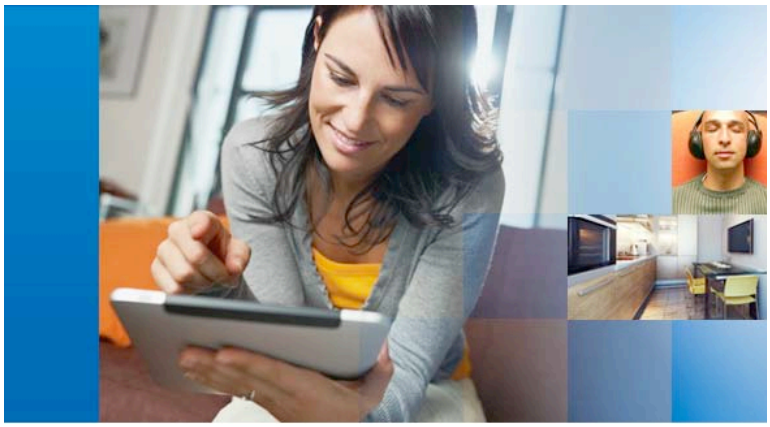
HSPA+ Advanced – Taking HSPA+ to the Next Level



QUALCOMM, Incorporated
2012

QUALCOMM Incorporated
5775 Morehouse Drive
San Diego, CA 92121-1714
U.S.A.

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1 Executive Summary

HSPA+ has experienced phenomenal success in recent years. It is at the forefront of the industry's efforts to address the explosive growth in data services, and has grown to be the undisputed leader in mobile broadband. In fact, the HSPA family (all releases of HSPA and HSPA+) has been the fastest growing wireless technology ever, in terms of subscriber growth—exceeding 1 billion subscribers by 2012, and expected to reach 2 billion by 2015. HSPA+ has become the new baseline. The move toward dual-carrier HSPA+ (Release 8) is in full swing, and there is a well defined roadmap up to Release 10. The natural question is "*What's next?*" Forward-looking companies such as Qualcomm are already working on what we call *HSPA+ Advanced*.

HSPA+ Advanced takes the performance of HSPA+ to a whole new level. It consists of enhancements being defined in Release 11 and beyond. These enhancements can be divided in to five broad areas: 1) Evolving Multicarrier to utilize all available spectrum assets; 2) Introducing features such as MultiFlow to exploit uneven network loading; 3) Optimizing HetNets to get even higher performance from small cells; 4) Further leveraging advanced antenna techniques; 5) Efficiently connecting the next explosion —think billions— of interconnected, low-traffic and bursty machine-to-machine devices and supporting the continued growth of smartphones.

This paper explores these new dimensions, and explains how HSPA+ Advanced will prepare operators to address the unabated and growing demand for data for years to come, and continue to offer excellent mobile broadband services.

2 HSPA+ is the Mobile Broadband Leader

HSPA+ has come of age very quickly from its early beginnings in 2008, to be the undisputed leader in mobile broadband technology. For starters, all WCDMA operators have upgraded to HSPA. With more than 185 operators adopting HSPA+, it has become a starting point for new deployments. Dual-carrier HSPA+ defined in Release 8 is quickly becoming prevalent—by early 2011, 62 networks had already launched. There were also about 250 HSPA+ and about 100 dual-carrier commercial devices available in the market covering all the market segments from USB dongles and embedded modules to feature phones, smartphones and tablets. *(source: www.gsacom.com)*

As shown in the Fig. 2.1, the dominance of HSPA+ continues well in to this decade.

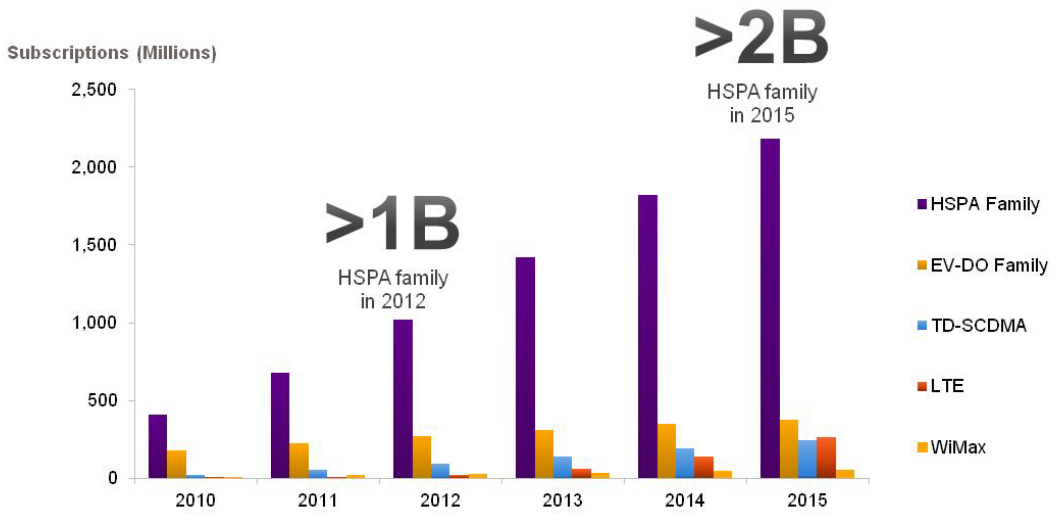


Fig. 2.1 – HSPA+'s dominance to continue well this decade

(Source: HSPA, EV-DO,TD-SCDMA & LTE subs – Wireless Intelligence (Oct '11) and WiMax - ABI (Aug '11))

HSPA family is the fastest growing mobile technology ever, in terms of subscriber growth. Its subscriptions are expected to surpass 1 billion in 2012, and 2 billion by 2015.

2.1 HSPA+ has a Strong Evolution Path

As shown in Fig 2.2 HSPA+ has a strong and well established roadmap that takes it up to Release10, followed by HSPA+ Advanced, which includes Release 11 and beyond.

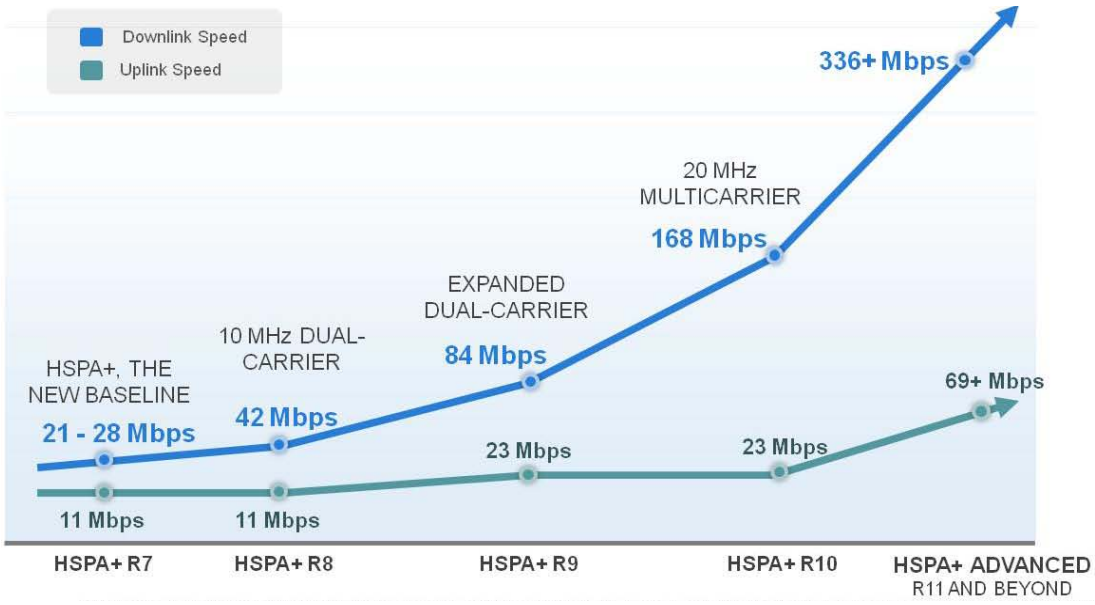


Fig. 2.2 – HSPA+ has a strong evolution path

Each HSPA+ release incrementally improves capacity, data rates and the user experience. Releases up to R8 dual-carrier are already commercial. The next step, Release 9, expands dual-carrier across spectrum bands and adds dual-carrier to the uplink. Release 10 allows aggregation of up to four carriers in the downlink, enabling 20 MHz deployments.

3 HSPA+ Advanced Maximizes the Performance of HSPA+

With the HSPA+ roadmap up to Release 10 clearly defined, there is a strong desire in the industry to continue the evolution. Market leaders such as Qualcomm and others are hard at work to bring new and innovative techniques to keep improving the performance of HSPA+. In fact, some of these techniques have already been prototyped and demonstrated by Qualcomm at leading global mobile telecommunications events.

Given all the advances of technology, we are approaching the physical limits of the radio link capacity. The next phase of HSPA+ development has to bring improvements of different dimensions. These improvements should adapt network to the changing market requirements such as the widespread proliferation of smartphones, and their bursty nature of traffic, or extremely high density albeit, limited data consumption of machine-to-machine devices etc. They also have to address the rapidly expanding small cell deployments. All of this while leveraging existing assets, providing full backward compatibility and offering cost-effective and scalable deployment options.

HSPA+ Advanced will deliver on all those points. Its enhancements can be divided into five broad areas: 1) Evolving multicarrier to utilize all available spectrum assets; 2) Introducing features such as MultiFlow to exploit uneven loading; 3) Optimizing HetNets to get even higher performance from small cells; 4) Providing more antenna gain; 5) Efficiently connecting a plethora of bursty and low-traffic machine-to-machine devices, smartphones, and others. The next sections explain how these enhancements will address each of the specific challenges mentioned above.

3.1 Evolving Multicarrier to leverage all spectrum assets

Spectrum is the life blood of wireless systems. But, being a limited resource, it is getting increasingly difficult and expensive to get more spectrum. The additional spectrum that operators get is usually in newer

bands, and sometimes unpaired. Many operators are refarming their 2G spectrum to deploy more efficient 3G networks. So, it is imperative for technologies to enable combining of spectrum from different bands, and modes so that all the available resources can be marshaled.

HSPA+ Release 9 supported Multicarrier across low and high bands, for e.g. combining 900 MHz and 2.1 GHz. Currently, there is work going on to define more such band combinations and support aggregation of up to eight carriers. These carriers could even be non-contiguous.

As evident, data traffic is usually asymmetric—there is more traffic in the downlink than the uplink. HSPA+ Release 9 enables an innovative feature called “supplemental downlink (SDL)” to significantly boost the downlink capacity. SDL essentially combines the unpaired spectrum with the downlink of the paired spectrum. HSPA+ evolution expands SDL to support up to four carriers, as shown in Fig. 3.1.

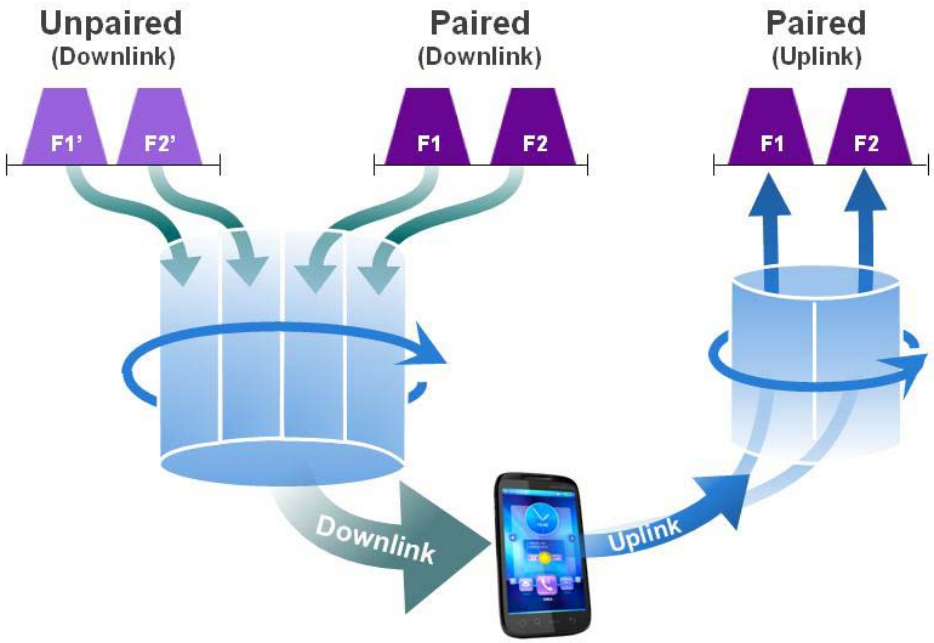


Fig. 3.1 Supplemental Downlink combines unpaired and paired spectrum bands

One of the key factors for the success of SDL is the harmonization of the unpaired spectrum to create economies of scale and ease of deployment across operators. Currently, there is an effort in the industry to harmonize 1.4 GHz L-band to potentially get up to 40 MHz of spectrum across Europe and beyond.

Qualcomm demonstrated a SDL prototype system at Mobile World Congress in 2011.

3.2 Introducing MultiFlow to Exploit Uneven Load

When you open the wraps of any wireless network, and look more closely at the loading patterns, two stark trends emerge. The first is that the loading is very dynamic and uneven. Second, highly loaded cells are usually surrounded by less loaded neighbors.

The MultiFlow feature of HSPA+ Advanced exploits this unevenness in demand. As shown in Fig. 3.2, MultiFlow enables a device to connect to both its highly loaded primary serving cell as well as a lightly loaded neighboring cell, so that the latter's unused capacity can be utilized.

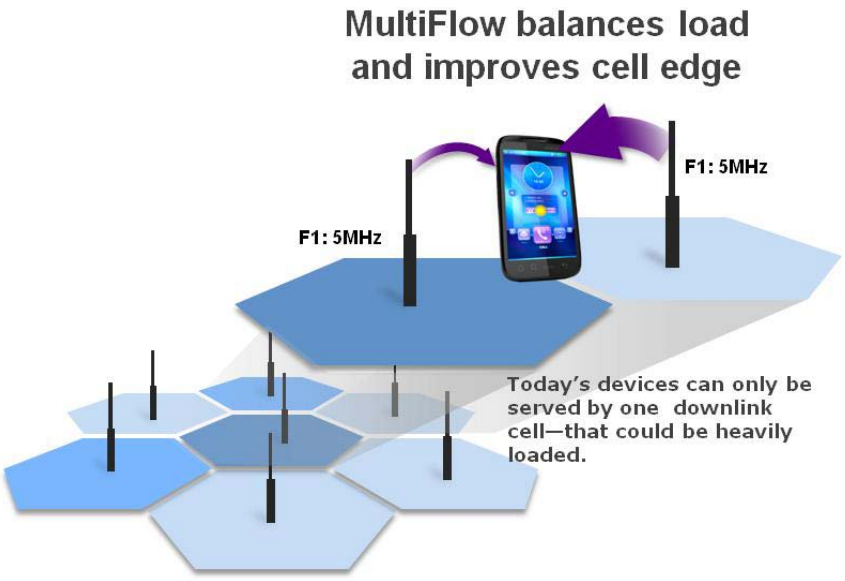


Fig. 3.2 MultiFlow allows utilization of unused capacity of neighboring cells

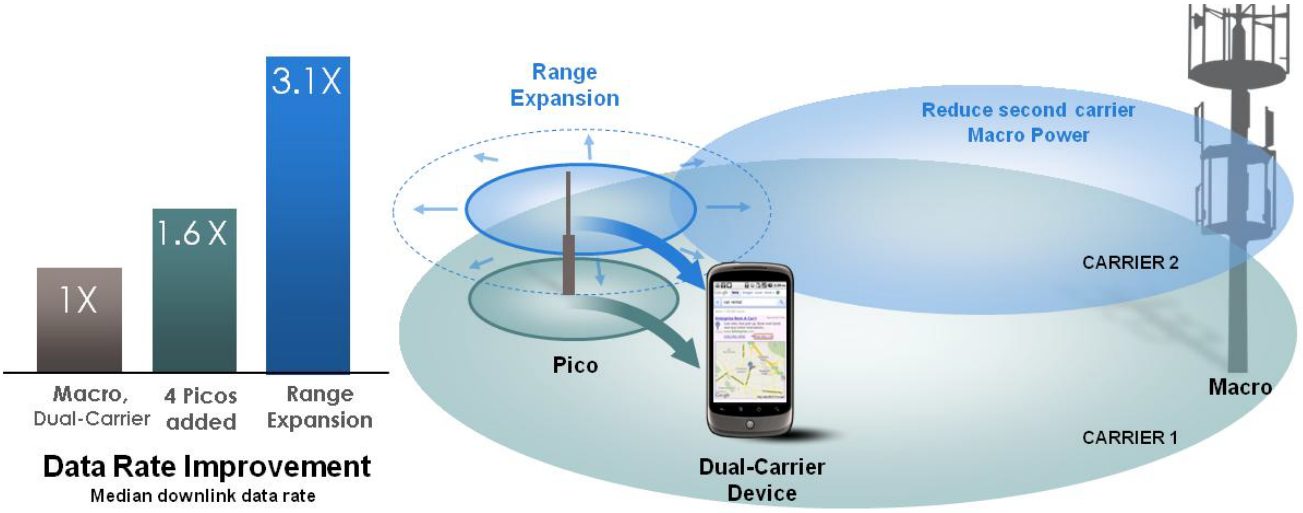
MultiFlow improves the performance in many ways: Improves the data rate and broadband experience of cell edge users as they are being served by two cells; Eases the load on the serving cell, improving the experience of users in it; Increases the overall network capacity as the unused capacity is utilized. Most importantly, it provides all of these benefits without requiring any new infrastructure or spectrum.

Qualcomm showed a demonstration of MultiFlow at Mobile World Congress in 2011.

3.3 Optimizing HetNets to get Higher Performance from Small cells

Heterogeneous Networks (HetNets) are networks with a mix of large macro cells and a collection of small cells such as pico and microcells. Small cells bring network "closer" to users and provide a leap in performance. But optimizations that are available today and the ones being introduced in HSPA+ Advanced can make that leap even bigger.

One such major optimization available today is "*Range Expansion"* which increases the utilization of pico cells. As shown in Fig. 3.3, Range Expansion essentially reduces the transmit power and hence, the coverage of the secondary carrier of macrocells, which in-turn expands the reach of picocells because of lower interference. This expansion, obviously benefits users close to the pico, but it also improves experience of users in the macrocell because of reduced load.



4 Picos added per macro and 50 % of users dropped in clusters closer to picos (within 40m), Model PA3 full buffer ISD 500m. Enabling range expansion features: reduced power on second macro carrier , dual carrier devices and mitigating uplink and downlink imbalance (3dB Cell-individual offset (CIO) and pico noise-figure pad)

Fig 3.3 Range Expansion improves the performance of small cells

Range Expansion can be introduced in two steps: 1) Parameter optimizations in existing networks to get sizable gains today; 2) deploying MultiFlow when available, to further increase those gains, especially at the edges of the cell, and to exploit uneven network load.

Devices with advanced receivers that incorporate interference cancellation can further improve the performance of Hetnets.

3.4 Providing more antenna gain

HSPA+ Advanced continues the evolution of advanced antenna techniques such as MIMO, and introduces uplink closed loop

beamforming. As shown in Fig. 3.4, beamforming utilizes multiple transmit antennas on the device to effectively create a radiation pattern that is directed toward the most desired site.

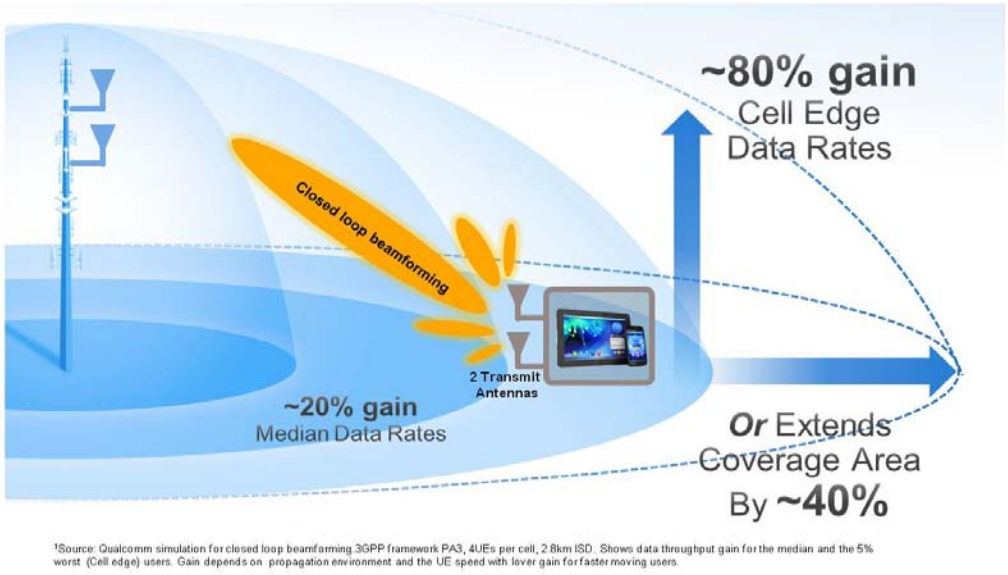


Fig 3.4 Uplink closed loop beamforming increases coverage and/or data rates

Closed loop beamforming is most beneficial to the users at the edge of the cell. It can increase their data rates by almost 80% or extend the uplink coverage area by about 40%. The increased coverage is useful especially in improving the indoor coverage in dense urban areas. On the other hand the capacity gains come in handy to cater to the increasingly popular uplink-heavy apps that support uploading of videos, photos, etc.

3.5 Efficiently connecting a large number of devices

Another aspect that doesn't get enough attention is the ability of the network to support a large number of devices. Many devices such as smartphones, typically generate bursty traffic, transferring small amounts of data. Frequently, the signaling traffic they generate is higher than the actual data itself. The widely expected wave of machine-to-machine connectivity is another classic case of such low-activity and chatty devices.

HSPA+ established the foundation to address this condition with a feature called Enhanced Cell-FACH. As with the other techniques, HSPA+ Advanced is making it even more efficient, so that a large number of devices can be in a connected state while consuming only a minimal amount of air link resources. The improved feature is aptly

Fig 3.5 HSPA+ Advanced supports a large number of low-activity and bursty traffic devices

called Further Enhanced Cell-FACH (FE Cell-FACH), and offers an impressive more than ten-fold increase in capacity over HSPA+ for small downlink bursts (in FACH). This enables operators to efficiently connect the "next billions" of low-activity, bursty traffic devices.

4 Conclusion

The HSPA family has proven itself to be a mobile broadband leader and is at the forefront of the industry's efforts to effectively cater to explosive demand for data services. HSPA+ has become the new baseline, and the move towards dual-carrier HSPA+ is in full swing. The strong growth of HSPA+ will continue for the foreseeable future with the subscriptions HSPA family forecasted to cross the 2 billion mark in 2015.

HSPA+ Advanced takes the evolution to Release 11 and beyond, bringing the performance of HSPA+ to the next level in multiple dimensions. It expands the role of Multicarrier enabling operators to utilize their entire available spectrum. HSPA+ Advanced brings innovative features such as MultiFlow that exploit the uneven network loading. It continues to enhance HetNet features such as Range Expansion. HSPA+ Advanced introduces uplink closed loop beamforming that improves uplink coverage and capacity. It also offers an impressive ten-fold increase in the capacity of bursty connections.

With all these enhancements, true to its fame of "market leader", HSPA+ evolution continues to provide the best possible mobile broadband experience to users while offering protection to operator's investments in today's HSPA+ and future HSPA+ Advanced networks.