Qualcomm, Technologies, Inc.

Qualcomm Research

HSPA Supplemental Downlink

June 2014

Table of Contents

Figures

Tables

Abstract

Supplemental Downlink (SDL) has been enabled in Release 9 as part of the evolution of High Speed Downlink Packet Access (HSDPA). While the serving carrier (cell) for an HSDPA UE is part of paired spectrum, the SDL carrier is part of unpaired spectrum in a different band. Thus, SDL operation helps efficiently utilize unpaired spectrum for HSDPA. Release 10 extends SDL operation by bonding up to 3 carriers in the unpaired band with the serving carrier(s) in the paired band. In this paper, we focus on Release 9 SDL performance. The SDL carrier just needs to support the Primary Common Pilot Channel as overhead, thereby leaving a larger share of power for HSDPA channels. For these reasons, SDL deployments can provide significant gains in both the user experience and number of users supported for a given user experience, when compared to a Single Carrier (SC) deployment.

Introduction

The Third Generation Partnership Project (3GPP) has been working on enhancements to the Wideband Code Division Multiple Access (WCDMA) systems since Release 5. In Release 8, Dual Cell High Speed Downlink Packet Access (DC-HSDPA) was standardized. In Release 9, Dual-Band (DB) DC-HSDPA operation was standardized, which enables the SDL feature. Release 10 extended DB-DC-HSDPA to a total of 4 carriers across the two bands. Release 8 DC-HSDPA deployments are currently occurring world wide. The high demand for data capacity has prompted operators to look for additional spectrum, including unpaired, to augment Frequency Division Duplex (FDD) deployments in the downlink, where there is a bigger need due to inherent asymmetry of data traffic. The Supplemental Downlink scheme provides a simple way to add unpaired spectrum to the downlink of existing Single Carrier deployments.

The SDL carriers are configured in the unpaired band (See Figure 1). As examples, the unpaired spectrum could be part of the L-Band (1425 MHz to 1492 MHz) in Europe or the 700 MHz band in the US. In this paper, we focus on the performance of Release 9 SDL operation with a single SDL carrier.

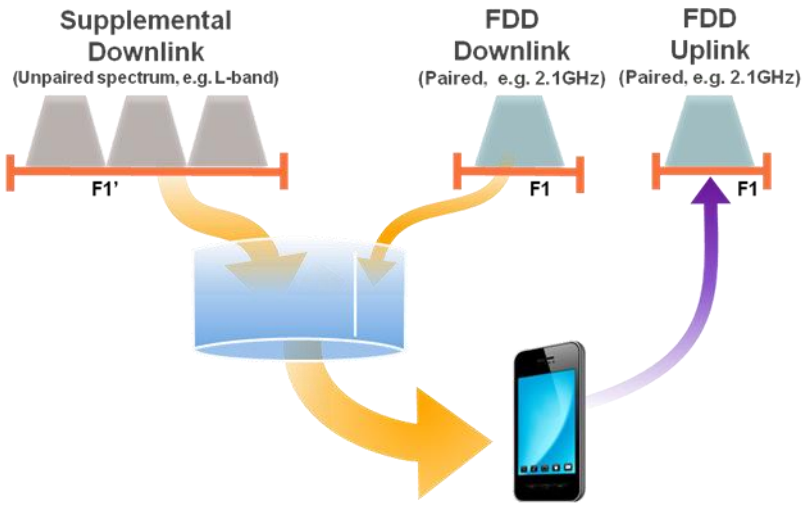

Figure 1: Supplemental Downlink Configuration. Up to 3 carriers from the unpaired spectrum can be bonded with 1 carrier in the paired spectrum for Release 10 capable UEs

Since the SDL carrier is not paired with an uplink, it cannot support UEs configured in pre-Release 9 modes (legacy UEs). It can only be used as the secondary serving cell (carrier) by Release 9, or later, UEs. On the downlink, the SDL carrier just needs to transmit the Primary Common Pilot Channel (P-CPICH) as overhead and all remaining power can be used for High-Speed Downlink Shared Channels (HS-DSCH) transmission along with the associated control channels, High Speed Shared Control Channel (HS-SCCH). On the other hand, carriers in the paired band need to assign power to other overhead channels such as Primary Common Control Physical Channel (PCCPCH), Synchronization channel (SCH), etc, in addition to supporting Dedicated Release 99 channels for voice calls. SDL operation therefore gives significant gains over single carrier (SC) operation.

Note that SDL operation is different from traditional Release 8 DC-HSDPA. In traditional Release 8 DC-HSDPA, both the carriers can support SC UEs as well as DC-HSDPA UEs. Hence, the Radio Network

Controller (RNC) can assign an SC UE to either of the two carriers. In contrast, the SDL carrier cannot support single carrier (pre-Release 9) operation.

Figure 2 shows Single Carrier (SC) and SDL operation. The carrier C1 is the SDL carrier. If all the UEs in the system are configured in SC-mode, all user traffic (including R99, HS-DSCH) is transmitted through carrier C0. However, if Release 9 capable UEs are configured in SDL mode, then they can be served on both carriers C0 and C1 (see green bars in Figure 2). The power available for SDL users more than doubles.

Figure 2: Power per channel differences between Single Carrier and SDL operation

Simulation

In this section, we explain the simulation setup. We compare the performance without (baseline) and with SDL operation to show the gains from the feature. To analyze the user experience gains, we hold the total number of UEs ("M" R99 UEs and "N" HS UEs) in the sector constant. All "N" HS users are assumed to be Release 9 capable. The baseline corresponds to all "M+N" UEs being served in the SC mode by the serving cell (carrier) C0, as the SDL carrier cannot support SC UEs. In the SDL mode, the "N" HS UEs are served by both the carriers, while the "M" R99 UEs are served by C0. Note that as shown in Fig 2, power available for HS transmission is higher on the SDL carrier (C1) than on C0. Table 1 contains the system simulation assumptions.

Table 1: System Simulation Assumptions

Parameter	Value
Layout	19 Node-Bs with 3 Cells/Node-B
Inter-Site Distance	1 km
Path Loss (dB)	$128.1 + 37.6\text{Log}_{10}D_{km}$
Antenna Pattern	Sectorized 2D pattern: $G = -Max\left[\left(\frac{\theta}{\theta_{3dB}}\right)^2, 20\right] dB,$ where $\theta_{3dB} = 70\ deg$

P-CPICH Power	10%
Total Overhead Power including P-CPICH	30% for Serving Cell (carrier) 10% for SDL Carrier
Channel Model	PA3
UE Receiver Type	Type 3i (LMMSE + RxD)
Traffic Type	Bursty Data (1 Mb burst arrives every "T" sec) T is exponentially distributed with a mean of 5 sec.
No. of R99 UEs/sector	16
R99 user power consumption	20%

Performance Gains

In this section, we show performance gains with SDL. Performance gain can be measured in two ways: User Experience Gain and Capacity Gain for a given experience level.

Figure 3 shows the HS user experience with and without SDL. We define user experience as the mean rate at which a traffic burst is downloaded for a given HS UE. Figure 3 shows the mean of the user experience across all HS UEs, as a function of users/sector. At a given number of HS users in the sector, the burst rate increases by more than 100% (as shown by the vertical arrow). For example, at around 4 HS UEs/sector, the mean user experiences w/o and w/SDL are 2.9 and 8.8 Mbps respectively, giving a user experience gain of around 200%.

At a given user experience, the number of HS users supportable increases significantly with SDL deployment. For example, in Figure 3, at a user experience of 3 Mbps, HSDPA can support 4 HS users in the baseline SC case, while it can support close to 46 HS users in SDL deployments, giving a gain of around 1000% for this example.

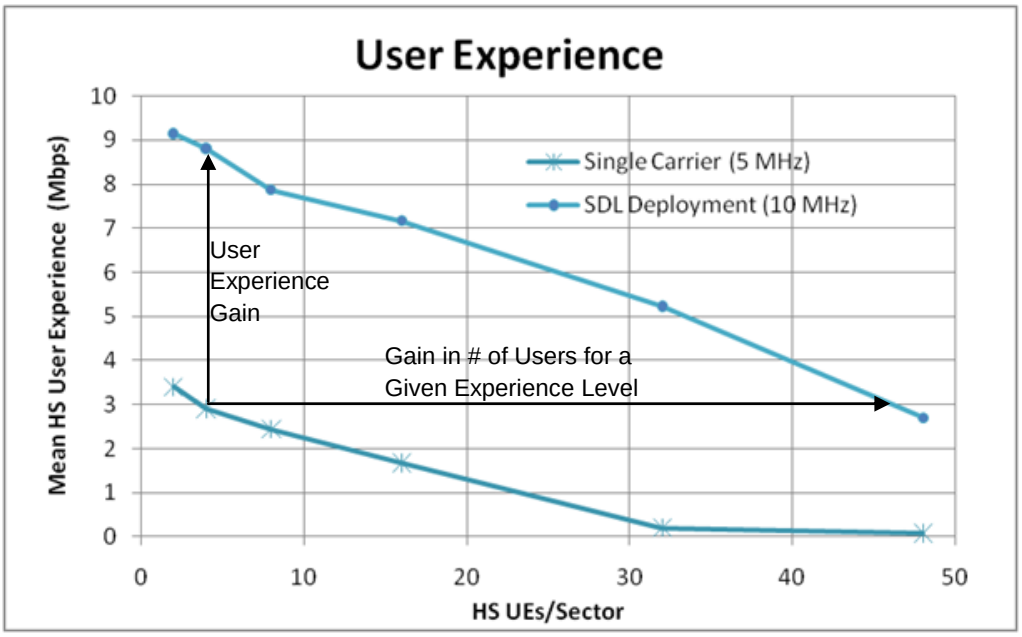

Figure 3: User Experience Vs Number of HS UEs/Sector

As the number of UEs/sector increases, the slot utilization increases and the baseline SC performance suffers. Deploying SDL in this cases prevents this from happening. For example, at 48 HS users/cell, the baseline SC system barely provides a mean user experience of 75 kbps, while deploying SDL improves this to 2.7 Mbps, providing a phenomenal gain at this extreme. This effect is shown in Figure 4 below.

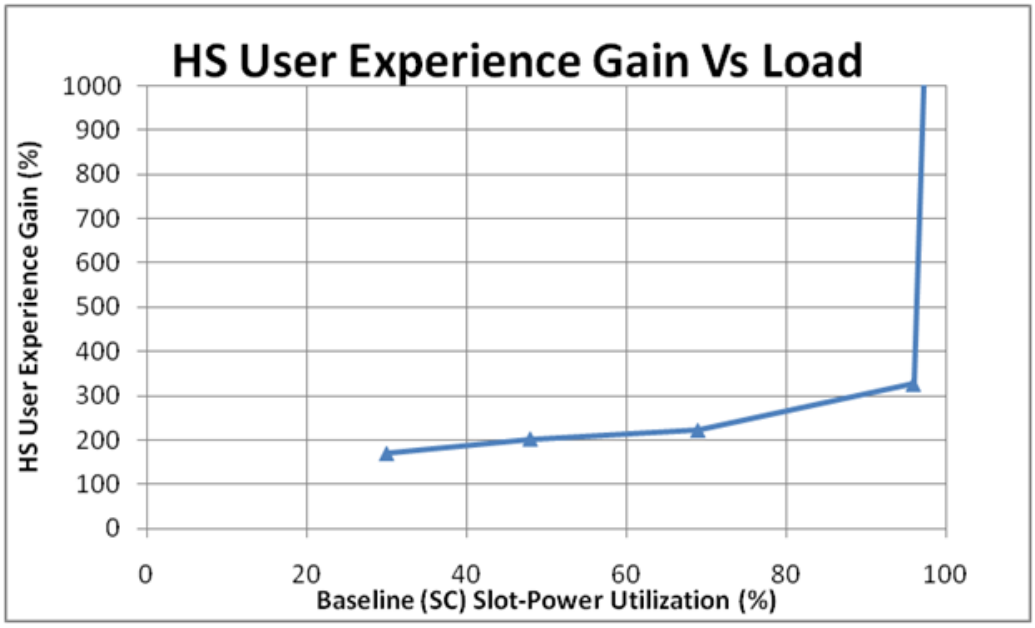

Figure 4: HS User Experience Gain Vs Loading

Conclusions

SDL operation allows the utilization of unpaired spectrum for HSDPA. Bonding of an additional downlink carrier to an existing FDD carrier using Release 9 capable UEs provides very significant user experience gains. These gains come from two areas for bursty traffic. First, since the SDL carriers are unpaired, they cannot support pre-Release 9 operation (setting the simulation baseline as a SC system). And second, the SDL carrier can assign greater power for HSDPA transmissions than carriers in the paired spectrum. We have presented simulation results which show significant gains in user experience and the number of users supported for a given user experience. User experience gain with SDL deployment over the baseline SC system is always higher than 100% and increases with loading. The gain in the number of users supported for a given user experience is close to an order of magnitude at low loads.

SDL operation will continue to evolve. For Release 10 capable UEs, up to 3 carriers from the unpaired band can be bonded with a downlink from the paired band. Other combinations for a total of 4 carriers across the two bands are also supported.

Revision History

Revision	Date	Table heading
A	June 2011	First Version
B	June 2014	Reformatted