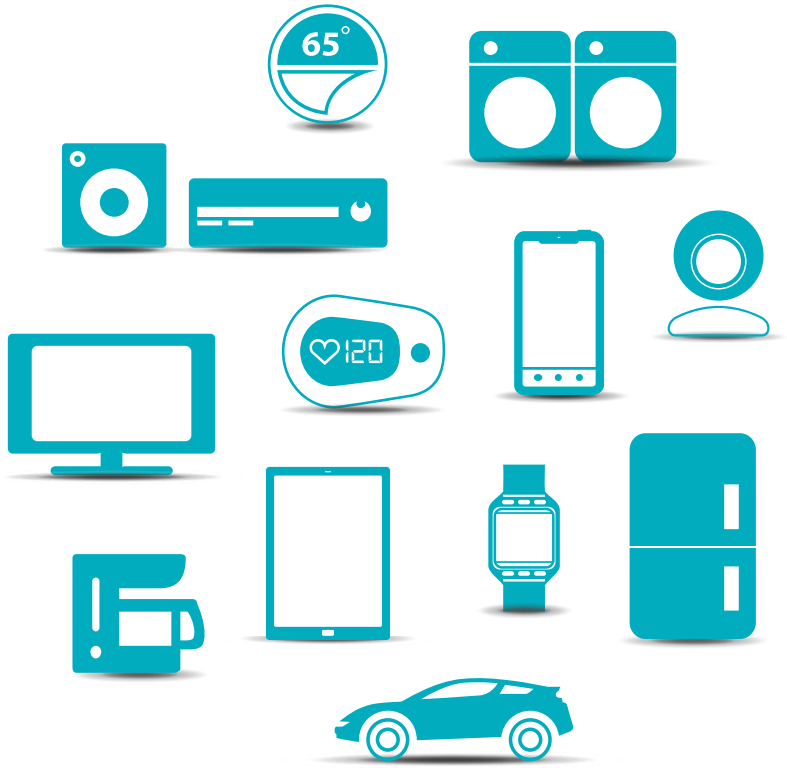
Note: All these are 3GPP R12 study items. In addition, Self-Organizing Networks (SON) techniques and are standardized in R10, such as Minimization of Drive Tests (MDT) and Automatic Neighbor Relation (ANR) with continued enhancements in R11 and beyond

# HSPA+ continues to accommodate smartphone growth

| | Commercial HSPA+<br>R7/R8 CELL-FACH[1] | HSPA+ Advanced<br>R11 FE-FACH[3] |
|---|---|---|
| **Small data bursts**   | **Up to 90% reduced signaling load** over HSPA | Another **>10x** capacity over HSPA+ |
| **Non full-buffer applications**   | **Extended battery life** over HSPA[2] | **Further extended battery life** |

[1]R7/R8 allows small amounts of data to be efficiently transported in CELL-FACH state: up to 90% reduction in network signaling load due for social media example. [2]Cell-DCH w/ R7 CPC allows non full buffer apps to use connected mode, DCH, more efficiently (DTX/DRX).
[3]A main enhancements is downlink triggered feedback (CQI) and acknowledgements on the FACH reverse link, which makes FACH efficient like a regular HSPA link, see simulation assumptions in R1-112679

# HSPA+ enhancements for Internet of everything




**Low data rate • Small data size • Infrequent transmissions/receptions • Limited power source**

**Further 3GPP R12/R13* enhancements such as:**

- Extended sleep period
- Very long DRX Cycle - days
- Fast return to Idle State
- Reduced measurements
- Reduced signaling

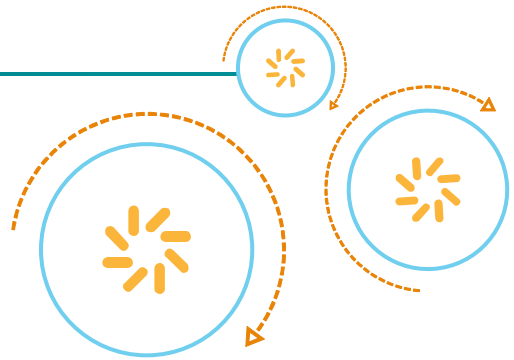
**Significantly increased battery life**

**Increased capacity**

*Extended sleep period (aka Power Saving mode (PSM) is part of R12, all others are potential candidates for Rel 13

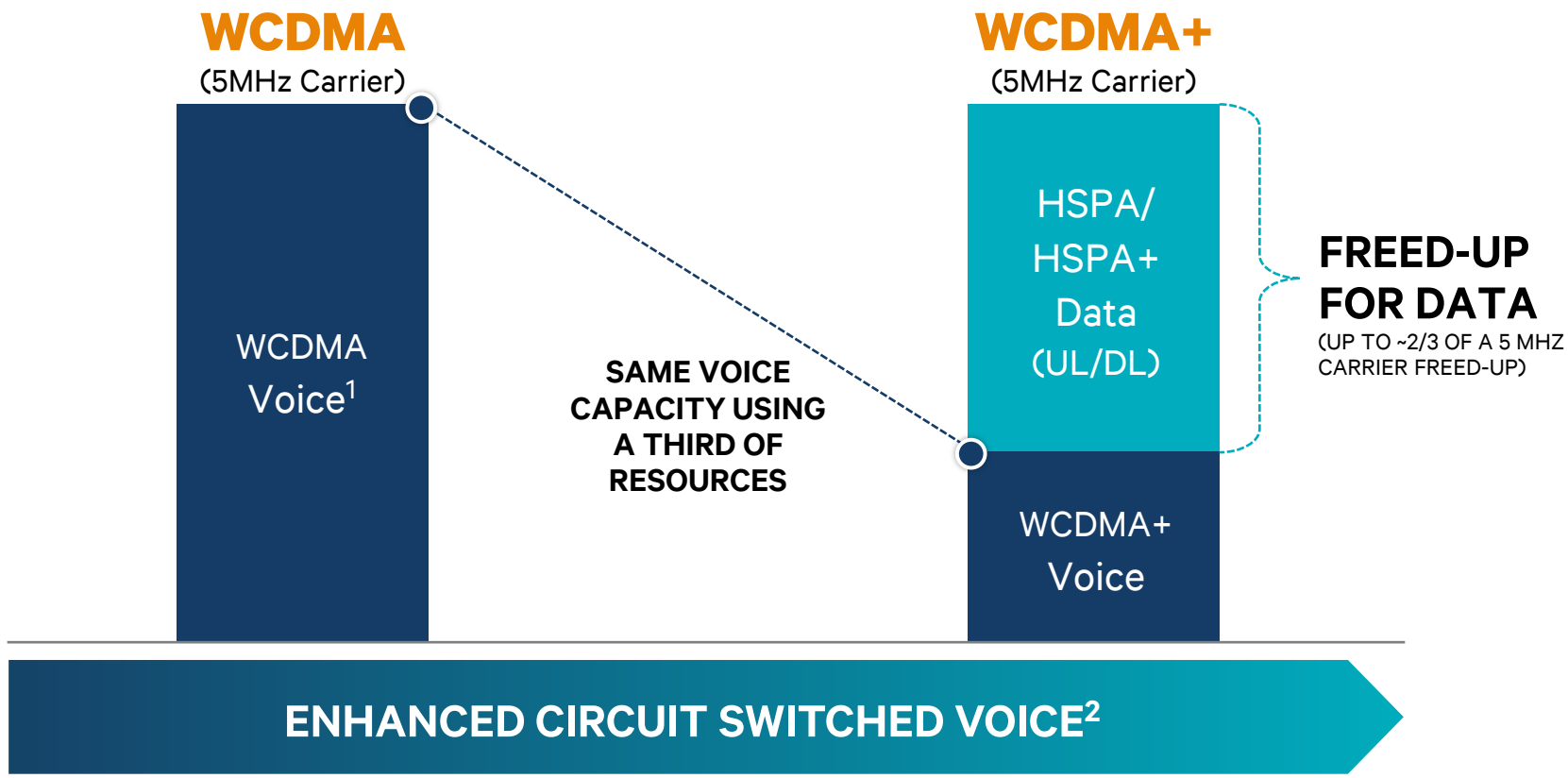
# WCDMA+ frees up capacity for HSPA+ data

More efficient voice frees-up resources for data



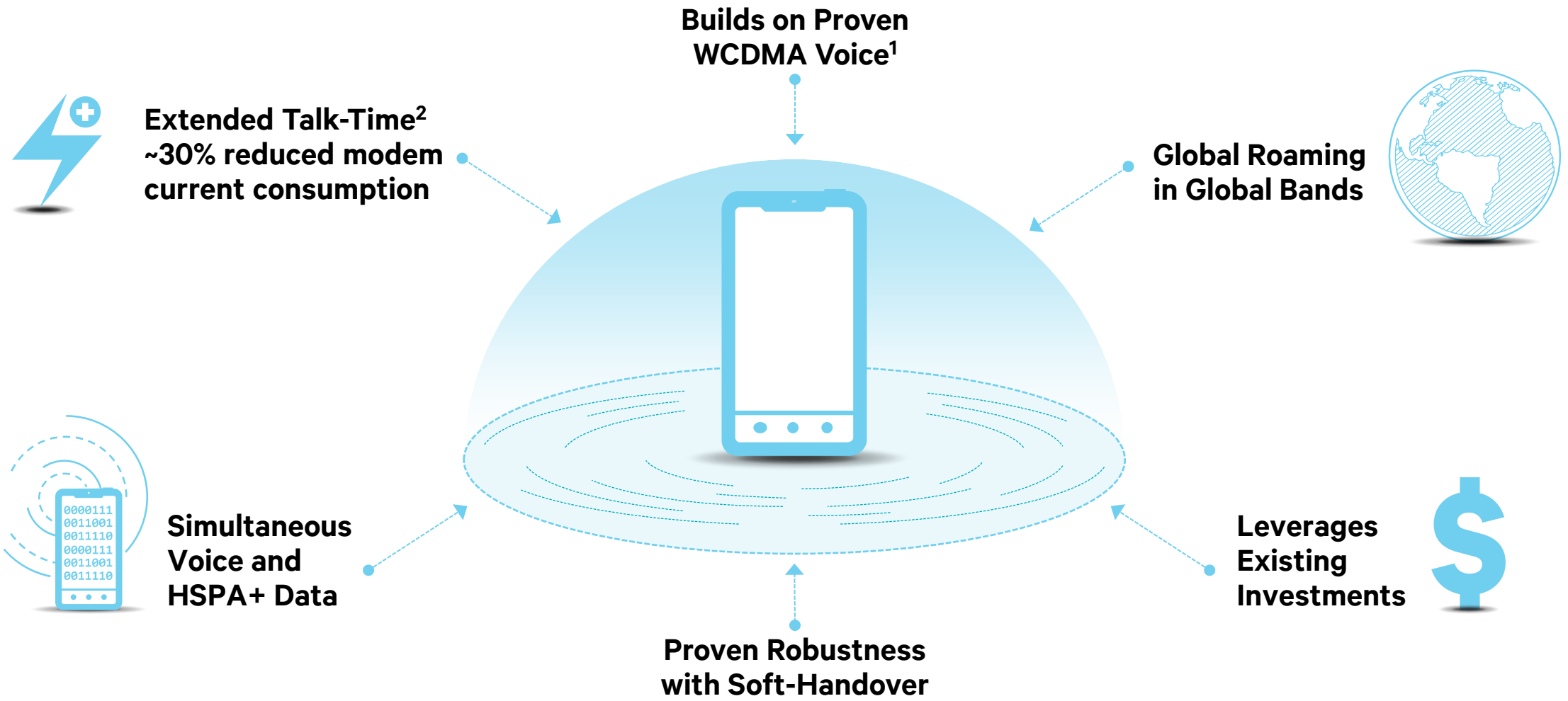
# WCDMA+ can free up ~2/3 of a carrier for data

## HSPA relies on WCDMA for voice, tripled voice efficiency means more resources left for data




1 There is ~10% DL data capacity available at max voice capacity not shown in the graph for WCDMA .Assumptions: single receive antenna and rake receiver assumed for voice, dual receive diversity assumed for data. .
2 WCDMA+ is a 3GPP R12 feature

# WCDMA+ ensures high quality, reliable, ubiquitous voice




[1] High quality, thanks to soft handover, proven interoperability and 10+ years of WCDMA circuit switched voice optimizations. [2] Modem current consumption reduced by ~30% with WCDMA+ compared to WCDMA.

# Circuit switched voice has a long life during the transition to richer, carrier grade VoIP

## IMS VoIP: Rich Voice – Ubiquity vs. OTT VoIP

VoLTE Timing is Operator Specific
VoIP over HSPA+ Driven by VoLTE

**2014**

Fallback to 2G/3G voice (CSFB) used by most LTE operators while the VoLTE with SRVCC ecosystem is being developed and expanded

## Proven Circuit Voice: High Quality, Reliable, Ubiquitous[1]

WCDMA+: Long life of HSPA+ means long life of WCDMA

**2020+**

1 Thanks to soft handover, proven interoperability and 10+ years of 1X/WCDMA optimizations. OTT=Over-The-Top, voice just like any data service without Quality of Service

# Qualcomm Technologies' committed to continued HSPA+ evolution



## Standards Leadership

**Major 3GPP contributor**

**Recognized expertise**

## Industry-first Demos

| | | | |
|---|---|---|---|
| **MWC 2007:** Voice over HSPA | **MWC 2008:** Dual-Carrier (CA) | **MWC 2009:** Dual-Carrier 42 Mbps | **MWC 2010:** Uplink beamforming |
| **MWC 2011:** MultiFlow (CA) and supplemental downlink | **MWC 2012:** HetNets range expansion | **MWC 2013:** WCDMA+ | **MWC 2014:** 4 carrier multiflow |

## Industry-first Chipsets

| MDM 8200 HSPA+ | MDM 8220 DC-HSPA+ | 9x25 LTE-A (cat4) HSPA+ CA | gobi 9x35 LTE-A (Cat6) HSPA+ CA |
|---|---|---|---|
| Launched Feb 2009 | Launched Aug 2010 | LTE-A CA Launched in 2013 | HSPA+ UL-CA launching in 2014 |

Qualcomm Snapdragon and Gobi are products of Qualcomm Technologies, Inc. ; Actual screenshot from WCDMA+ Demo, first shown at MWC 2014

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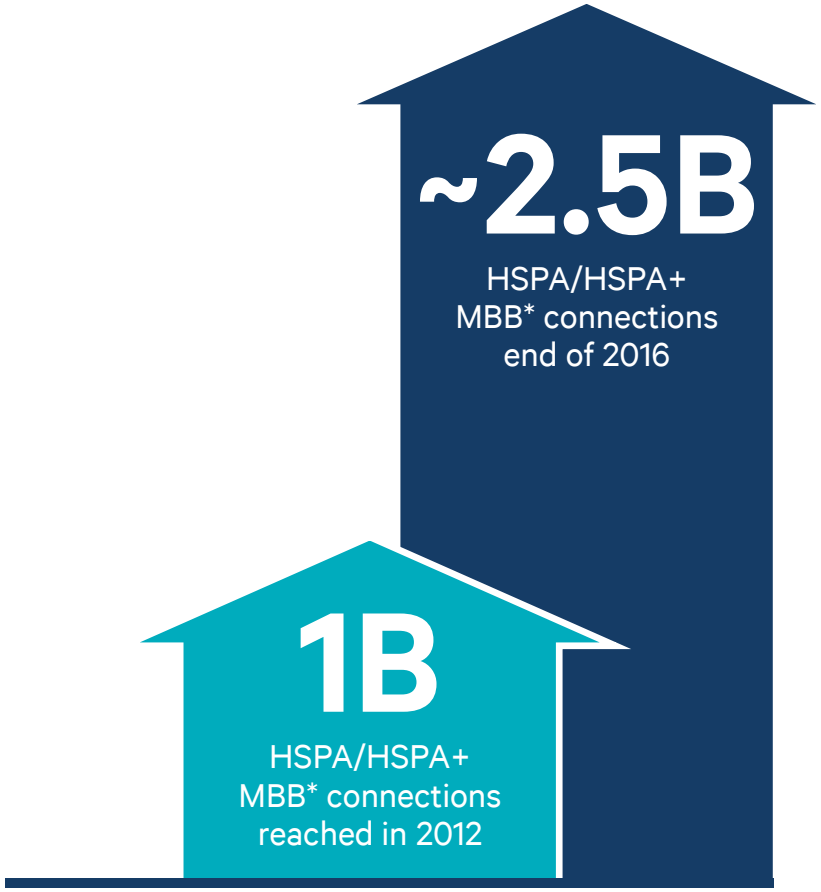


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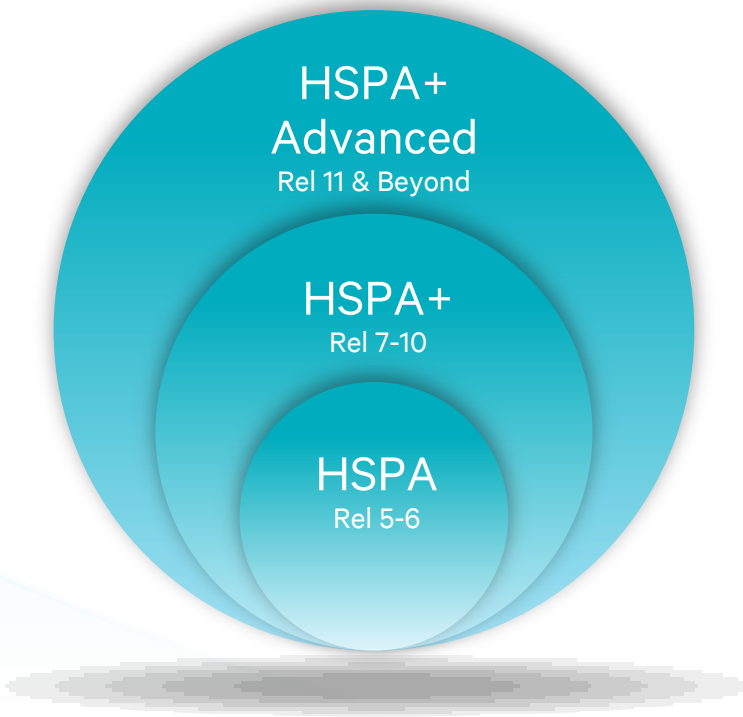
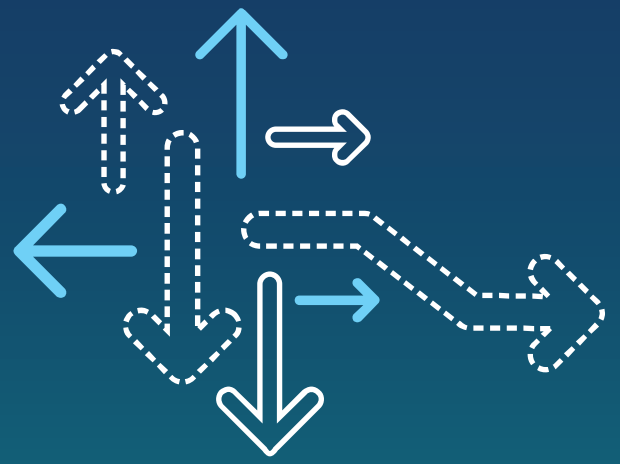
# Pushing wireless boundaries


To learn more, go to
www.qualcomm.com/1000x

www.qualcomm.com/hspa
to learn more about the HSPA+ evolution



# Questions? - Connect with Us



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