August 2014

Evolution of HSPA+ Carrier Aggregation

QUALCOMM®

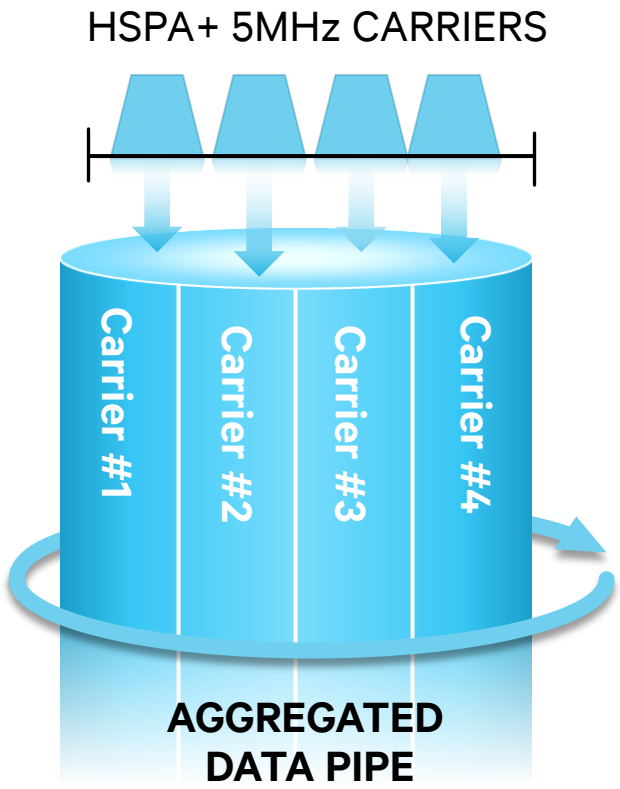
HSPA+ carrier aggregation evolution

1. **Carrier aggregation enhances broadband experience**
   All users in the cell improved with higher data rates and lower latencies

2. **Evolving to leverage all spectrum assets**
   Aggregation across bands, across carriers (multiflow), more carriers, and uplink,

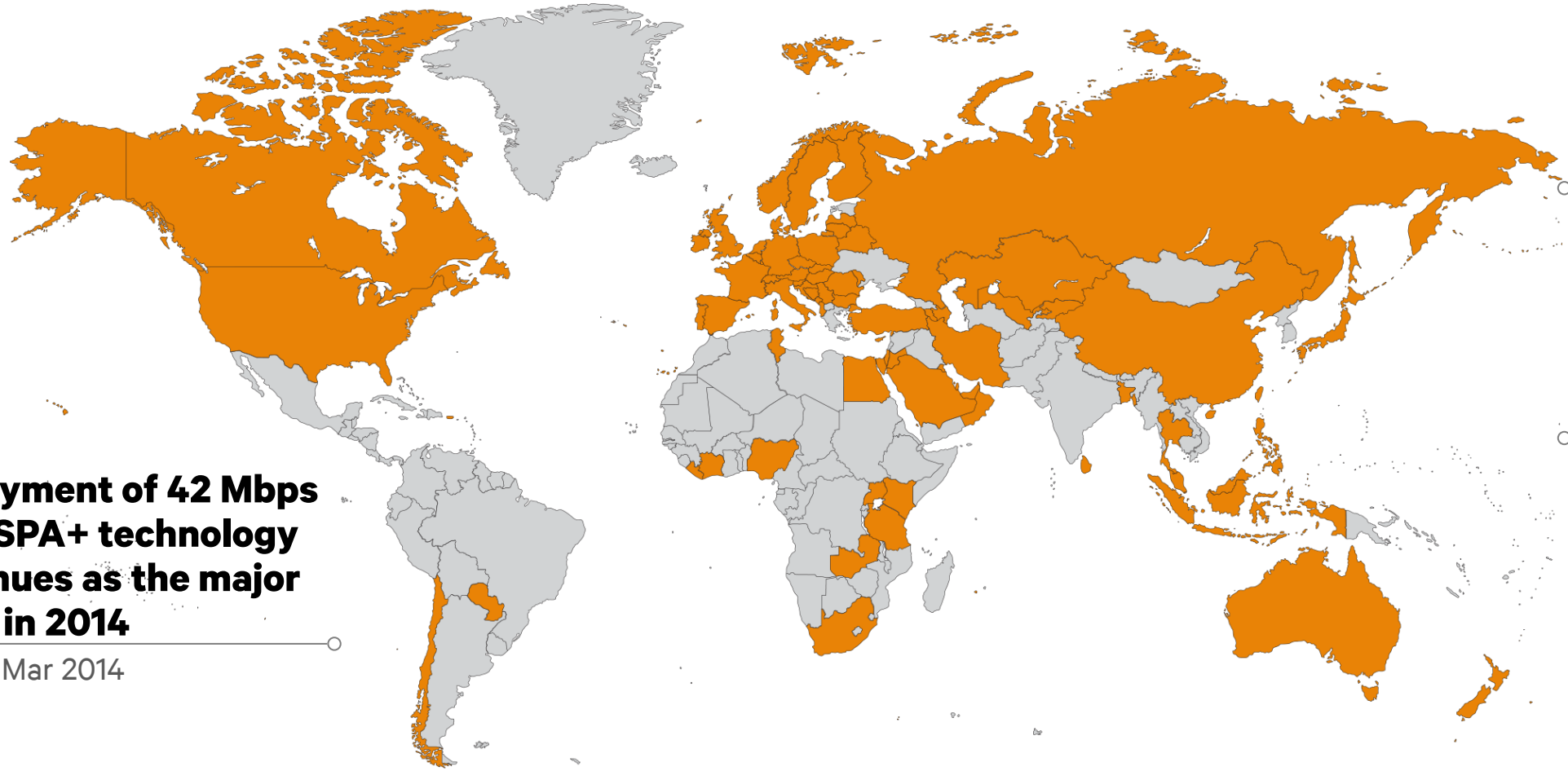
3. **Benefits HetNets—even better with multiflow**
   Multiflow evolves carrier aggregation to across cells

4. **Expanded chipset support for carrier aggregation**
   Carrier aggregation across bands, uplink and beyond two carriers



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

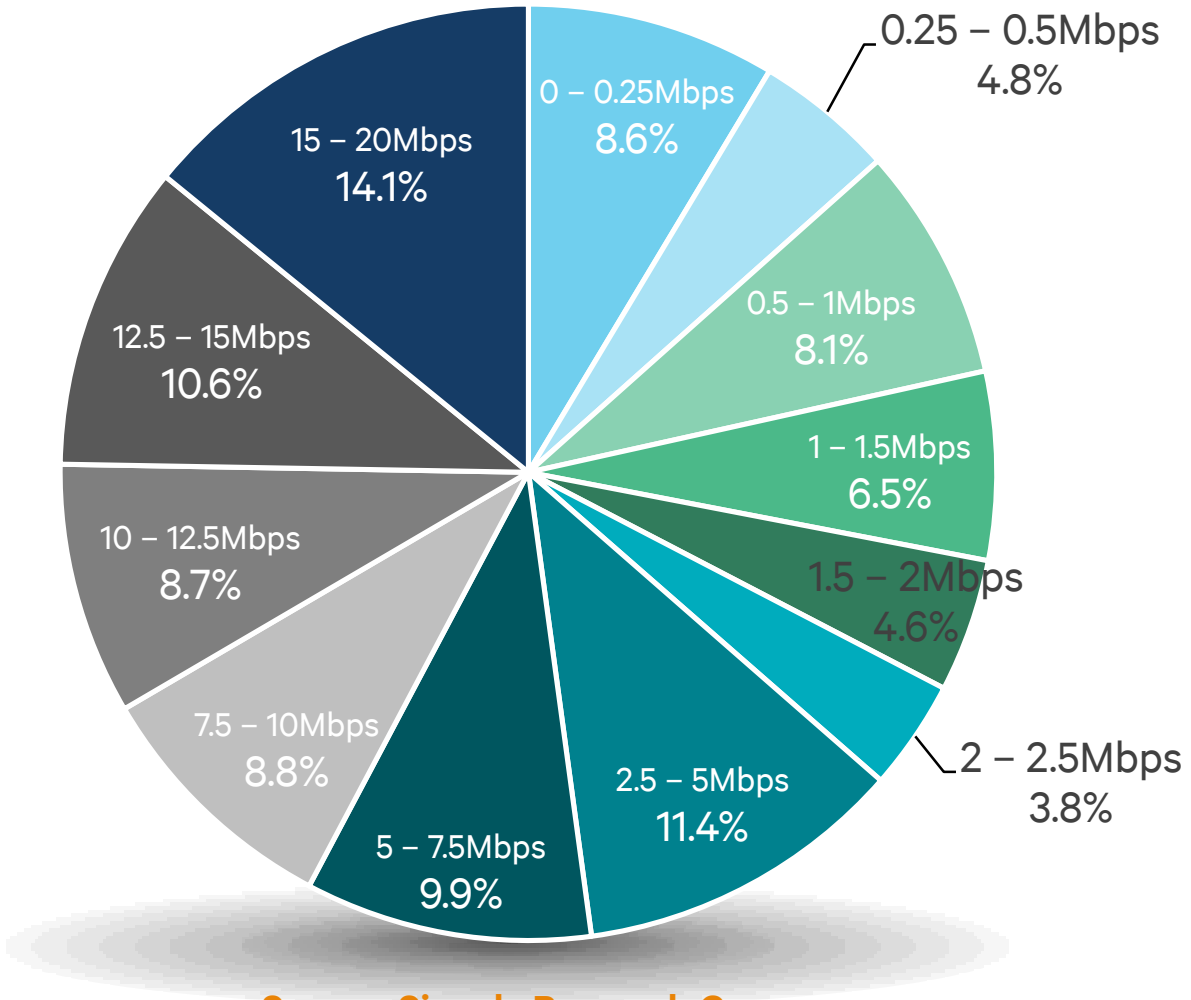
>5Mbps >50%

USER DATA RATE OF THE TIME

>1Mbps ~80%

USER DATA RATE OF THE TIME

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



Source: Signals Research Group

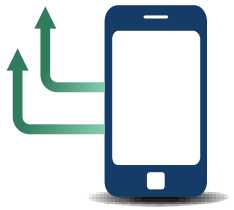
Signals Ahead, September 2011, "The Mother of all Network Benchmark Tests"

HSPA+ Carrier aggregation expanding reach

Leveraging all spectrum assets

Uplink

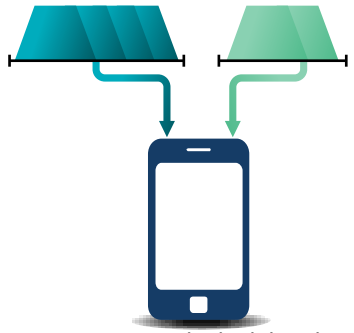
DUAL-CARRIER IN THE UPLINK[1]



Across Bands

HIGH BAND (e.g Band I & II)

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

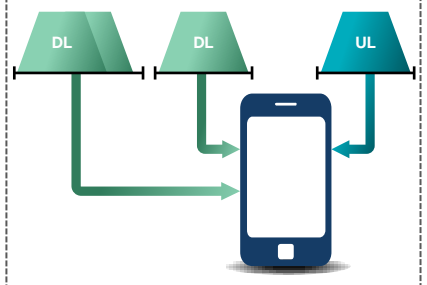


1-3 carriers in the high band, and 1-2 in the low band[2]

Supplemental Downlink

UNPAIRED SPECTRUM

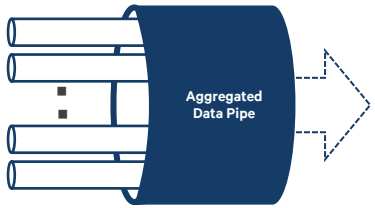
PAIRED SPECTRUM



Combining unpaired spectrum with the downlink [3]

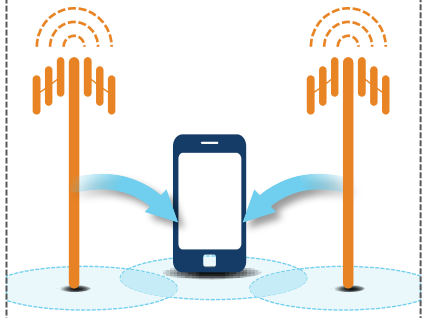
More Carriers

DUAL-CARRIER NOW & COUNTING[4]



Multiflow

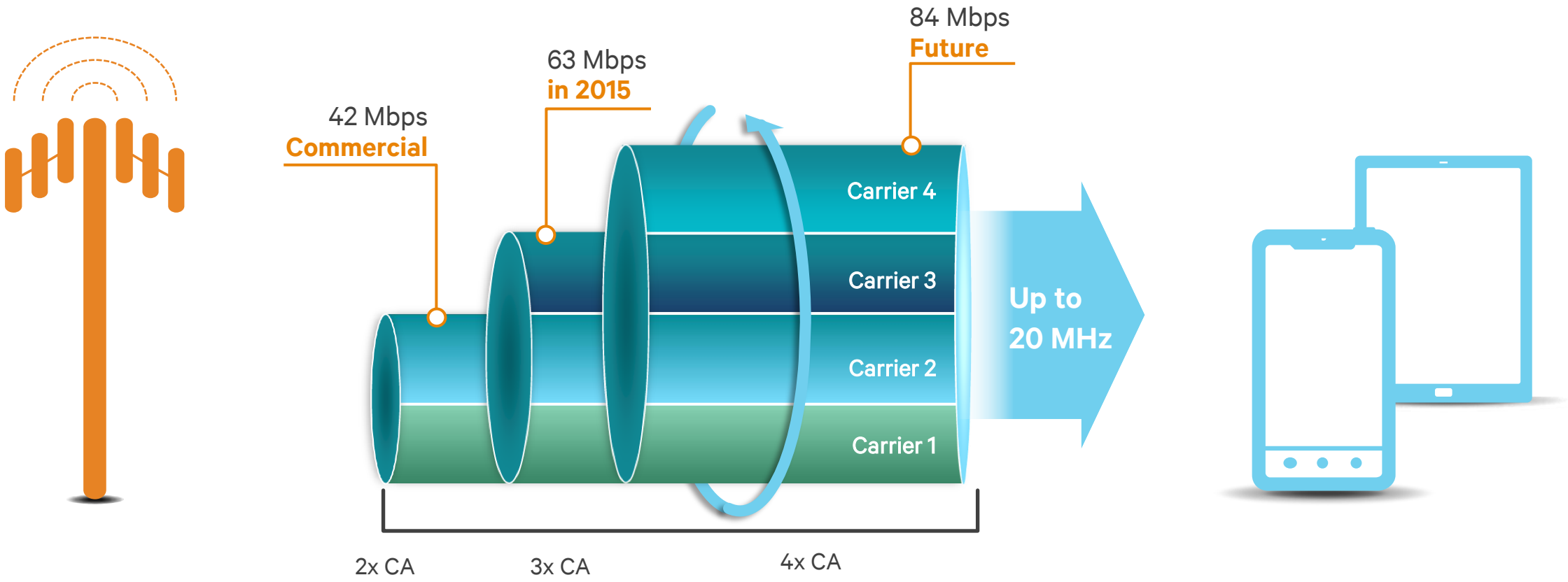
AGGREGATION ACROSS CELLS[5]



3GPP continually defines new band combinations

[1]Defined in Rel 9; [2] Originally 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-carrier in Rel 10, and 8-carriers in Rel11; Defined in Rel 11

Carrier aggregation enhances user experience



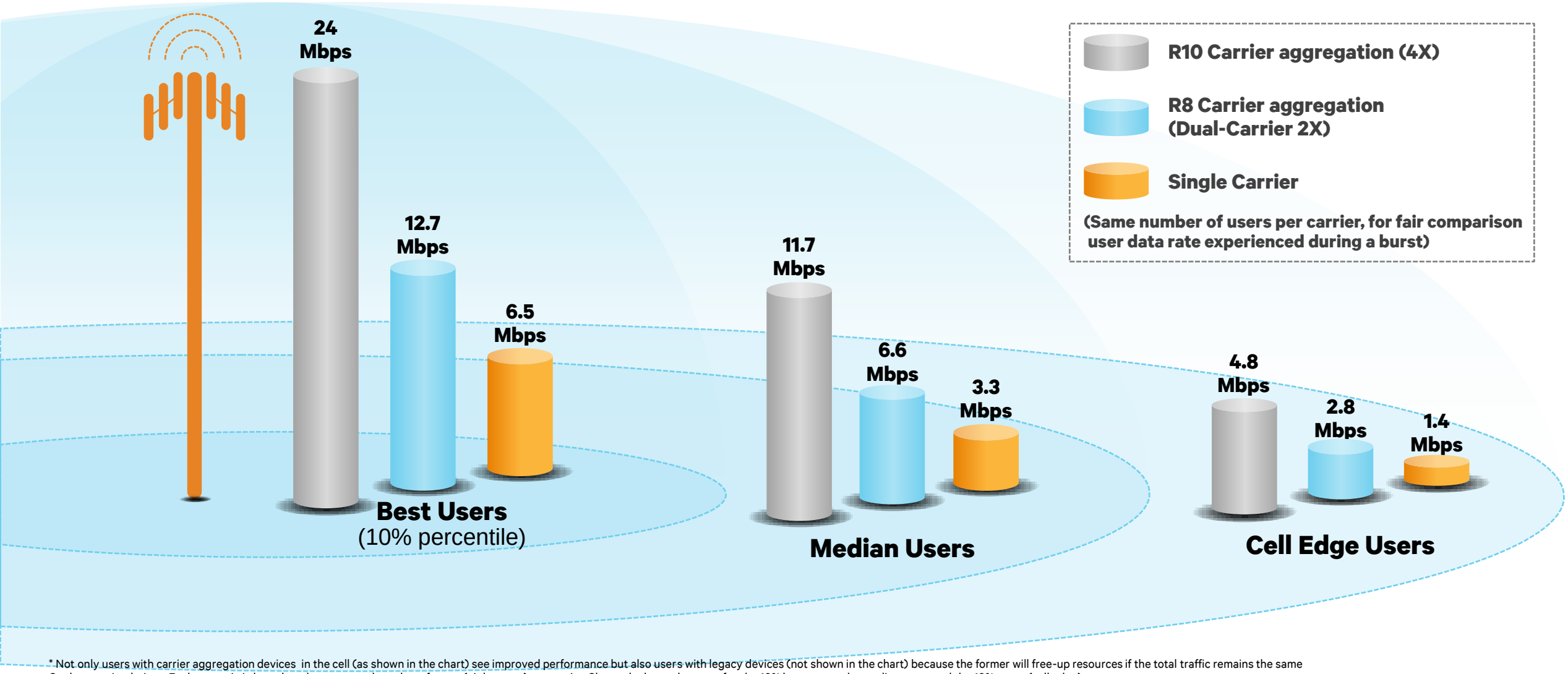
Increased data rates for all users

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.

User data rates increase with bandwidth—all users improved*



* Not only users with carrier aggregation devices in the cell (as shown in the chart) see improved performance but also users with legacy devices (not shown in the chart) because the former will free-up resources if the total traffic remains the same
Qualcomm simulations. Each scenario is based on the same total number of users (eight users) per carrier. Shows the burst data rate for the 10% best users , the median users and the 10% worst (cell edge) users.
MIMO with Carrier aggregations part of R9 and R10, but MIMO has not been considered in this simulation.

Carrier aggregation combinations—standard progress

3GPP R12 expected to be completed toward the end of 2014

Dual-band, Dual carrier

Approved bands (up to R11)

- I + VIII
- II + IV
- I + V
- I + XI
- II + V

Dual-band, 4 carrier

Approved bands (up to R11)

- I + VIII
- II+ IV
- I + V
- II + V

Non-contiguous, 4 carrier

Approved bands (up to R11)

- 2.1 GHz (Band I)
  5 & 10 MHz gap between blocks, depending on configuration
- 2.1 GHz (AWS - Band IV)
  5, 10, 15, 20, & 25 MHz gap between blocks, depending on configuration

Supplemental downlink

Targeted for R12

- 2.1 GHz (Band I) – Anchor
  +
  1.4 GHz (Band XXXII) – Downlink

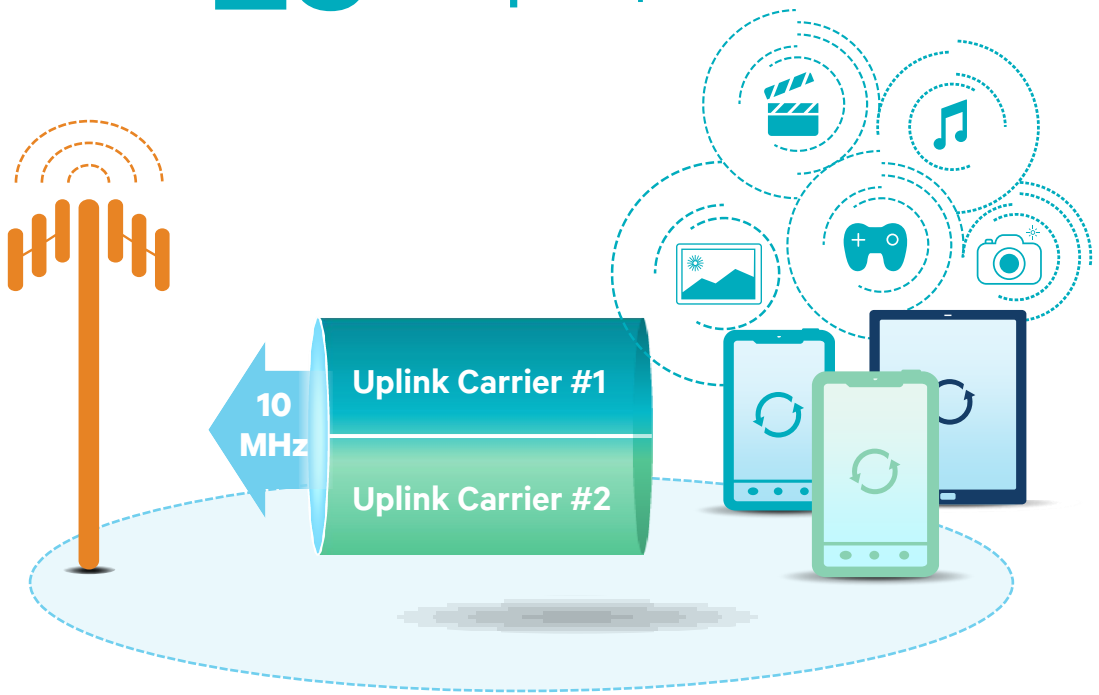
Band I – 2.1 GHz; Band II – 1900 MHz; Band IV – 2.1GHz (AWS); Band V – 850 MHz; Band VIII – 900 MHz; Band XI – 1500 MHz; Band XXXII – 1.4 GHz (L-Band)

Brining benefits of dual-carrier to uplink

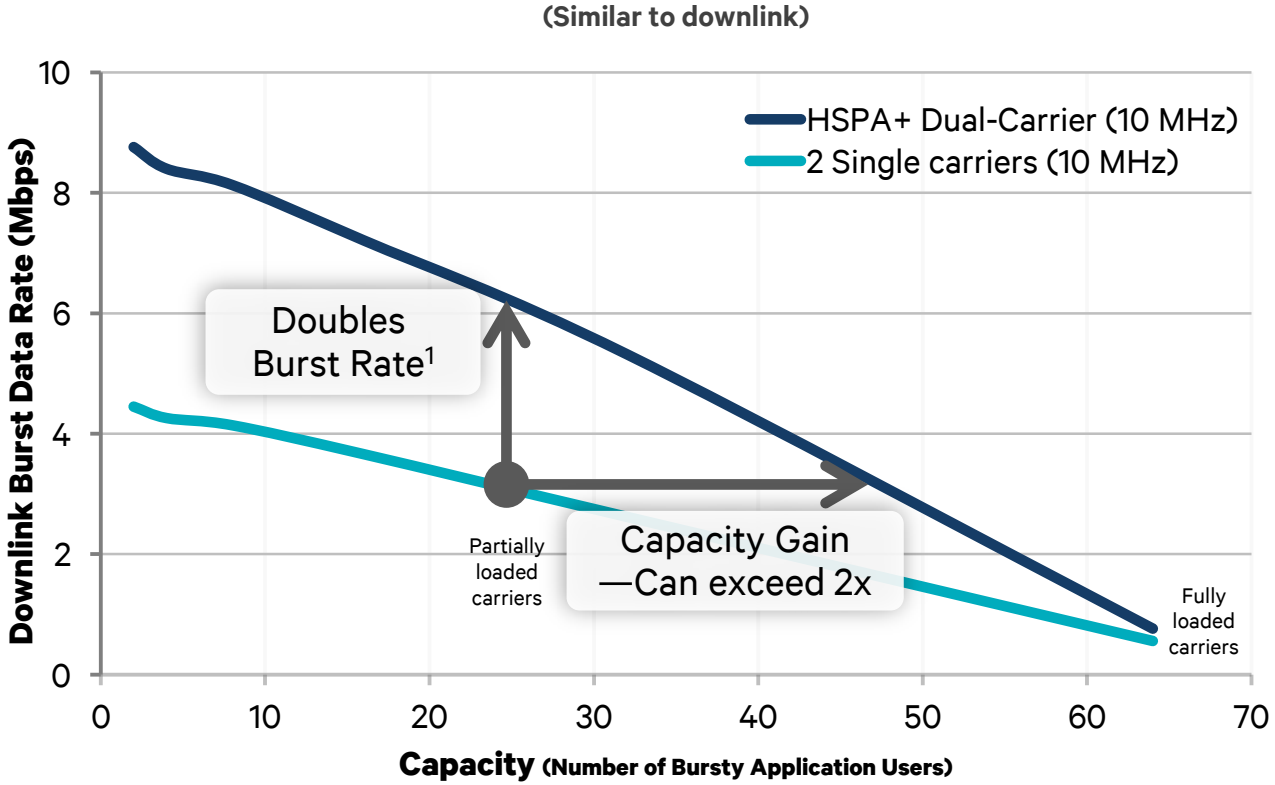
Addressing the needs of today's smartphones and media sharing (e.g. photo and video uploads)

Higher Uplink data rates

23 Mbps (peak)



Higher uplink capacity for bursty apps

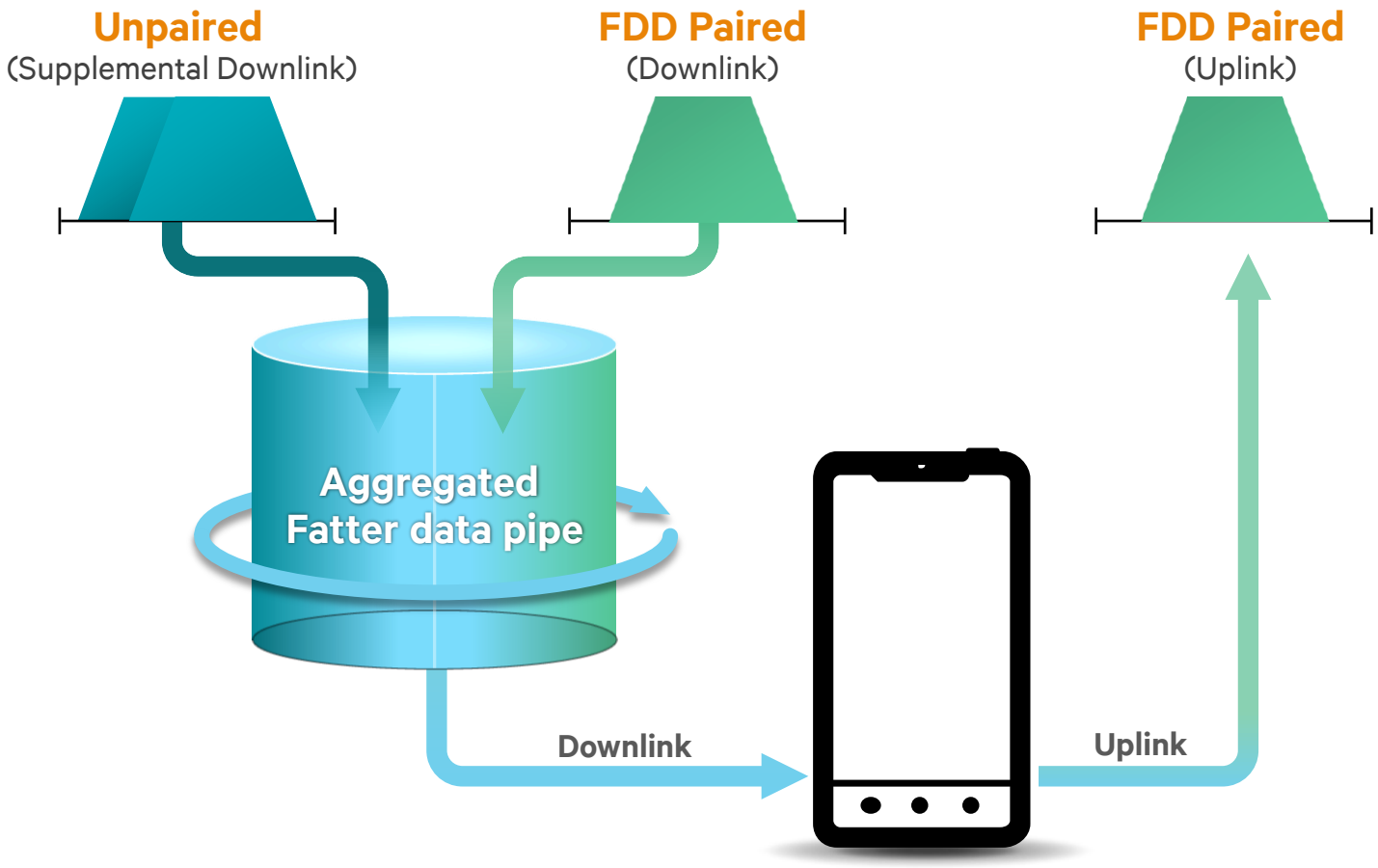


Leveraging unpaired spectrum with supplemental downlink

Boosts downlink capacity

L-Band 1.4GHz (Band XXXII) Harmonized in Europe[1]

- L-Band has 40 MHz of idle unpaired spectrum available [2]
- 3GPP specs expected in Jun 2014[2]
- Chipsets planned for commercial devices in 2015[3]



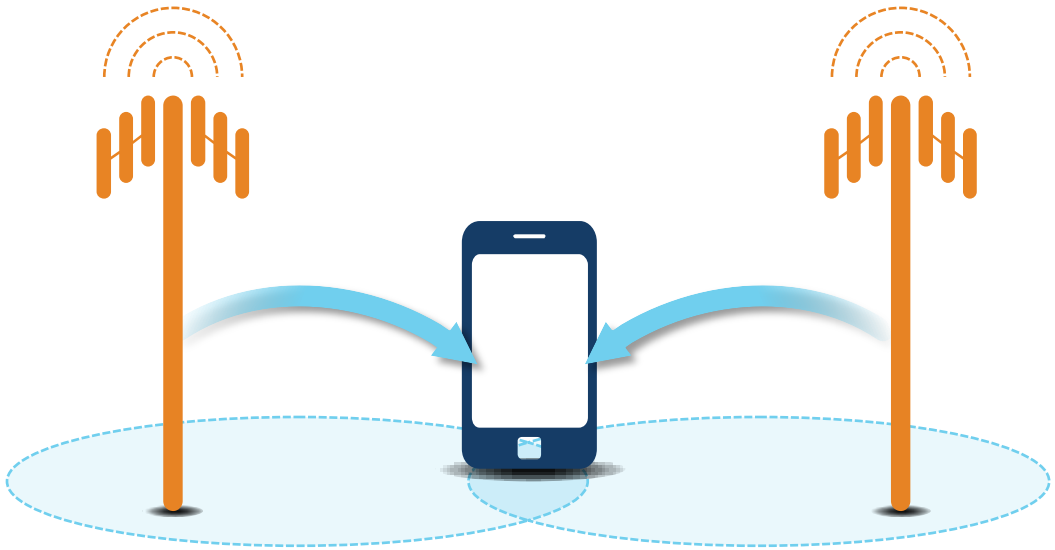
1 L-Band in Europe: 1452 MHz to 1492 MHz, sometimes referred to as 1.4GHz or 1.5GHz spectrum.

2 Aggregation across bands is supported in HSPA+ R9 for two downlink carriers, but each specific band combination, e.g. combination of band 1 and L-band, has to be defined in 3GPP.

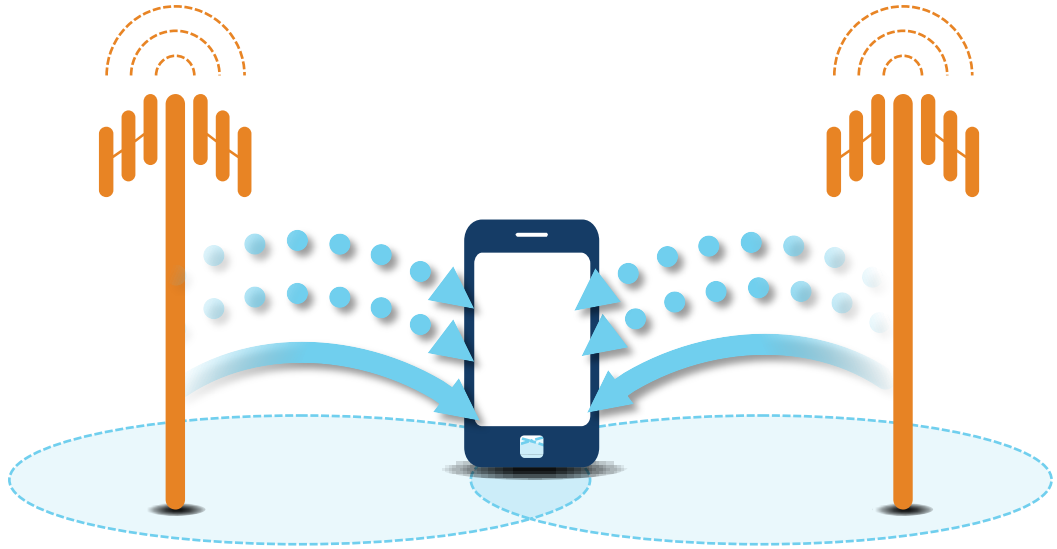
3 subject to timely completion of standard with reasonable technical specifications

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]

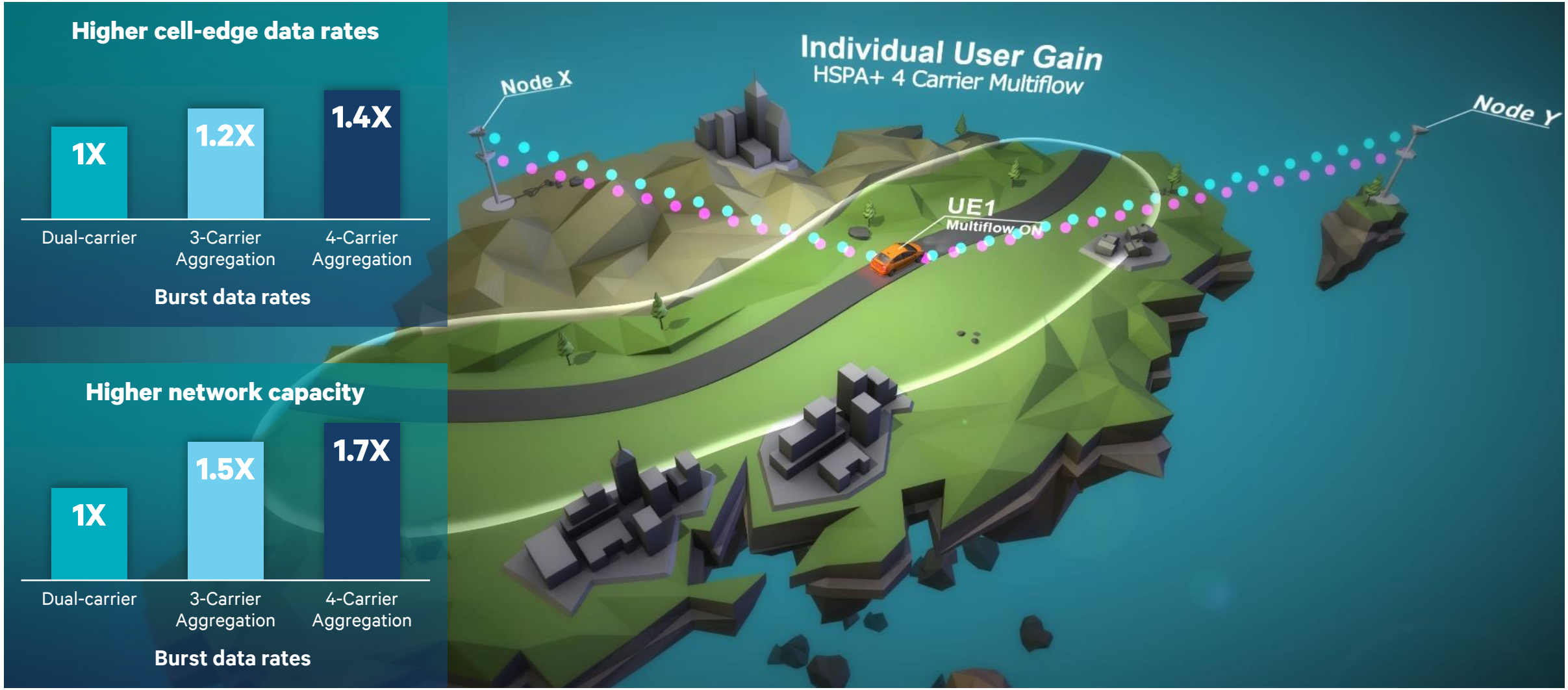
Higher cell-edge data rates

Better network load balancing

Higher network capacity

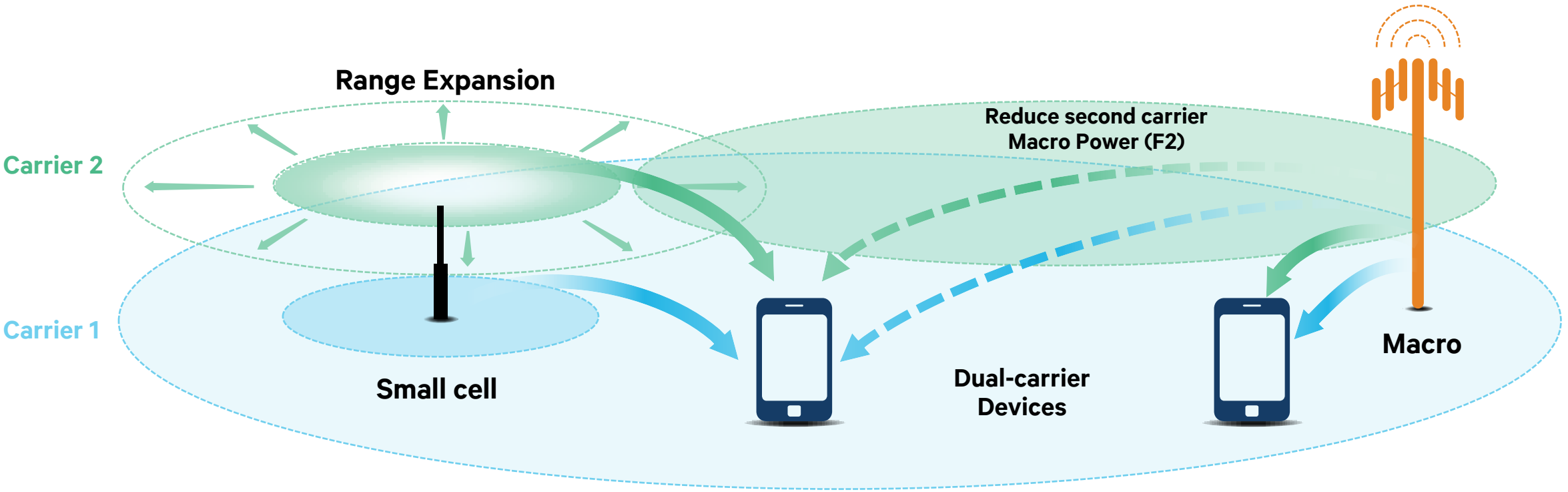
[1]With the evolution to supporting 4 carrier aggregation, multiflow can aggregate up to 3 carriers from one site/cell and one carrier from the other cells in the future

Multiflow Improves cell-edge data rates and network capacity



Assumptions: 57 cell wrap around with 1km Inter-site distance (ISD). Receiver type LMMSE, Rx Diversity. Traffic model: 3GPP bursty source with 1 Mb burst, exponential inter-arrival with 5s mean. Power allocation: 30% total overhead power (incl. 10% of C-PICH). Antenna pattern: 2D with 70deg 3dB beam width. Channel Model: PA3. HS-DPCCH Decoding: For Intra-NB, at Node-B with soft combining. For inter-NB, at both NodeBs.

HSPA+ hetnet range expansion leverages carrier aggregation



Small cell better utilized

Macro offloaded

All users improved

Enabling features: reduced power on second macro carrier , dual carrier devices (or dual frequency Multiflow), and mitigating uplink and downlink imbalance (3dB Cell-individual offset (CIO) and pico noise-figure pad)

Expanded HSPA+ carrier chipset 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

Small cell better utilized

Macro offloaded

All users improved

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

Four carrier multiflow demo at MWC 2014

Aggregating across four cells (and two frequencies)

Improved cell-edge performance

Better network load balancing

Bringing 4-carrier benefits to dual-carrier deployments

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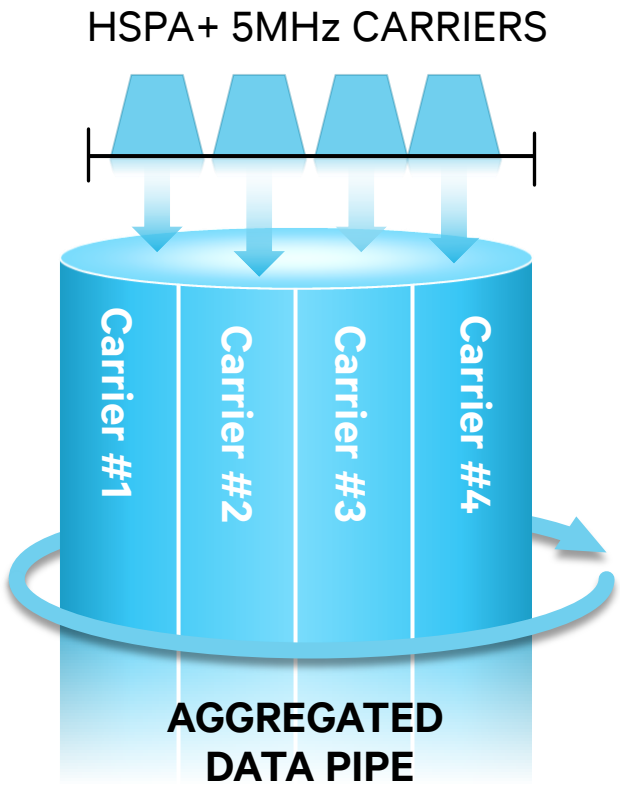
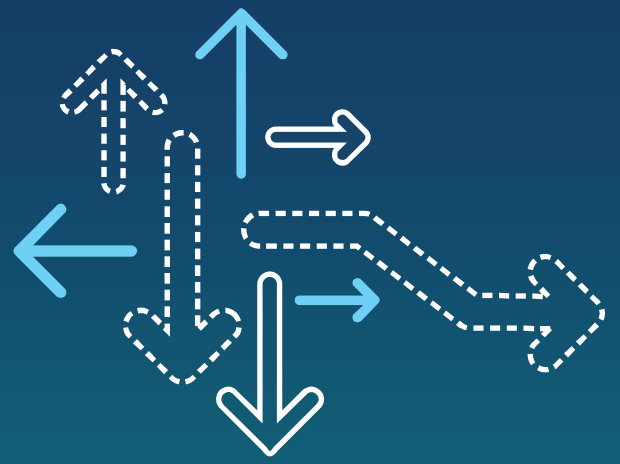


Questions? - Connect with Us



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