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Qualcomm Wins Licenses to Double Its Spectrum in 28 Key East and West Coast Markets to Expand Award-Winning FLO TV Service

New 700 MHz Licenses Will Broaden Content and Service Offering To More Than 68 Million Potential Consumers

SAN DIEGO – April 03, 2008 – Qualcomm Incorporated (Nasdaq: QCOM), a leading developer and innovator of advanced wireless technologies and data solutions, today announced that it has acquired eight licenses in the U.S. Federal Communications Commission's 700 MHz spectrum auction at a total cost of $558.1 million. Qualcomm purchased licenses in the E block covering the Boston, Los Angeles, New York City, Philadelphia and San Francisco Economic Area regions. These licenses double Qualcomm's 700 MHz spectrum holdings throughout a footprint of more than 68 million people in 28 individual markets for MediaFLO USA's award-winning FLO TV™ service (21 of its top 100 markets) at a cost of $554.6 million. In addition, Qualcomm purchased three licenses on the B block at a cost of $3.5 million.

Qualcomm's E block licenses cover five of the nation's top seven Economic Area regions. These regions consist of large contiguous areas on the East and West Coasts, stretching from New Hampshire to Maryland and from Orange County to Northern California, respectively.

"This investment in new spectrum underscores our commitment to continue to deliver the most innovative technologies to a growing wireless industry," said Dr. Paul E. Jacobs, CEO of Qualcomm. "Our strategic purchase of E block licenses will enhance our efforts in the mobile TV space and further MediaFLO USA's mission to bring world-class mobile entertainment to American consumers."

The new E block spectrum will give MediaFLO USA greater flexibility to deliver additional content and services in these top markets, building on the Channel 55 spectrum for which Qualcomm already owns licenses in these markets and throughout the rest of the country and the FLO TV service now available to more than 130 million people.

"We have defined the mobile TV experience nationwide with our FLO TV service, and the acquisition of additional spectrum in many of America's largest cities provides us with the flexibility to take the mobile entertainment experience to the next level," said Gina Lombardi, president of MediaFLO USA.

In addition, Qualcomm won the B block in the California-Imperial, New Jersey-Hunterdon and Yuba City, Calif. Cellular Market Areas. These licenses will provide Qualcomm with 12 MHz of paired 700 MHz spectrum near key Qualcomm offices to enable the Company's research and development (R&D) teams to deploy their innovative mobile broadband technologies, thus enabling faster development and broader deployment of these solutions for Qualcomm's customers and partners.

Spectrum License Details:
The E block licenses cover Allentown, Pa.; Atlantic City, N.J.; Bakersfield, Calif.; Boston; Bridgeport, Conn.; Cape Cod, Mass.; Dover, Del.; Hartford, Conn.; Long Island, N.Y.; Lancaster, Pa.; Los Angeles; Manchester, N.H.; Monterey, Calif.; Nashua, N.H.; New Haven, Conn.; Newark, N.J.; New York; Northeast and Northwest New Jersey; Oakland, Calif.; Orange County; Palm Springs, Calif.; Philadelphia; Pittsfield, Mass.; Pocono, Pa.; Pottsville, Pa.; Poughkeepsie, N.Y; Providence, R.I; San Francisco; San Joaquin Valley, Calif.; San Jose, Calif.; San Luis Obispo, Calif.; Santa Barbara, Calif.; Scranton, Pa.; Springfield, Conn.; Stamford, Conn.; Wilkes-Barre, Pa.; Wilmington, Del.; Worcester, Mass.; and Yuma, Ariz.

The B block licenses cover three key locations near Qualcomm R&D offices in: Imperial County, Calif., near the Company's headquarters in San Diego; Hunterdon County, New Jersey, near the Qualcomm Flarion office in Bedminster; and in Yuba City, Calif., near the Company's offices in Northern California.

MediaFLO USA, Inc. unleashes the power of TV for mobile consumers, combining the best content, an intuitive user interface and a superior multicast network to deliver a true TV experience. The award-winning MediaFLO USA mobile entertainment service, called FLO TV, offers full-length simulcast and time-shifted programming from the world's best entertainment brands, including CBS, CBS College Sports, CBS News, Comedy Central, ESPN, FOX, FOX News, FOX Sports, MTV, NBC, NBC Sports, NBC News, CNBC, MSNBC, NickToons and Nickelodeon. Based in San Diego, Calif., MediaFLO USA is a wholly owned subsidiary of Qualcomm Incorporated. Further information is available at www.mediaflousa.com and www.flotv.com.

Qualcomm Incorporated (www.qualcomm.com) is a leader in developing and delivering innovative digital wireless communications products and services based on CDMA and other advanced technologies. Headquartered in San Diego, Calif., Qualcomm is included in the S&P 500 Index and is a 2007 FORTUNE 500® company traded on The Nasdaq Stock Market® under the ticker symbol QCOM.

Except for the historical information contained herein, this news release contains forward-looking statements that are subject to risks and uncertainties, including the Company's ability to deliver additional content and services as a result of its acquisition of the additional spectrum licensees, the Company's ability to acquire compelling content on a cost effective basis, the Company's ability to develop and deploy, alone or in partnership with others, services that are well received by subscribers, and the Company's ability to utilize the B block licenses it acquired for research and development activities. For additional risks and uncertainties, reference is made to those other risks detailed from time to time in the Company's SEC reports, including the report on Form 10-K for the year ended September 30, 2007, and most recent Form 10-Q.

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Topics: Gina Lombardi, mobile TV, OFDM (FLO), Open

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Advancing HSPA+ forward...

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While so many *telecommers* continue to ponder whether HSPA+ is truly 4G or not... we *Qualcommers* are busy pushing the HSPA+ envelope to **HSPA+ Advanced** — the evolution beyond Rel. 10.

The **HSPA+** release (starting from R7) is successively increasing capacity and user experience, reaching the phenomenal peak data rate of 168 mbps in the downlink. So what is the objective of **HSPA+ Advanced** you might ask? Well, we are razor focused on one single goal — achieving the best possible performance in multicarrier deployments (each carrier is 5 MHz). This single goal, obviously, manifests into many tangible enhancements — and sometimes into different dimensions that HSPA+ hasn't seen before. Let me explain...

Traditionally, emphasis has always been on achieving higher spectral efficiency, which considers the network to be uniformly loaded. But, in reality, loading is very dynamic, and changes continuously. A particular part of the network might be busy during morning hours. Another part might be more busy in the evening and other parts in between.

Another interesting point is, when you look closely at the highly loaded cells, more often than not, they are surrounded by others that are less loaded. "**Smart Networks**" an important component of HSPA+ Advanced, exploits these two realistic network conditions to improve network performance. Also, the improvement is provided exactly *when and where needed*. This, we believe, is a new dimension of enhancement.

Multipoint is one of the notable Smart Network techniques. It allows the aggregation of cells that are on the same frequency/carrier. It improves data rates for users on the cell-edge, and increases overall capacity by utilizing unused capacity of the neighboring cells surrounding the loaded cells. When applied to HetNets (networks with low-power nodes such as picocells), Multipoint increases their effective coverage and hence further increases overall network capacity.

HSPA+ Advanced takes the multicarrier concept into many new directions, such as aggregating up to 8 carriers (across spectrum bands, etc). One interesting twist on that concept, worth mentioning here, is Supplemental Downlink. This feature conveniently aggregates unpaired TDD spectrum with HSPA+ carriers, providing for the typically higher downlink data traffic. This is an attractive proposition particularly for the unpaired L-band spectrum (1.4 GHz spectrum) available in many parts of Europe.

There are many other interesting value propositions worth noting, including further optimization of HetNets, schemes to prepare for the expected explosion of inter-connected *low* traffic devices such as massive M2M deployments, further expansion of Smartphone and tablet market.

In closing, HSPA+ evolution keeps on going, akin to the legendary "Energizer bunny." Rest assured that Qualcomm and the whole industry is hard at work to bring these evolutions to

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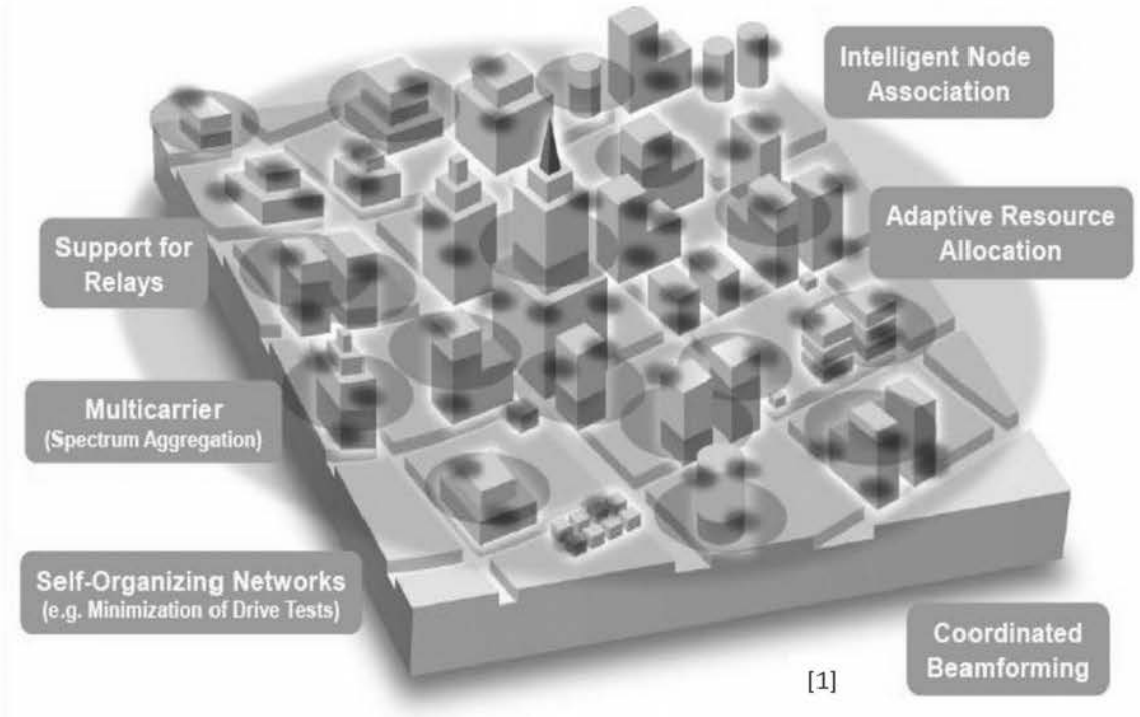
Advanced Telecommunication

LTE-ADVANCED RELEASE 10



[1]

Lunds Universitet | Gerardo Calvo Logroño

Abstract

LTE Advanced is a preliminary mobile communication standard. Formally submitted as a candidate 4G system to the ITU-T, it is expected to be completed in 2011. It is being standardized by the 3rd Generation Partnership Project (3GPP) as a major enhancement of the pre-4G 3GPP Long Term Evolution (LTE) standard, which proved to be insufficient to satisfy market's demand.

The 3GPP group has been working on different aspects to improve LTE performance, using for this purpose the framework provided by LTE Advanced, which includes higher order MIMO, carrier aggregation (carriers with multiple components), and heterogeneous networks (relays, picos and femtos).

In this report we will briefly discuss the previous releases as well as the motivations that made this new release possible. Later on, we will see how LTE Advanced solves the problems detected in previous releases and the most relevant aspects of this standard. To end with, we will see which is the actual state of the standard, looking into the stages that have already been accomplished and the ones that are still going on.

Content

Introduction

It seems like only yesterday that the 3G technology finally arrived, and yet it is time to move on. The increasing demand of higher transmission rates, lower latencies and IP-based architecture mobile networks has pushed both the service provider companies and the regulators towards the creation of a technology standard, LTE.

Due to user's demand of new services with high quality of experience and the growth of killer applications like P2P data sharing and video streaming (which consume a very high bandwidth percentage of the total available and can introduce non neglectable jitter), the limits of LTE have been reached and, once more and although LTE is an unknown technology in most countries of the world, it is time to move on to the next stage: LTE-Advanced, the favorite one to become the fourth generation (4G) standard of mobile technologies.

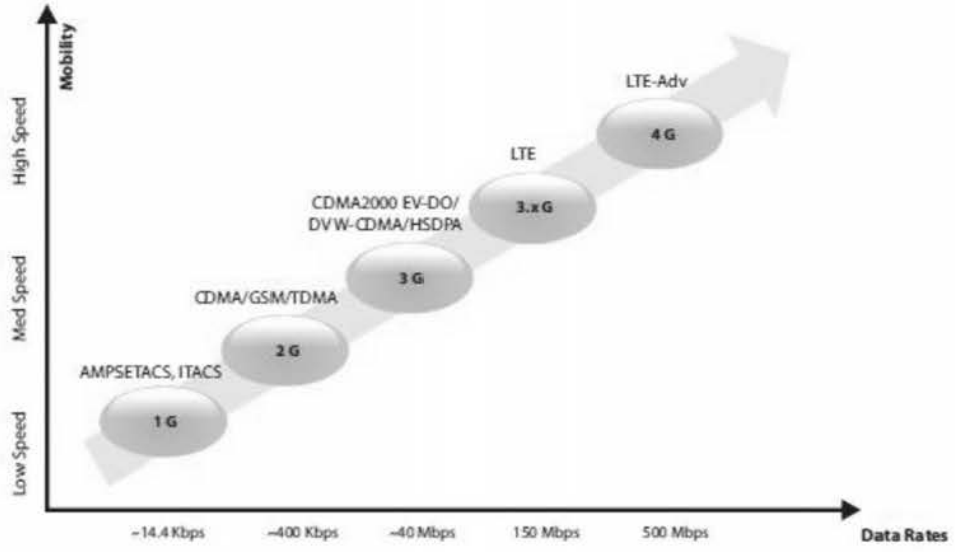


Figure 1. Evolution of radio access technologies [2]

As we can see in the previous figure, each new mobile generation increases the data rate and the mobility in almost an exponential way with respect to the previous standard.

But user's quality of experience demand and the appearance of new killer applications weren't the only motives for the development of LTE-Advanced. Here are three more motives that came from the side of the service providers:

- The wireless data traffic is increasing exponentially. We saw in the previous figure that the bit rates have to increase to deal with the new demands, but the network needs to be adapted to not suffer overcharges.

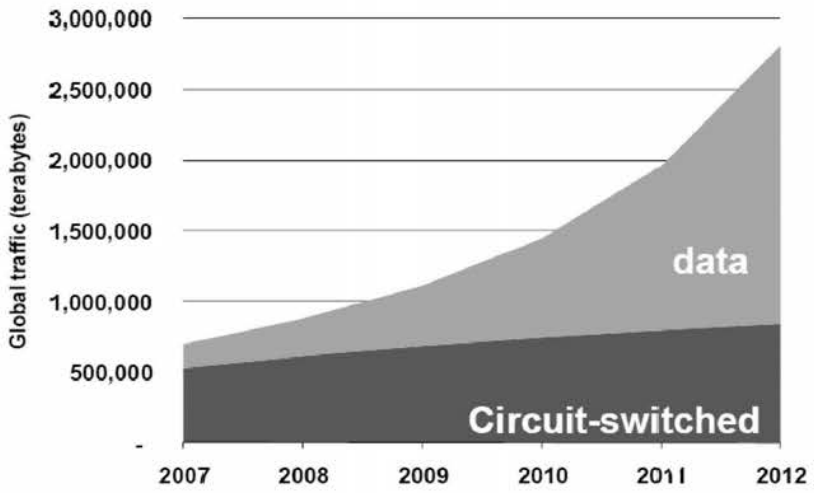


Figure 2. Wireless data traffic increase [3]

- The revenue is growing each time more slowly. There is a necessity from the service providers of lowering the cost of the data transmission. LTE-Advanced enables low-cost deployments and the cost per megabyte will be much smaller than in 3G.

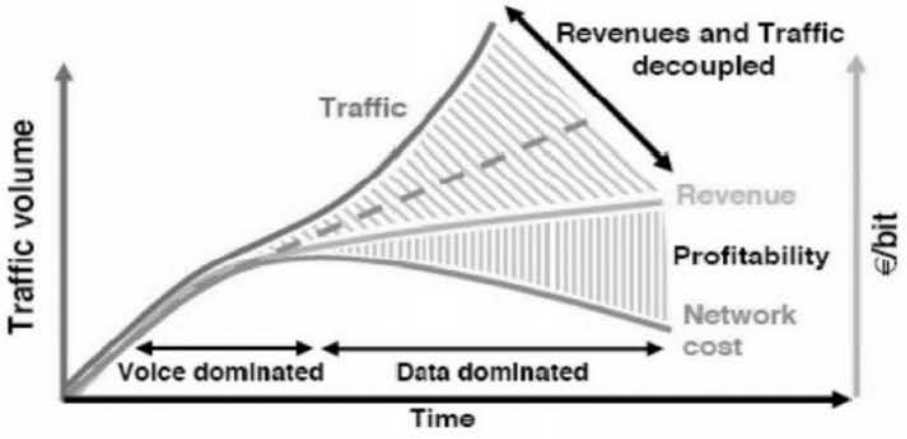


Figure 3. Downsize in the revenue growth [3]

- The radio link improving is reaching the limit. The next step will be using advanced topology networks that will provide benefits like a significantly higher network capacity, an extension of the range of the nodes and the relays will extend coverage and will improve capacity.

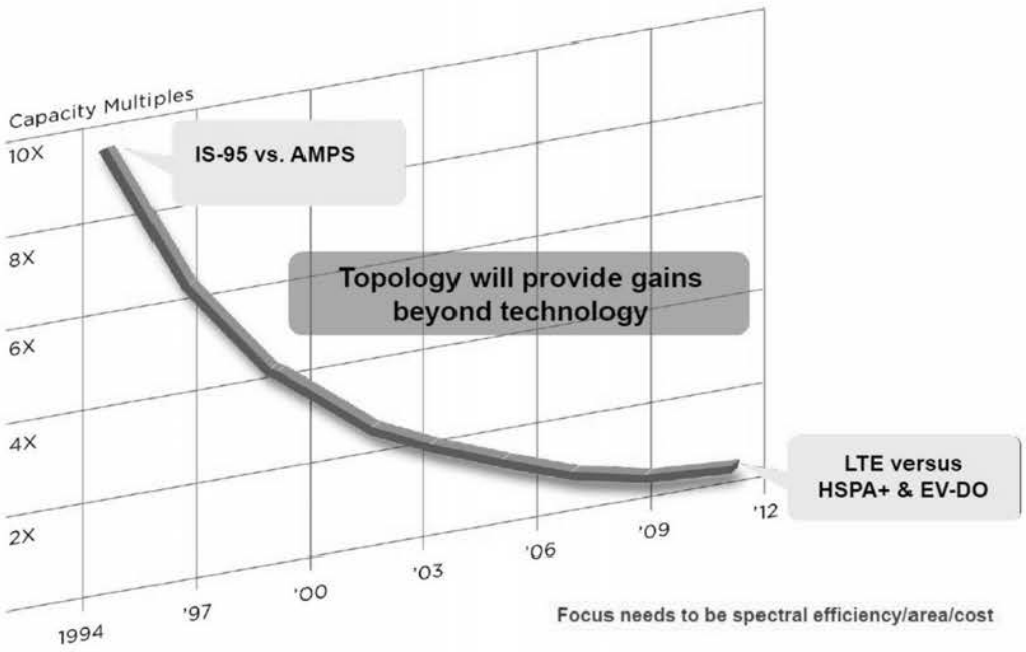


Figure 4. Link improvement reaching the limit [3]

Many service provider (network operators) are already aware of the explosion of the data traffic that is coming and are fully conscious of how quickly the demand of high quality networks (in terms of high capacity, low delays, stable connections and high bit rates) will produce once all the millions of users that now are not technological advanced enough join the mobile communications world. So every operator must ensure he is ready for the exponentially growing traffic incoming demand. And as we have seen before, the only cost-effective way of doing this in the long run is through more efficient technology.

Here is when LTE-Advanced comes into scene. It is important to remark that LTE-Advanced aims to provide a uniform user experience to users located at any point inside a cell by using heterogeneous networks.

New features of LTE-Advanced: from Release 8 to Release 10

LTE is the result of the standardization work done by the 3GPP to achieve a new high speed radio access in the mobile communications frame. It was introduced in the Release 8 in 2008. In 2010 the Release 9 has come to provide some enhancements to LTE and in 2011 Release 10 will bring LTE-Advanced, which will expand the limits and features of Release 8 to meet the requirements of the IMT-Advanced of ITU-R for the fourth generation of mobile technologies (4G), and the future operator and end user's requirements. LTE-Advanced terminals have to be compatible with LTE-Release8 networks and vice versa, LTE-Release 8 terminals have to be compatible with LTE-Advanced networks.

The key measure of LTE is the ability to provide very high bit rates. In addition, it provides high spectral efficiency, very low latency and support of variable bandwidth. Some of the LTE new features are:

- OFDMA, a multi-user version of the modulation scheme called (Orthogonal Frequency-Division Multiplexing) in the downlink. This gives robustness against multipath interference and connects with some advanced techniques also used like MIMO and frequency domain channel-dependent scheduling.

- Single-Carrier FDMA with Dynamic Bandwidth in the uplink. SC-FDMA has lower peak-to-average power ratio (PAPR) which is a major improvement for the user equipment (UE), as it improves the transmission power efficiency.

- Multiple antenna solutions. MIMO (Multiple Input Multiple Output) is probably the most important feature of LTE for improving the data bit rates and the spectral efficiency. It consists on the use of multiple antennas in both the receiver and the transmitter in order to use the multipath effects, which reduces the interference and leads to high transmission rates. MIMO works by dividing the data flow into multiple unique flows, and transmits them in the same radio channel at the same time. They will be merged using an algorithm or special signal processing.

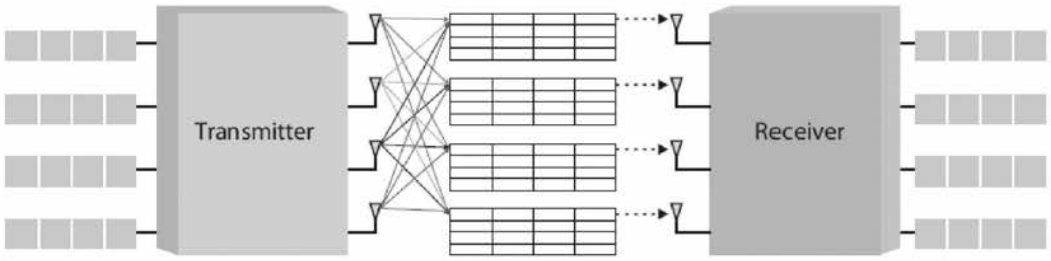


Figure 5. MIMO block

- Very low latency due to a short setup time and small transfer delays. This is a basic feature as many applications, especially the ones related to voice and video transfer, rely on low latency times.

- LTE can support variable bandwidths, in the range between 1.4 and 20MHz.

LTE-Advanced extends the features of LTE in order to exceed or at least meet the IMT-Advanced requirements. It should be a real broadband wireless network that behaves as an advanced fixed network like FTTH (Fiber To The Home) but with better quality of service. It also must fulfil operators' demands like a reduced cost (per Mbit transmitted), compatibility with all 3GPP previous systems and a better service providing in terms of homogeneity, constant quality of the connection and smaller latency.

Here we list some of the LTE-Advanced proposals to achieve the goals of this standard:

- Support of asymmetrical bandwidths and larger bandwidth (maximum of 100MHz). In LTE (release 8), the bandwidth could have different sizes but had to be the same in the downlink and in the uplink. In LTE-Advanced (Release 10) bandwidths can be different because due to actual demand in mobile networks, the traffic from the station to the user is bigger than the one from the user to the station. And they can be as asymmetric as they want within the limit of the 100 MHz LTE-Advanced provides. The sum of both bandwidths (downlink + uplink) cannot exceed 100 MHz. Carrier aggregation to achieve wider bandwidth is a key factor as well as the support of spectrum aggregation, to achieve higher bandwidth transmissions.

- Enhanced multi-antenna transmission techniques. LTE introduced MIMO in the data transmission and LTE-Advanced the MIMO scheme has to be extended to gain spectrum efficiency (which is proportional to the number of antennas used), cell edge performance and average data rates. LTE-Advanced considers a configuration 8x8 in the downlink and 4x4 in the uplink.

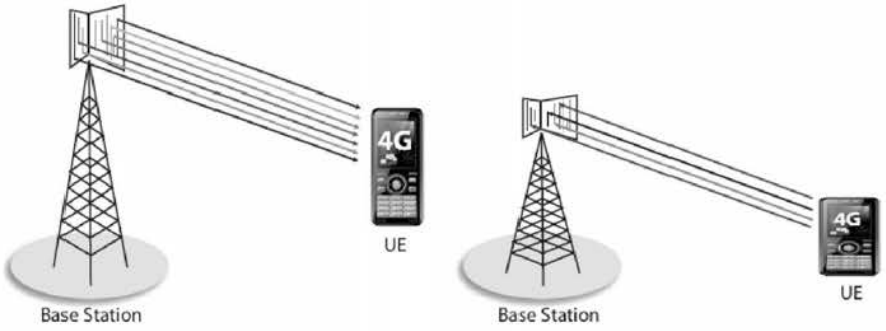


Fig a: DL Direction Fig b: UL Direction

Figure 6. MIMO scheme (8x4) [2]

- Coordinated multipoint transmission and reception (CoMP) which improves the received signal of the user terminal. Both the serving and the neighbour cells are used in a way that the co-channel interference from neighbouring cells is reduced. It implies dynamic coordination between geographically separated transmission points in the downlink and reception at separated points in the uplink. This mechanism will improve the coverage of high data rates and will increase the system bit rate.

- Relaying. Relaying increases the area covered and the capacity of the network. User's mobile devices communicate with the relay node, which communicates with a donor eNB (enhanced Node B, that's 3GPP's term for base stations). Relay nodes can also support higher layer functionality like decoding user data from the donor eNB and re-encoding the data before transmitting it to the user terminal.

  Type 1 relay nodes control their cells with their own cell identity, and among their tasks we can find the transmission of synchronization channels and reference symbols. This type of relays guarantee compatibility with previous releases as it appeared in Release 8 to provide service to Release 8 mobile terminals.

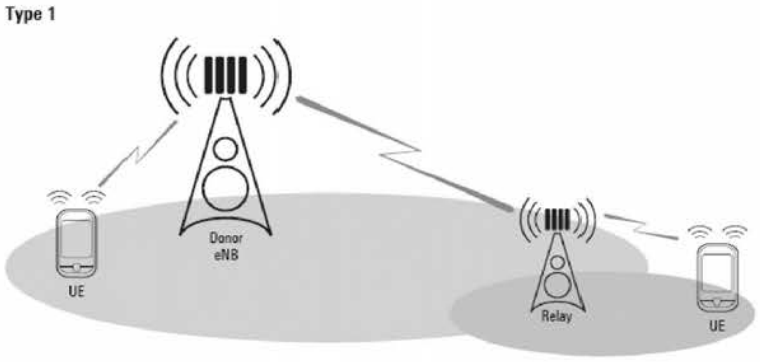


Figure 7. Type 1 relays [4]

Type 2 relay nodes don't own an identity, so the mobile user won't be able to distinguish if a transmission comes from the donor eNB or from the relay. eNBs transmit control data and relays transmit user data.

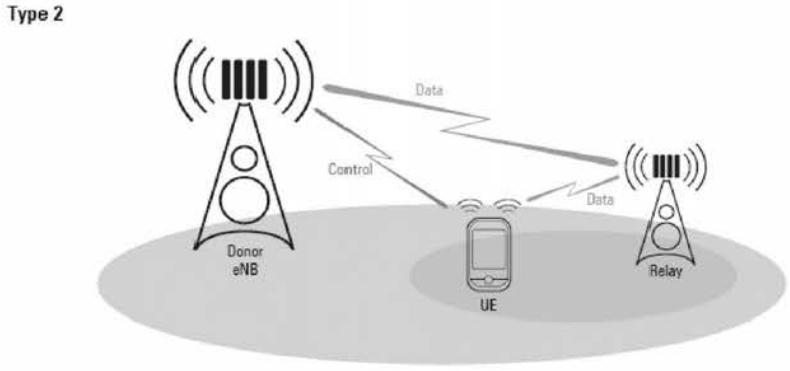


Figure 8. Type 2 relays [4]

There are many others features included in the Release 10, like a deeper reduction of delays, a new enhanced transmission scheme and enhanced techniques to extend the covered area using Remote Radio Requirements (RREs).

The next table will compare different aspects of LTE and LTE-Advanced.

Technology	LTE	LTE--A
Peak data rate Down Link (DL)	150 Mbps	1 Gbps
Peak data rate Up Link (UL)	75 Mbps	500 Mbps
Transmission bandwidth DL	20MHz	100 MHz
Transmission bandwidth UL	20MHz	40 MHz (requirements as defined by ITU)
Mobility	Optimized for low speeds(<15 km/hr) High Performance At speeds up to 120 km/hr Maintain Links at speeds up to 350 km/hr	Same as that in LTE
Coverage	Full performance up to 5 km	a) Same as LTE requirement b) Should be optimized or deployment in local areas/micro cell environments.
Scalable Band Widths	1.3,3, 5, 10, and 20 MHz	Up to 20–100 MHz
Capacity	200 active users per cell in 5 MHz.	3 times higher than that in LTE

Table 1. Differences between LTE and LTE-Advanced [2]

As we can see, LTE-Advanced highly improves LTE specifications. But apart from its superior features, it will increase the benefit for the operators as cost of transmitting information will be reduced and will provide a higher quality of service and a more reliable service.

New network topology

As the radio link can no longer be improved because we are reaching the physical limits, it is time to look in some other direction.

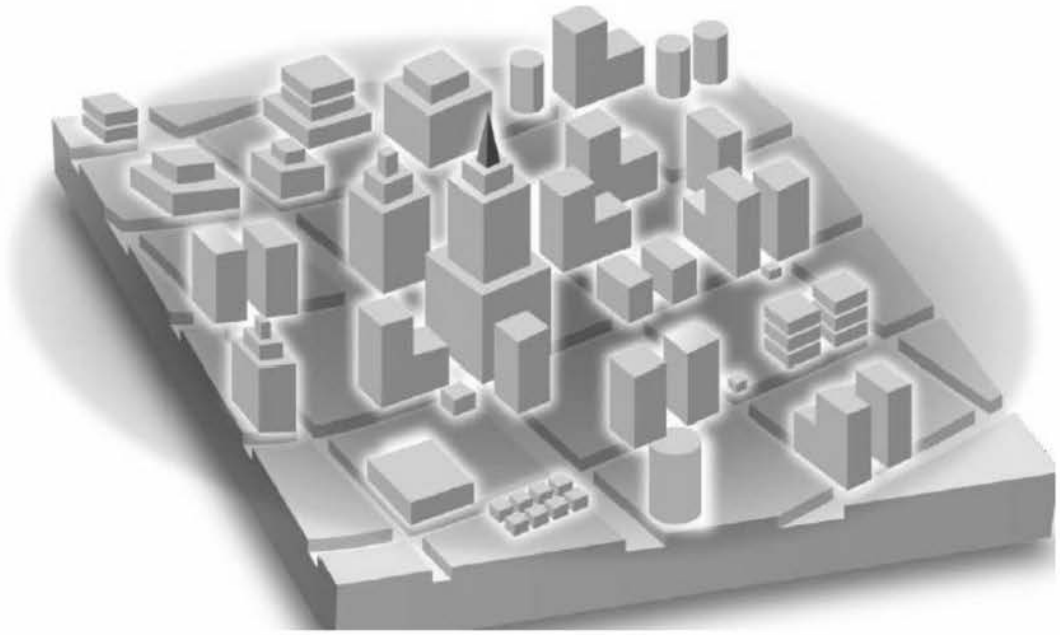


Figure 9. Traditional Macro Network [1]

The traditional network model settles the principles for wide area coverage, but still has to deal with many problems like cell splitting, indoor coverage, changes in the topology of the network, etc.

LTE-Advanced tries to get the network closer to the user to provide a uniform user experience and to increase the capacity of the network. For that purpose, it uses advanced topology networks.

Advanced topology networks provide the benefits and the performance increase we discussed in the previous chapter. Some of the characteristics of this type of networks are [1]:

- They are self-organizing networks; this will minimize the number of Drive Tests for example.
- Intelligent Node Association
- Support for relays
- Adaptive Resource Allocation
- Multicarrier (spectrum aggregation)
- Coordinated Beamforming

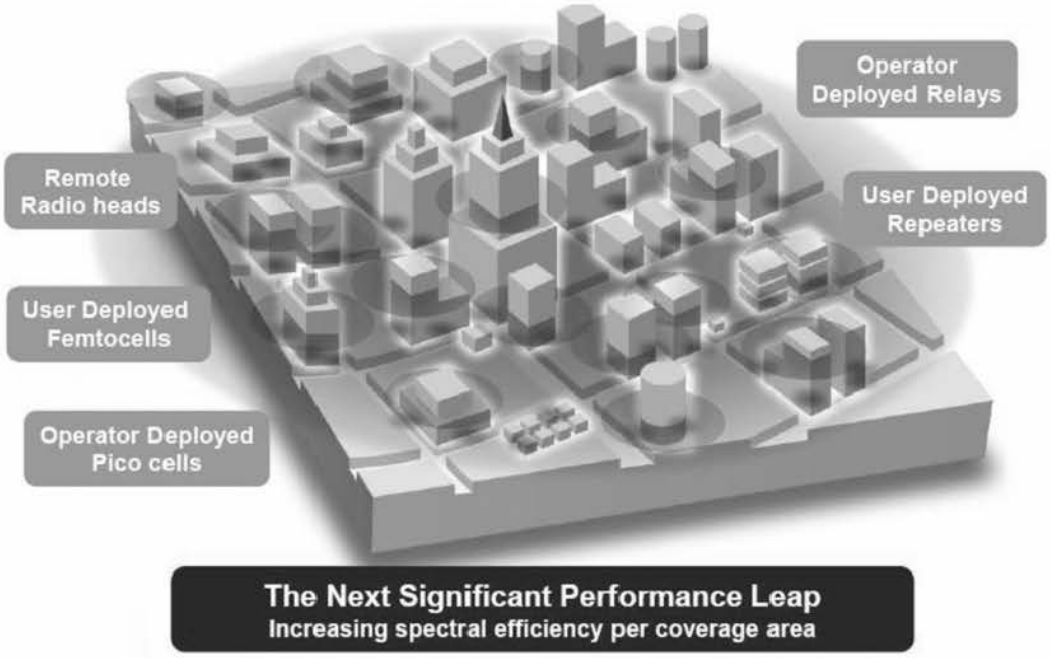


Figure 10. Advanced Topology Networks [1]

With the use of picocells, femtocells and relays we have a much more efficient and uniform network that will provide a higher quality of service to the final user.

Let's consider the scenario in figure 10. This cellular system consists of several macro base stations with a high transmission power (5-40W) while pico, femto and relay base stations are overlaid to the previous macro. These new base stations have a much lower transmission power (100mW-2W). While macro base stations are placed in a planned way, pico, femto and relay base stations are usually placed in a quite unplanned way. The low power base stations can be placed to improve the capacity of the macro cell in certain hot spots and to eliminate coverage holes.

Actual state of the standard

The last steps are being given. In a year time all the stages will be accomplished and the Release 10 will finally see the light.

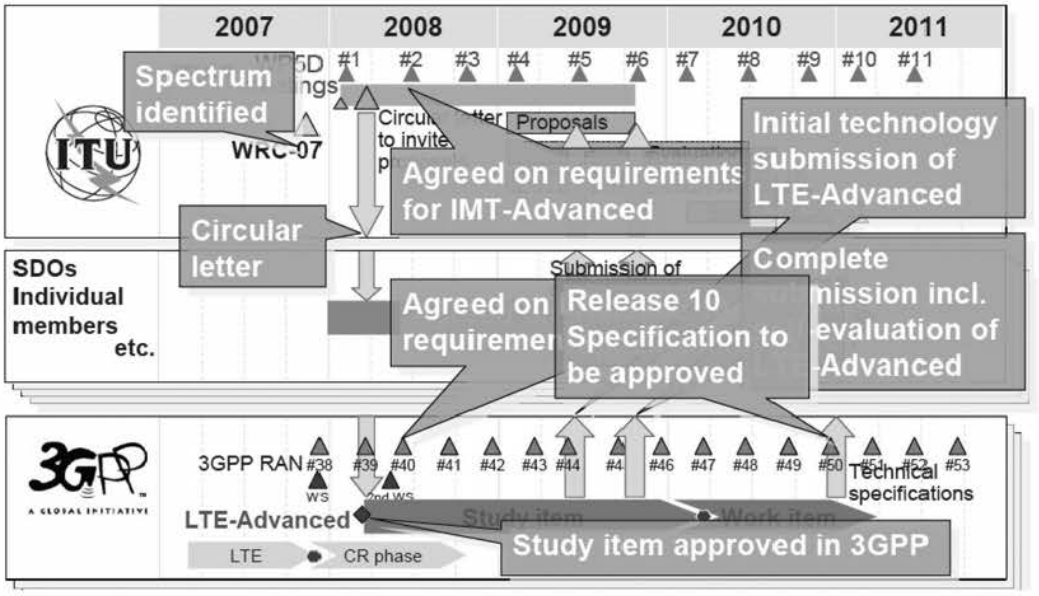


Figure 11. Standardization process [5]

LTE-Advanced is in the middle of the process of acceptation as the new 4G standard. In the year 2011 the IMT will give say whether or not LTE-Advanced meets the requirements to become the next generation standard of mobile technologies.

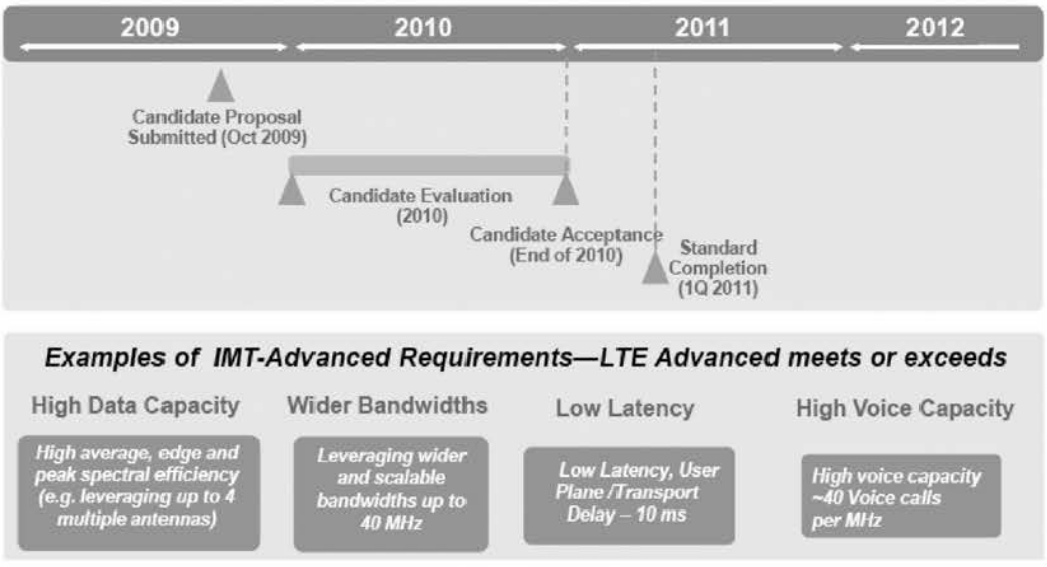


Figure 12. LTE as Global 4G solution [1]

Market impact

One question that could come out when we hear about the 4G when in many countries the 3G is not widely accepted by the users is: why is it necessary to invest in networks and new and powerful terminals?

We could find the answer in the global landscape. User's demands and expectations increase exponentially. Customers are starting to be satisfied with high speed fixed connections: they are fast, the cost is reasonable and it is very stable and reliable. But the there is an underlying global need of making everything wireless, placement independent and mobile. People want to work on a plane or in a park as they will do in their office. There is also a change in the behaviour of the customer. With the arrival of the so called Web 2.0 customers started to generate a huge amount of data traffic while until a few years ago mobile devices were used with only a direct communication purpose. So networks have to be adapted to deal with this new behaviour.

In February 2008 there were 20 million subscribers to HSDPA networks and this number increases exponentially, especially with the growing economical power and interest of emerging countries.

Network operators are thus presented a chance to provide their customers with a higher level product that could compete with fixed networks but with the advantage of mobility and the global compatibility. And they could bring new customers as they will give access to areas where there are no fixed networks or it is too expensive to be deployed. And as we saw before, LTE-Advanced provides a higher benefit as the costs have been reduced. This will also allow them to use more attractive rates for the user, which is maybe the mayor drawback of 3G penetration in many countries.

And while LTE-Advanced aims to the future, it doesn't mean a breakup with current and past technologies. In the standard it is clearly stated the need of compatibility with the previous standards and operators will be able to reuse most of the existing structure.

As a result of all this, LTE-Advanced will allow operators to revalue their existing networks and obtain new higher-profitable sources of business. And as a result of the new features that LTE-Advanced provides with and all the services that finally will be able to deliver, operators will be able to manage a wide variety of business products that will make their incomes grow as the revenue will be bigger than with the actual networks.

And for mobile terminal manufacturers this will be a tremendous opportunity to spread the number of models and families of products they actually have. The flexibility of this technology will be translated into much more powerful devices and they will be oriented towards an Internet and media direction.

The following table summarizes how LTE-Advanced will widen the possibilities of business and will create new service opportunities.

Service category	Current environment	LTE environment
Rich voice	Real-time audio	VoIP, high quality video conferencing
P2F messaging	SMS, MMS, low priority e-mails	Photo messages, IM, mobile e-mail, video messaging
Browsing	Access to online information services, for which users pay standard network rates. Currently limited to WAP browsing over GPRS and 3G networks	Super-fast browsing, uploading content to social networking sites
Paid information	Contentforwhich users pay over and above standard network charges. Mainly text-based information.	E-newspapers, high quality audio streaming
Personalisation	Predominantly ringtones, also includes screensavers and ringbacks	Realtones (original artist recordings), personalised mobile web sites
Games	Downloadable and online games	A consistent online gaming experience across both fixed and mobile networks
TV/ video on demand	Streamed and downloadable video content	Broadcast television services, true on-demand television, high quality video streaming
Music	Full track downloads and analogue radio services	High quality music downloading and storage
Content messaging and cross media	Peer-to-peer messaging using third party content as well as interaction with other media	Wide scale distribution of video clips, karaoke services, video-based mobile advertising
M-commerce	Commission on transactions (including gambling) and payment facilities undertaken over mobile networks	Mobile handsets as payment devices, with payment details carried over high speed networks to enable rapid completion of transactions
Mobile data networking	Access to corporate intranets and databases, as well as the use of applications such as CRM	P2P file transfer, business applications, application sharing, M2M communication, mobile intranet/ extranet

Table 2 Future market oportunities [6]

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[1]http://www.qualcomm.com/common/documents/white_papers/LTE_Heterogeneous_Networks.pdf last access (2010/04/30)

[2] http://lteworld.org/whitepaper/tcs-lte-advanced-future-mobile-broadband last access (2010/04/30)

[3] http://netseminar.stanford.edu/seminars/01_29_09.pdf last access (2010/04/30)

[4] http://www2.rohde-schwarz.com/file_13420/LTE_advanced_po_en.pdf last access (2010/05/2)

[5] http://www.3gpp.org/IMG/pdf/2009_10_3gpp_IMT.pdf last access (2010/05/2)

[6] http://www.scribd.com/doc/5540011/UMTS-Forum-Towards-Global-Mobile-Broadband-LTE-White-Paper last access (2010/05/2)

HSPA+ Advanced

HSPA+ enhancements beyond R10

January 2011

The Biggest Platform in the History of Mankind

>5 BILLION WIRELESS SUBSCRIBERS

>1B

3G SUBSCRIPTIONS
NOW

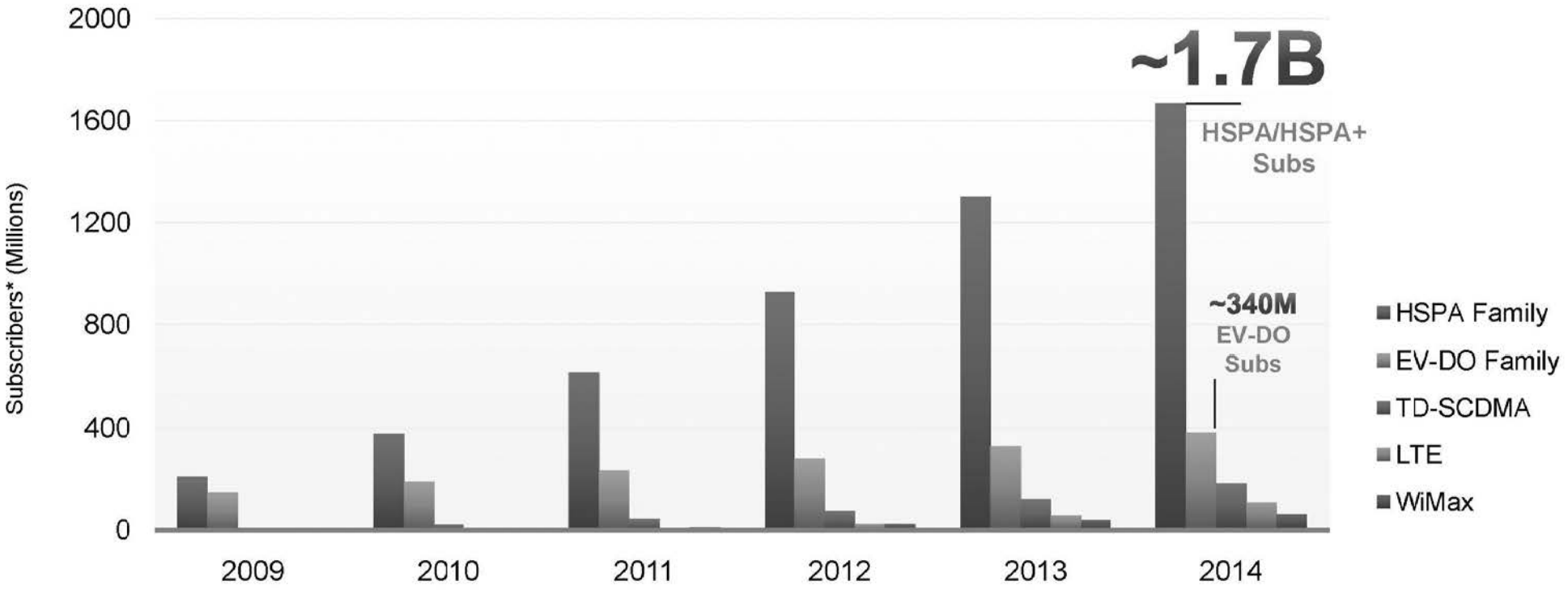
~2.8B

3G SUBSCRIPTIONS
BY 2014

Note : 3G includes CDMA2000, WCDMA and TD-SCDMA.

Source: Wireless Intelligence estimates as of Nov.2 , 2010 for the quarter ending Sep 30, 2010; *number of unique wireless connections.

HSPA+ is The Mobile Broadband Leader



Total 3G* mobile broadband subscribers expected to be ~2.2B by 2014 (of total 2.8B 3G)

Note: * 3G includes EV-DO family, HSPA family and TD-SCDMA, ** number of unique wireless connections.
Source: 3G subs – Wireless Intelligence (Nov-10), LTE – Avg. of ABI (Oct-10) and Yankee (Sep-10) and WiMax - ABI (Oct-10).

HSPA+ is The New Baseline

HSPA+ IS THE NEW BASELINE

103
LAUNCHES

148
NETWORK COMMITMENTS

OPERATORS QUICKLY MOVING TO Dual-Carrier

13
LAUNCHES

Aug 2010
FIRST LAUNCH

HSPA+ DEVICES ACROSS ALL SEGMENTS

>50
DEVICES

>11
VENDORS

Source: www.gsacom.com, Jan 24 2011, Devices as of July 12 2010

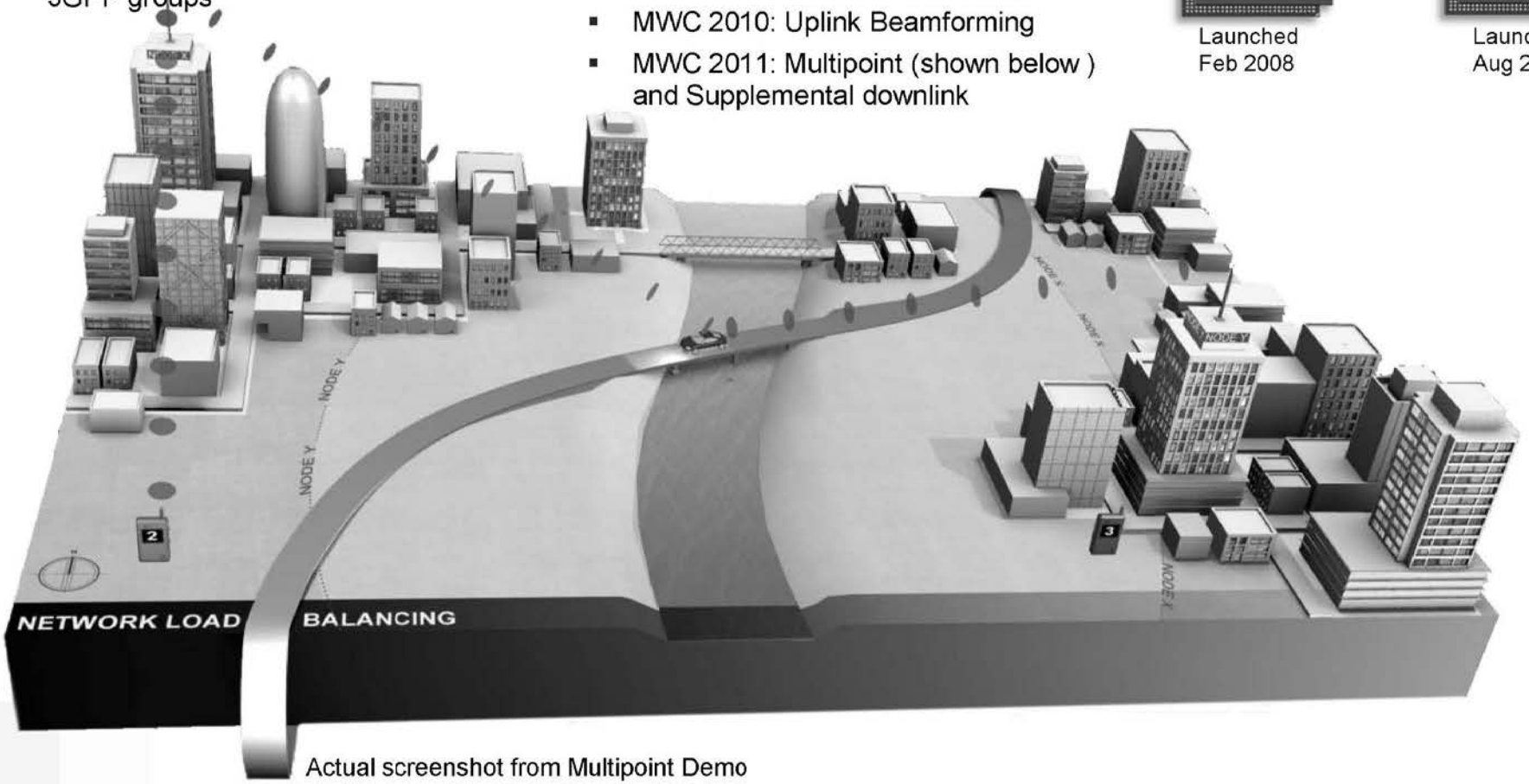
Qualcomm is a Leader in HSPA+ Research, Standards and Chipsets

COMMITTED TO CONTINUED HSPA+ EVOLUTION

- **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**

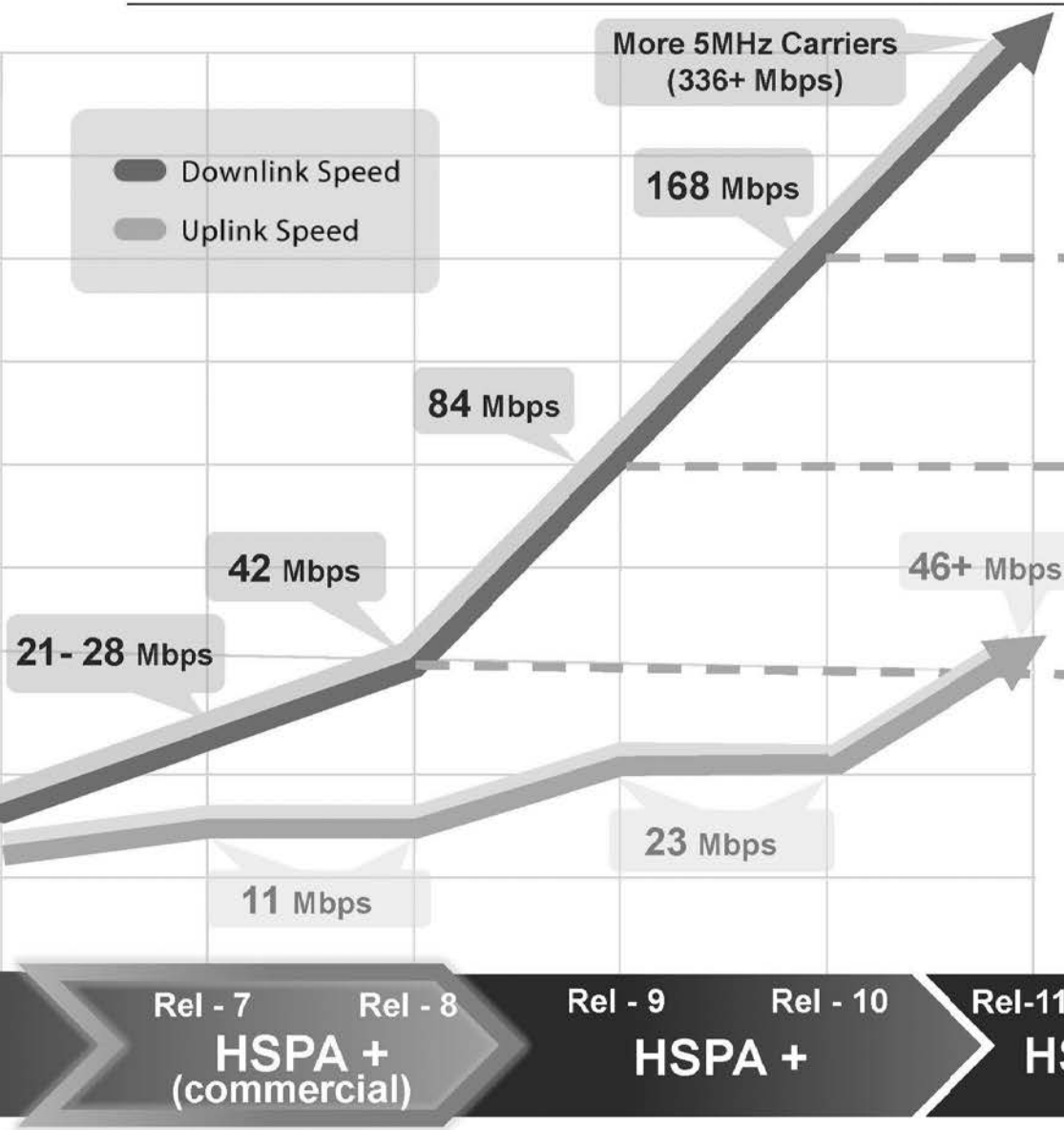
QUALCOMM MDM 8200 HSPA+ — Launched Feb 2008

QUALCOMM MDM 8220 DC-HSPA+ — Launched Aug 2010



Actual screenshot from Multipoint Demo

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

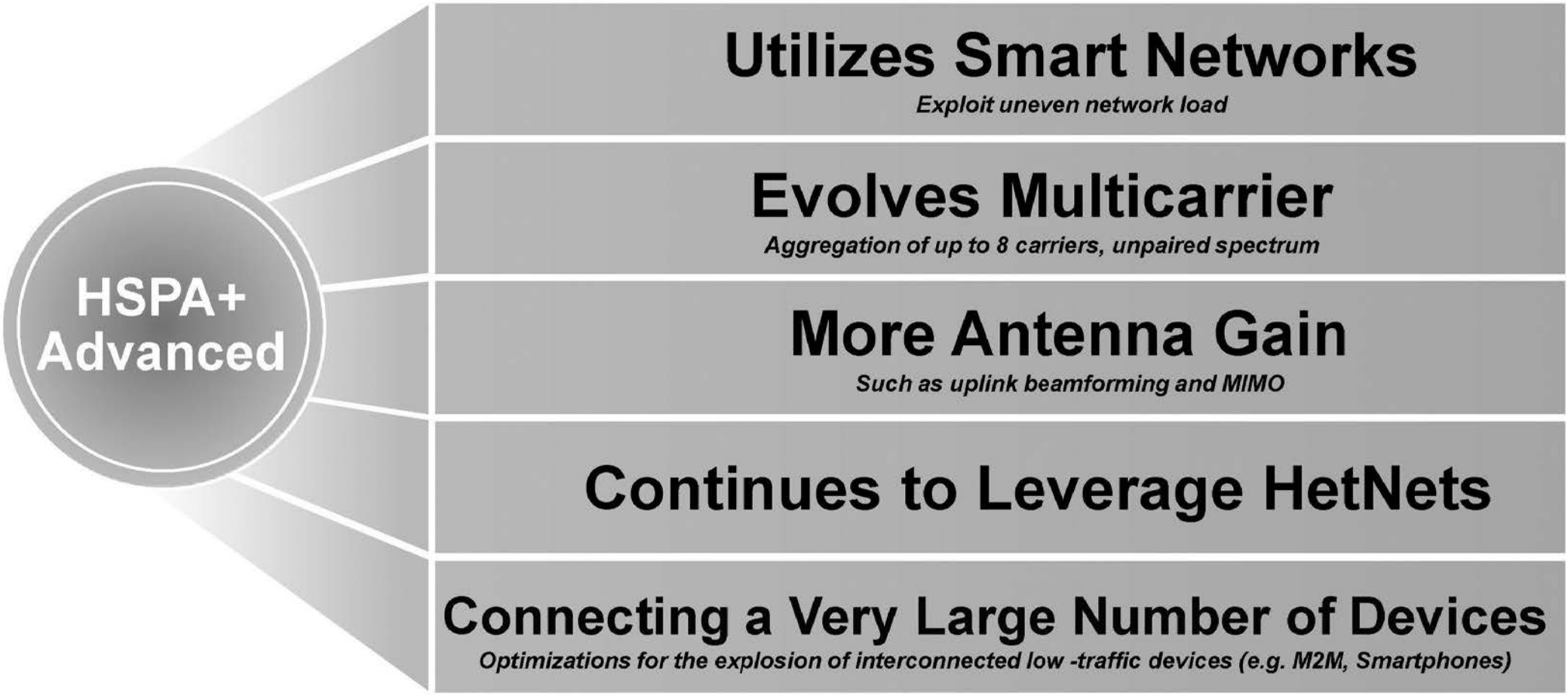
- Enhances broadband—doubled data rates to all users
- Introduction of femtocell support
- Alleviates signaling traffic e.g., from Smartphones

Rel - 7 Rel - 8	Rel - 9 Rel - 10	Rel-11 and Beyond
HSPA + (commercial)	HSPA +	HSPA + Advanced

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.

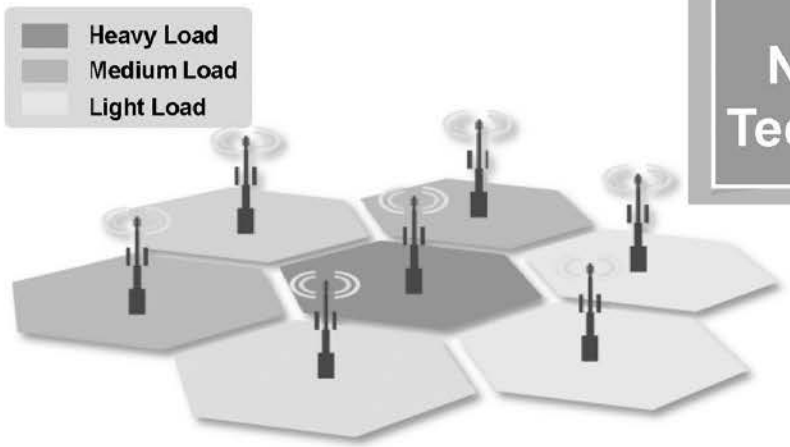
HSPA+ Advanced: Maximum Performance in Multiple 5 MHz Carriers



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

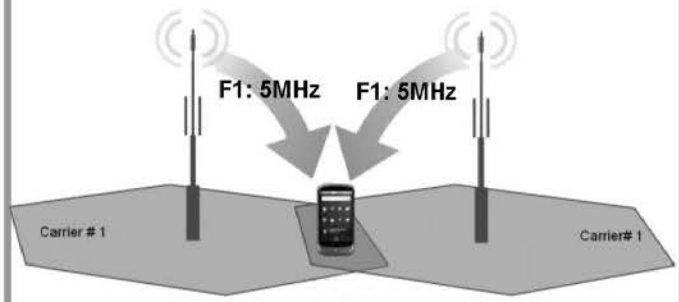
Smart Networks Exploit Uneven Load

Typically uneven load that changes with time and location



Smart Network Techniques

Multipoint Transmission
Different Data From Multiple Cells



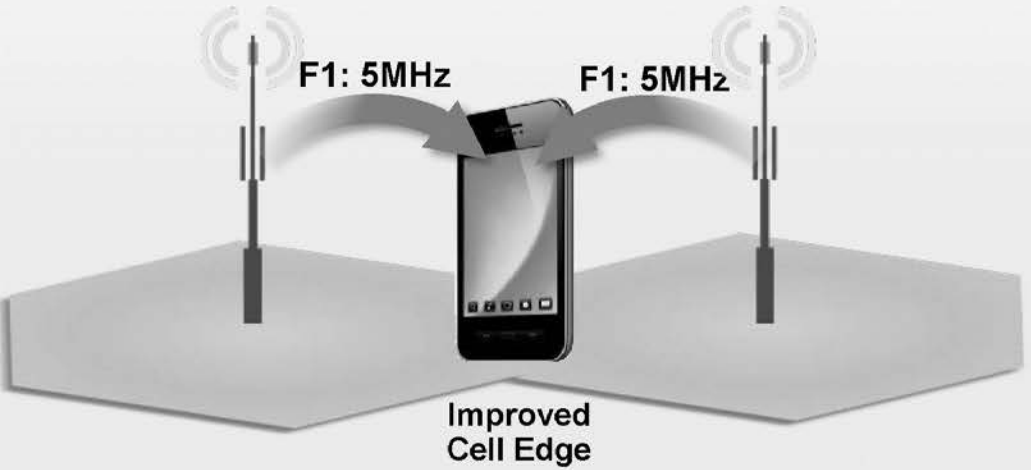
Multicarrier capable device
(with receive diversity)[1]

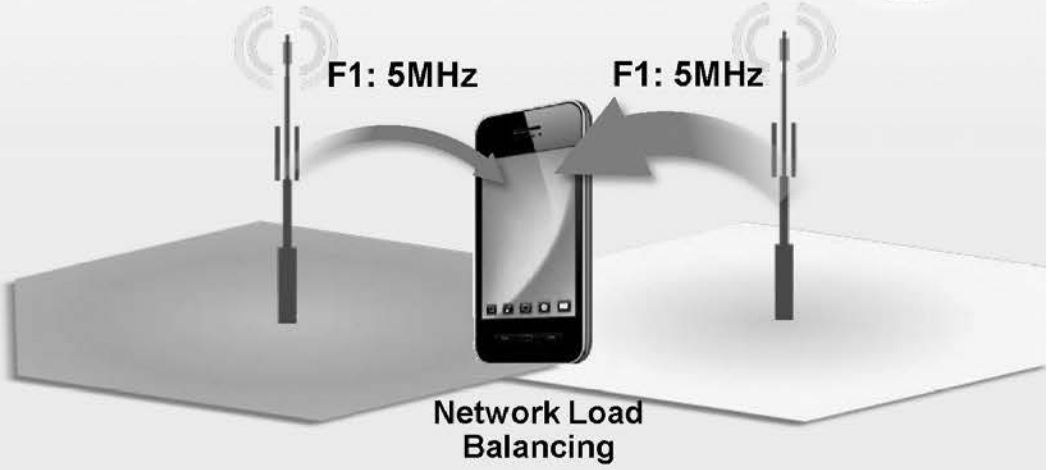
[1]Receive diversity with interference suppression (Type 3i receiver) required.

Multipoint Improves Overall Network Capacity

EVOLVES MULTICARRIER—DATA FROM MULTIPLE CELLS/NODEBs

Demo at **MWC 2011**

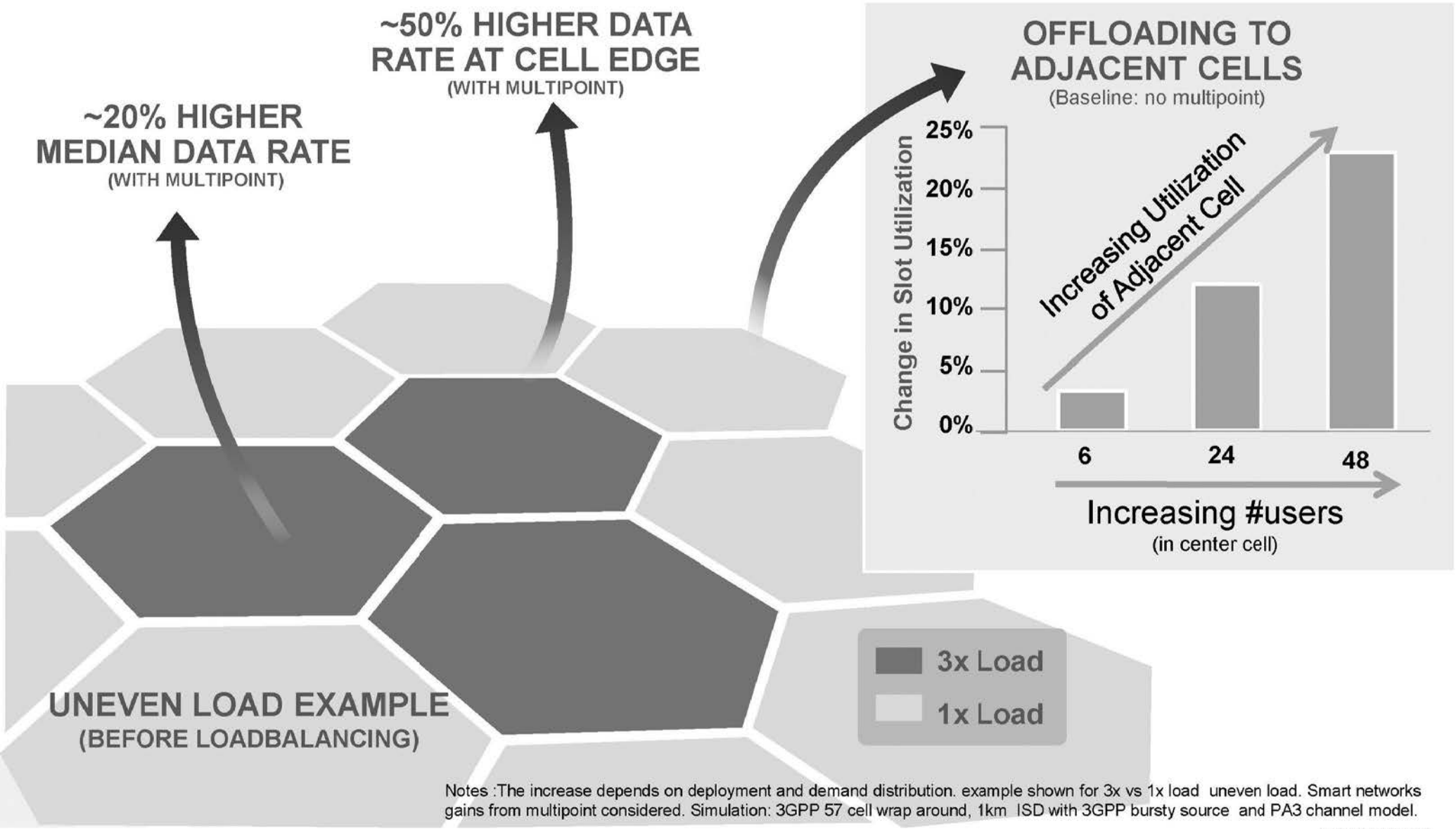




Improved Cell Edge	Network Load Balancing	Range Expansion
By serving user from multiple cells	Utilizes unused capacity in neighboring cells Improves user experience in loaded cell	Effectively increases small cell boundary —better utilization and higher network capacity

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.

Multipoint Offloads Capacity-Constrained Cells and Improves Cell Edge

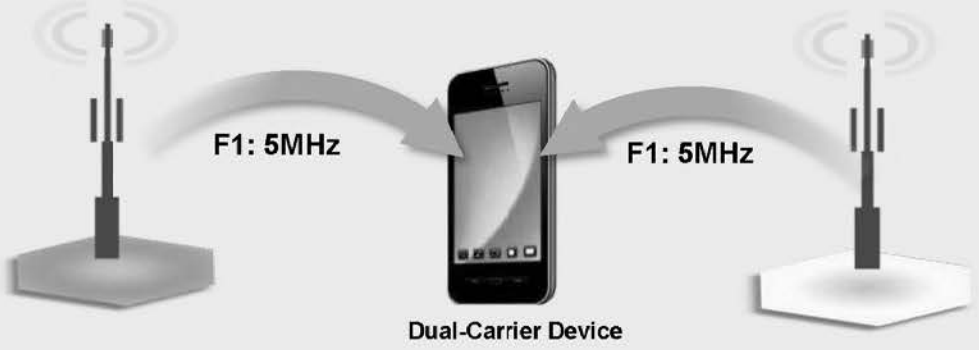


Notes :The increase depends on deployment and demand distribution. example shown for 3x vs 1x load uneven load. Smart networks gains from multipoint considered. Simulation: 3GPP 57 cell wrap around, 1km ISD with 3GPP bursty source and PA3 channel model.

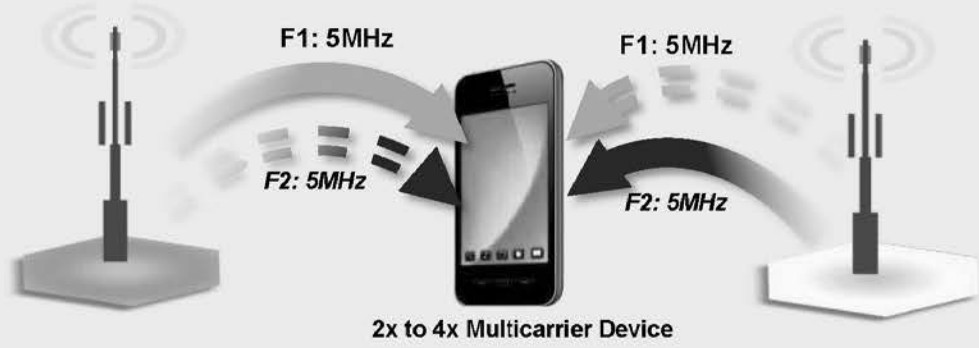
QCRQ001803

Multipoint Benefits Single and Multiple Carrier Deployments as well as HetNets

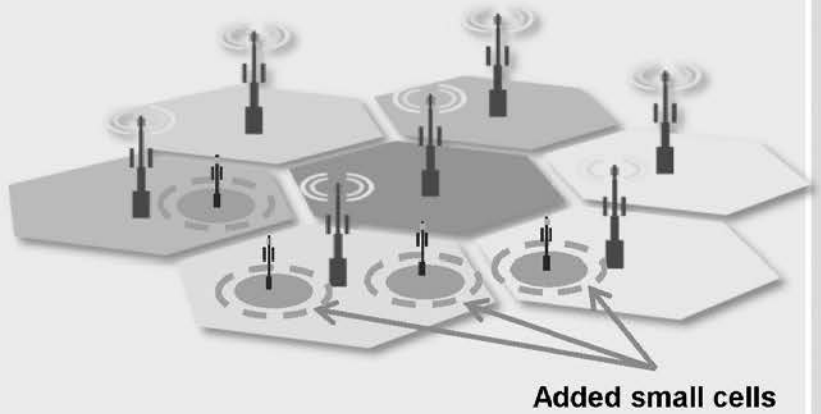
EXTENDS BENEFITS TO 5 MHz DEPLOYMENTS



BENEFITS MULTIPLE CARRIER DEPLOYMENTS



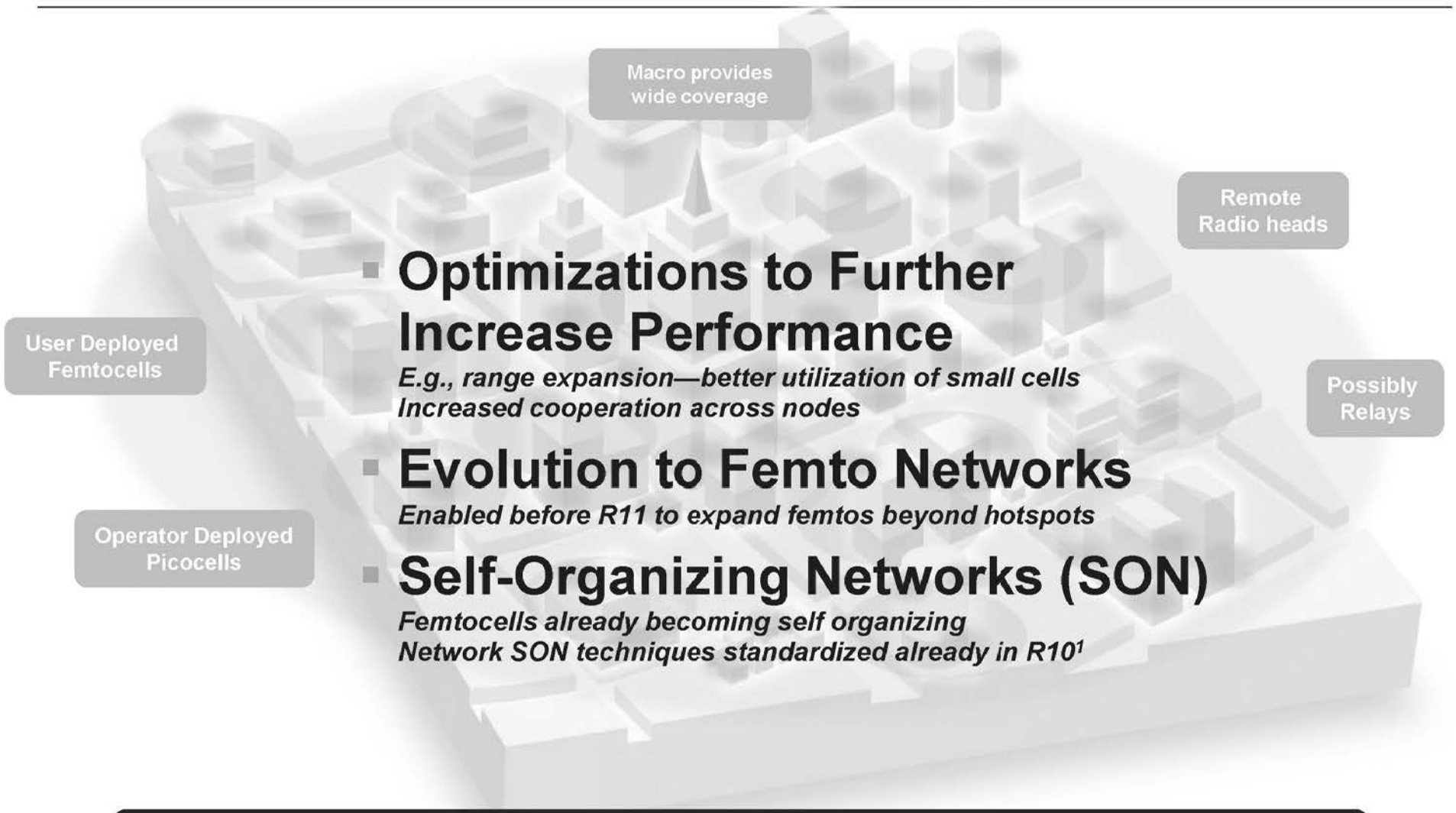
RANGE EXPANSION—MORE USERS BENEFIT FROM SMALL CELLS



More overlapping coverage with small cells—Multipoint effectively expands its range[1]

[1]Benefits HetNets (mix of macro networks with added small cells like picocells) due to more overlapping coverage with small cells.

Leveraging Heterogeneous Networks for the Next Leap in Performance

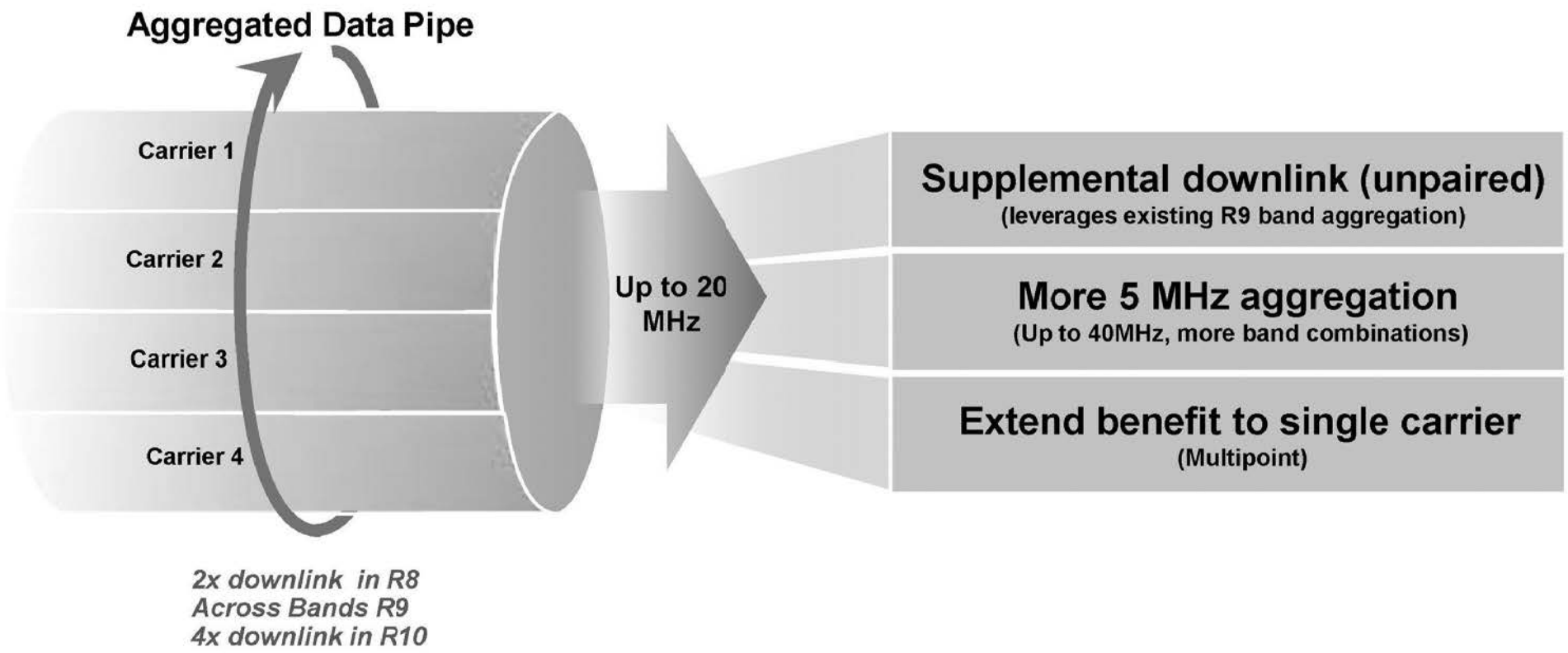


- **Optimizations to Further Increase Performance**
  E.g., range expansion—better utilization of small cells
  Increased cooperation across nodes
- **Evolution to Femto Networks**
  Enabled before R11 to expand femtos beyond hotspots
- **Self-Organizing Networks (SON)**
  Femtocells already becoming self organizing
  Network SON techniques standardized already in R10[1]

Bring Network Closer to User by Adding Small Cells

[1]For example Minimization of Drive Tests (MDT) and Automatic Neighbor Relation (ANR) are part of 3GPP R10. Heterogeneous networks: macro network with added small cells like picocells and femtocells.

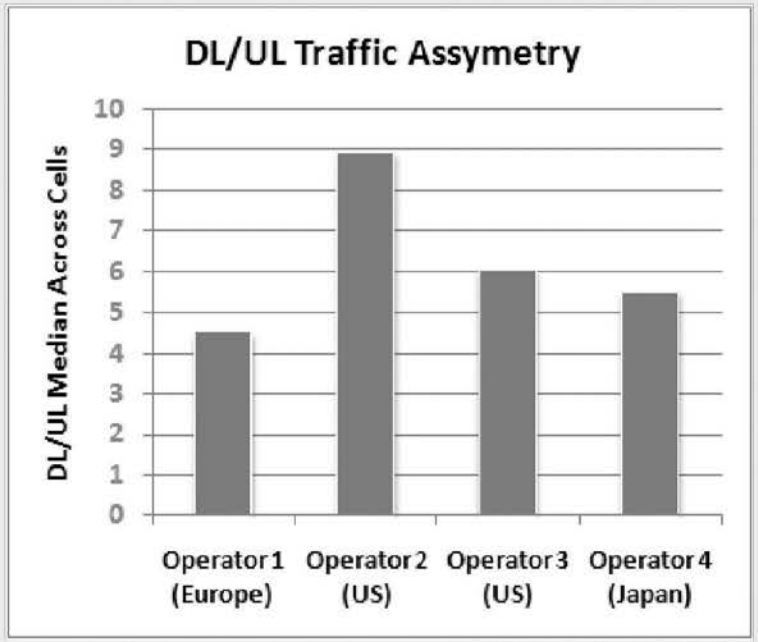
Continued Multicarrier Evolution



Mobile Traffic Typically Downlink Centric

NEED MORE DOWNLINK CAPACITY[2]

MAJORITY OF TRAFFIC ON DOWNLINK (DL)[1]



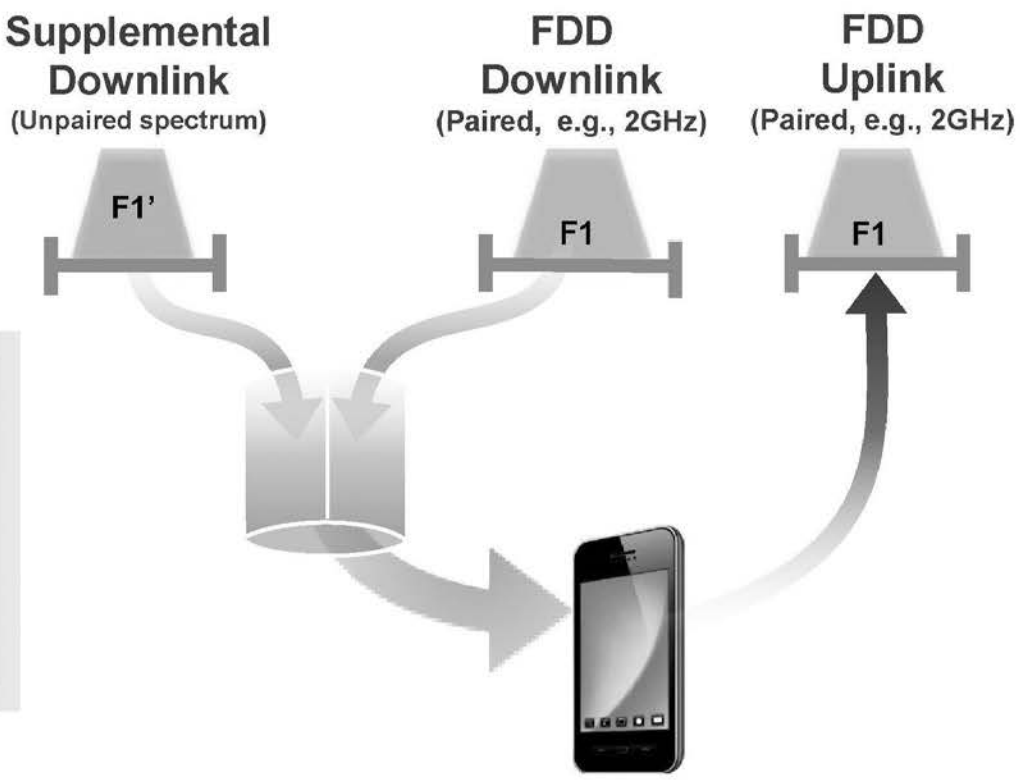
MORE DOWNLOAD, MORE VIDEO AND RICH MEDIA TO NEW DEVICE SEGMENTS

[1] Based on measurements in live networks. Median shown. [2]Uplink is also important, not only for capacity reasons: downlink improvement can be used to extend coverage. Faster TCP/IP feedback on the uplink means faster downlink Applications like social networking will drive more uplink data.

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

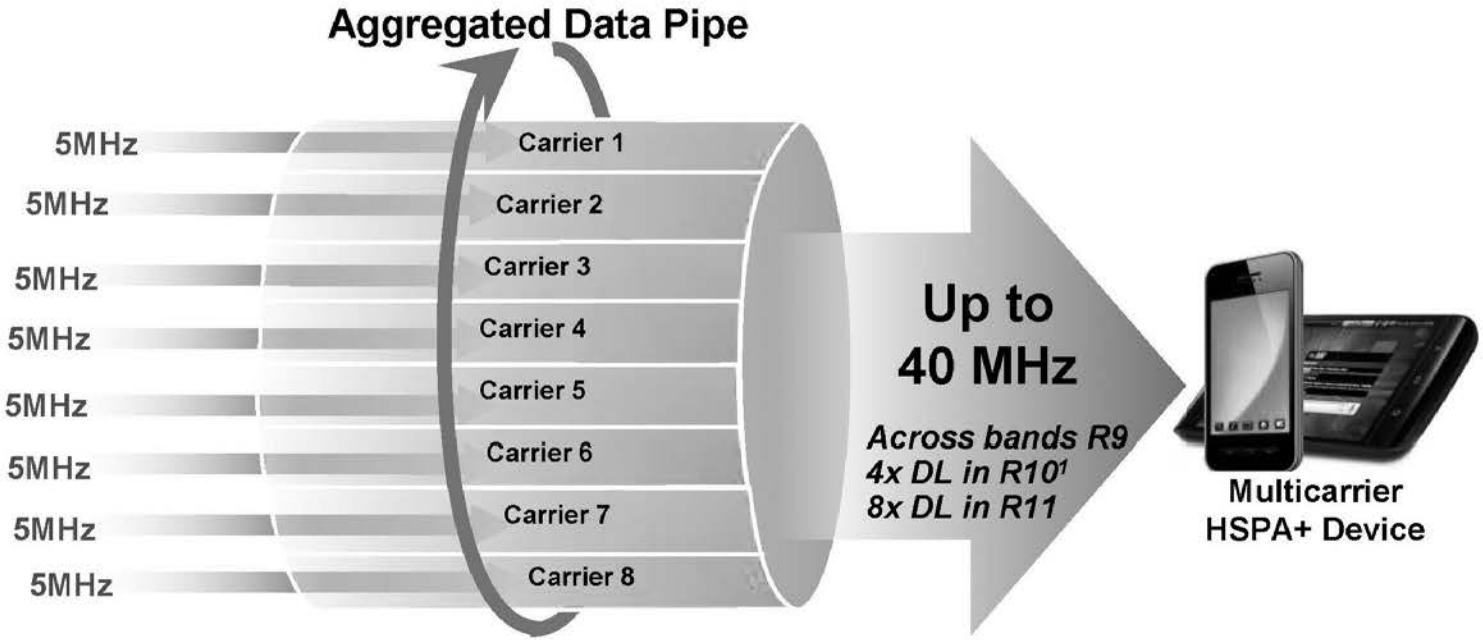
- Harmonization possible in Europe and beyond, with up to 40 MHz of unpaired spectrum[2]
- Other opportunities, such as 700MHz in the US, depend upon country-specific spectrum situations

[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:

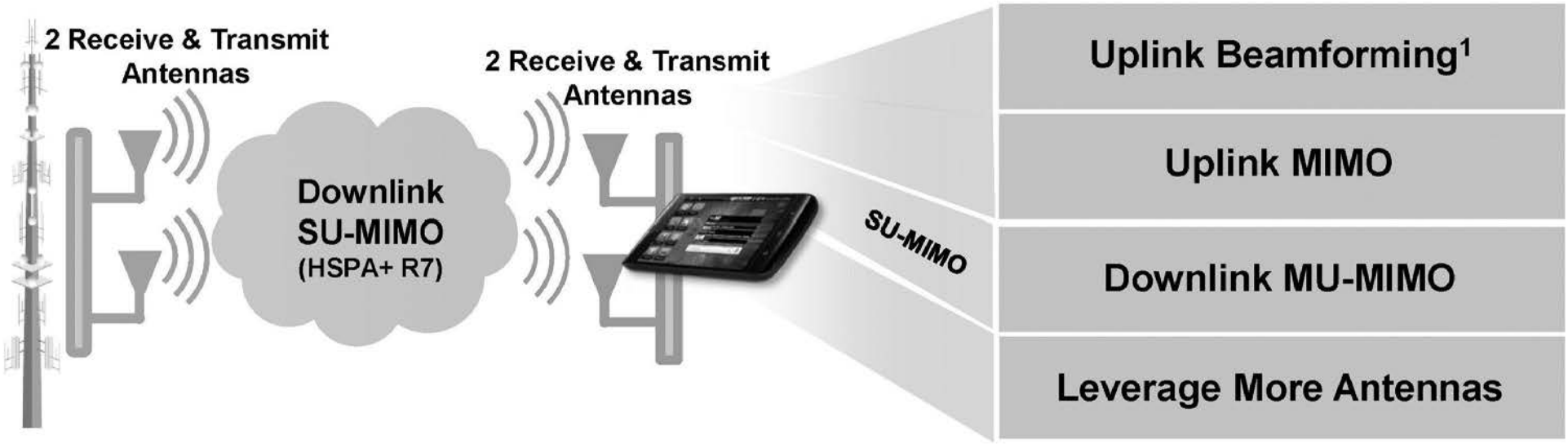
- **2.1 GHz** (Band I)
- **1900 MHz** (Band II)
- **1800 MHz** (band III)
- **1700 MHz** (Band IV)
- **900 MHz** (Band VIII)
- **850 MHz** (Band V)



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

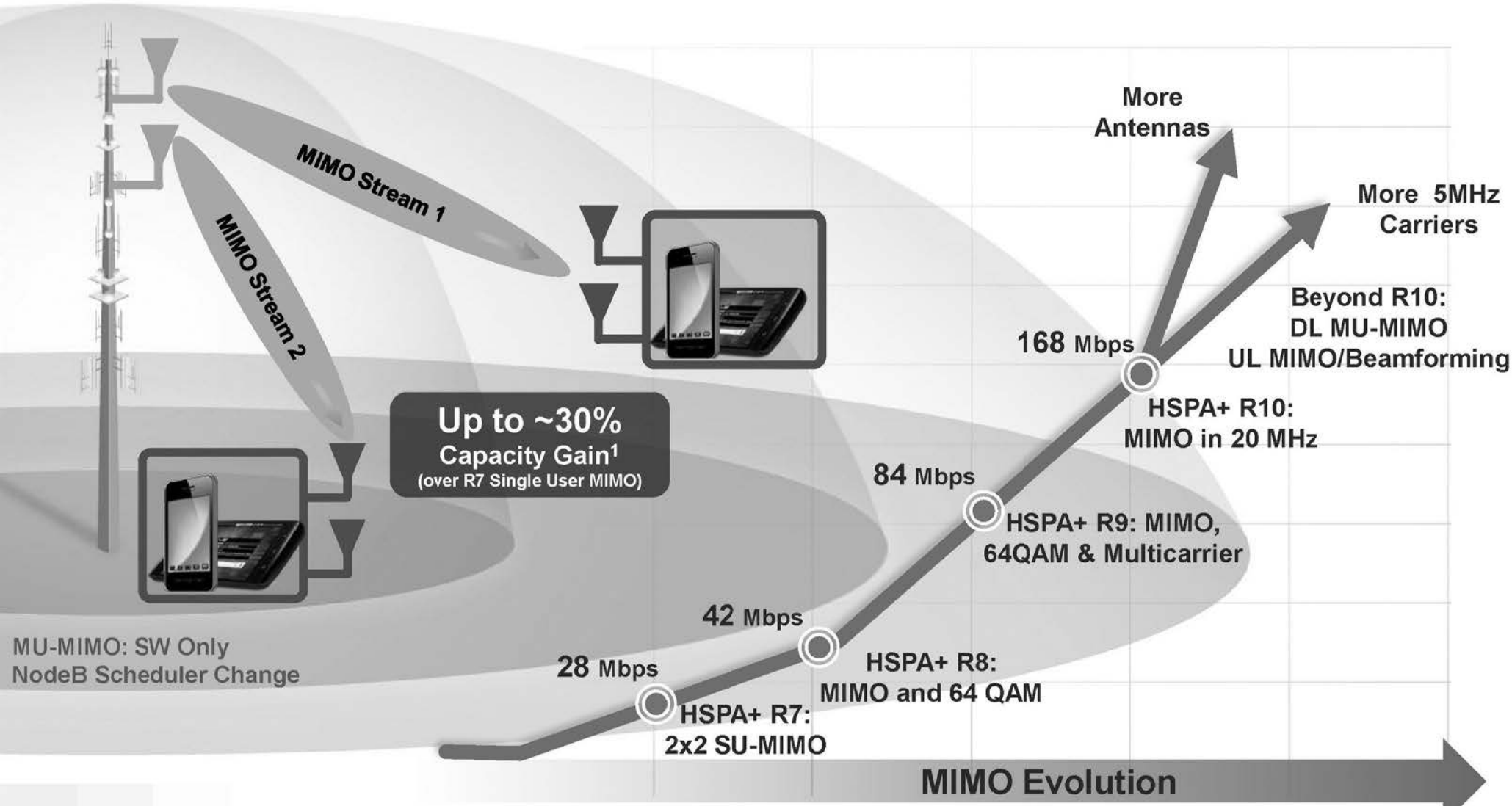
More Antenna Gain



[1]A form of closed loop transmit diversity.

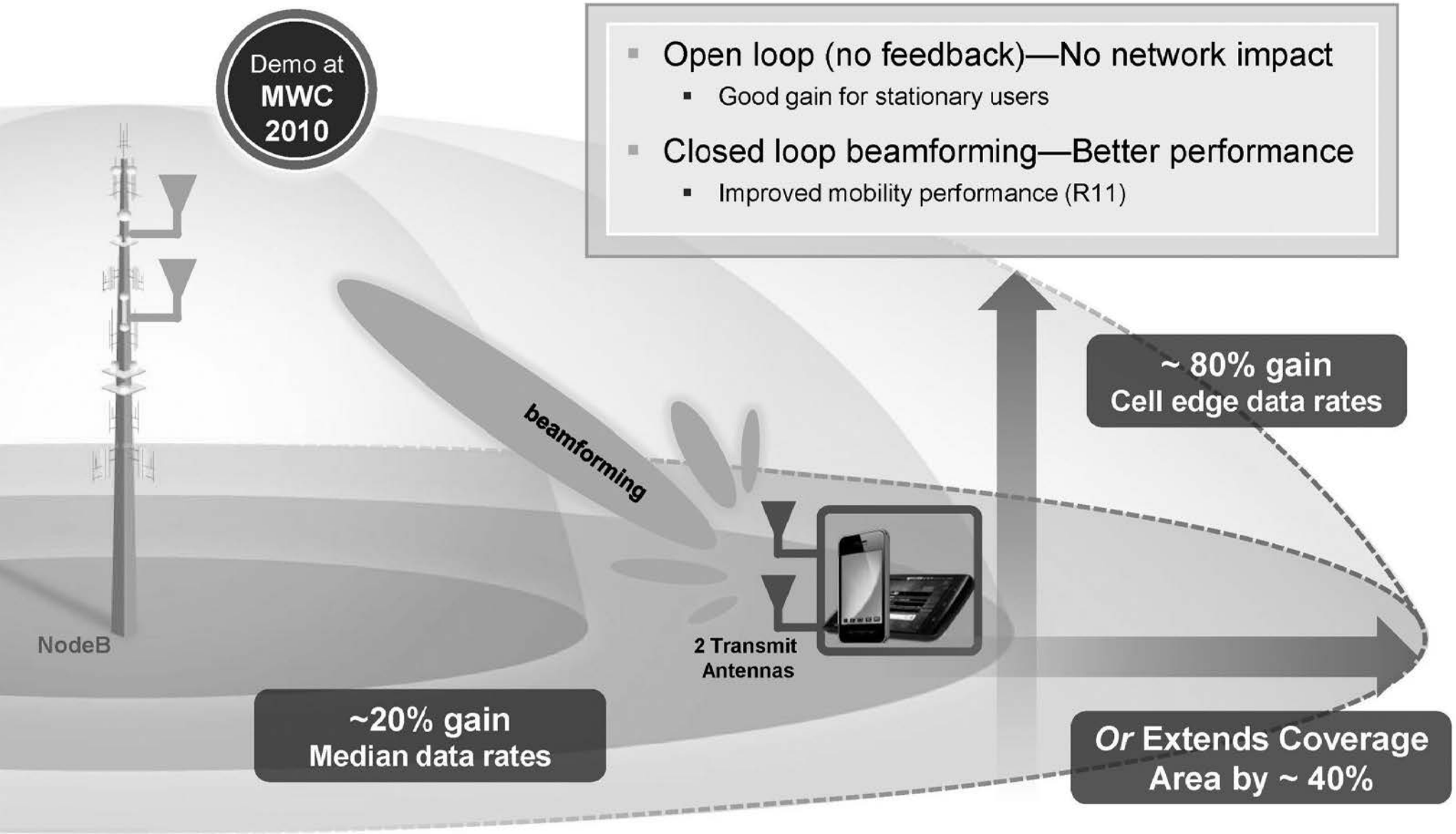
Leverage Today's MIMO Investment —Can Easily Evolve to MU-MIMO

COMPLEMENTS SU-MIMO—UP TO 50% TOTAL MIMO GAIN



[1]Source Qualcomm simulations. NGMN D1, ISD = 500 m, Total Overhead Power = 30% (20% for SIMO), SCM Urban: Ant Separation:4λ, Correlation = 50% Full-buffer with 16 users per cell .The more users the better gain MU-MIMO gain due to more opportunities to schedule multiple users simultaneously .

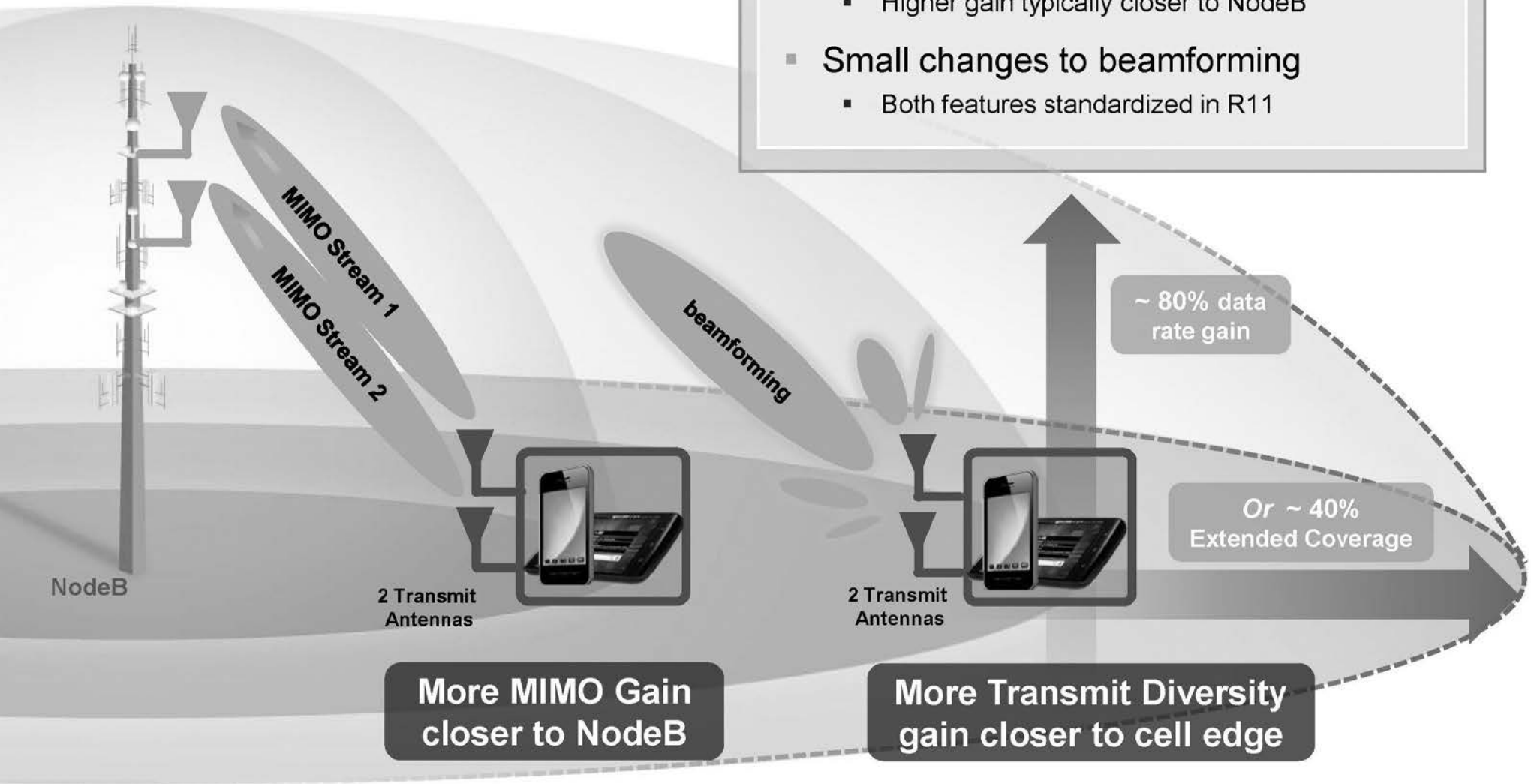
Closed Loop Beamforming Improves Uplink Data Rates or Coverage



[1] Source: Qualcomm simulation for closed loop beamforming.3GPP framework PA3, 4UEs per cell, 2.8km ISD. Shows data throughput gain for the median and the 5% worst (Cell edge) users. Gain depends on propagation environment and the UE speed with lover gain for faster moving users. The open loop gain would be slightly less.

Closed Loop Beamforming Evolves to MIMO

- Complements beamforming
  - Higher gain typically closer to NodeB
- Small changes to beamforming
  - Both features standardized in R11



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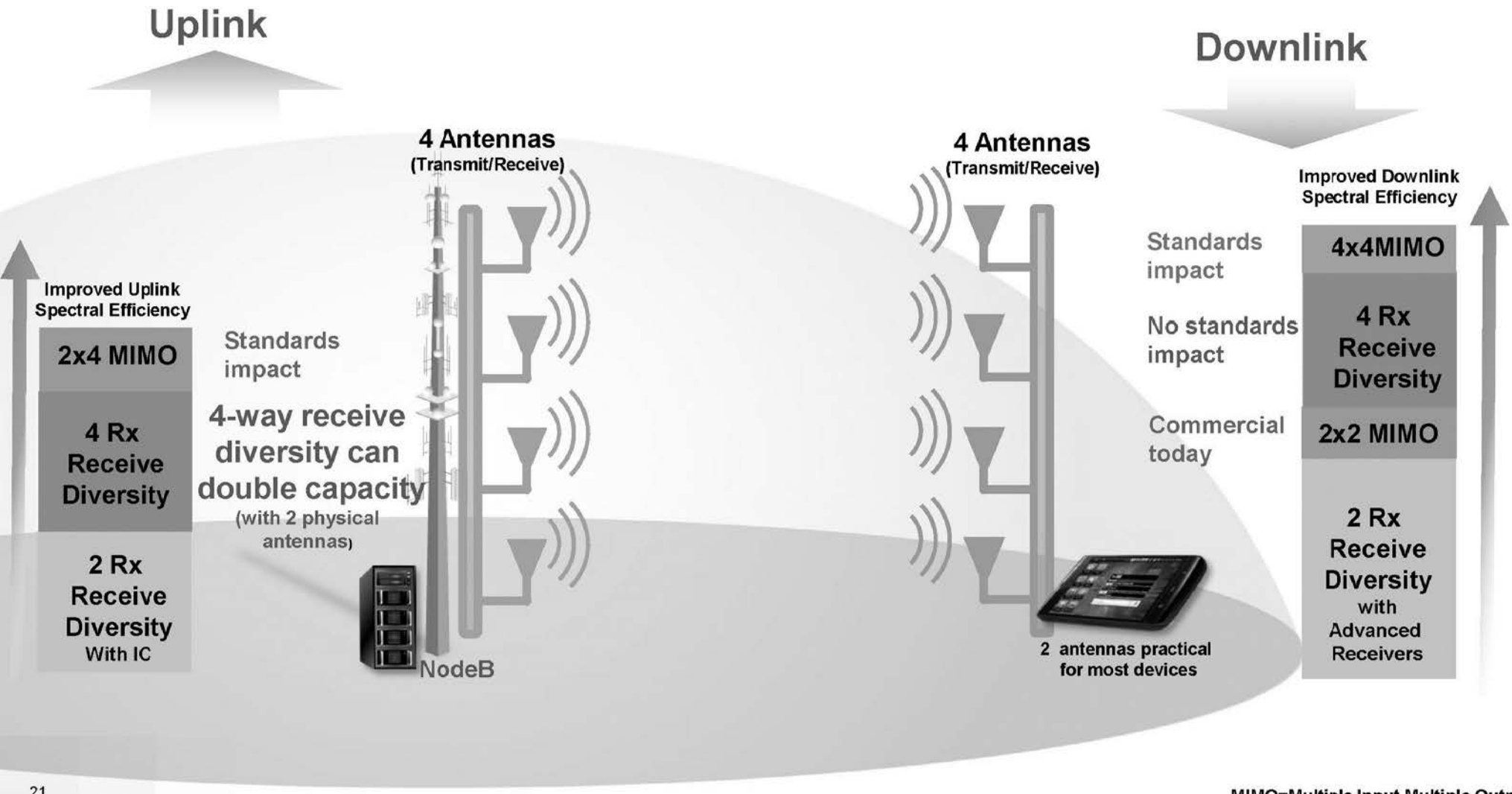
HSPA+ Can Leverage More Antennas

MOST GAIN FROM RECEIVE DIVERSITY WITHOUT IMPACTING STANDARD



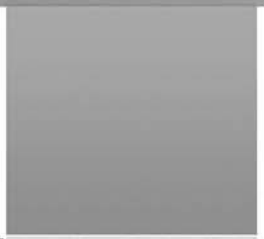
MIMO=Multiple Input Multiple Output.




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: Industry's First HSPA+ Chipsets

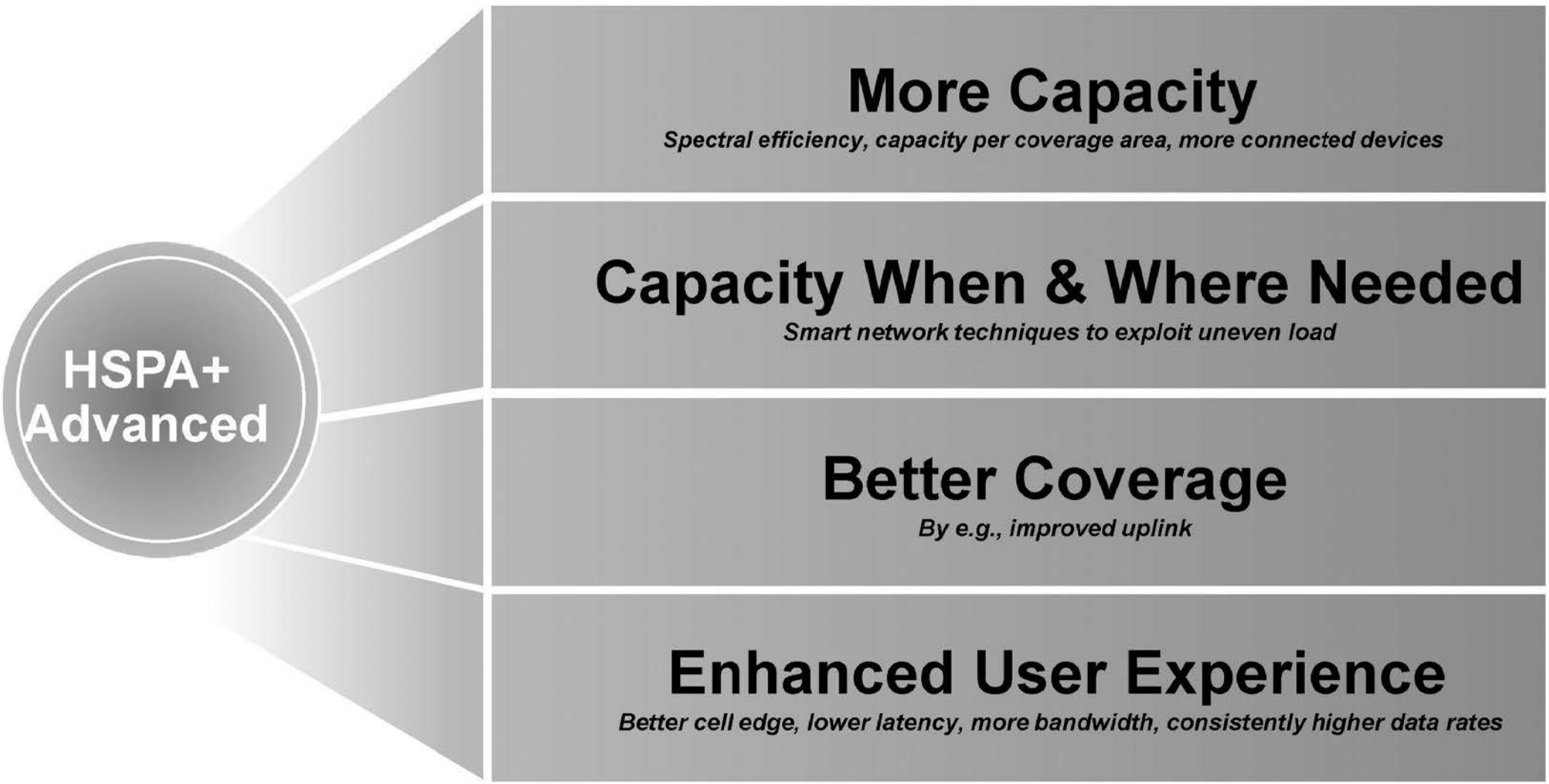
	HSPA+ R7	HSPA+ R8
Smartphones, Tablets &Other Smart Devices 	QSD 8672 HSPA+ MSM 7230 HSPA+ MSM 8255 HSPA+	MSM 8960 DC-HSPA+ MSM 8270 DC-HSPA+
Feature & Basic Phones 	QSC 6295 HSPA+	
Modems & Data Cards 	MDM 8200 HSPA+ MDM 6200 HSPA+	MDM 8220 DC-HSPA+

* Only Select Chipsets Shown

snapdragon by Qualcomm gobi by Qualcomm

Industry First Launches

HSPA+ Advanced: Maximum Performance in Multiple 5 MHz Carriers



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

Questions? Connect with Us

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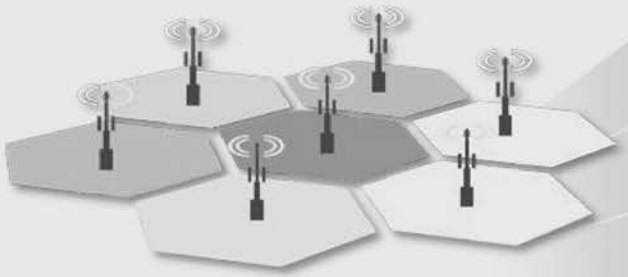
http://www.qualcomm.com/blog/contributors/prakash-sangam

Additional Slides

HSPA+ Advanced Features—Examples

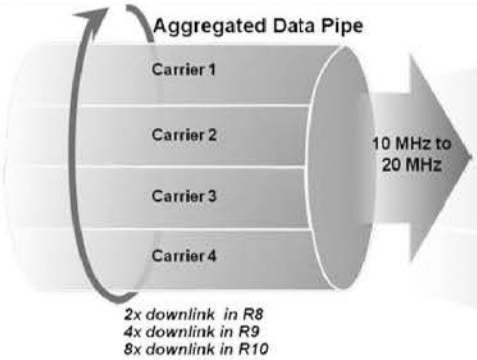
Smart Network Techniques— Exploit Uneven Load



- **Multipoint Transmission**
- **HetNet Range Expansion**
  (Better utilization of small cells)
- **Any technique exploiting uneven load**

Evolve Multicarrier

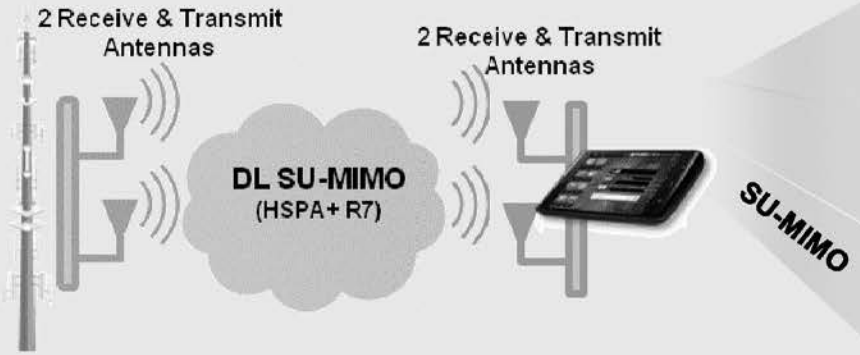
Within and across spectrum bands.



- **Supplemental downlink (unpaired)**
- **More 5 MHz aggregation**
  (more band combinations, up to 40MHz)
- **Extend benefit Same carrier**
  (Multipoint)

Leverage Multiple Antennas

And more antennas

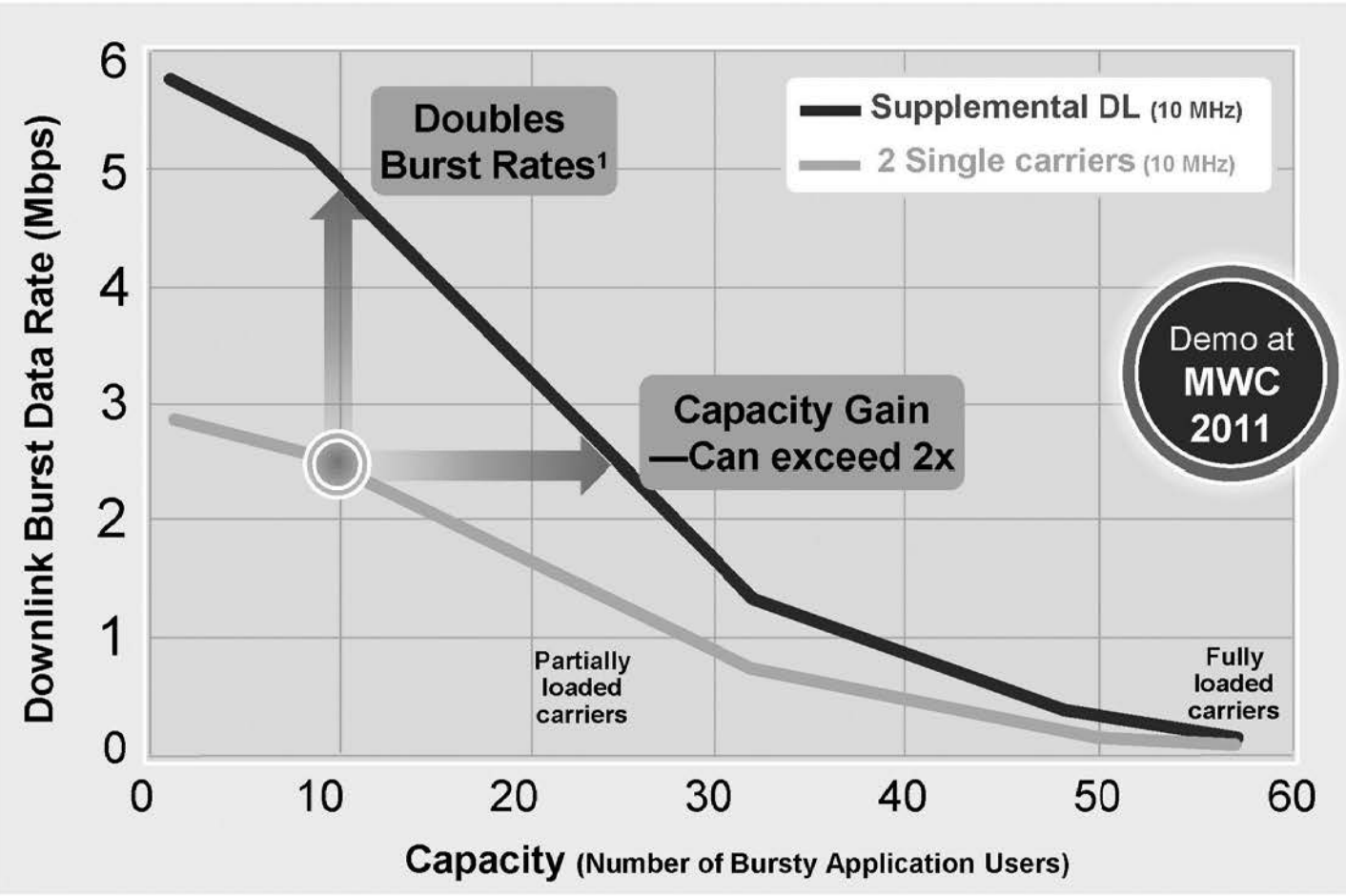


- **Uplink MIMO/Beamforming[2]**
- **More Antennas**
- **Downlink MU-MIMO**

HSPA+ Advanced is used as the name for features beyond 3GPP Release 10. [1]A form of closed loop transmit diversity

Supplemental Downlink Enhances User Experience and Further Increases Capacity

Bursty Data Applications



[1]For all users, which reduces over-the-air latency ~50% for all SDL users in the cell

Qualcomm simulations, Reference R1-090992, 3GPP TSG-RAN WG1 #56, System Simulation Results for Inter-Band Multi-Carrier HSDPA Operation. The bursty nature means that a multicarrier can support more users at the same burst rate for partially loaded carriers. The gain depends on the load and can exceed 100% for fewer users (less loaded carrier) but less for many users (starting to resemble full buffer).

HSPA+ 3GPP R11 Candidates

PRELIMINARY WI/SI AT 3GPP DECEMBER 2010 PLENARY

R11 Candidate	Key Benefits
Uplink Closed Loop Beamforming (Transmit Diversity)	Improves uplink data rates Or extends the coverage
2x2 Uplink MIMO (Relies on UL TX diversity design)	Improves Uplink Data Performance Complements UL Beamforming
Multipoint—Same frequency Aggregation, Inter NodeB	Enhanced cell edge Network load balancing Dual-Carrier device benefit to 5MHz deployments
8x Multicarrier in 40 MHz	Enhanced user experience—higher data rates Aggregate more spectrum across bands
Expanded support for low-traffic devices Examples of possible enhancements are: - Addition of Extended Access Class Barring (EAB) to handle very large density of low-traffic devices - Improvement of call rejection mechanisms to protect networks and legacy users from access overload - Improvement of low power consumption states (CELL_FACH and paging states) to better handle bursty traffic	Support for very large number of low-traffic devices (e.g., for M2M or smartphone traffic)

Rel.10 was completed in December 2010 and the specification freeze is expected in March 2011. Rel.11 standardization started in 3GPP (Q4 2010)

LTE Advanced

February 2011

The Biggest Platform in the History of Mankind

>5 BILLION WIRELESS SUBSCRIBERS

>1B

3G SUBSCRIPTIONS
NOW

~2.8B

3G SUBSCRIPTIONS
BY 2014

Note : 3G includes CDMA2000, WCDMA and TD-SCDMA

Source: Wireless Intelligence estimates as of Nov.2 , 2010 for the quarter ending Sep 30, 2010; *number of unique wireless connections

LTE Has Strong Commitments

LTE MULTIMODE LAUNCHED

17
LAUNCHES

180
NETWORK COMMITMENTS

LTE TDD GAINING MOMENTUM

>15
TRIALS

NOV 2010
QUALCOMM MOBILITY FIELD TRIAL

GROWING DEVICE ECOSYSTEM

>26+
DEVICES

>12+
VENDORS

Source: www.gsacom.com, Jan 12 2011

Qualcomm is a Leader in Research, Standards and Chipsets

COMMITTED TO CONTINUED LTE EVOLUTION

- **Standards Leadership**
  - A Main contributor to key LTE Advanced features
  - Major contributor for ITU IMT-Advanced submission
- **Industry First Demos**
  - MWC 2011: Live Heterogeneous Network Demo
- **Industry First LTE/3G Multimode Chipsets**
  - Commercial launch 4Q 2010

Demo at **MWC 2011**

Screenshot from the HetNet demo, showing range expansion of Picocells, within one macrocell

LTE Advanced—The Global 4G Solution

LTE Advanced

Realizes Full Benefits of Heterogeneous Networks

Higher Capacity & Enhanced User Experience

Range expansion—better utilization of picocells, better macro offload

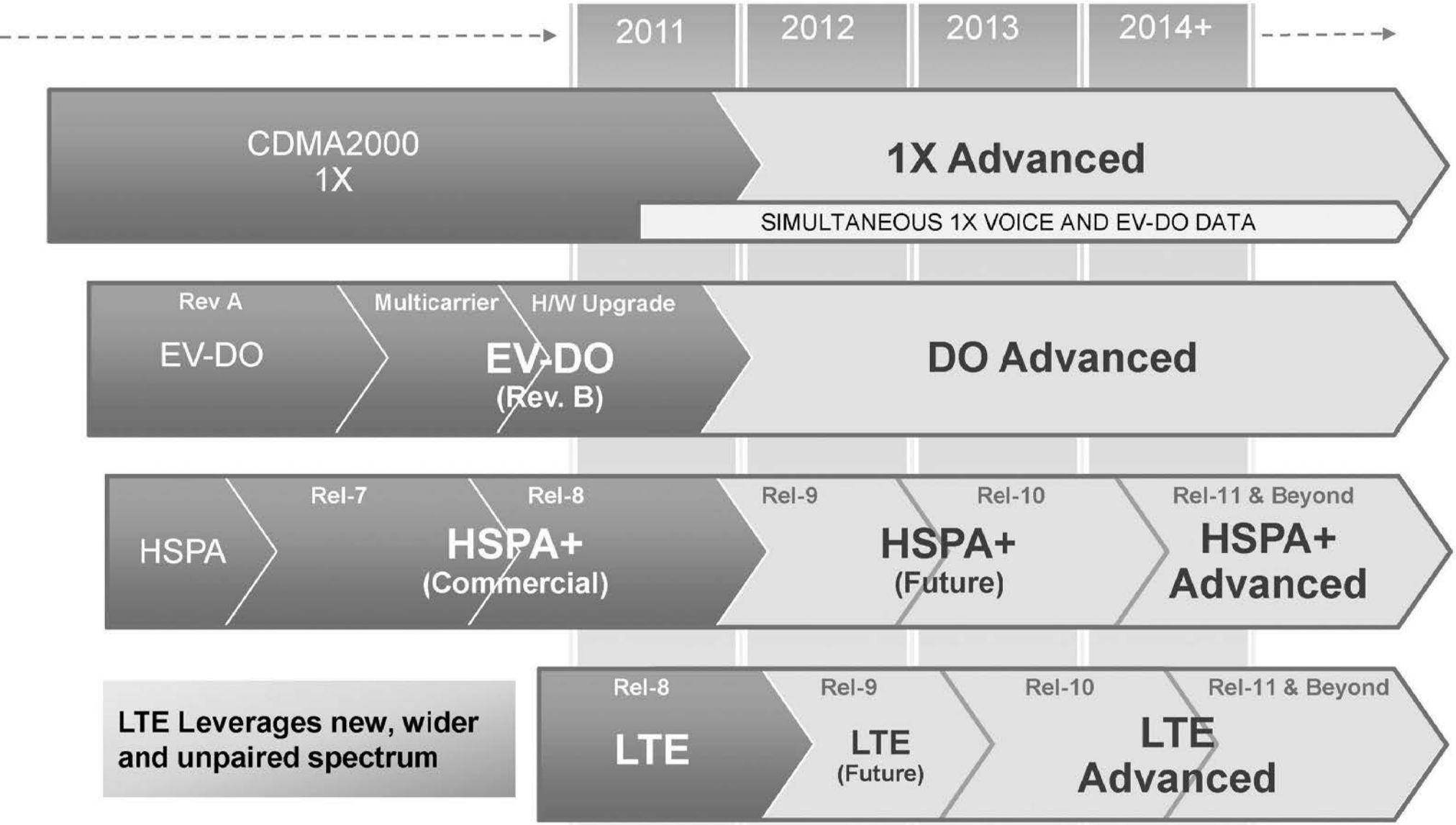
Software Upgrade to Optimize HetNets

Qualcomm: LTE Advanced Leadership

Over-the-Air prototype test bed, design and standards leadership

Heterogeneous Networks : macro network with added small cells like picocells and femtocells

Qualcomm is a Leader in 3G and 4G



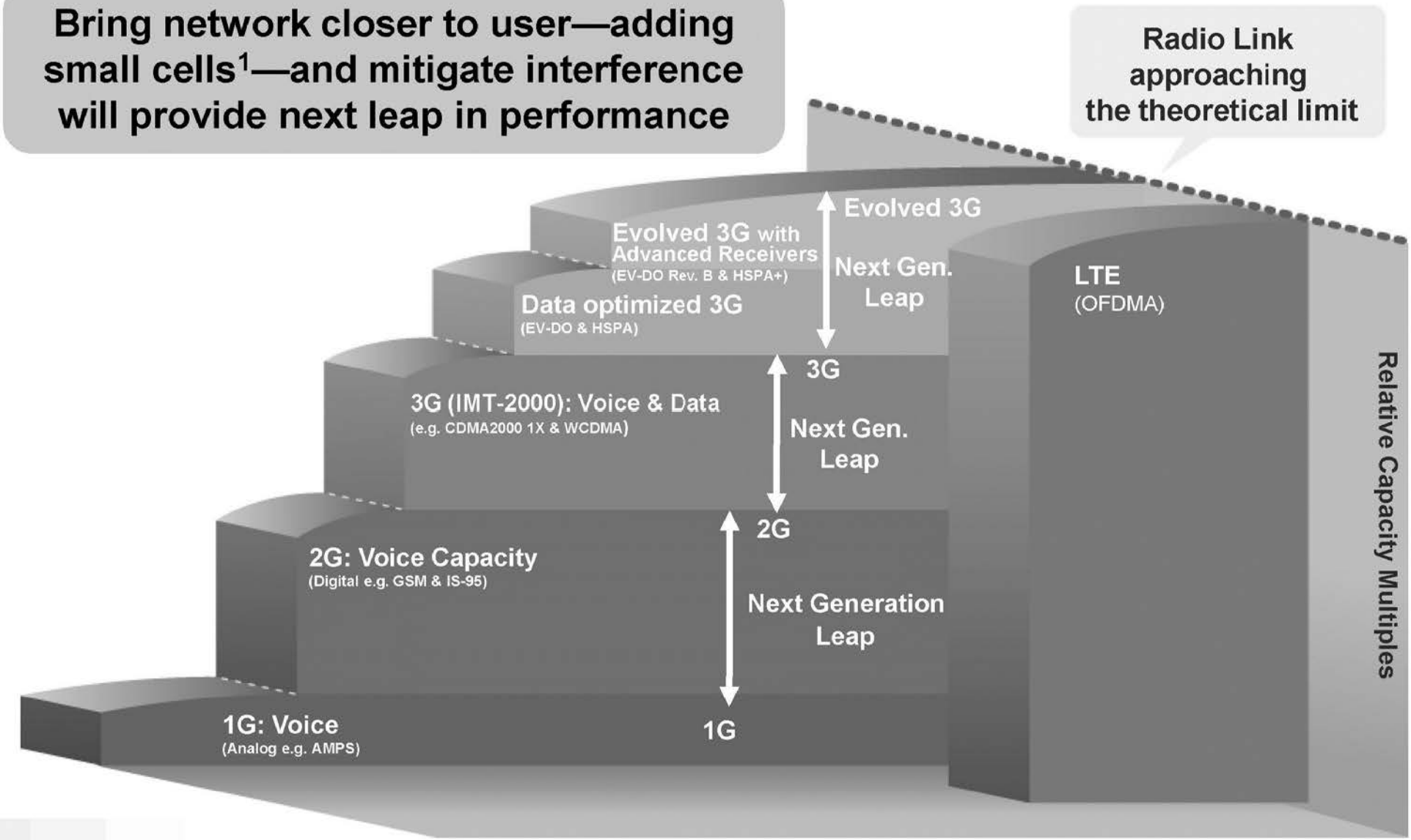
■ Commercial

Note: Estimated commercial dates.

Created 01/24/2011

Radio Link Improvement is Slowing, What Is Next?

Bring network closer to user—adding small cells[1]—and mitigate interference will provide next leap in performance

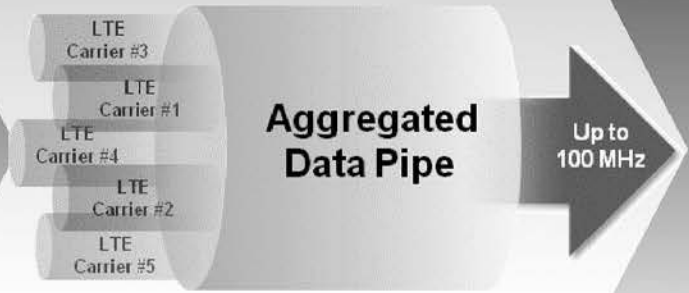


[1]Leveraging heterogeneous network topology: macro network with added small cells like picocells and femtocells

LTE Advanced Brings Different Dimensions of Improvements—Most Gain From HetNets

Leverage wider bandwidth

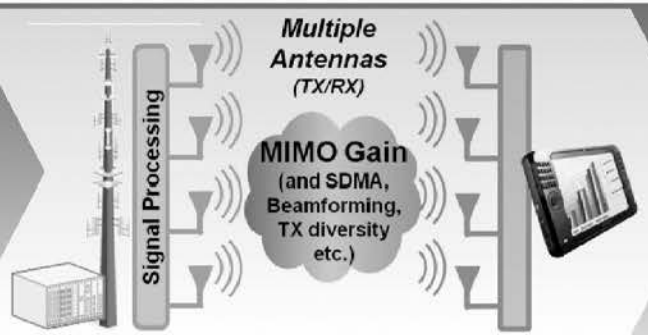
Carrier aggregation across multiple carriers and multiple bands



Primarily higher data rates
(bps)

Leverage more radio links, more antennas

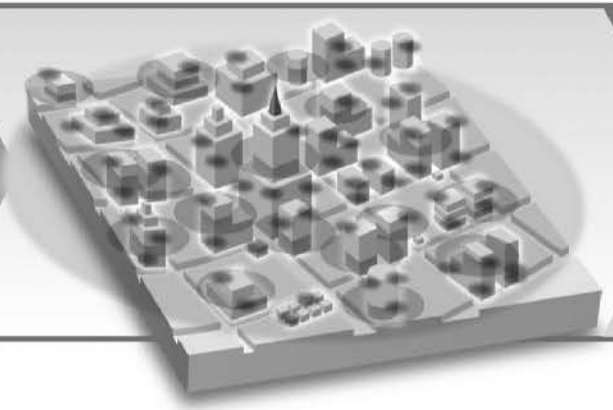
Downlink MIMO up to 8x8, enhancec MU-MIMO and uplink MIMO up to 4x4



Higher spectral efficiency
(bps/Hz)

Leverage heterogeneous network topology

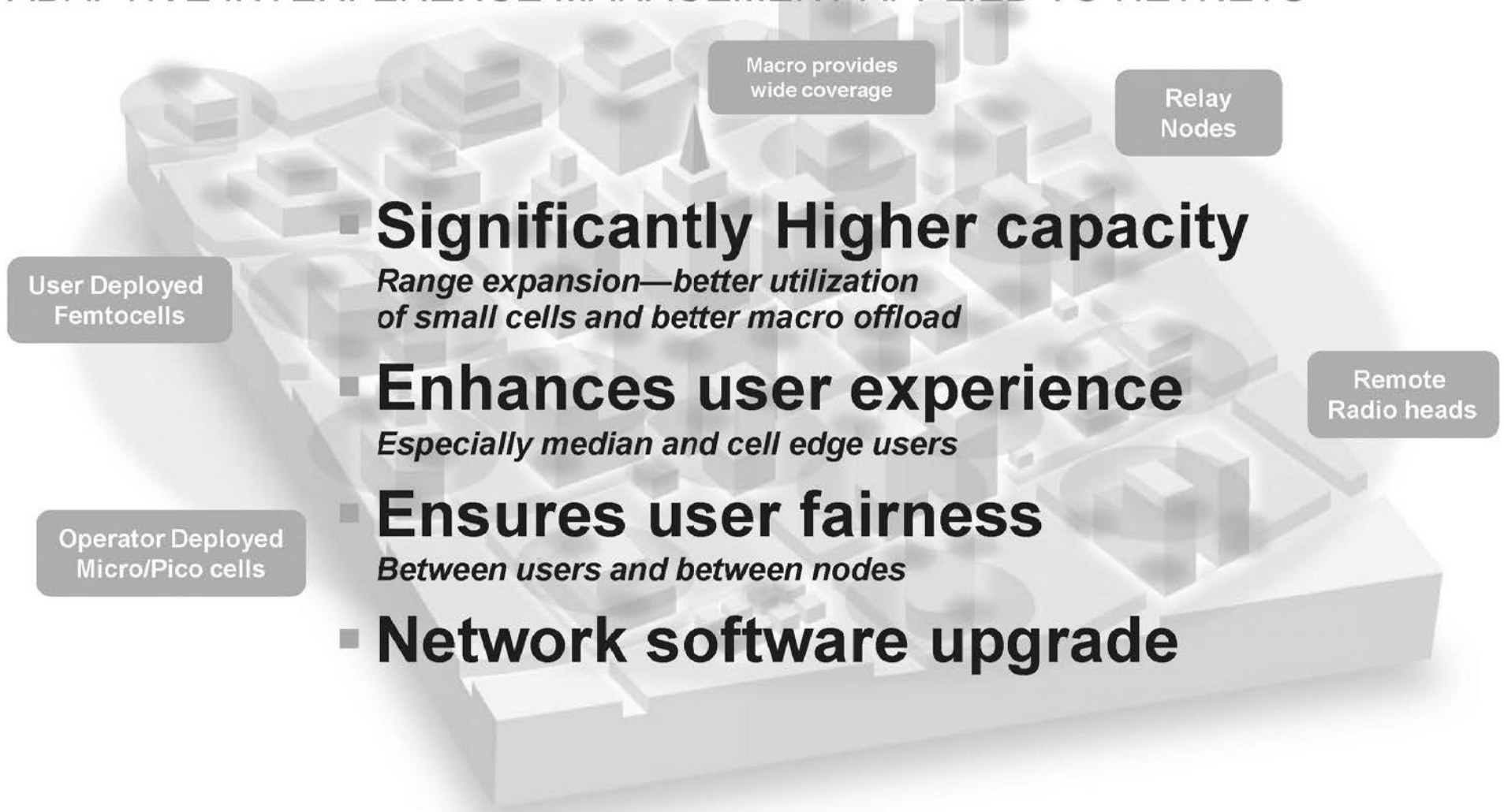
With advanced interference management (low power picocells with adaptive resource partitioning and advanced receiver based devices)



Higher spectral efficiency per coverage area
(bps/Hz/km^2)

LTE Advanced Realizes Full Benefits of Heterogeneous Networks

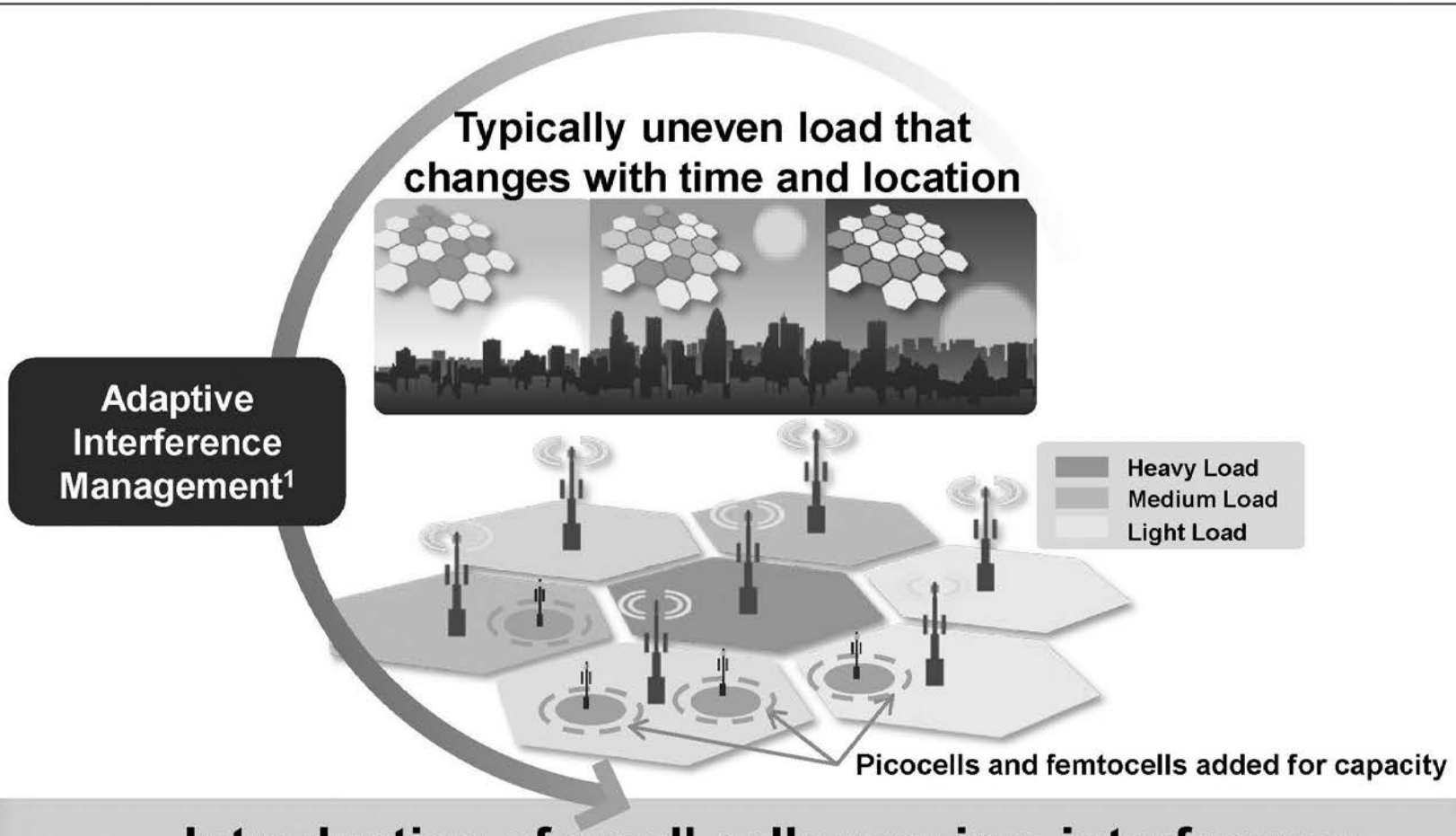
ADAPTIVE INTERFERENCE MANAGEMENT APPLIED TO HETNETS



- **Significantly Higher capacity**
  Range expansion—better utilization of small cells and better macro offload
- **Enhances user experience**
  Especially median and cell edge users
- **Ensures user fairness**
  Between users and between nodes
- **Network software upgrade**

Advanced interference management techniques: advanced receivers (cancels overhead channels), enhanced time-domain adaptive resource partitioning with enhanced RRM and RLM. Heterogeneous Networks : macro network with added small cells like picocells and femtocells

HetNets with Adaptive Interference Management Meets Actual Network Load

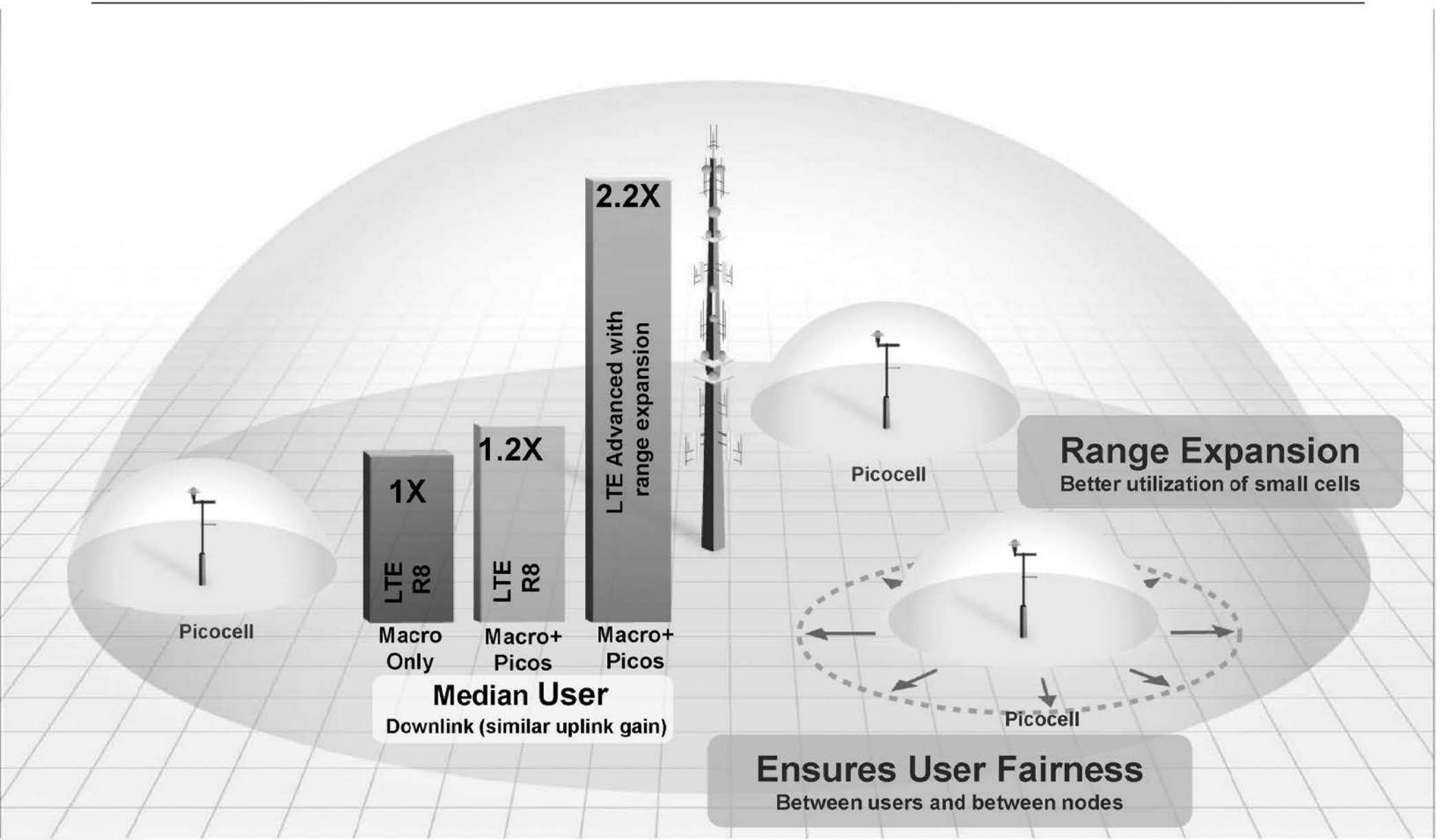


Introduction of small cells requires interference management that adapts to load and topology changes

- ***Necessary for dense HetNets sharing same spectrum***
- ***Provides network load balancing***

[1]Advanced adaptive interference management : enhanced time-domain adaptive resource partitioning with enhanced RRM/RLM and advanced receiver devices

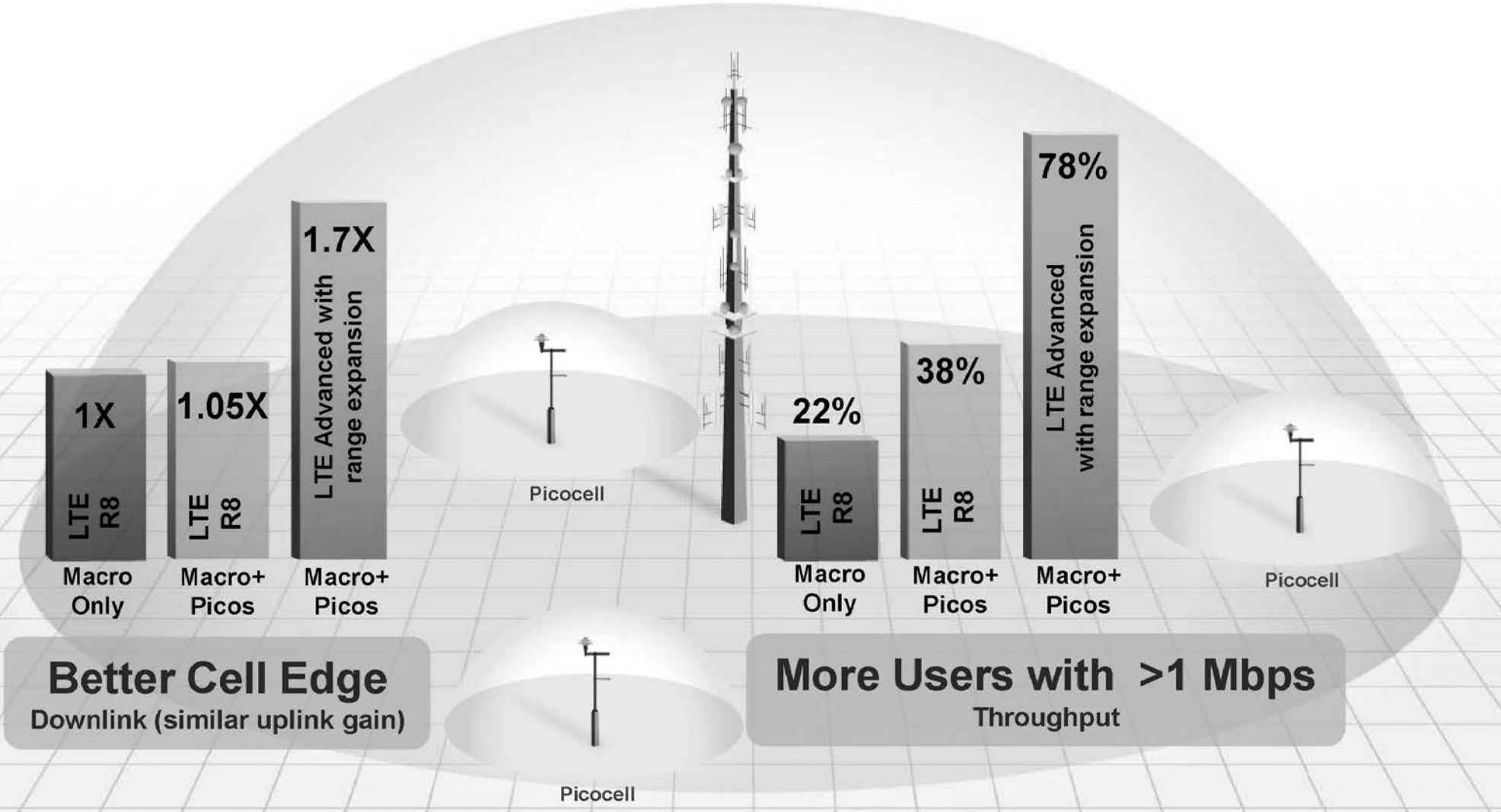
LTE Advanced Increases Network Capacity, User Experience and Ensures Fairness



Assumptions: 4 Picos per Macro randomly dropped within macro coverage, see 3GPP R1-101509. Based methodology in TR 36.814: 10 MHz FDD, 2x2 MIMO, 25 users and 500m ISD . Advanced interference management : enhanced time-domain adaptive resource partitioning, advanced receiver devices with enhanced RRM and RLM

Ensures Ubiquitous Broadband Experience

EVEN WHEN SMALL CELLS CANNOT BE PLACED AT OPTIMAL LOCATION



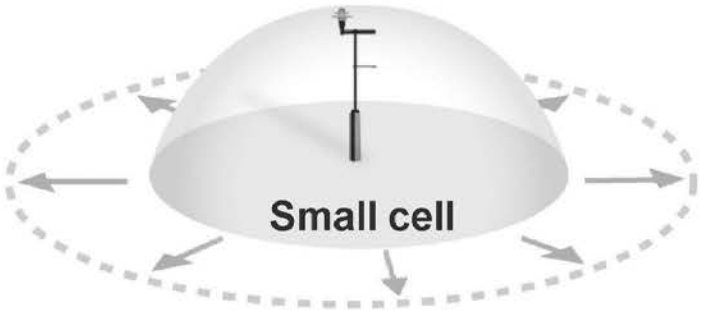
Assumptions: 4 Picos per Macro randomly dropped within macro coverage, see 3GPP R1-101509. Based methodology in TR 36.814: 10 MHz FDD, 2x2 MIMO, 25 users and 500m ISD . Cell edge user is defined as 5 percentile user

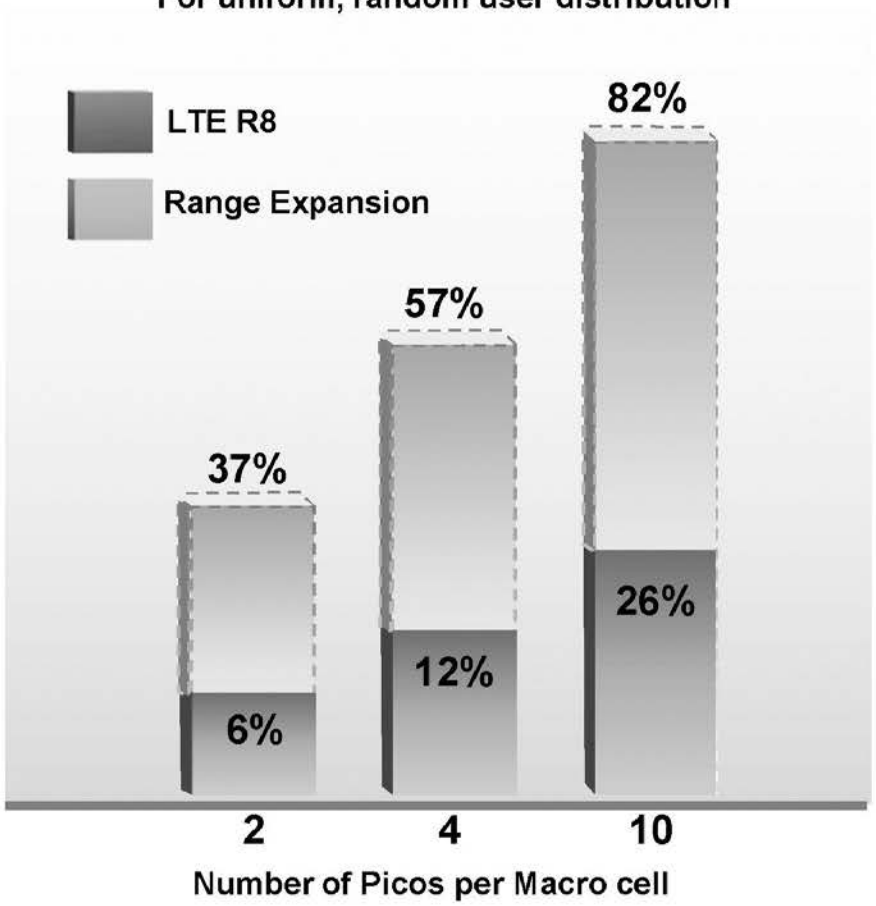
Range Expansion Allows More Users to Benefit From Small Cells

SIGNIFICANTLY BETTER MACRO OFFLOAD

Range Expansion
enabled by:

1)Resource Partitioning
2) Advanced Receiver Devices
3) Enhanced RRM/RLM[1]





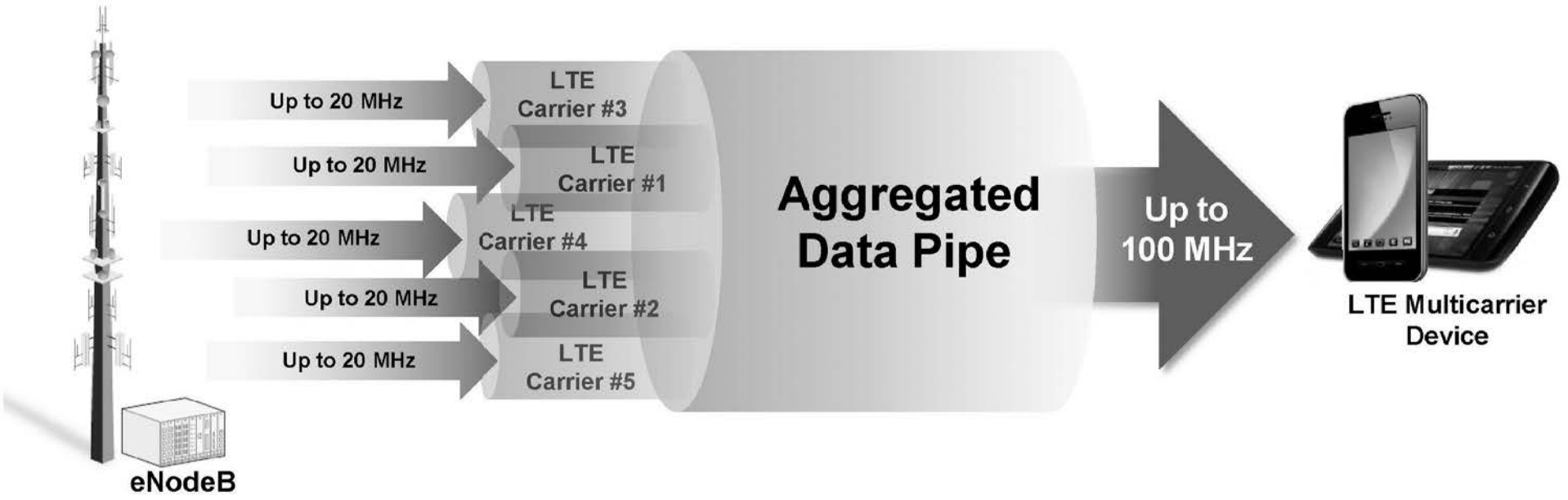
Assumptions: TR 36.814, Macro ISD=500m, 10^0 antenna downtilt 25 UEs per Macro cell, uniform random layout, 10 MHz FDD, 2x2 MIMO. [1]Enhanced RRM and RLM to allow handover to weak cells, to maintain reliable link with weak cells, and to provide accurate feedback with resource partitioning

Qualcomm's LTE Advanced Test Bed

Evaluating the design and features to realize full benefits of heterogeneous networks

- Advanced Interference Management in a co-channel deployment
  - Adaptive time–domain resource partitioning
  - Advanced Receiver terminals
  - Range expansion of pico cells
- Enhanced Mobility
  - Forward handover
- Over-The-Air
  - Enhanced mobility currently shown
  - LTE Advanced features in March 2011

Carrier Aggregation Enhances User Experience

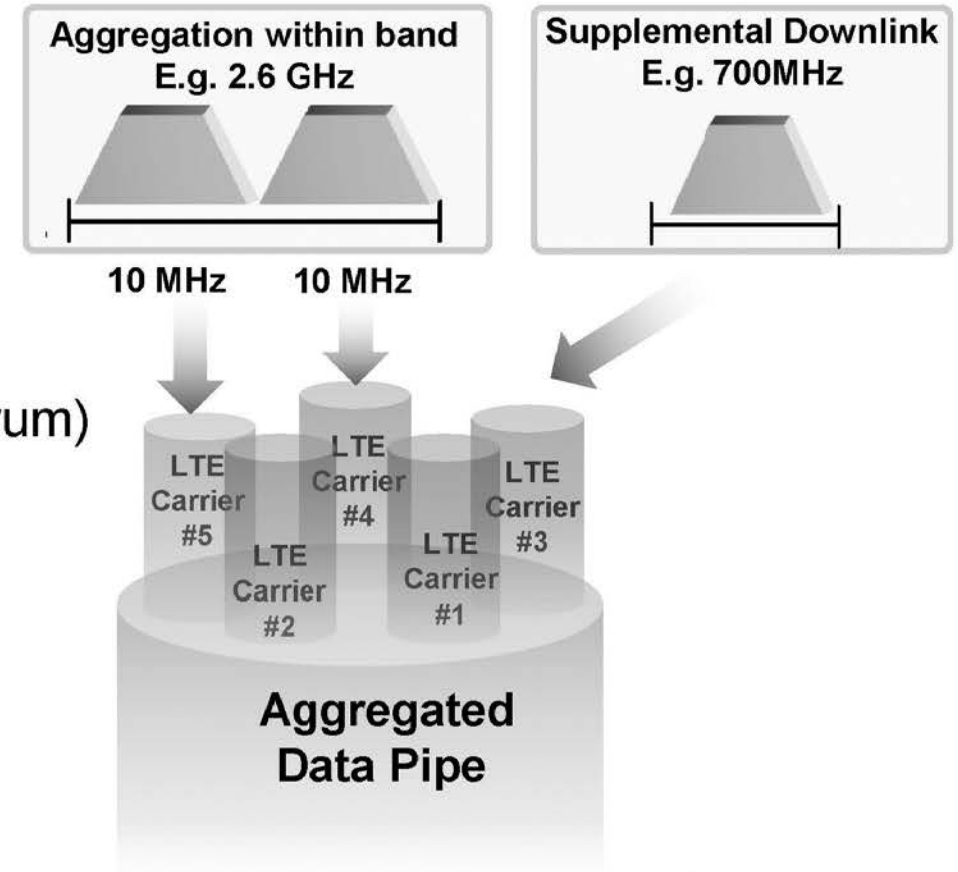


- Increased data rates and lower latencies for all users in the cell
  - Can more than double bursty application capacity
- Data rates scale with bandwidth—over 1 Gbps peak data rate
  - Aggregating 40 MHz to 100 MHz provide peak data rates of 300 Mbps to 750 Mbps[1] (2x2 MIMO) and over 1 Gbps (4x4 MIMO)

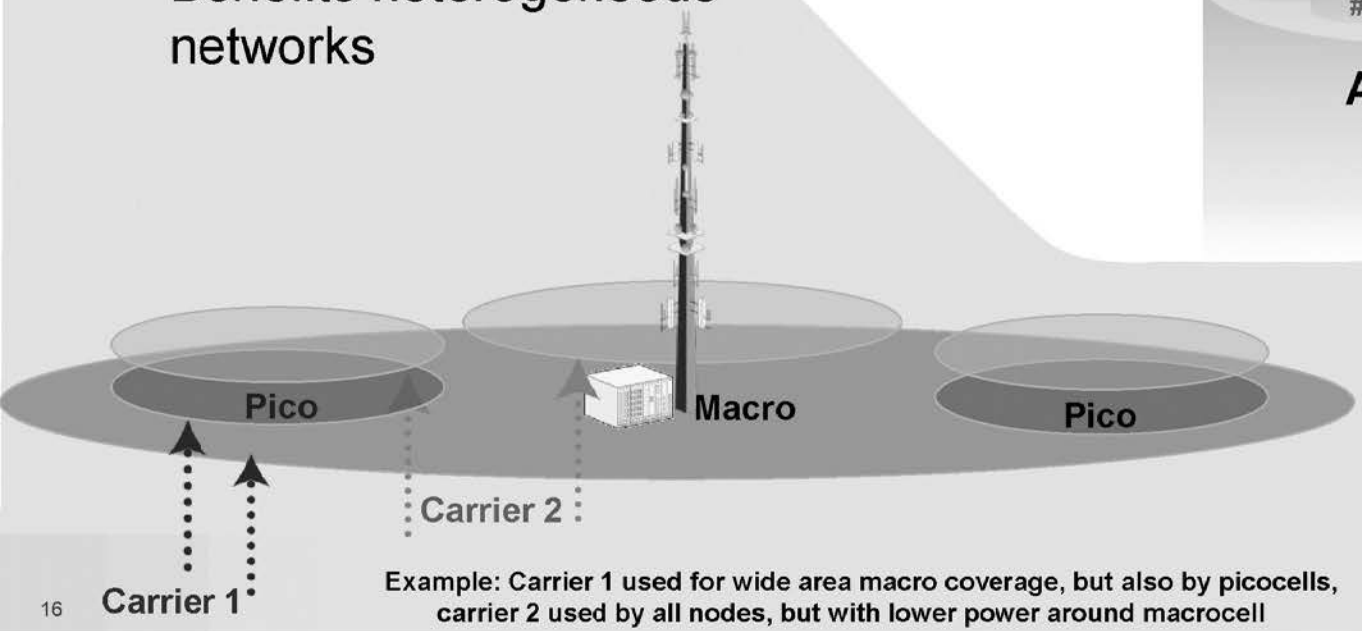
[1]LTE R8 supports 4x4 MIMO, which enables 300 Mbps in 20 Mhz. Theoretically, LTE Advanced can support over 1Gbps peak data rates by aggregating at least 4 20 MHz carriers (up to100 MHz of spectrum) using 4x4 MIMO.

Carrier Aggregation Leverages All Spectrum Assets

- Aggregate spectrum within a band to create a fatter data pipe
- Aggregate across spectrum bands
- Aggregate more downlink capacity—supplemental downlink (unpaired spectrum)



- Benefits heterogeneous networks



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

Qualcomm: Continued LTE Advanced Standards Leadership

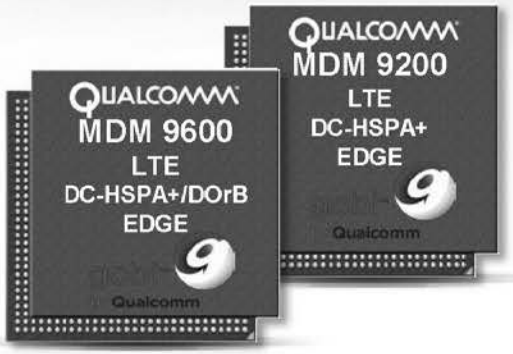
- A leading contributor for LTE performance definition in 2009[1]
- Leader in several key LTE standards areas[2]

- A Main contributor to key LTE Advanced features
  - Carrier aggregation, self-organizing network, relay, waveform
- Major contributor for ITU IMT-Advanced submission
  - First company to show results satisfying IMT-Advanced requirements[3]
- LTE Heterogeneous network work item approved in Rel-10
  - Focus on co-channel heterogeneous network scenarios (March 2010)—supported by 32 companies[4]
  - Proposed to include time-domain and power settings as baseline (July 2010)
  - Target completion 1H 2011

Notes [1]Based on pre-meeting contribution count for 3GPP RAN WG4 (in charge of performance requirements) . [2]E.g. for femtocells and positioning across all working groups and areas . Examples of features such as Mobility, access control, local IP access, system definition, security . [3]for single point transmission results, also showed that that Network-MIMO/CoMP techniques were not required to satisfy those requirements. [4]Such as CMCC, DoCoMo, Orange, Verizon, AT&T, TIM, KDDI, Deutsche Telekom

Common LTE FDD & TDD Chipset Platform

Modems & Data Cards



- 50+ designs by 25+ OEMs
- Commercial 4Q 2010
- 100 Mbps DL/50 Mbps UL

Smartphones & Tablets

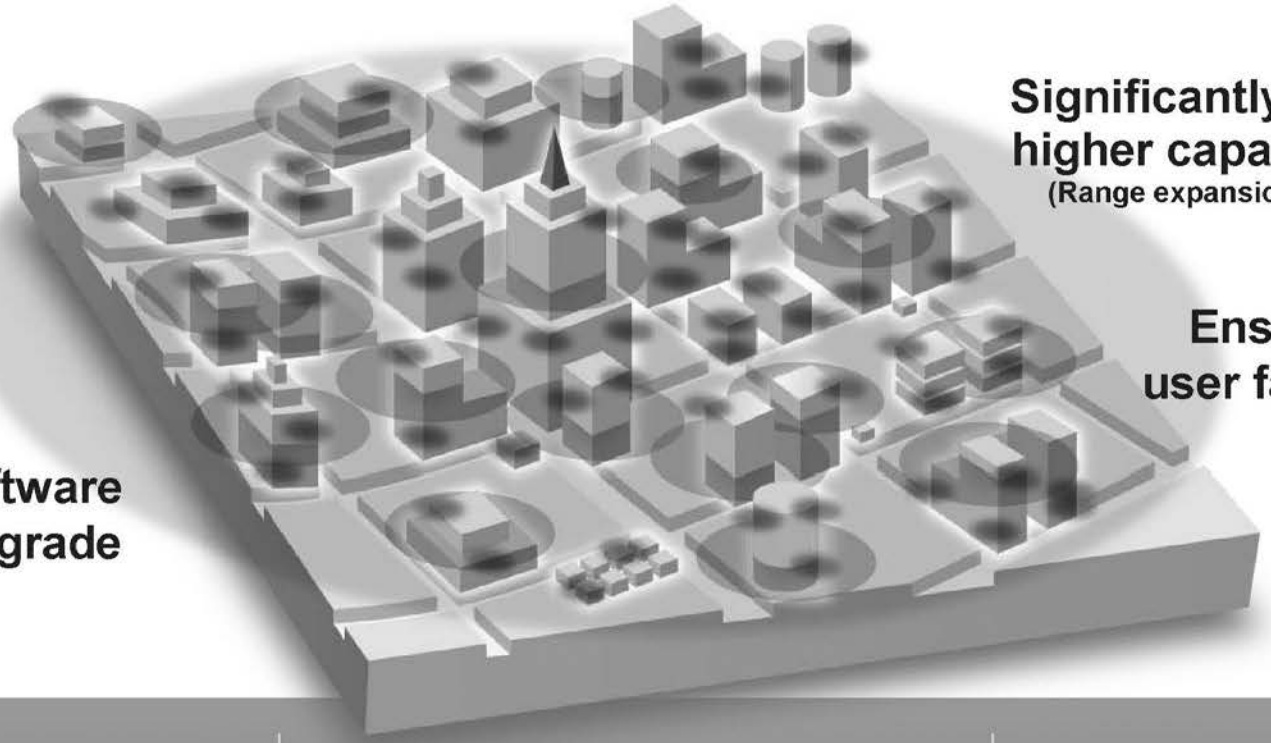
- Dual-Core CPU (28nm)
- Superior graphics & multimedia
- Integrated connectivity (WLAN, GPS, Bluetooth, FM)

- MSM8960 launches in 2012
- Handset & tablet launches in 2011 based on (MDM9x00+MSM)

Industry's First LTE/3G Multimode Chipsets

Qualcomm: LTE Advanced Leadership

LTE ADVANCED REALIZES FULL BENEFITS OF HETNETS



A Leading Contributor to LTE Advanced Standards

Spearheading Technology Design Efforts

State-of-the-Art LTE Advanced Test Bed

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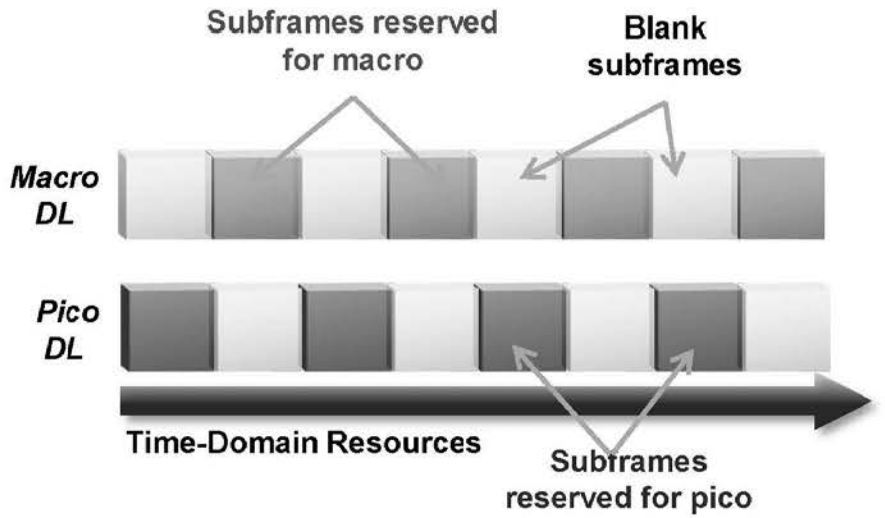
Additional Slides

Adaptive Time-Domain Resource Partitioning

- Adapts to topology, load and user distribution
- Mitigates interference
- Ensure fairness
- Flexible and adaptive partitioning options

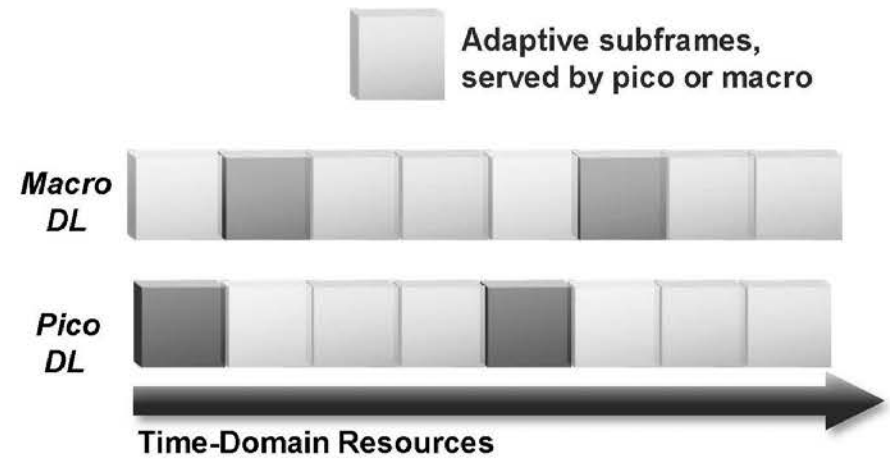
Time Domain Partitioning

a.k.a enhanced inter-cell interference coordination



Adaptive Partitioning Example

25% Semi static to macro and pico, 50% adaptive

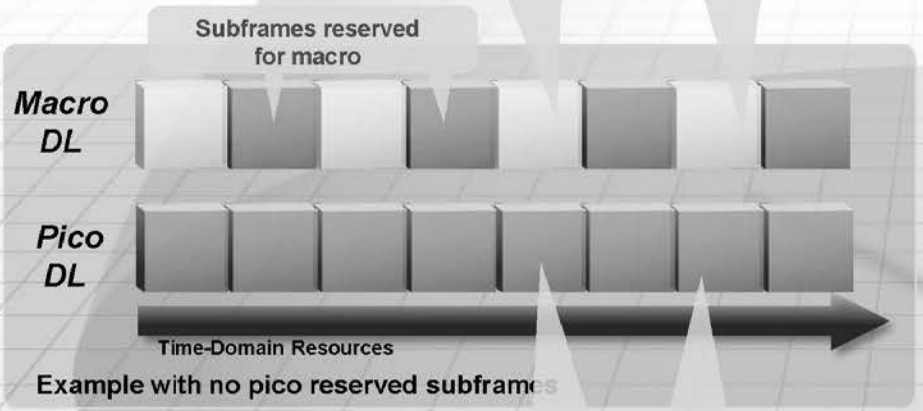


LTE R8 provides limited interference management; primitive X2-based—adaptive resource partitioning utilizes modified X2. Frequency partitioning is the only option for asynchronous networks (Networks without GPS timing) [1]Static and semi static allocation signaled to device. Enables flexible partitioning options, e.g. pico could also use reserved macro subframes (without benefits of range expansion)

Advanced Receiver Devices with Interference Cancellation Enables Full Range Expansion

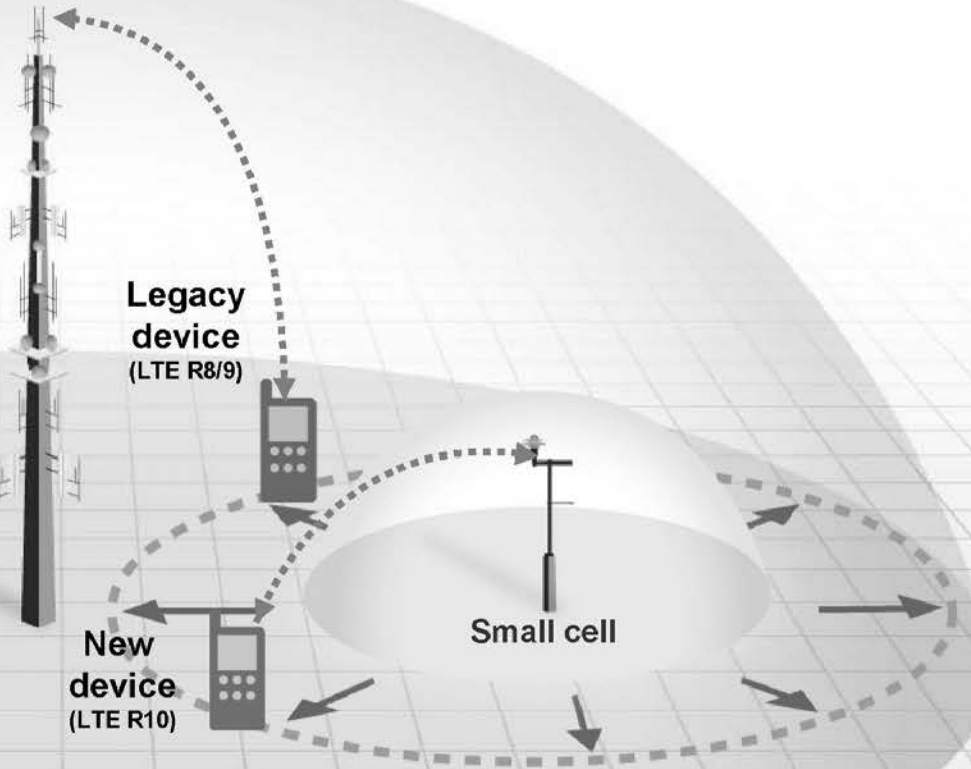
Support for Legacy Devices[1]

Continue to transmit overhead channels in 'blank' frames



Range expansion for new devices

Subframes not used by macro reduces interference



Full Range Expansion[2]

1) Detects small cell in 'expanded range'
2) Expands range by canceling overhead

[1]Adding overhead channels such as synch, broadcast and common reference signal to 'blank subframes' to support legacy devices [2]Device interference cancellation cancels overhead channels such as such as synch, broadcast and common reference signal(CRS) to enable full range expansion.