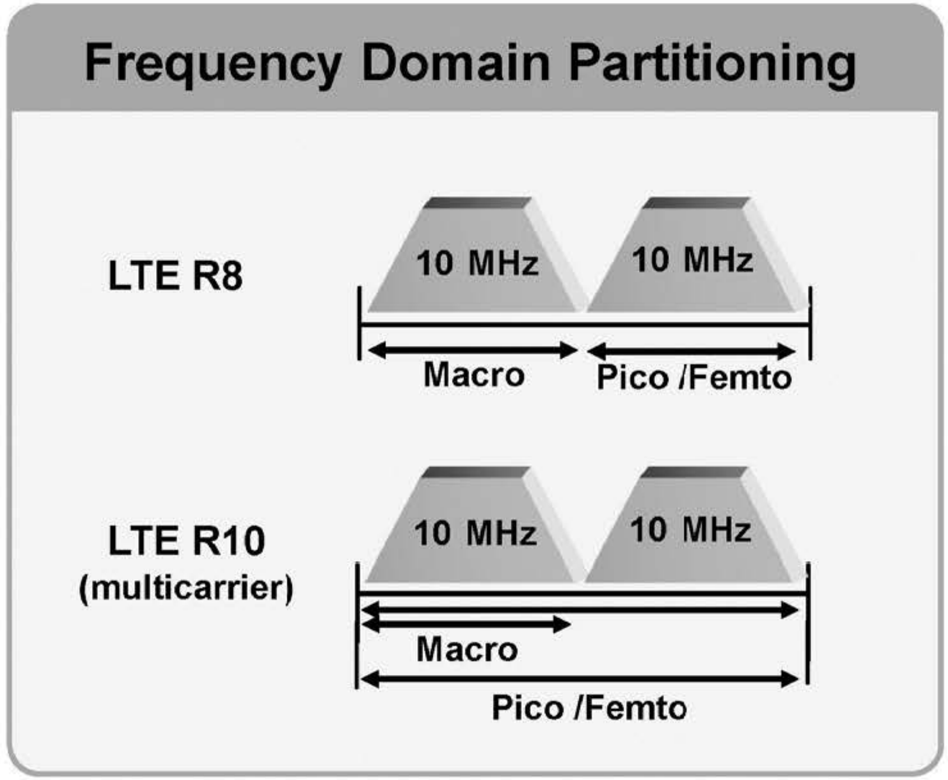
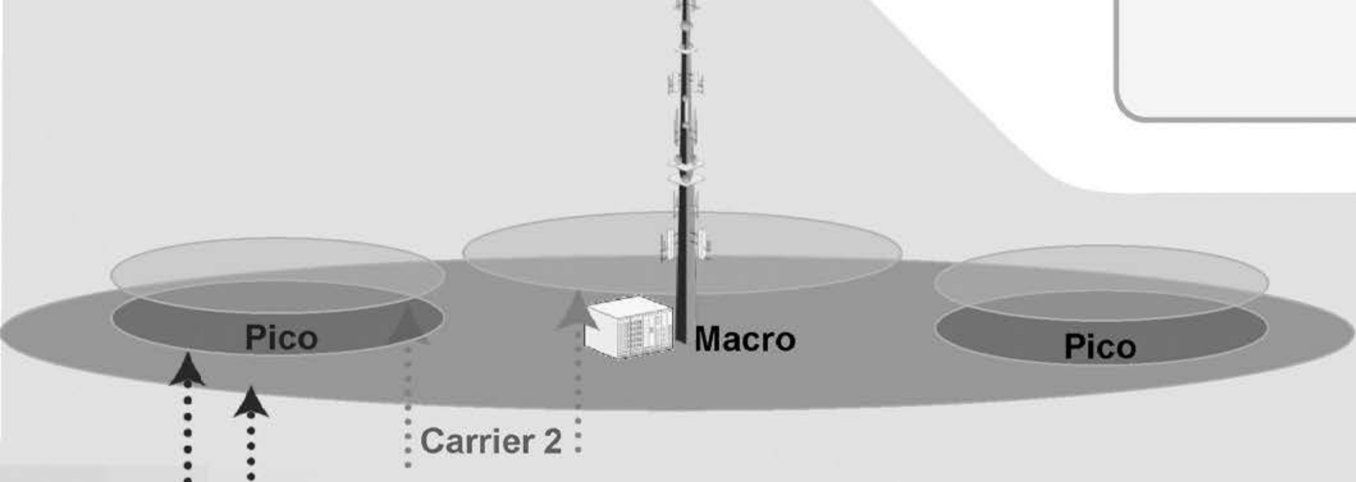
Frequency Partitioning Possible for HetNets with Abundant Spectrum

- Macro and pico/femtos on different frequencies to avoid strong interference
- Reduced performance compared to time-domain partitioning[1]



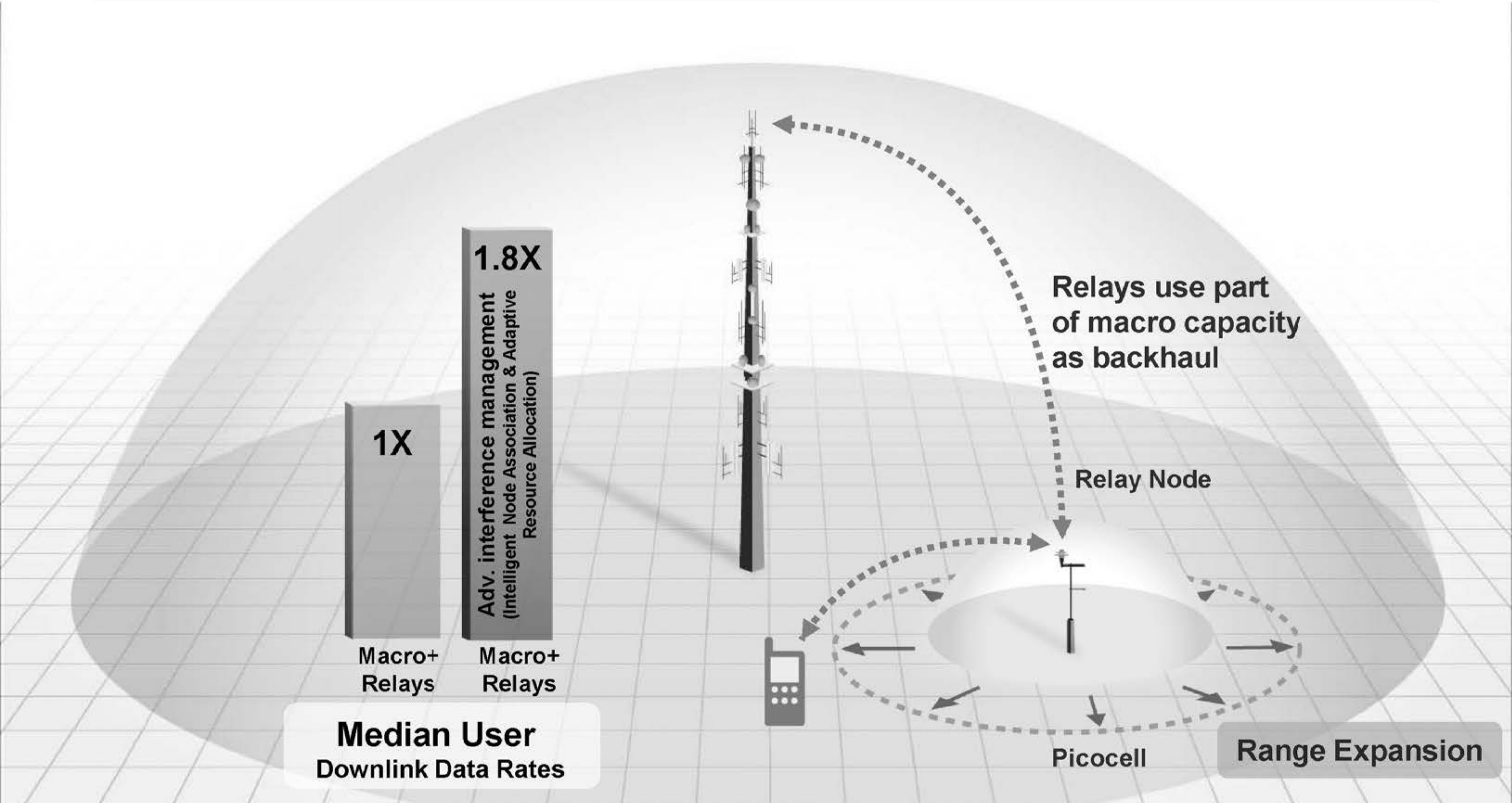
- Helps to manage HetNet Interference:



Example: Carrier 1 used for wide area macro coverage, but also by picocells, carrier 2 used by all nodes, but with lower power around macrocell

[1]A less granular and flexible option—but does not require synchronized nodes

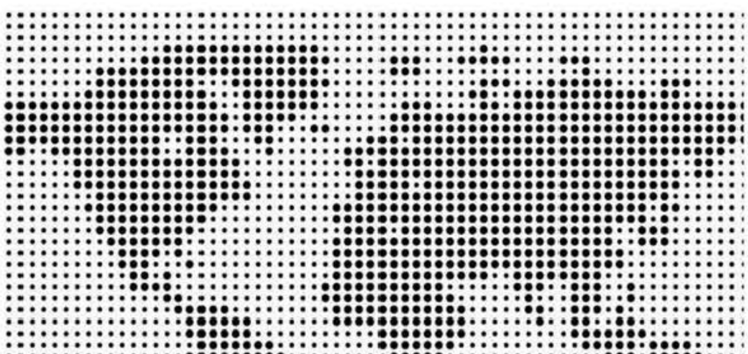
Relays Extend Coverage and Improve Capacity without Backhaul Expenses



Adaptive interference management further improves capacity and coverage

Assumptions: Results from 3GPP R1-094230; Based on methodology in R1-084026 10 MHz FDD, 2x2 MIMO UE, 10 Layer 3 Relays per Macro cell, uniform random layout. Advanced interference management includes intelligent node association and adaptive resource allocation

LTE Advanced: Heterogeneous Networks



Qualcomm Incorporated
February 2010

LTE-Advanced: Heterogeneous Networks

Table of Contents

Executive Summary

Long-Term Evolution (LTE) allows operators to use new and wider spectrum and complements 3G networks with higher data rates, lower latency and a flat IP-based architecture. To further improve broadband user experience in a ubiquitous and cost effective manner, 3GPP has been working on various aspects in the framework of LTE Advanced.

Since radio link performance is approaching theoretical limits with 3G Enhancements and LTE, the next performance leap in wireless networks will come from the network topology. LTE Advanced is about improving spectral efficiency per unit area. Using a mix of macro, pico, femto and relay base-stations, heterogeneous networks enable flexible and low-cost deployments and provide a uniform broadband experience to users anywhere in the network.

This paper discusses the need for an alternative deployment model or topology using heterogeneous networks. To enhance the performance of these networks, advanced techniques are described which are needed to manage and control interference and deliver the full benefits of such networks. Range extension allows more user terminals to benefit directly from low-power base-stations such as picos, femtos, and relays. Adaptive inter-cell interference coordination provides smart resource allocation amongst interfering cells and improves inter-cell fairness in a heterogeneous network. In addition, the performance gains with heterogeneous networks using an example macro/pico network are shown.

[1] Introduction

Developed by 3GPP, LTE is the leading OFDMA wireless mobile broadband technology. LTE offers high spectral efficiency, low latency and high peak data rates. LTE leverages the economies of scale of 3G, as well as the ecosystem of infrastructure and devices vendors to provide the highest performance in a cost effective manner.

The LTE standard was first published in March of 2009 as part of the 3GPP Release 8 specifications. Comparing the performance of 3G and its evolution to LTE, LTE does not offer anything unique to improve spectral efficiency, i.e. bps/Hz. LTE improves system performance by using wider bandwidths if the spectrum is available.

Topology will provide the next performance leap for wireless networks beyond radio link improvements.

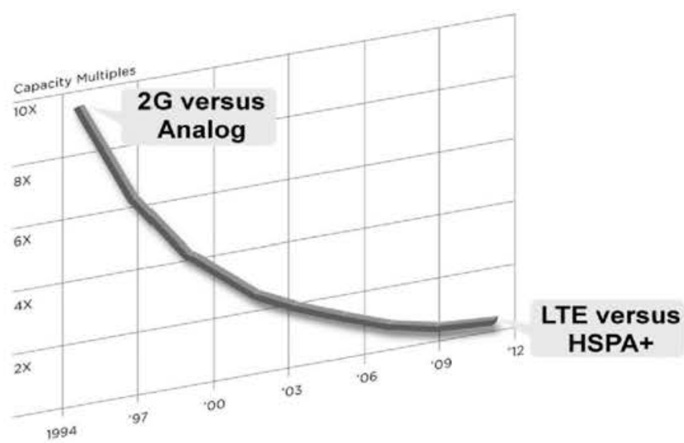


Figure 1 Improvements in spectral efficiency is approaching theoretical limits

3GPP has been working on various aspects to improve LTE performance in the framework of LTE Advanced, which include higher order MIMO, carrier aggregation (multiple component carriers), and heterogeneous networks (relays, picos and femtos). Since improvements in spectral efficiency per link is approaching theoretical limits with 3G and LTE, as shown in Figure 1, the next generation of technology is about improving spectral efficiency per unit area. In other words, LTE Advanced needs to provide a uniform user experience to users anywhere inside a cell by changing the topology of traditional networks. A key aspect of LTE Advanced is about this new deployment strategy using heterogeneous networks.

[2] Heterogeneous Networks

2.1 Traditional Network Deployment Approach

Current wireless cellular networks are typically deployed as homogeneous networks using a macro-centric planned process. A homogeneous cellular system is a network of base-stations in a planned layout and a collection of user terminals, in which all the base-stations have similar transmit power levels, antenna patterns, receiver noise floors, and similar backhaul connectivity to the (packet) data network. Moreover, all base-stations offer unrestricted assess to user terminals in the network, and serve roughly the same number of user terminals, all of which carry similar data flows with similar QoS requirements.

The locations of the macro base-stations are carefully chosen by network planning, and the base-station settings are properly configured to maximize the coverage and control the interference between base-stations. As the traffic demand grows and the RF environment changes, the network relies on cell splitting or additional carriers to overcome capacity and link budget limitations and maintain uniform user experience. However, this deployment process is complex and iterative. Moreover, site acquisition for macro base-stations with towers becomes more difficult in dense urban areas. A more flexible deployment model is needed for operators to improve broadband user experience in a ubiquitous and cost effective way.

Heterogeneous network enables flexible and low-cost deployment using mix of macro, pico, femto, and relay base-stations.

2.2 An Alternate Approach Using Heterogeneous Network

Wireless cellular systems have evolved to the point where an isolated system (with just one base-station) achieves near optimal performance, as determined by information theoretic capacity limits. Future gains of wireless networks will be obtained more from advanced network topology, which will bring the network closer to the mobile users. Heterogeneous networks utilizing a diverse set of base-stations can be deployed to improve spectral efficiency per unit area.

Consider the heterogeneous cellular system depicted in Figure 2. This cellular system consists of regular (planned) placement of macro base-stations that typically transmit at high power level (~5W - 40 W), overlaid with several pico base-stations, femto base-stations and relay base-stations, which transmit at substantially lower power levels (~100 mW – 2 W) and are typically deployed in a relatively unplanned manner. The low-power base-stations can be deployed to eliminate coverage holes in the macro-only system and improve capacity in hot-spots. While the placement of macro base-stations in a cellular network is generally based on careful network planning, the placement of pico/relay base-stations may be more or less ad hoc, based on just a rough knowledge of coverage issues and traffic density (e.g. hotspots) in the network.

Due to their lower transmit power and smaller physical size, pico/femto/relay base-stations can offer flexible site acquisitions. Relay base-stations offers additional flexibility in backhaul where wireline backhaul is unavailable or not economical.

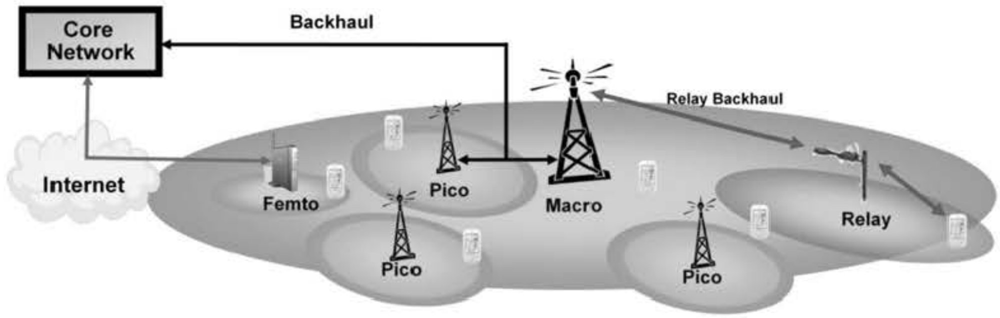


Figure 2 Heterogeneous Network utilizing mix of macro, pico, femto and relay base-stations

Next generation networks should allow a uniform user experience across the cell by improving the cell edge and median data rates

In a homogeneous network, each mobile terminal is served by the base-stations with the strongest signal strength, while the unwanted signals received from other base-stations are usually treated as interference. In a heterogeneous network, such principles can lead to significantly sub-optimal performance. In such systems, smarter resource coordination among base-stations, better server selection strategies and more advanced techniques for efficient interference management can provide substantial gains in throughput and user-experience as compared to a conventional approach of cellular communications.

2.3 Technology Performance

The potential performance improvement from LTE-Advanced heterogeneous networks can be demonstrated in an example with mixed macro/pico deployment. The 3GPP evaluation methodology specified in [2] is used with configuration 1 (uniform layout). The network consists of macro base-stations (with 43dBm transmit power and 17dB antenna gain) and 4 pico cells per macro base-station (with 30dB transmit power and 5dB antenna gain), with or without heterogeneous network enhancements.

Figure 3 shows the user data rate improvement using heterogeneous network features for downlink. As seen in the figure, both cell-edge and median user rates are improved significantly as the result of the intelligent server selection and advanced interference management techniques described in the following sections.

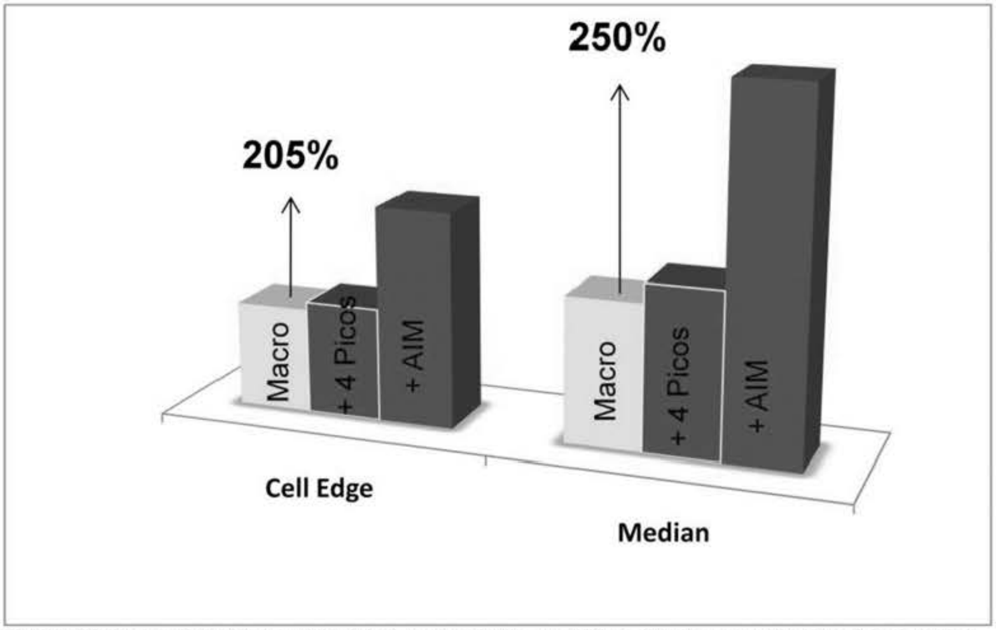


Figure 3 Downlink Throughput in mixed Macro/Pico deployment with Advanced Interference Management (AIM)

[3] Key Design Features

Range extension allows more user terminals to benefit directly from low-power base-stations such as picos, femtos, and relays, and maximizes the user experience.

3.1 Range extension

A pico base-station is characterized by a substantially lower transmit power as compared to a macro base-station, and a mostly ad-hoc placement in the network. Because of unplanned deployment, most cellular networks with pico base-stations can be expected to have large areas with low signal to interference conditions, resulting in a challenging RF environment for control channel transmissions to cell-edge users. More importantly, the potentially large disparity (e.g. 20 dB) between the transmit power levels of macro and pico base-stations implies that in a mixed macro-pico deployment, the downlink coverage of a pico base-station is much smaller than that of a macro base-station.

This is not the case for the uplink, where the strength of the received signal from a user terminal at different base-stations depends on the terminal transmit power which is the same for all uplinks from the terminal to different base-stations. Hence the uplink coverage of all the base-stations is similar and the uplink handoff boundaries are determined based on channel gains. This can create a mismatch between downlink and uplink handoff boundaries, and make the base-station to user terminal association or server selection more difficult in heterogeneous networks compared to homogenous networks, where downlink and uplink handoff boundaries are more closely matched.

If server selection is predominantly based on downlink received signal strength which is used in LTE Rel-8, the usefulness of pico base-stations will be greatly diminished. This is because the larger coverage of high power base stations can limit the benefits of cell-splitting by attracting most user terminals towards macro base-stations based on the signal strength but not having enough resources at macro base-stations to efficiently serve these user terminals, while lower power base-stations may not be serving any user terminals. Even if all the lower power base-stations have at least one user terminal to serve and can use their available spectrum, the difference between the loadings of different base-stations can result in a very unfair distribution of data rates and uneven user experiences among the user terminals in the network. Therefore, from the point of view of network capacity, it is desirable to balance the load between macro and pico base-stations by expanding the coverage of pico base-stations and subsequently increase cell splitting gains. We will refer to this concept as *range extension*.

Enabling range extension requires mitigating the downlink interference caused by high power macro base-stations to the user terminals served by low power base-stations. This can be achieved through either interference cancellation at the user terminals or resource coordination among base-stations. The user terminals can cancel interference caused either by higher power macro stations or by close-by femto stations that the user terminals are prohibited to access. To enable resource coordination among base-stations, two different sets of resources may be allocated for two classes of high power and low power base-stations. The resources can be time domain (slots or subframes) in a synchronous system or in frequency domain (groups of sub-carriers). Capacity gains can be achieved through cell splitting on the resources that are allocated for low power base-stations, while sufficient coverage is provided by high power base-stations on the resources that are allocated to them.

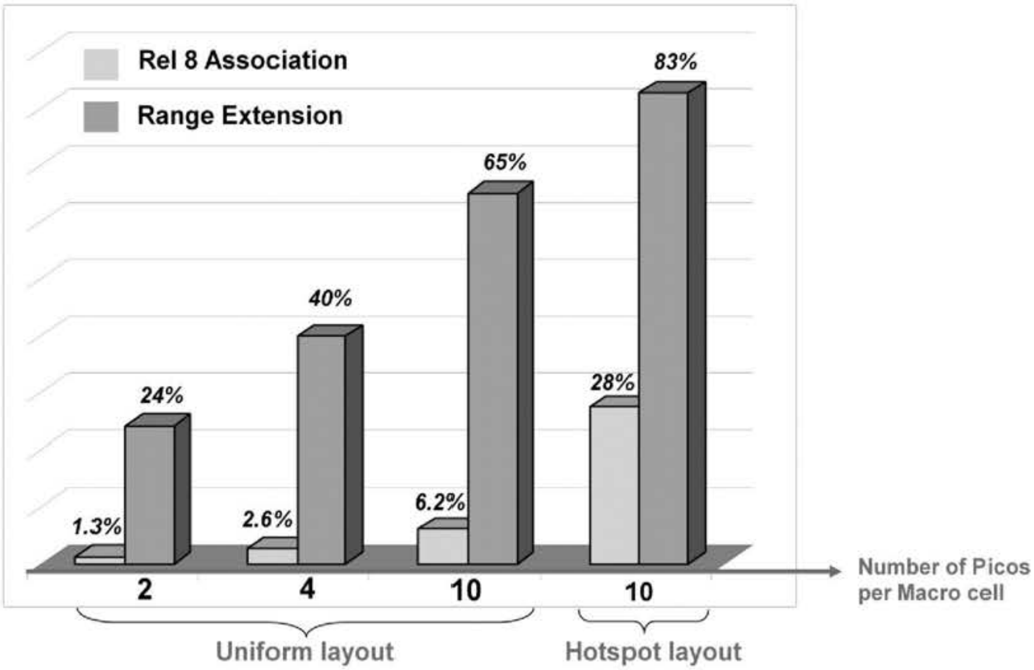


Figure 4 Pico-cell user association statistics with and without range extension

A simple example of fixed resource coordination among two categories of macro and pico base-stations can be used to demonstrate potential gains from range extension. Figure 4 shows the user association statistics with and without range extension for the mixed macro and pico deployment (configuration 1 in [2]). The range extension here is achieved by performing base-station to terminal association based on path loss (associating with base-station with the minimum path loss rather than the base-station with the maximum downlink signal strength) and a fixed partitioning of resources equally between the macro and pico base-stations. As seen in the figure, range extension allows many more users to associate with the pico base-stations and enables more equitable distribution of air-link resources to each user. The effect is even more pronounced in hotspot layouts (configuration 4 in [2]) where users are clustered around pico base-stations.

3.2 Advanced Interference Management

3.2.1 Inter-cell Interference Coordination (ICIC)

In a heterogeneous network with range extension, in order for a user terminal to obtain service from a low power base-station in the presence of macro base-stations with stronger downlink signal strength, the pico base-station needs to perform both control channel and data channel interference coordination with the dominant macro interferers.

In case of femto base-stations, only the owner or subscribers of the femto base-station may be allowed to access the femto base-stations. For user terminals that are close to these femto base-stations but yet barred from accessing them, the interference caused by the femto base-stations to the user terminals can be particularly severe, this makes it very difficult to establish a reliable downlink communication to these user terminals.. Hence, as opposed to homogeneous networks, where resource reuse one (with minor adjustments) is a good transmission scheme, femto networks necessitate more coordination via resource partitioning across base-stations to manage inter-cell interference.

As a result, *Inter-cell Interference Coordination* (ICIC) is critical to heterogeneous network deployment. A basic ICIC technique involves resource coordination amongst interfering base-stations, where an interfering base-station gives up use of some resources in order to enable control and data transmissions to the victim user terminal. More generally, interfering base-stations can coordinate on transmission powers and/or spatial beams with each other in order to enable control and data transmissions to their corresponding user terminals.

Advanced Interference Management techniques such as resource coordination are needed to realize full benefits of heterogeneous deployments.

The resource partitioning can be performed in time-domain, frequency domain, or spatial domain. Time-domain partitioning can better adapt to user distribution and traffic load changes. For example, a macro base-station can choose to reserve some of the subframes in each radio frame for use by pico stations based on the number of user terminals served by pico and macro base-stations and/or based on the data rate requirements of the user terminals. Frequency domain partitioning offers less granular resource allocation and flexibility, but is the viable method especially in an asynchronous network.

3.2.2 Slowly-Adaptive Interference Management

In this approach, resources are negotiated and allocated over time scales that are much larger than the scheduling intervals. The goal of the slowly-adaptive resource coordination algorithm is to find a combination of transmit powers for all the transmitting base-stations and user terminals and over all the time and/or frequency resources that maximizes the total utility of the network. The utility can be defined as a function of user data rates, delays of QoS flows, and fairness metrics.

Such an algorithm can be computed by a central entity that has access to all the required information for solving the optimization problem, and has control over all the transmitting entities. Such a central entity may not be available or desirable in most cases due to several reasons including the computational complexity as well as delay or bandwidth limitations of the communication links that carry channel information or resource usage decisions. As a result, a distributed algorithm that makes resource usage decisions based on the channel information only from a certain subset of nodes may be more desirable.

The coordination can be performed via the backhaul (X2 interface in LTE) and/or over-the-air (OTA) messages. For example, pico stations can send load information and resource partitioning request to macro stations using X2 messages, while macro stations send resource partitioning response and update back to pico stations. In some cases, the backhaul may not always be available between different types of base-stations or the backhaul may not meet the delay and bandwidth requirements for adaptation. Therefore, OTA messages can be used for adaptive resource partitioning.

[4] Conclusion

Heterogeneous networks and the ability to manage and control interference in networks will allow for substantial gains in the capacity and performance of wireless systems in the future. Maximizing bits per seconds per hertz per unit area by controlling inter-base-station fairness in the context of macro-pico networks enables a more uniform user experience throughout the cell, as demonstrated by the gains in the cell edge and median user experience. Heterogeneous networks allow for a flexible deployment strategy with the use of different power base-stations including femtos, picos, relays, and macros to provide coverage and capacity where it is needed the most. These techniques provide the most pragmatic, scalable and cost-effective means to significantly enhance the capacity of today's mobile wireless networks by inserting smaller, cheaper, self-configurable base-stations and relays in an unplanned, incremental manner into the existing macro cellular networks.

[5] Glossary

3GPP	Third-Generation Partnership Project
DL	Downlink
eNode B	Evolved Node B
ICIC	Inter-cell Interference Coordination
LTE	Long-Term Evolution
LTE-A	Long-Term Evolution Advanced
MIMO	Multiple-input multiple-output
OFDM	Orthogonal frequency-division multiplexing
OFDMA	Orthogonal frequency-division multiple access
OTA	Over the air
QoS	Quality of service
RAN	Radio Access Network
SINR	Signal-to-Interference-and-Noise Ratio
TDM	Time-Division-Multiplexing
UE	User equipment
UL	Uplink

[6] References

[1] 3GPP TR 36.912 V2.0.0, "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility study for Further Advancements for E-UTRA (LTE-Advanced) (Release 9)", Aug 2009.

[2] 3GPP R1-084026, LTE-Advanced Evaluation Methodology, Oct 2008.


GSMA
MOBILE
WORLDCONGRESS
Barcelona | 14-17 February 2011
LEADING
THE TRANSFORMATION
App Planet
Rasmus Hellberg
2/22/2011

HSPA+ Advanced

February 2011

Rasmus Hellberg, Ph.D.
Director, Technical Marketing

Qualcomm is Committed to Continued HSPA+ Evolution

A LEADER IN HSPA+ RESEARCH, STANDARDS AND CHIPSETS

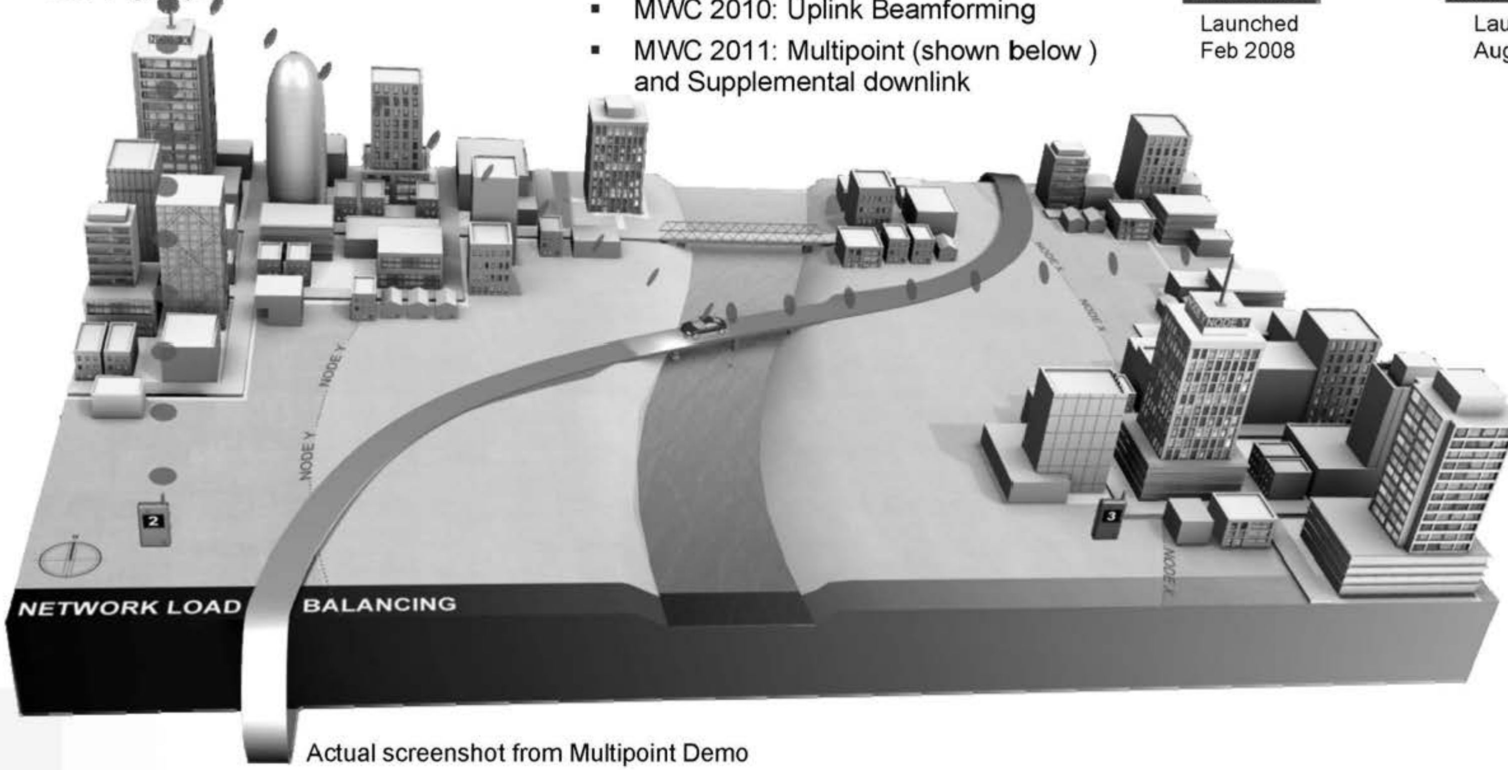
- **Standards Leadership**
  - Major 3GPP contributor on all HSPA+ features
  - Recognized expertise across all 3GPP groups

- **Industry-First Demos**
  - MWC 2007: Voice over HSPA
  - MWC 2008: Dual-Carrier
  - MWC 2009: Dual-Carrier 42 Mbps
  - MWC 2010: Uplink Beamforming
  - MWC 2011: Multipoint (shown below) and Supplemental downlink

- **Industry-First Chipsets**

Launched
Feb 2008

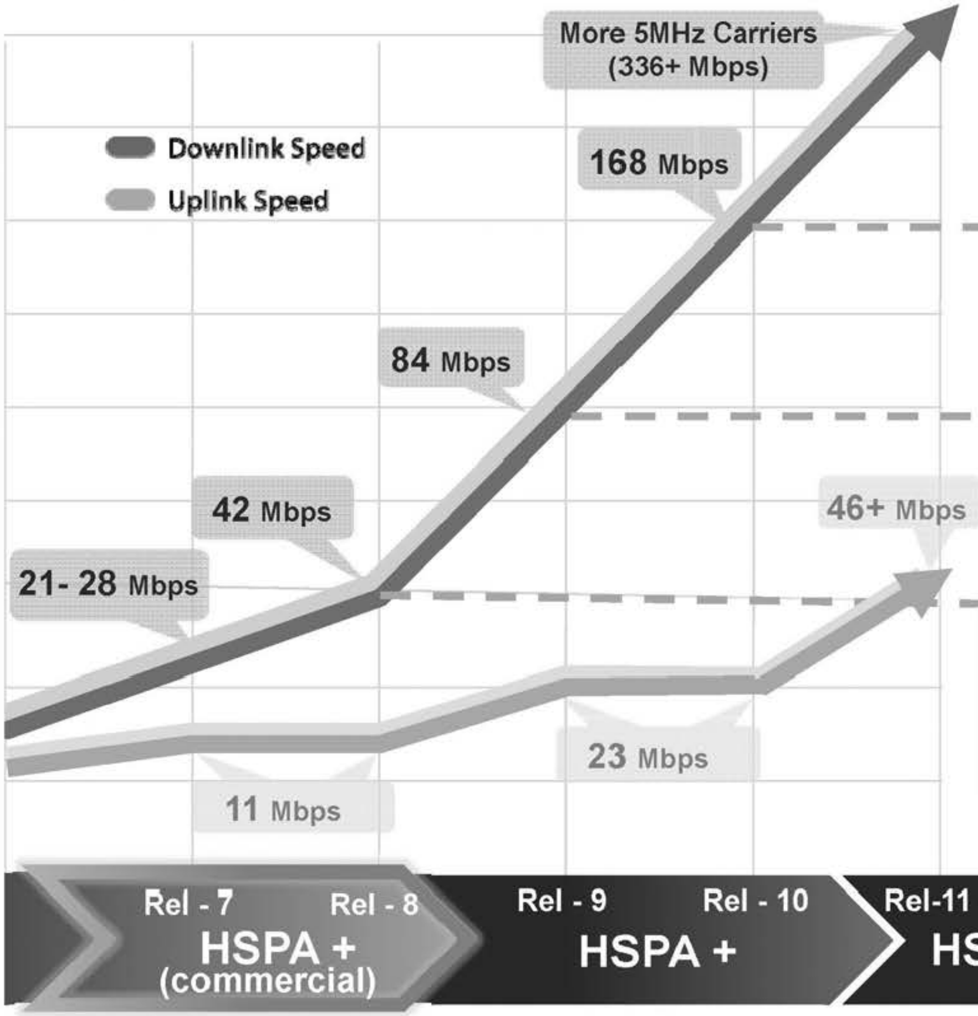
Launched
Aug 2010



Actual screenshot from Multipoint Demo


VIDEO INCLUDED ON
WEBPAGE

HSPA+ Has A Strong Evolution Path



R11 and Beyond: HSPA+ Advanced

- Expands HSPA+ to 40MHz deployments
- Further leverages multiple antennas (UL MIMO/Beamforming)
- Exploits smart networks (multipoint) and HetNet enhancements

R10: 20 MHz Multicarrier

- Expands HSPA+ to 20 MHz deployments
- Evolution to femtocell networks

R9: Expands Dual-Carrier

- 10 MHz Dual-Carrier in uplink
- Combination of MIMO and Dual-Carrier in downlink
- Aggregation across spectrum bands
- Femtocell enhancements: active mobility

R8: 10 MHz Dual-Carrier

- Enhances broadband—doubled data rates to all users
- Introduction of femtocell support
- Alleviates signaling traffic e.g., from Smartphones

Created 01/21/11

Notes: R8 reaches 42 Mbps by combining 2x2 MIMO and HOM (64QAM) in 5 MHz, or by utilizing HOM (64QAM) and multicarrier in 10 MHz. R9 combines multicarrier and MIMO in 10 MHz to reach 84 Mbps peak rates. Uplink multicarrier doubles the uplink peak data rate to 23 Mbps in 10 MHz in R9. R10 expands multicarrier to 20 MHz to reach 168 Mbps. R11 expands multicarrier to 40MHz to reach 336 Mbps.

HSPA+ Advanced: Maximum Performance in Multiple 5 MHz Carriers

HSPA+ Advanced

Utilizes Smart Networks
Exploit uneven network load

Evolves Multicarrier
Aggregation of up to 8 carriers, unpaired spectrum

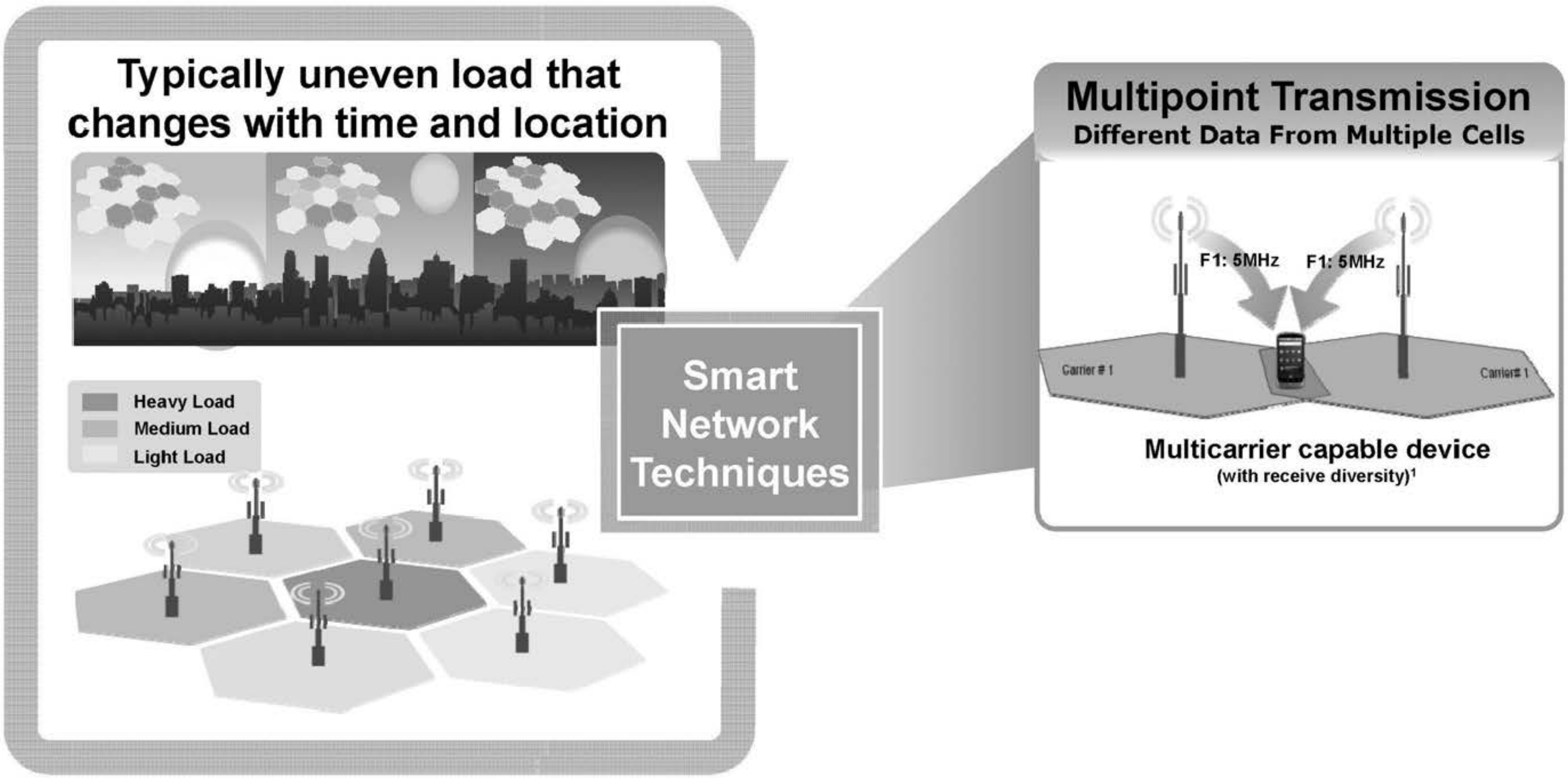
More Antenna Gain
Such as uplink beamforming and MIMO

Continues to Leverage HetNets

Connecting a Very Large Number of Devices
Optimizations for the explosion of interconnected low -traffic devices (e.g. M2M, Smartphones)

[1]HSPA+ Advanced is used as the name for features beyond 3GPP Release10.

Smart Networks Exploit Uneven Load

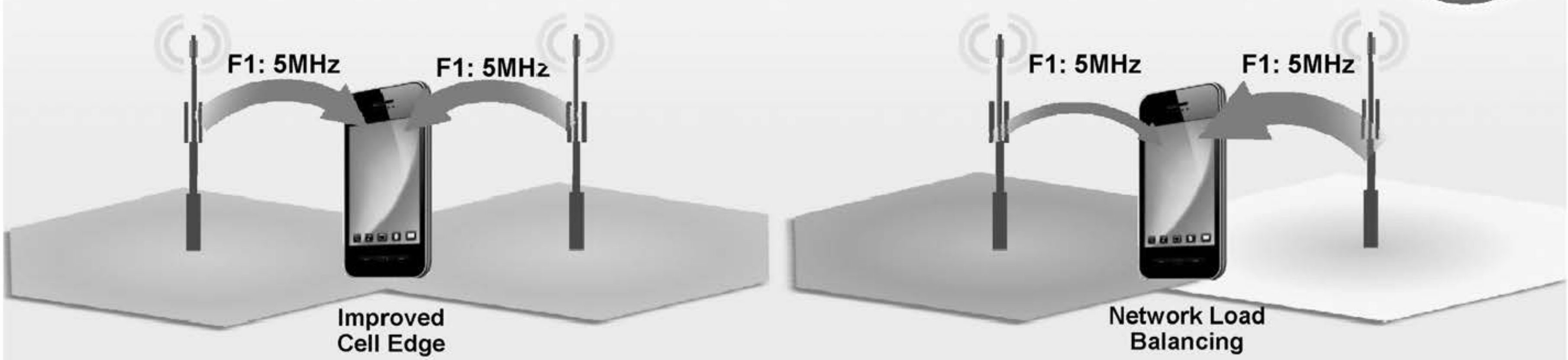


[1]Receive diversity with interference suppression (Type 3i receiver) required.

Multipoint Improves Overall Network Capacity

EVOLVES MULTICARRIER—DATA FROM MULTIPLE CELLS/NODEBs

Demo at MWC 2011



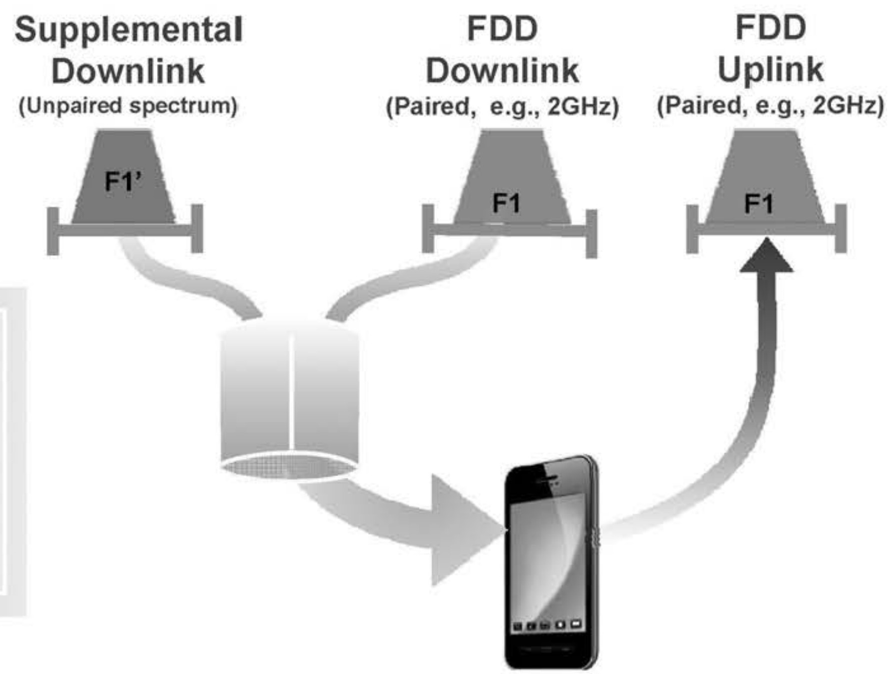
Improved Cell Edge	Network Load Balancing	Range Expansion
By serving user from multiple cells	Utilizes unused capacity in neighboring cells Improves user experience in loaded cell	Effectively increases small cell boundary —better utilization and higher network capacity

Note: Multipoint transmission is a 3GPP R11 candidate, a.k.a. SFDC. Receive diversity with interference suppression (type 3i receiver) required to reject other-cell interference.

Supplemental Downlink Addresses Traffic Asymmetry

- Leverage unpaired spectrum for more downlink capacity
- Implemented using HSPA+ R9 carrier aggregation[1]

Demo at MWC 2011



L-Band (1.4GHz) key opportunity

- Harmonization possible in Europe and beyond, with up to 40 MHz of unpaired spectrum[2]
- Other opportunities, such as 700MHz in the US, depend upon country-specific spectrum situations

[1]Aggregation across bands already supported in 3GPP R9, but each additional band combination has to be defined in 3GPP.
[2]L-Band in Europe: 1452 MHZ to 1492 MHz.

Leverage Spectrum Within & Across Bands

Spectrum Examples:

2.1 GHz (Band I)

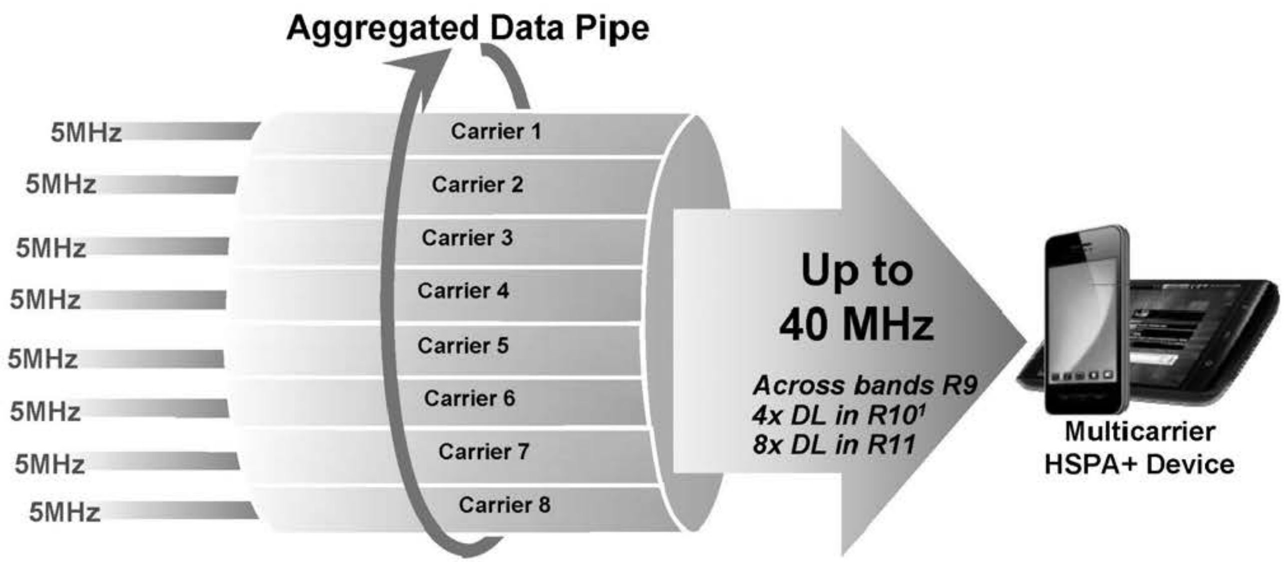
1900 MHz (Band II)

1800 MHz (band III)

1700 MHz (Band IV)

900 MHz (Band VIII)

850 MHz (Band V)



Additional spectrum bands and band combinations continuously defined in 3GPP[2]

[1]With 4x multicarrier in R10 (and 8x in R11), carriers within the same band need to be adjacent and inter-band aggregation can span two different bands.
[2] E.g., support for band XI (1500MHz Japan) combinations has been added and band III (1800MHz) is being added, beyond 4X combinations expected to be added in R11

HSPA+ Advanced: Maximum Performance in Multiple 5 MHz Carriers

HSPA+ Advanced

More Capacity

Spectral efficiency, capacity per coverage area, more connected devices

Capacity When & Where Needed

Smart network techniques to exploit uneven load

Better Coverage

By e.g., improved uplink

Enhanced User Experience

Better cell edge, lower latency, more bandwidth, consistently higher data rates

[1]HSPA+ Advanced is used as the name for features beyond 3GPP Release10

Connecting a Very Large Number of Devices

The Next Era of Networking and Computing, Where Everything is Intelligently Connected

HSPA+ optimizations to support the explosion of interconnected low-traffic devices, e.g., M2M and Smartphones

Examples of improvements: Addition of Extended Access Class Barring (EAB) to handle very large density of low-traffic devices. Call rejection improvements to protect networks from access overload. Improvement of low power consumption states to handle bursty traffic even better .

QUALCOMM

Thank You

QUALCOMM

Wireless Broadband Future and Challenges

Oct. 27Th, 2010

SAMENA TELECOMMUNICATIONS COUNCIL

Convergence to Casablanca

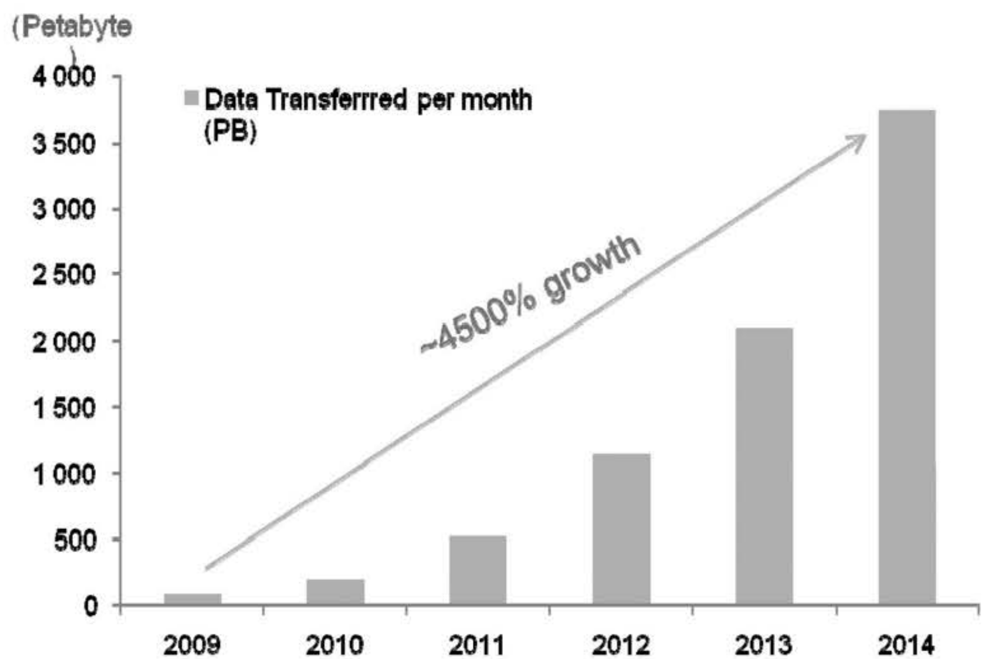
Transforming Challenges Into Growth

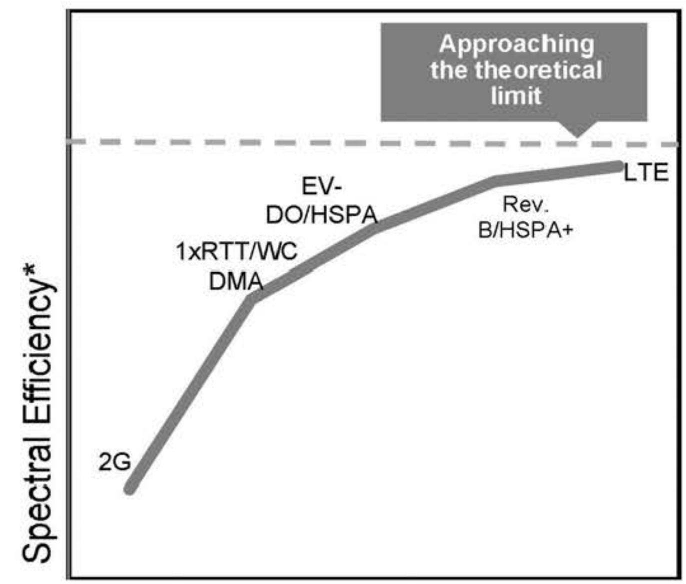
QUALCOMM

This presentation may refer to, describe and/or include images of parts (or devices containing such parts) whose manufacture, use, sale, offer for sale, or importation into the United States is limited or prohibited by certain injunctions against QUALCOMM Incorporated. This presentation is not an offer to sell any such parts or devices for use in or importation into the U.S., nor is it to be construed as assistance in the making, using, selling, offering to sell, or importation of any such part or device in or into the U.S. This presentation is intended solely to provide information for those products and uses of products that are outside the scope of the injunctions.

QUALCOMM Incorporated, 5775 Morehouse Drive, San Diego, CA 92121-1714

Data Usage Increasing While Radio Links Reach Theoretical Limits

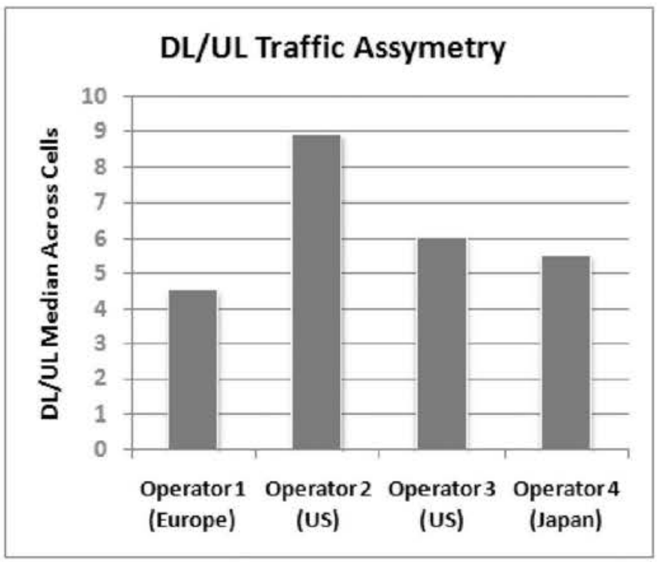




Source: ABI Research, April 09

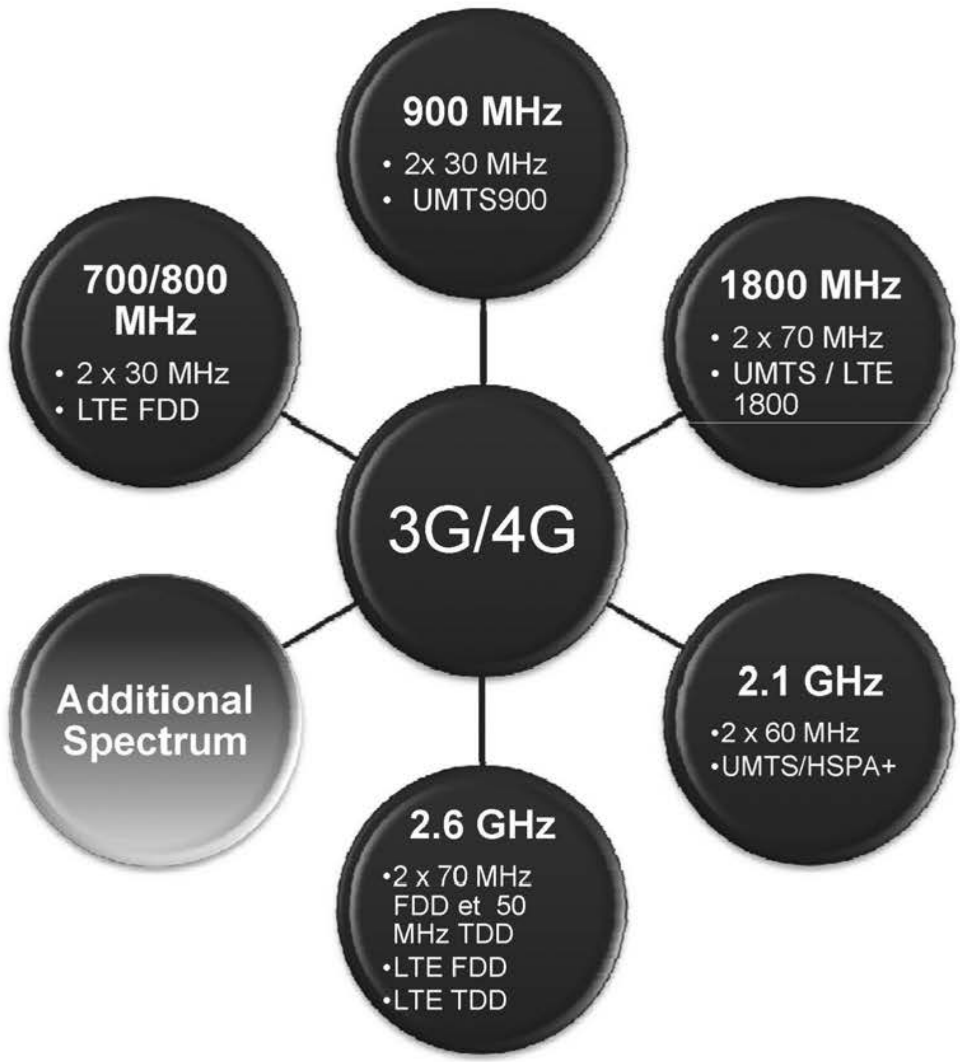
*While using the same number or antennas; uses logarithmic scale

Mobile Traffic Significantly Downlink Centric

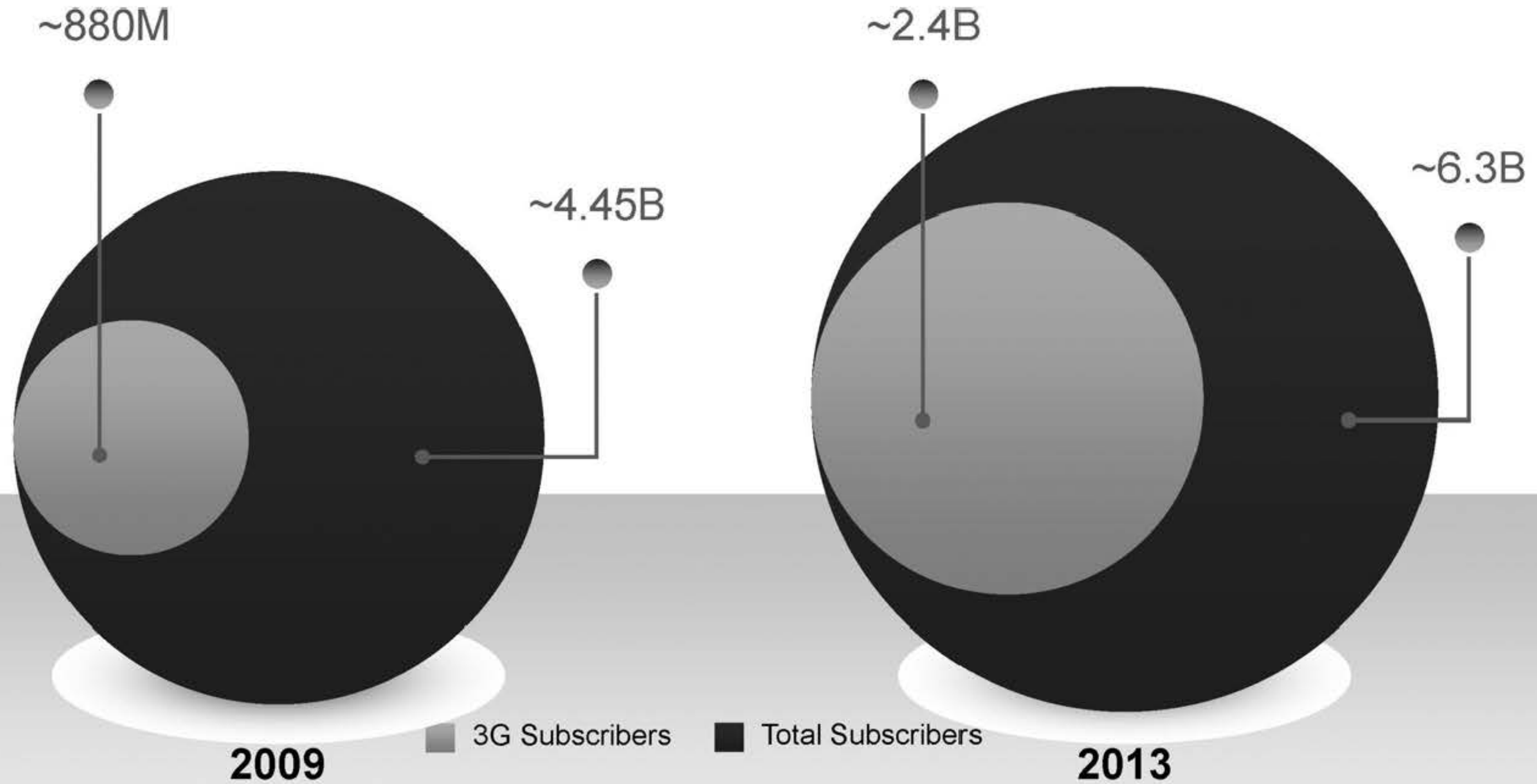


[1] Based on measurements in live networks. Median shown
[2] Cisco VNI Mobile, 2010

Five Bands Already on Track to Support 3G/4G Successful Growth in Europe but further spectrum required



3G Today Catering for Data Growth



> 80% of Operators Offer 3G Services
> 600K 3G Subscribers Added Every Day

Source: GSA, CDG, Oct 2009. Wireless Intelligence, Oct 2009, number of unique wireless connections

LTE Boosts Data Capacity in Dense Urban Areas

- 3G provides ubiquitous data coverage and voice
- Seamless service continuity with 3G from day one
- 3G/LTE multimode devices required

Industry's first LTE/3G multimode solutions

3G Coverage

Evolved 3G ensures similar user experience outside LTE coverage

LTE Voice Through Fallback to 3G, Long Term Solution is VoIP using IMS

Initial Launches
Data Cards

Initial Voice Solution
LTE Data Handsets

Long Term Voice Solution
LTE VoIP Handsets

3G coverage

LTE data only
LTE coverage

LTE data only
LTE coverage

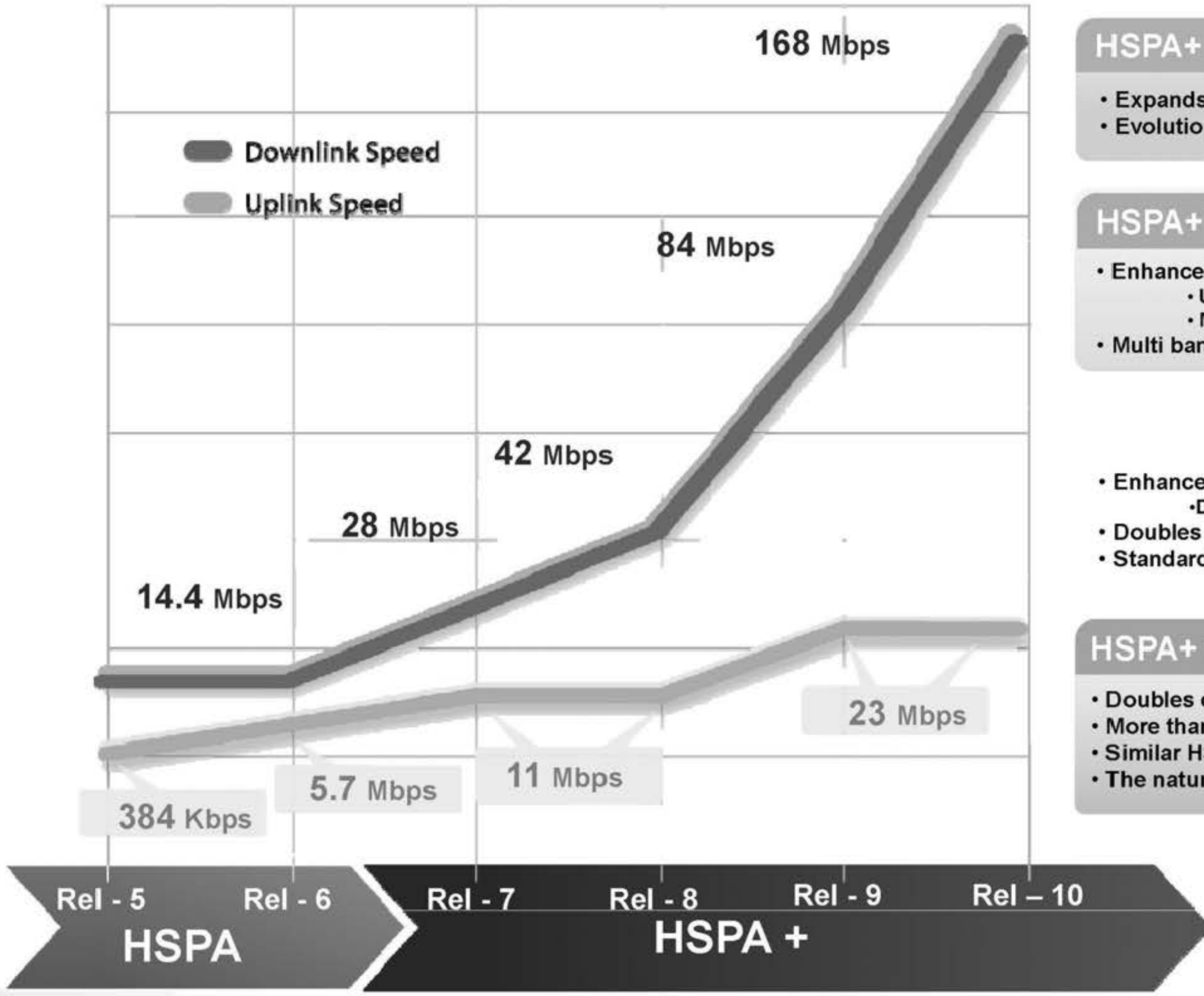
Simultaneous VoIP and LTE data[2]
LTE coverage

Rely on 3G for Voice and Simultaneous Voice and Data[1]
1X voice and EV-DO data (SVDO)
WCDMA voice and HSPA+ data

LTE focused on data while leveraging 3G for voice[3]

[1]Simultaneous 1X Voice and DO (SVDO) planned across future Qualcomm DO chipsets, simultaneous WCDMA voice and HSPA data available today. HSPA+ will also support 'CS over HS' voice. Simultaneous Voice and data also through VoIP over EV-DO. [2]Requires VCC for service continuity [3]LTE air interface supports VoIP, but initial focus is on data with data optimized devices.

HSPA+: A Strong Evolution Path



HSPA+ R10: 20 MHz Multicarrier

- Expands HSPA+ to 20 MHz deployments
- Evolution to femtocell networks

HSPA+ R9: Expands 10 MHz Multicarrier

- Enhanced performance in 10 MHz
    - Uplink multicarrier
    - MIMO support with multicarrier
- Multi band multicarrier—aggregation across bands

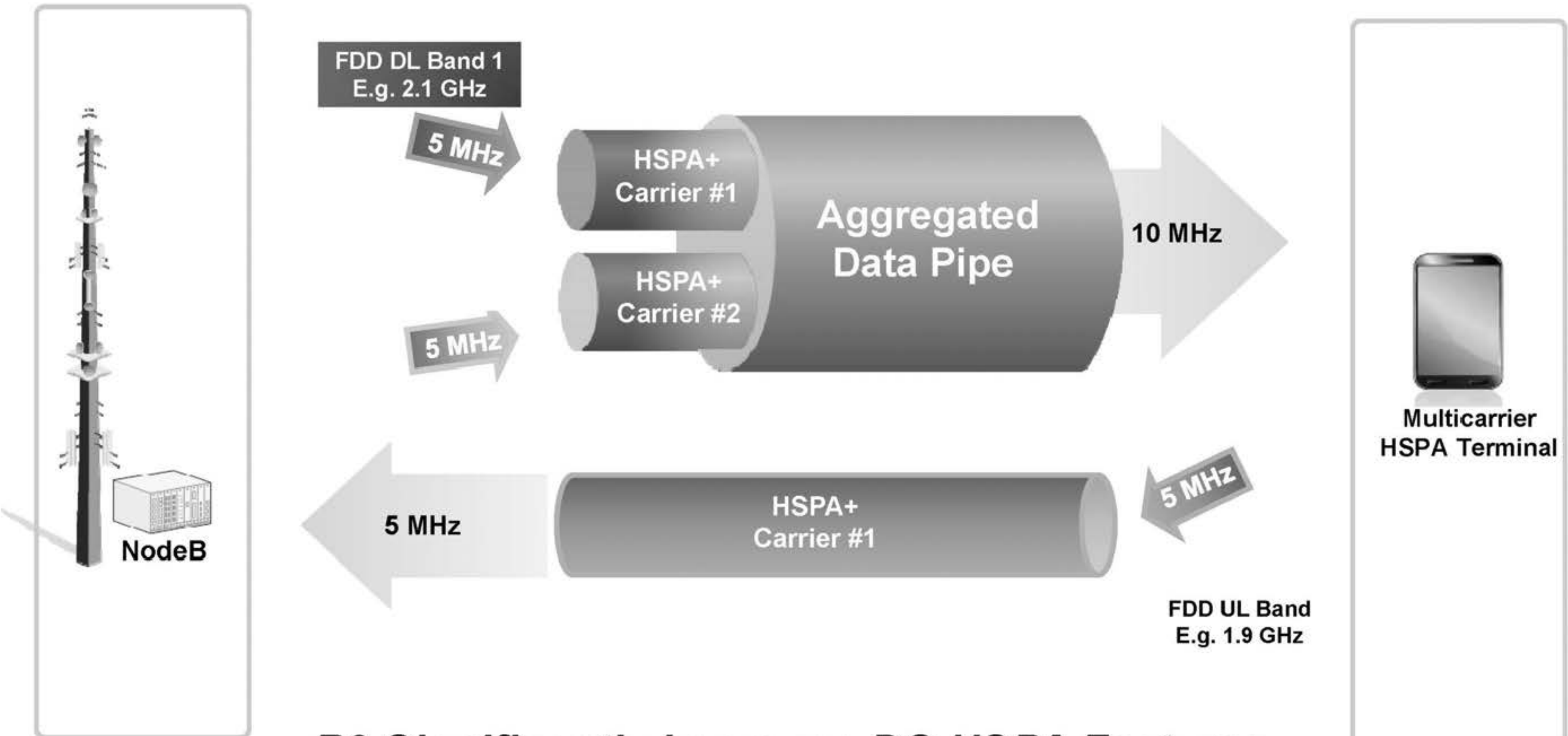
- Enhances broadband experience
    - Doubles data rates to all users
- Doubles bursty application capacity
- Standardized femtocell support

HSPA+ R7: Next Gen. Performance Today

- Doubles data capacity
- More than doubles voice capacity
- Similar HSPA+ and LTE performance
- The natural evolution at a lower cost

Notes: R8 will reach 42 Mbps by combining 2x2 MIMO and HOM (64QAM) in 5 MHz, or by utilizing HOM (64QAM) and multicarrier in 10 MHz. R9 combines multicarrier and MIMO in 10 MHz to reach 84 Mbps peak rates. Uplink multicarrier double the uplink peak data rate to 23 Mbps in 10 MHz in R9. R10 expands multicarrier to 20 MHz to potentially reach 168 Mbps when using MIMO.

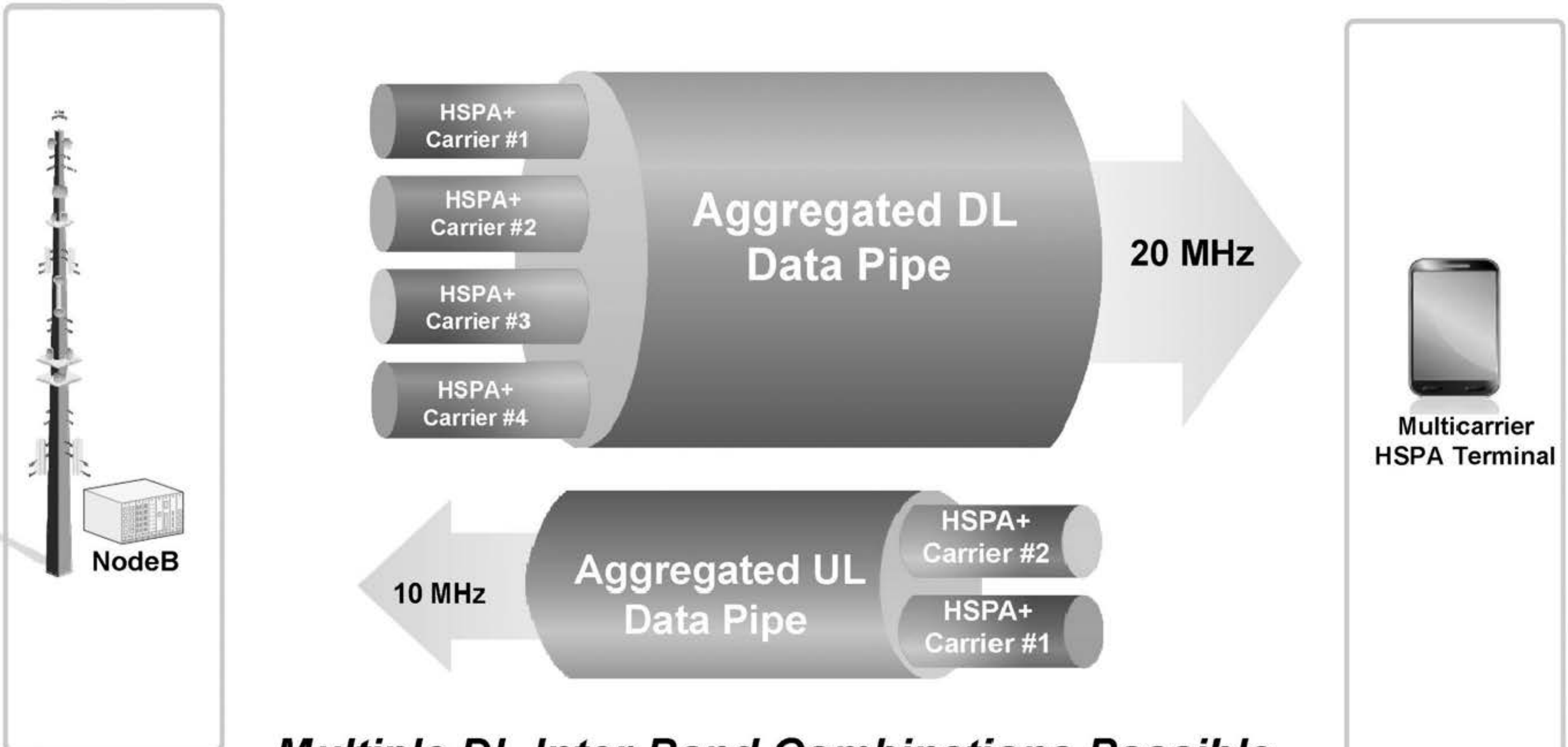
R9 Enables DL Aggregation Across Bands



R9 Significantly Improves DC-HSPA Features

Also Introduces UL Aggregation and Combined MIMO and DC-HSPA on DL

R10 Enables Up to 4 Carrier DL Aggregation



Multiple DL Inter-Band Combinations Possible

(e.g., 3 Carrier in Band 1 and 1 Carrier in Band 2 or 2 Carriers in Band 1 and 2 Carriers in Band 2)

3 to 4 multicarrier is supported in the downlink only and is independent of the uplink, e.g. a single uplink carrier can support 4 multicarrier in the downlink

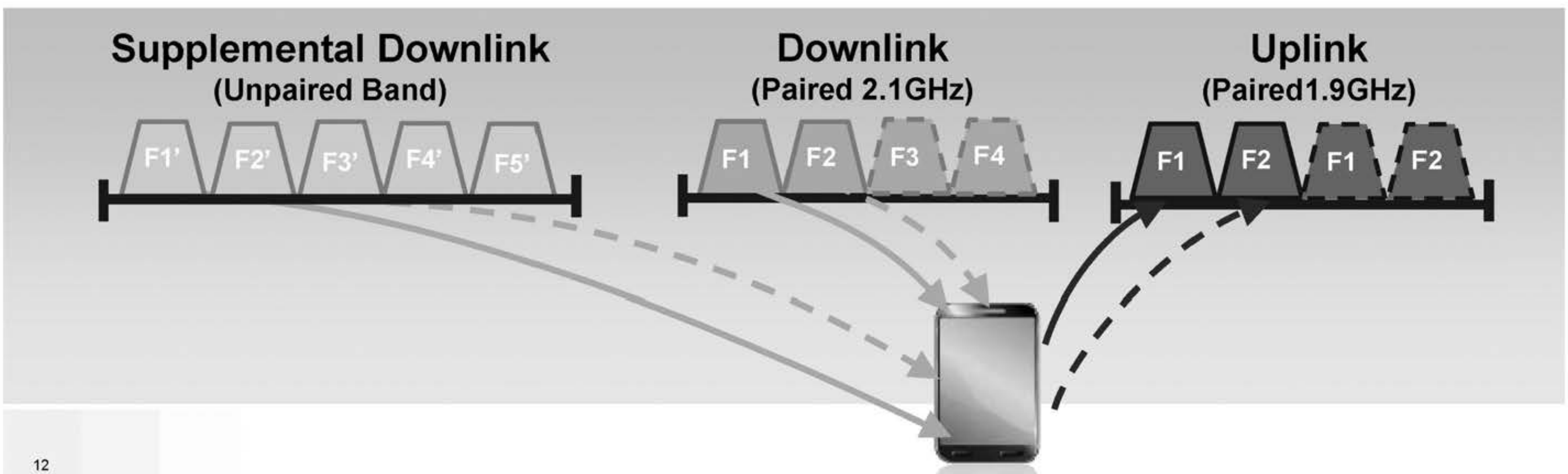
Addressing Traffic Asymmetry with HSPA+

Unpaired Spectrum Bands Used As Supplemental Downlink (DL)

- Aggregate bandwidth with paired DL and use existing paired UL

3GPP R9 & 10 Features Support Such Configuration

- Band combinations to be added in RAN4 (independent of 3GPP release cycle)



L-band is a Unique Opportunity for Supplemental DL Spectrum

L-Band (1.4GHz) Offers 40 MHz of Unpaired Spectrum

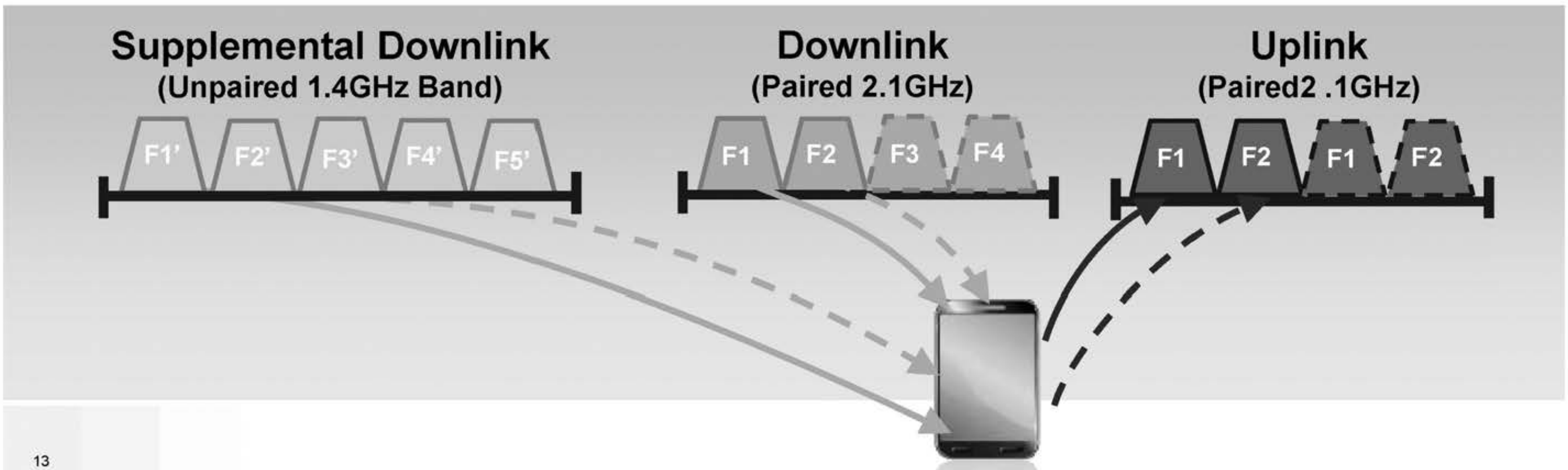
- Potential allocations of 5MHz each

Harmonization possible in Europe and MENA

- Scarcely utilized today

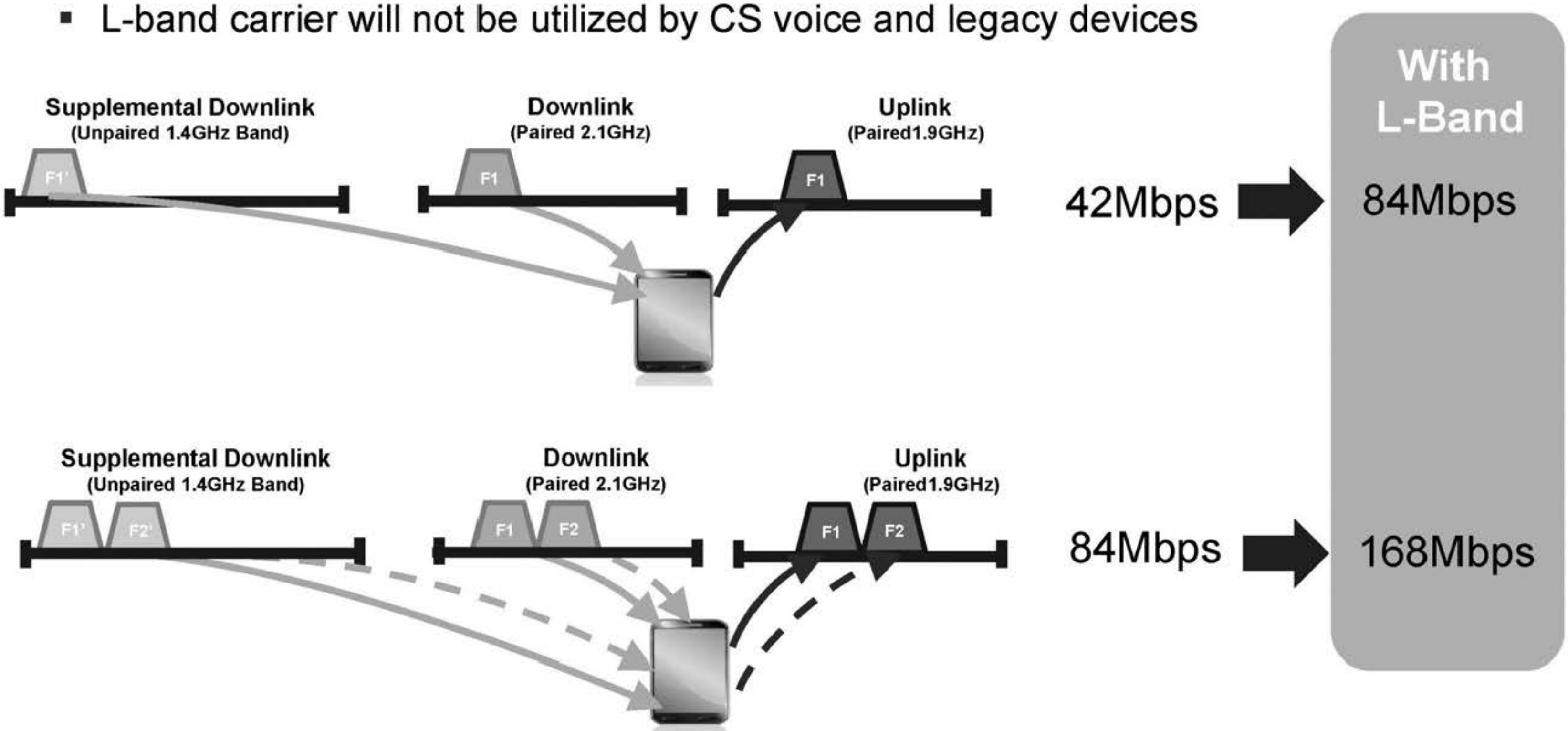
Ideal for Aggregating with 2.1GHz Spectrum

- Using 2.1GHz sites will enable great coverage for L-Band DL



L-Band Aggregation Will Significantly Improve Data User Experience

- Peak Data Rates Linearly Increase with Number of Carriers
- In Practice, Greater Than Linear User Experience Improvement
  - L-band carrier will not be utilized by CS voice and legacy devices



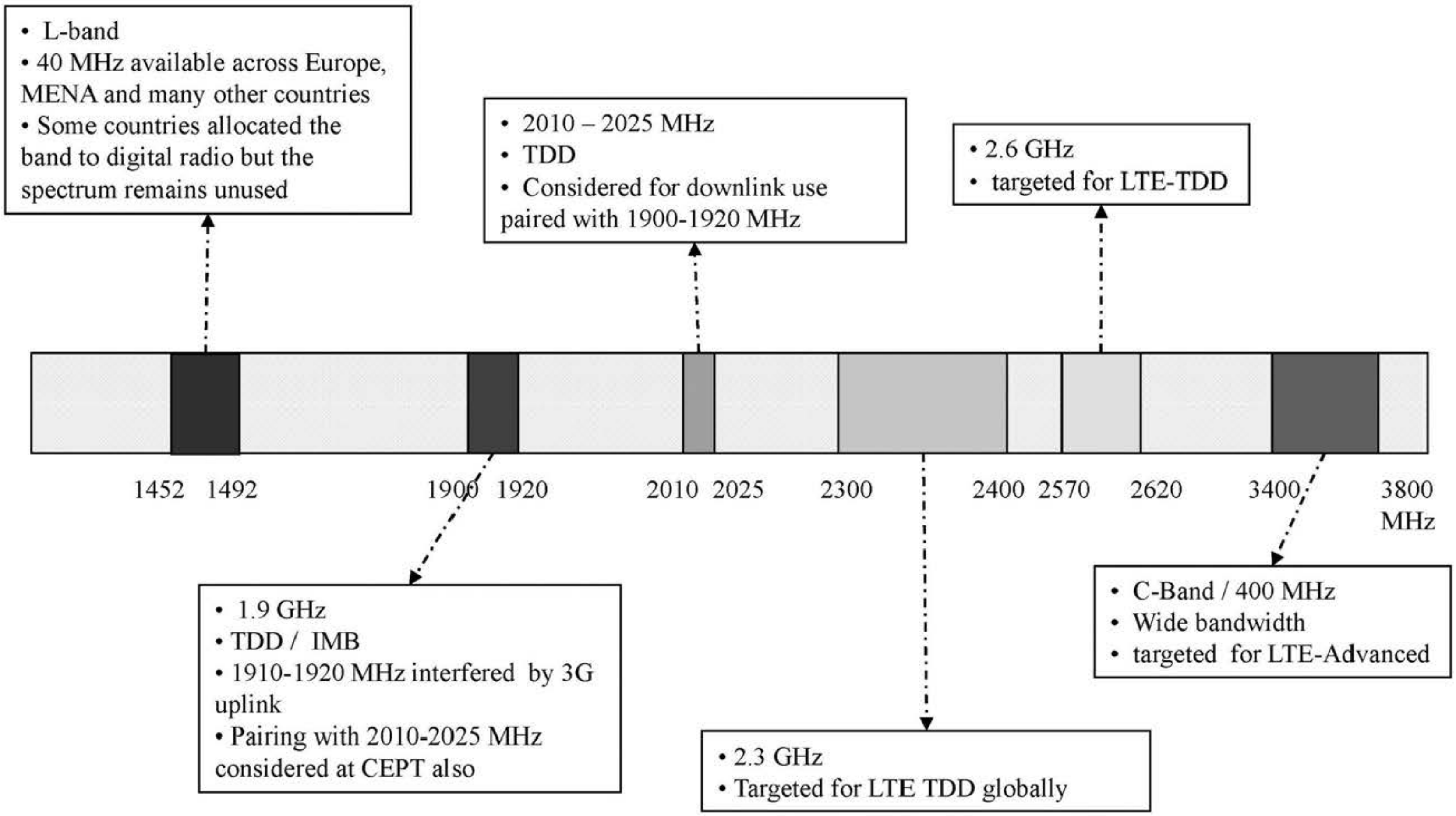
QUALCOMM®

Thank You

Moheb Ramsis, mramsis@qualcomm.com

- Back UP

L-band is a Unique Opportunity for Supplemental Mobile Downlink Spectrum



L-band : 1452 – 1492 MHz

- Divided in 2 harmonized segments:
  - Terrestrial: 1452 – 1479.5 MHz (27.5 MHz)
  - Satellite :1479.5 – 1492 MHz (12.5 MHz)
- The Terrestrial segment is:
  - T-DAB (possibility to do mobile multimedia on a national level)
  - Remains unused in most European countries (France, Spain, Sweden, Switzerland, UK, Poland, Italy etc.) and MENA countries
  - Under review in Europe
- The satellite segment is:
  - No commercial services
  - Satellite paper filings

A Streamlined Regulatory Process by 2012

Process already successfully started

Today

- Strong support at FM (FR, UK, PT, NL, CH, RS…)
- FM 45 tasked to assess compliance with Maastricht and report to ECC

3Q210

- Trigger topic at ECC, RSC, RSPG

2011

- Detailed discussions at RSC, RSPG, ECC

<u>2012</u>: ECC Decision on L-Band for Supplemental DL

- Band plan, BEMs, pairing options