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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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Introduction

A study item for further improved minimum performance requirements for UMTS/HSDPA UE (FDD) was approved at the 3GPP RAN #30 meeting [1]. This technical report summarizes the work that RAN4 has accomplished in this study item to assess the feasibility of both one-branch and two-branch interference cancellation/mitigation UE receivers. These receivers attempt to cancel the interference that arises from users operating outside the serving cell. This type of interference is also referred to as 'other-cell' interference. In past link level evaluations, this type of interference has been modelled as AWGN, and as such can not be cancelled. The study item has developed models for this interference in terms of the number of interfering Node Bs to consider, and their powers relative to the total other cell interference power, the latter ratios referred to as Dominant Interferer Proportion (DIP) ratios. DIP ratios have been defined based on three criteria; median values of the corresponding cumulative density functions, weighted average throughput gain, and field data. In addition, two network scenarios are defined, one based solely on HSDPA traffic (HSDPA-only), and the other based on a mixture of HSDPA and Rel. 99 voice traffic (HSDPA+R99).

Interference aware receivers, referred to as type 2i and type 3i, were defined as extensions of the existing type 2 and type 3 receivers, respectively. The basic receiver structure is that of an LMMSE sub-chip level equalizer which takes into account not only the channel response matrix of the serving cell, but also the channel response matrices of the most significant interfering cells. HSDPA throughput estimates are developed using link level simulations, which include the other-cell interference model plus OCNS models for the serving and interfering cells based on the two network scenarios considered. In addition, system level performance is assessed to determine the gains that interference cancellation/mitigation receiver might provide in throughput and coverage. Complexity issues associated with implementing these types of receivers are also discussed. The content of each specific clause of the report is briefly described as follows.

Clause 1 of this document defines the scope and objectives of this feasibility study. Clause 4 describes the receiver methods that can be applied to one-branch and two-branch Interference Cancellation (IC) receivers. The reference receivers for the type 2i and type 3i are defined, both of which are based on LMMSE sub-chip level equalizers with interference-aware capabilities. Clause 5 describes the two network scenarios that were defined and used to generate the interference statistics, which were then used to develop the interference models described in clause 6. Clause 6 defines the interference models/profiles that were developed in order to assess the link level performance of IC receivers. The DIP ratio is defined as a key statistical measure, which forms the basis of the three types of interference profiles considered.

Clause 7 defines the code and power characteristics of the signals transmitted by the serving and interfering cells for the two network scenarios defined in clause 5. These latter definitions essentially define the signal characteristics of the desired user, the common channels and the OCNS for both serving and interfering cells. Clause 8 summarizes the link level simulation results based on the assumptions developed in clauses 6 and 7, while clause 9 summarizes the system level performance characterization. Clause 10 discusses the possible receiver implementation losses for a two-branch, sub-chip based LMMSE equalizer with interference aware capabilities. Finally, clause 11 provides the relevant conclusions that can be taken from this study.

1 Scope

The objective of this study is to evaluate the feasibility and potential performance improvements of interference cancellation/mitigation techniques for UTRA FDD UE receivers, based on realistic network scenarios. Scope of the work includes:

- Determine realistic network scenarios.
- Determine suitable interference models for 'other cell' interference.
- Evaluate the feasibility of two-branch interference cancellation receivers through link and system level analysis and simulations.
- Evaluate feasibility of one-branch interference cancellation receivers through link and system level analysis and simulations.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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[2] R4-060514, "Reference structure for interference mitigation simulations with HSDPA and receiver diversity", Nokia, RAN4 #39.

[3] R4-060364, "Minutes of Ad Hoc on Further Improved Performance Requirements for UMTS/HSDPA UE (FDD)", Nokia, RAN4 #38.

[4] R4-060117, "Analysis for simulation scenario definition to interference mitigation studies", Nokia, RAN4#38.

[5] R4-060180, "Network Scenarios and Associated Interference Profiles for Evaluation of Generalized Interference Cancellation (IC) Receivers", Cingular, RAN4 #38.

[6] TR 25.848 v4.0.0, "Physical layer aspects of UTRA High Speed Downlink Packet Access (Release 4)".

[7] TR 25.896 V6.0.0 (2004-3), "Feasibility Study for Enhanced Uplink for UTRA FDD (Release 6)".

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[9] R4-061068, "Some observations on DIP values as a function of network geometries", TensorComm, RAN4 #40.

[10] R4-060512, "Analysis simulation results for scenario definition to interference mitigation studies", Nokia, RAN4 #39.

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[12] R4-060369, "Observations on Other-Cell Interference Modelling", Motorola, RAN4 #39.

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[14] TR 45.903, "Feasibility Study on Single Antenna Interference Cancellation (SAIC) for GSM Networks (Release 6)".

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[18] R4-061183, "Throughput simulation results for type 3 and type 3i receivers based on an alternative method for determining DIP values", AT&T Labs, Inc. & Cingular Wireless, RAN4 #41.

[19] R4-070042, Throughput simulation results for type 3 and type 3i receivers for Ior/Ioc = -3 dB based on an alternative method for determining DIP values, AT&T Labs, Inc. & Cingular Wireless, RAN4 #42.

[20] R4-061241, "HSDPA Simulation Results for Type 3i with Weighted DIP Values", Motorola, RAN4 #41.

[21] R4-070041, Minutes of interim conference call on interference cancellation study item, AT&T Labs, Inc. & Cingular Wireless, RAN4 #42.

[22] R4-061315, "Interference data collection on a live UMTS network", Orange, RAN4 #41.

[23] R4-061309, "Interference Statistics Based on Field Measurements from an Operational UMTS/HSDPA Market", Cingular, AT&T and TensorComm, RAN4 #41.

[24] R4-061316, "Scenario definition for interference cancellation evaluation based on measurements taken in 3 UK's operational network", 3, RAN4 #41.

[25] R4-060593, "Further Thoughts on Scenario Definition for Studying Link Performance of Generalized IC Receivers", Ericsson, RAN4 #39.

[26] R4-060638, "Code Structure of Serving and Interfering Base Stations", Motorola, RAN4 #39.

[27] R4-060494, "Details of the Code Structure and Power Allocation for the HSDPA UE IC Case", Qualcomm, RAN4 #39.

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3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

DIP	Dominant Interferer Proportion
IC	Interference Cancellation
LMMSE	Linear Minimum Mean Squared Error
UE	User Equipment
UTRA	UMTS Terrestrial Radio Access

4 Receiver methods

In this clause we give the system equations for the LMMSE chip-level equalizer with and without receive diversity for evaluating the benefits for interference mitigation [2]. In the assumptions used in earlier work for enhanced performance requirements Type 2 and Type 3 the interference structure was assumed to be white and the variance to be ideally known. In the structure presented in following clauses the interference structure is now assumed to be colored and the covariance matrix is structured based on ideal knowledge of the channel matrices of the interfering base stations. This enables the evaluation of benefits of interference mitigation in the equalizer structure while the approach to derive (estimate) the interference covariance matrix does not need to be defined.

4.1 Two-branch interference mitigation

The received signal is assumed to be expressed as a sum of "own" signal, interfering signals and the white noise:

$$\underbrace{\mathbf{r}}_{received\ signal\ vector} = \underbrace{\mathbf{M}^0\mathbf{d}_0}_{own\ signal} + \underbrace{\sum_{j=1}^{N_{BS}}\mathbf{M}^j\mathbf{d}_j}_{coloured\ noise} + \underbrace{\mathbf{n}}_{white\ noise}, \qquad (1)$$

where $\mathbf{M}^j,\ j=\{0,...,N_{BS}\}$ represents the channel matrix corresponding to BS j, containing the contribution from both receive antenna branches. The $\mathbf{M}^j \overset{\Delta}{=} \begin{bmatrix}(\mathbf{H}_1^j)^H \\ (\mathbf{H}_2^j)^H\end{bmatrix}$ where $\mathbf{H}_i$ equals channel-matrix for the i-th receiver antenna.

As a general concept, the equalizer consists of two FIR filters w_1 and w_2 of length $F \cdot N_s$:

$$\mathbf{w}_i = \left[w_i(0) \quad \cdots \quad w_i(F\cdot N_s - 2) \quad w_i(F\cdot N_s - 1)\right]^T, i = 1,2 \qquad (2)$$

where the N_s is the number of samples per chip and F is the length of the equalizer in units of chips. The sampled received vectors at two antennas are denoted by

$$\mathbf{r}_i(m) = [r_i((m+D+1)\cdot N_s - 1) \quad \cdots \quad r_i(m\cdot N_s) \quad \cdots \quad r_i((m+D-F+1)\cdot N_s)]^T, i = 1,2, \tag{3}$$

where D is a delay parameter ($0 \le D \le F + L'$). The equalization operation amounts to obtaining the filtered signal

$$y(m) = \mathbf{w}_1{}^T \cdot \mathbf{r}_1(m) + \mathbf{w}_2{}^T \cdot \mathbf{r}_2(m) . \tag{4}$$

The received signal $\mathbf{r}_i$(m) can be expressed as

$$\mathbf{r}_i(m) = \mathbf{H}_i^{0^T} \cdot \mathbf{d}_0(m) + \sum_{j=1}^{N_{BS}} \mathbf{H}_i^{j^T} \cdot \mathbf{d}_j(m) + \mathbf{n}_i(m) , \tag{5}$$

where

$$\mathbf{H}_i = \begin{bmatrix} \mathbf{h}^i_{N_s\times(L'+1)} & \mathbf{0}_{N_s\times1} & \mathbf{0}_{N_s\times1} & \cdots & \mathbf{0}_{N_s\times1} \\ \mathbf{0}_{N_s\times1} & \mathbf{h}^i_{N_s\times(L'+1)} & \mathbf{0}_{N_s\times1} & \cdots & \mathbf{0}_{N_s\times1} \\ \mathbf{0}_{N_s\times1} & \mathbf{0}_{N_s\times1} & \mathbf{h}^i_{N_s\times(L'+1)} & \ddots & \vdots \\ \mathbf{0}_{N_s\times1} & \mathbf{0}_{N_s\times1} & \mathbf{0}_{N_s\times1} & \ddots & \mathbf{0}_{N_s\times1} \\ \mathbf{0}_{N_s\times1} & \mathbf{0}_{N_s\times1} & \cdots & \mathbf{0}_{N_s\times1} & \mathbf{h}^i_{N_s\times(L'+1)} \end{bmatrix}^T \tag{6}$$

is the (F+L') x FN_s channel-matrix for the i-th antenna with

$$\mathbf{h}^i_{N_s\times(L'+1)} = \begin{bmatrix} h_i(N_s-1) & h_i(2N_s-1) & \cdots & h_i((L'+1)N_s-1) \\ h_i(N_s-2) & h_i(2N_s-2) & \cdots & h_i((L'+1)N_s-2) \\ \vdots & \vdots & \ddots & \vdots \\ h_i(0) & h_i(N_s) & \cdots & h_i(L'N_s) \end{bmatrix} \tag{7}$$

where $L' = \lfloor L/N_s \rfloor$ is the delay spread normalized by the chip interval. Moreover,

$$\mathbf{d}_j(m) = [d_j(m+D) \quad \cdots \quad d_j(m) \quad \cdots \quad d_j(m+D-F-L'+1)]^T \tag{8}$$

is the m-th subsequence of the transmitted chip-rate sequence, and $\mathbf{n}_i(m)$[1] is the corresponding noise vector. Under the assumptions that the noise is colored and the total transmit power from own cell is 1, the LMMSE equalizer taps can be calculated as follows

$$\begin{pmatrix} \mathbf{w}_1 \\ \mathbf{w}_2 \end{pmatrix} = \underbrace{\mathbf{C}_{rr}^{-1}}_{received\ sig\ cov\ matrix} \cdot \begin{pmatrix} (\mathbf{H}_1^0)^H \delta_D \\ (\mathbf{H}_2^0)^H \delta_D \end{pmatrix} = \mathbf{C}_{rr}^{-1} \underbrace{\begin{bmatrix} (\mathbf{H}_1^0)^H \\ (\mathbf{H}_2^0)^H \end{bmatrix}}_{(\mathbf{M}^0)^H - own\ matrix} \delta_D \tag{9}$$

where the notation $\mathbf{X}\delta_D$ means the D-th column of the matrix **X**. The C_{rr} is based on the known propagation channels only, i.e. $\mathbf{M}^j, j = \{0,...N_{BS}\}$ is based on the ideal channel coefficients. Thus the $\mathbf{C}_{rr}$ matrix is constructed as:

$$\mathbf{C}_{rr} = \left(\mathbf{M}^0(\mathbf{M}^0)^H + \sum_{j=1}^{N_{BS}} P_j \mathbf{M}^j (\mathbf{M}^j)^H + \sigma_n^2 I \right), \tag{10}$$

where the $P_j, j = \{1,...,N_{BS}\}$ represent the transmission power of the BS *j* taking into account that the transmission power of the own base station is normalized to unity[1]. σ_n^2 is the variance of the noise vector $\mathbf{n}_i(m)$, which is assumed to be same for *i*=1,2. The above equation also assumes that the noises at different antennas are independent.

4.2 One-branch interference mitigation

In previous clause 4.1, the system equations were presented assuming two receiver branches. These equations can be modified for single branch receiver.

The signal model in equation (1) can be used by assuming that the channel matrix equals $\mathbf{M}^j \stackrel{\Delta}{=} (\mathbf{H}_1^j)^H$ for single receive antenna equalizer.

Using the same assumptions, the LMMSE equalizer taps can be calculated as follows

$$\mathbf{w}_1 = \underbrace{\mathbf{C}_{rr}^{-1}}_{received\ sig\,\mathrm{cov}\,matrix} \cdot (\mathbf{H}_1^0)^H \delta_D \qquad (11)$$

where the notation $\mathbf{X}\delta_D$ means the D-th column of the matrix $\mathbf{X}$. The $\mathbf{C}_{rr}$ is based on the known propagation channels only, i.e. $\mathbf{M}^j, j = \{0,...N_{BS}\}$ is based on the ideal channel coefficients. Thus, the $\mathbf{C}_{rr}$ matrix is constructed as:

$$\mathbf{C}_{rr} = \left(\mathbf{M}^0\mathbf{M}^{0H} + \sum_{j=1}^{N_{BS}} P_j \mathbf{M}^j (\mathbf{M}^j)^H + \sigma_n^2 I \right), \qquad (12)$$

where the $P_j, j = \{1,...,N_{BS}\}$ represent the transmission power of the BS *j* taking into account that the transmission power of the own base station is normalized to unity. σ_n^2 is the variance of the noise vector $\mathbf{n}_i(m)$.

5 Network scenarios

To estimate the link gain that UE Interference Cancellation (IC) receivers might provide for UMTS/HSDPA downlinks it is necessary to first define the network scenarios under which the receivers must operate. A network scenario for downlink performance evaluation is typically defined in terms of Node B transmit characteristics, UE receive characteristics, traffic mix, inter-site distance, path loss model, etc. Once the network scenario(s) is defined one can then determine the associated interference profile/model that will be used in the actual link level characterization. This clause describes the network scenarios agreed to in this study, while the following clause defines the interference models that were developed based on system level simulations of these network scenarios.

Two network scenarios have been defined in this feasibility study as shown in Table 5.1, with one scenario focusing on HSDPA-only traffic, and the second scenario focusing on HSDPA + Release 99 voice traffic.

Table 5.1: Network Scenarios

	Network Scenario 1	Network Scenario 2
Traffic	HSDPA-only	HSDPA + Release 99 voice

The main system level assumptions are identical for each scenario, and are summarized in Table 5.2. This amounts to defining two network scenarios which are identical except for the traffic assumed. The system parameters and their associated values provided in Table 5.2 were initially defined in [3], which summarized the results of an ad-hoc meeting

[1] $I_{oc} = \sum_{j=1}^{N_{BS}} \hat{I}_{orj} + \sigma_n^2$

held during TSG RAN WG4 #38. These assumptions were based on the merging of information provided in [4] and [5]. The vast majority of these assumptions are based on prior work within 3GPP RAN WG4 including [6] and [7]. In some of these latter studies a second inter-site distance of 2800 m was also considered in addition to the 1000 m specified in Table 5.2, but since we are primarily interested in interference-limited environments the group felt that the 1000 m condition alone was sufficient.

For HSDPA traffic the full-buffer traffic assumption was made to ensure that all cells were fully loaded. Also, since the purpose of these system level simulations was to generate statistics to accurately characterize the interference in the system, a round-robin packet scheduler was recommended for the system simulations to ensure that all UEs had an equal chance of being scheduled. This type of scheduler ensured that when the system simulator was executed over many iterations, that interference statistics were collected uniformly over the entire simulated area. Choosing a scheduler such as "Max C/I" would skew the generated statistics because a Max C/I scheduler tends to schedule UEs that are closer in to the cell site (due to better C/I at closer-in locations).

System level simulations were then conducted based on the above assumptions for the purposes of collecting interference statistics. Static system level simulators were deemed sufficient for this exercise, and are preferred over dynamic simulators since they are typically easier to develop and require less computation time. For every "iteration" in the static simulator UEs are randomly distributed across the simulated area and the relevant statistics collected. From these collected statistics certain key measures are developed, which provide some insight into how well an interference cancellation receiver might work. These key measures and the resulting interference modelling required for link level performance characterization are discussed in the next clause.

Table 5.2: System level assumptions for network scenarios

Parameter	Assumption as in [5]
Cellular layout	Hexagonal grid, 19 sites with 3 sectors
Site to site distance	1000 m
Propagation Model	L= 128.1 + 37.6Log_{10}(R_{km})
Std. of slow fading	8 dB
Correlation between sectors	1.0
Correlation between sites	0.5
Carrier frequency	2000MHz
MCL	70 dB
BS antenna gain	14dB
BS antenna pattern	$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right]$ where $-180 \le \theta \le 180$ θ is defined as the angle between the direction of interest and the boresight of the antenna, θ_{3dB} is the 3dB beamwidth in degrees, and A_m is the maximum attenuation. Front-to-back ratio, A_m, is set to 20dB. θ_{3dB} used is 70 degrees .
BS total TX power	20W
UE antenna gain	0dBi
UE noise figure	9dB

6 Interference modelling

6.1 General

In this clause we define the interference models/profiles that were developed in order to assess the link level performance of Interference Cancellation (IC) receivers. Clause 6.2 defines a number of statistical measures that were defined during the study, and which provide useful insight into understanding the complex interference environment. One of these measures, referred to as the Dominant Interferer Proportion (DIP) ratio, was agreed to in [3] as a key parameter for defining the interference profiles. System level simulations were conducted to generate results for the statistical measures defined in clause 6.2. Based on these simulation results interference profiles were developed, which were used in the link level performance characterization described in clause 8.

For the HSDPA-only network scenario, the working group defined the following types of interference profiles:

i) Interference profile based on median values

ii) Interference profiles based on weighted average throughput gain

iii) Interference profiles based on field data

Initially, the group defined an interference profile based on median DIP values. However, after the initial link level characterization, there were some in the group that thought this profile was too pessimistic. This led the group to explore other methods that might be more representative of the gains that an IC receiver would actually provide. Subsequently, profiles conditioned on geometry were defined based on the "weighted average throughput gain" method as described in [8]. There were some that even thought that this latter method was too pessimistic when compared to field data [9], but the majority of the group felt that it was a good compromise between the profile based on median values and one based on field data. Clauses 6.3, 6.4, and 6.5 present the interference characterization results leading to the development of the above three types of interference profiles respectively.

For the HSDPA + R99 network scenario, the group decided to use the same interference profiles as the HSDPA-only network scenario to assess link level performance of IC receivers.

Finally, clause 6.6 presents a summary of all the interference profiles developed for this study item.

6.2 Statistical measures

Network interference statistics are computed using the following defined measures. Geometry G is defined as

$$G = \frac{\hat{I}_{or1}}{I_{oc}} = \frac{\hat{I}_{or1}}{\sum_{j=2}^{N_{BS}} \hat{I}_{orj} + N},$$

where $\hat{I}_{orj}$ is the average received power from the j-th strongest base station ($\hat{I}_{or1}$ implies serving cell), N is the thermal noise power over the received bandwidth, and N_{BS} is the total number of base stations considered including the serving cell.

The Dominant Interferer Proportion (DIP) defines the ratio of the power of a given interfering base station over the total other cell interference power. It was defined in [3], and can be written as,

$$DIP_i = \frac{\hat{I}_{or(i+1)}}{I_{oc}},$$

where $I_{oc} = \sum_{j=2}^{N_{BS}} \hat{I}_{orj} + N$.

Note that power from the serving cell, $\hat{I}_{or1}$, is never included in any DIP calculation.

Results for the Dominant Interferer Ratio (DIR) were also presented in the working group meetings to characterize the interference environment. However, in [1] it was agreed that DIP ratios would be used to define the interference profiles and to serve as the interface between system level simulation results and link level performance characterization. Hence, results for DIR statistics are not included in this feasibility study report. The reader is referred to references [10] and [11] for DIR definitions and results.

6.2 Interference profile based on median values

This clause presents interference characterization results leading to the development of the interference profile based on median DIP values. This clause first presents geometry statistics obtained from system level simulations. This is followed by results from contributions, which attempt to determine the number of interfering base stations which should be considered for proper link level characterization. These latter results indicated that five interfering cells should be modelled in the interference profile. DIP ratio statistics are presented after that showing unconditional DIP CDFs and conditional median DIP values, the latter conditioned on various geometry values. This led to the group selecting an interference profile defined by a single set of median DIP values for all geometries.

Figures 6.1 to 6.4 show the cumulative distribution functions (CDFs) of geometry ($\hat{I}_{or1}/I_{oc}$) generated by various companies for the HSDPA-only network scenario. The maximum value of geometry is limited to 17 dB due to the 20 dB front-to-back ratio of the antenna specified in clause 5. These figures show good agreement between results. For example the median value is about -2.5 dB for all of the curves. This close agreement verifies to some extent, proper operation of each company"s static system level simulator.

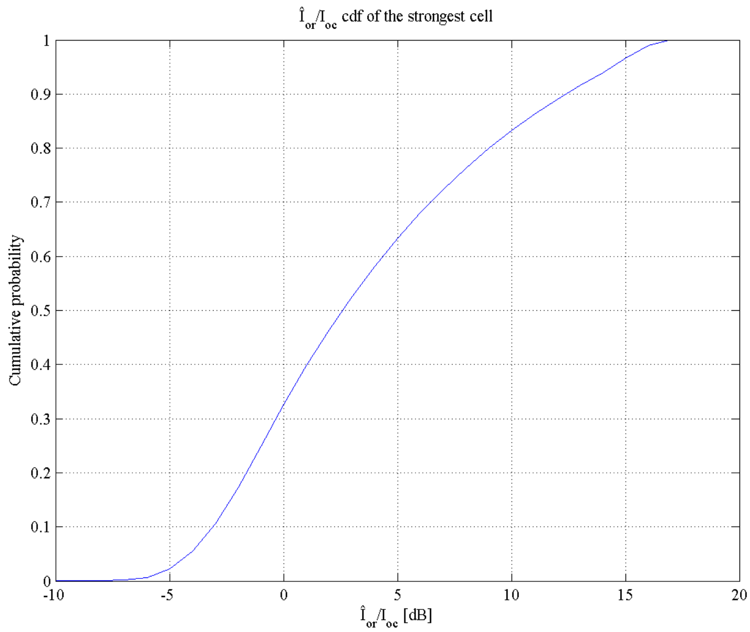

Figure 6.1: Geometry CDF [10]

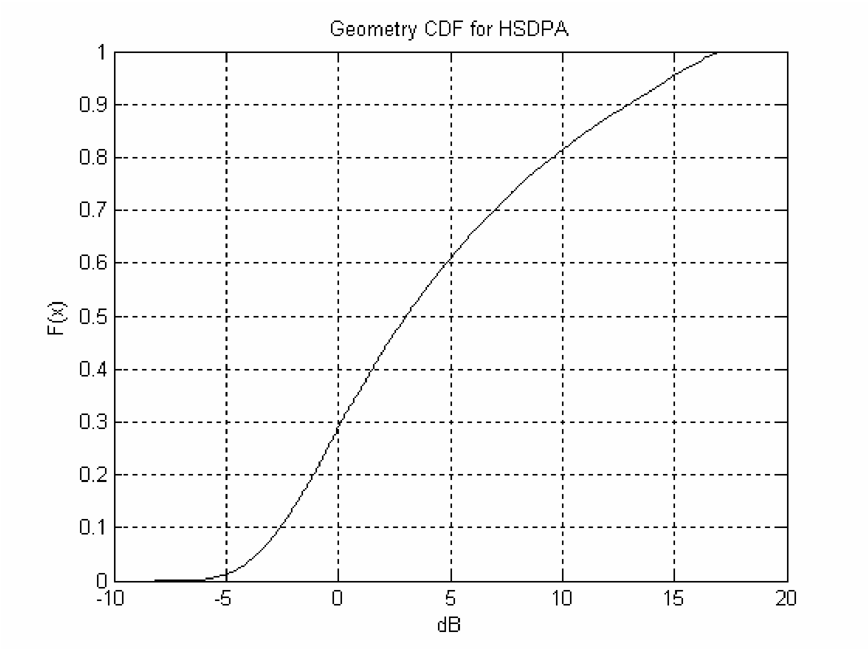

Figure 6.2: Geometry CDF [11]

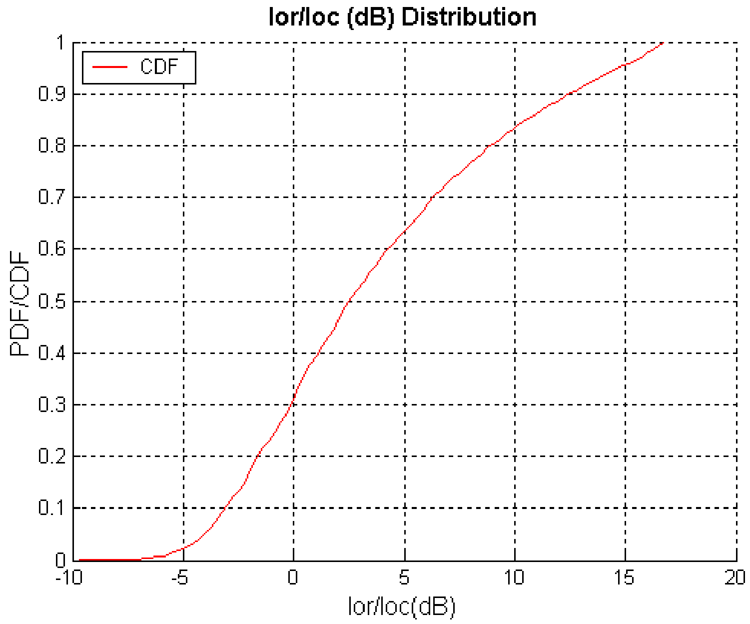

Figure 6.3: Geometry CDF [12]

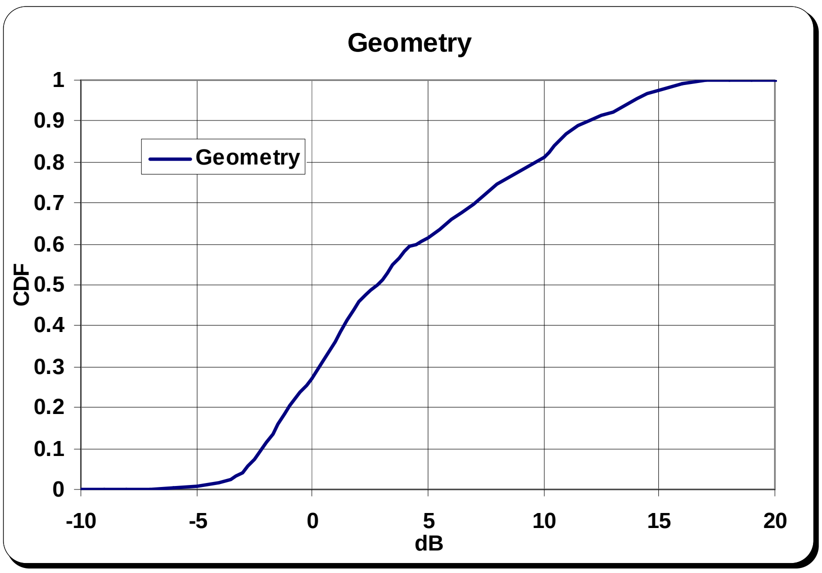

Figure 6.4: Geometry CDF [13]

In order to decide the appropriate number of interferers to model for link level characterization, it was agreed [3] to initially evaluate interference statistics for the eight strongest interfering cells. There is a trade-off - a larger number of modeled interferers in the profile makes link level characterization simulations and eventual testing more complex, but it also makes the interference model more accurate. After reviewing results for measured statistics, the group decided [14] that an appropriate trade-off between complexity and accuracy can be achieved by defining the interference profile with five strongest interfering base stations plus a filtered AWGN component to model the residual interference. Figures 6.5 to 6.8 present results generated by various companies to show the contribution of the eight strongest interfering cells to the total interference in the system. Here, the term total interference refers to I_{oc} as defined in Clause 6.2. It can be observed that the five strongest interferers contribute a large majority of the total interference.

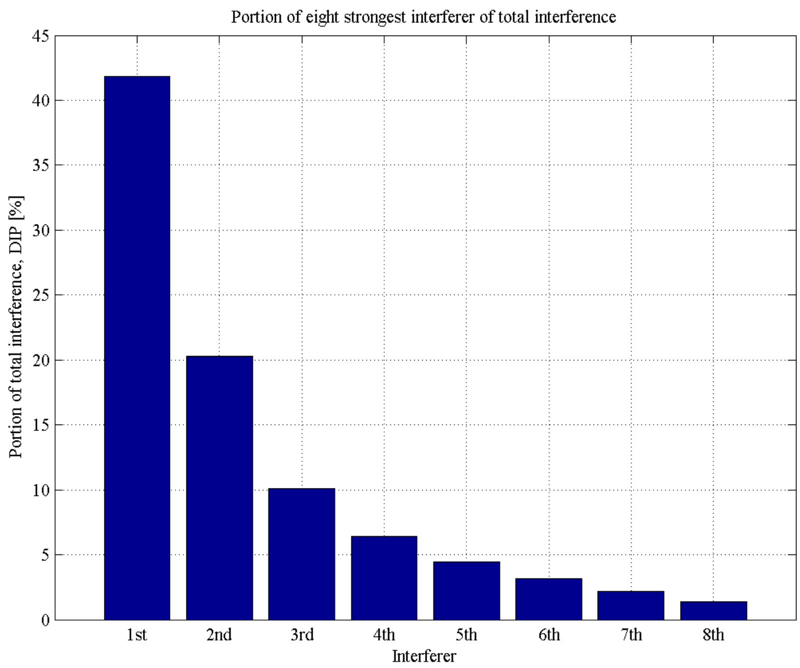

Figure 6.5: 8 Strongest Interferers [9]

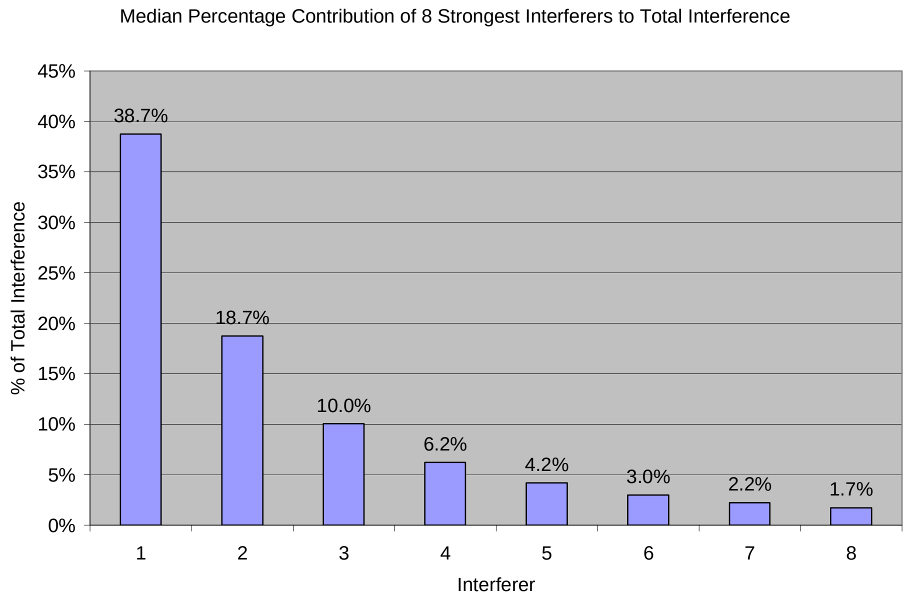

Figure 6.6: 8 Strongest Interferers [10]

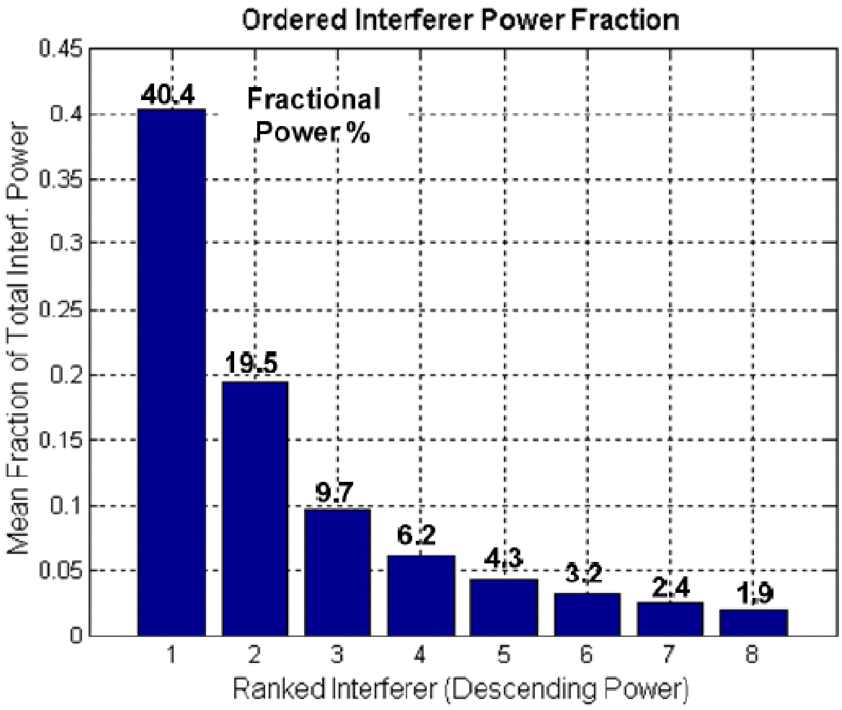

Figure 6.7: 8 Strongest Interferers [11]

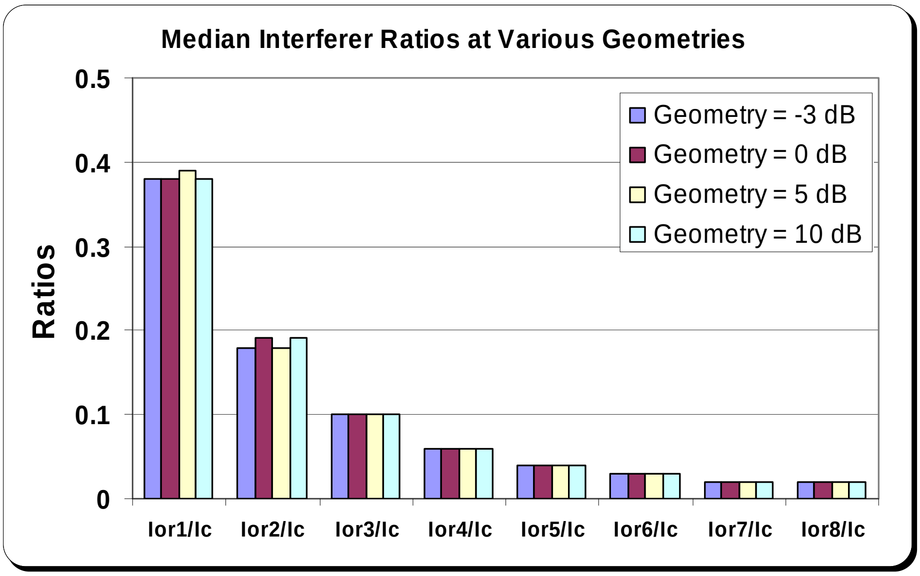

Figure 6.8: 8 Strongest Interferers [12]

The group evaluated unconditional DIP values for the eight strongest interfering cells, as well as conditional DIP values conditioned on -3 dB, 0 dB, 5 dB, and 10 dB values of geometry. Figures 6.9 to 6.12 show CDFs of unconditional DIP_i for the eight strongest interferers. Figures 6.13 to 6.15 show median values of conditional DIP_i for different values of geometry. Based on these DIP results at that time the group decided that since there was not a large variability in DIP values for different geometries, the group could simplify the number of simulation scenarios by defining an interference profile with a single set of median DIP values for all geometries.

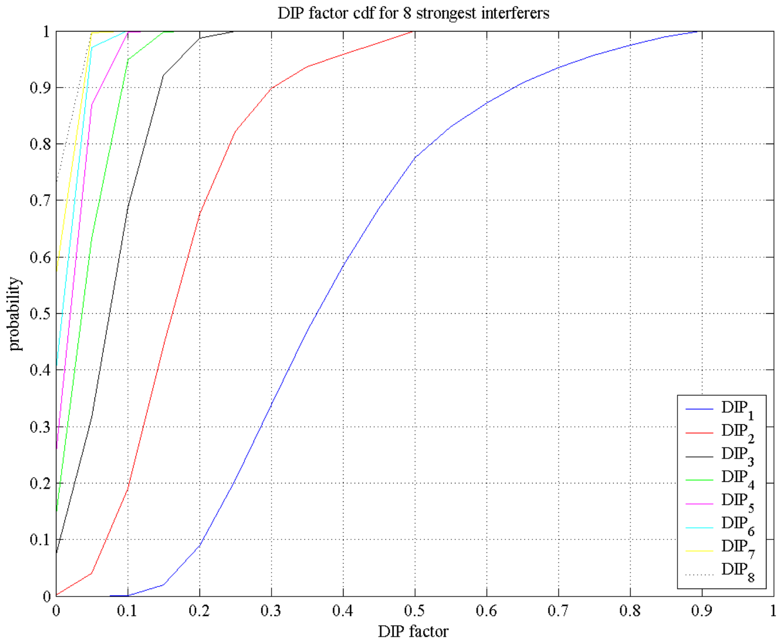

Figure 6.9: Unconditional DIP CDFs [10]

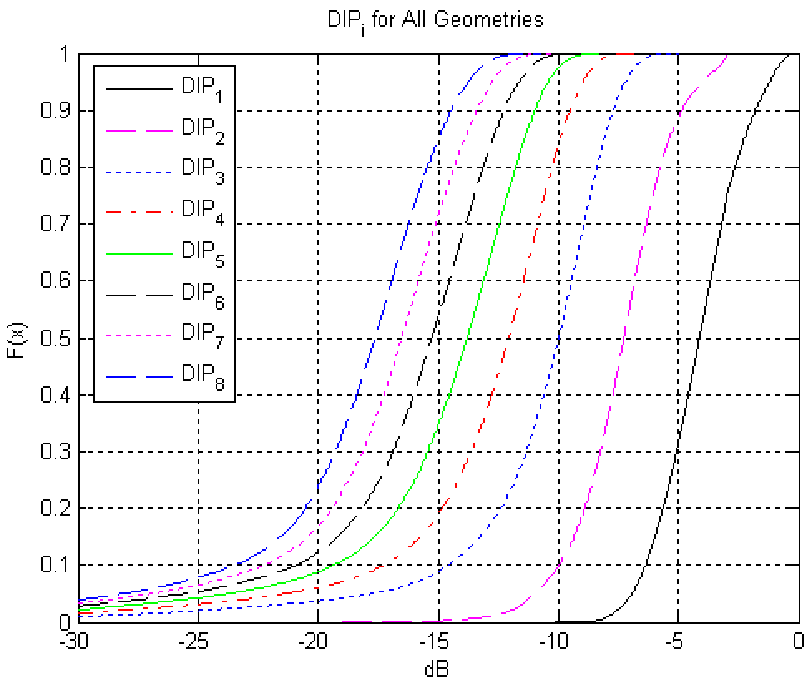

Figure 6.10: Unconditional DIP CDFs [11]

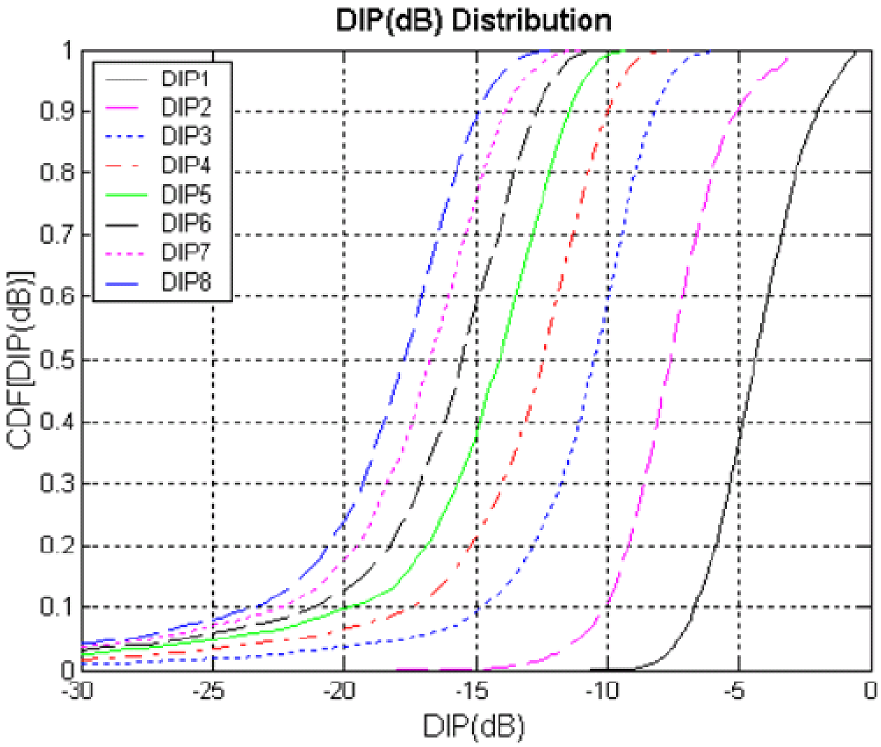

Figure 6.11: Unconditional DIP CDFs [12]

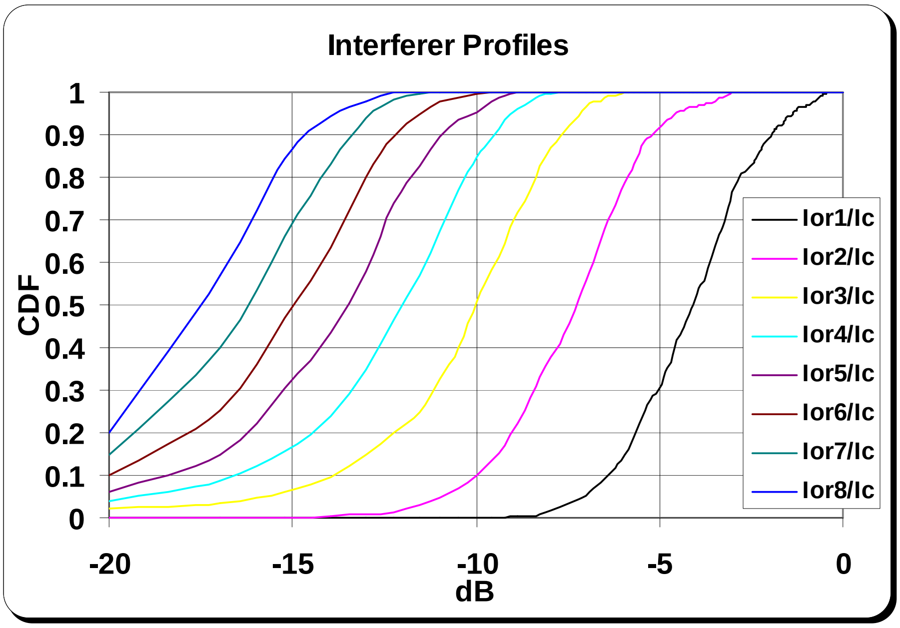

Figure 6.12: Unconditional DIP CDFs [13]

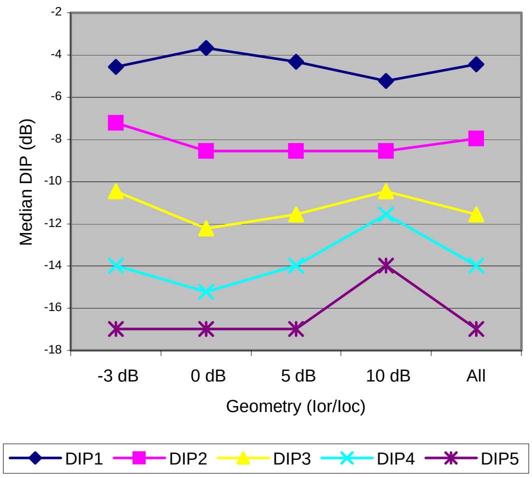

Figure 6.13: Conditional Median DIPs [10]

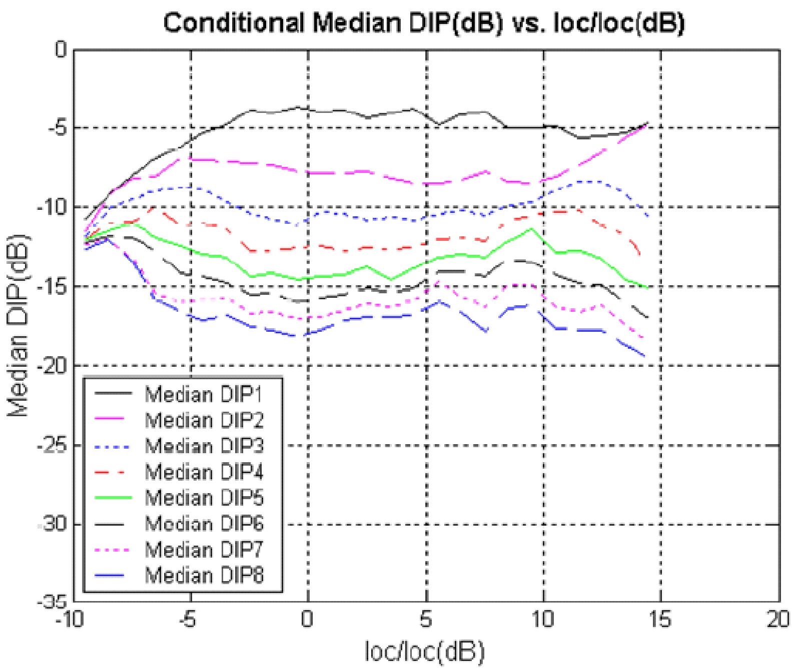

Figure 6.14: Conditional Median DIPs [12]

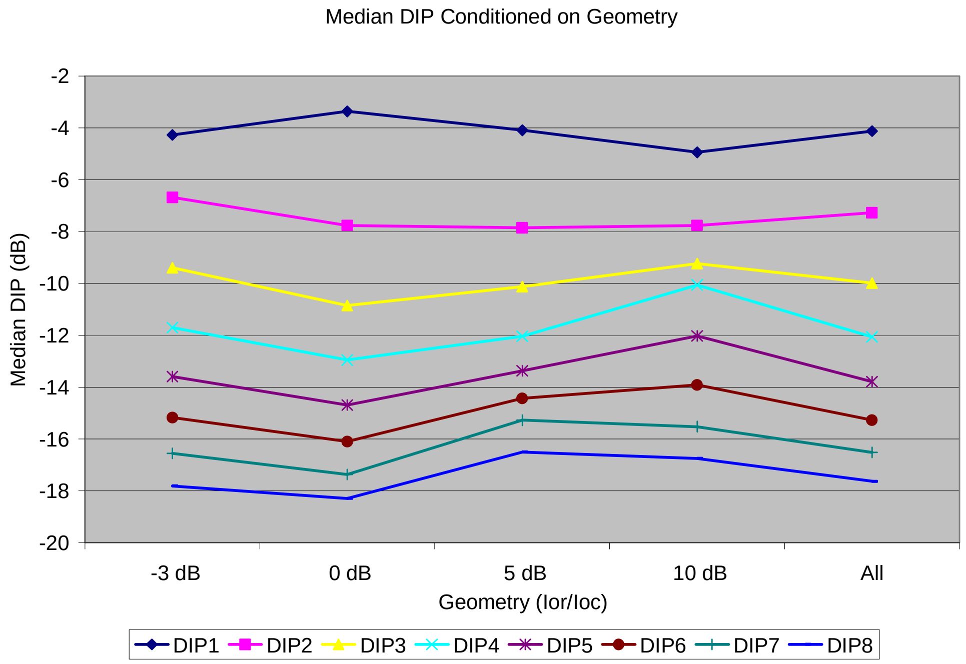

Figure 6.15: Conditional Median DIPs [11]

Thus, an interference profile was defined on the basis of averaging unconditional median DIP values submitted by four companies as shown in Table 6.1. It was agreed [15] that the interference profile would consist of the averaged set of five median DIP values and one residual interferer to model the remaining interference. It was also agreed that the residual interferer would be modeled as filtered AWGN. Based on the DIP values shown in Table 6.1, the ratio AWGN/I_{oc} should be set to -5.8 dB, which is equivalent to about 26% of the total other cell interference power. The AWGN source should be filtered using the pulse shaping filter defined in TS 25.104 to insure correct spectral properties. These median DIP values plus the residual AWGN were to be used with each of the geometries considered in the initial link level characterization. The geometry values used in that initial characterization were -3 dB, 0 dB, 5 dB and 10 dB, see clause 8.

Table 6.1: Interference Profile Based on Averaged Set of Unconditional Median DIP Values [14]

	Cingular	Qualcomm	Motorola	Nokia	**Average**
DIP_1	-4.1	-4.1	-4.4	-4.4	**-4.2**
DIP_2	-7.3	-7.3	-7.6	-8.0	**-7.5**
DIP_3	-10.0	-10.0	-10.5	-11.5	**-10.5**
DIP_4	-12.1	-12.0	-12.5	-14.0	**-12.6**
DIP_5	-13.8	-13.6	-14.1	-17.0	**-14.4**
AWGN/I_{oc}	-6.6	-6.7	-5.6	-4.6	**-5.8**
	22%	21%	28%	35%	**26%**

6.3 Interference profiles based on weighted average throughput gain

6.3.0 General

Upon reviewing the initial link level performance results for the interference profile based on median DIP values, some companies expressed concern that these values were too conservative, and led to under-estimation of the benefits of IC receivers. This led to the development of an alternative method for calculating DIP values based on what is called the "weighted average throughput gain" as described in [8]. This method develops multiple sets of DIP ratios, the resulting throughputs of which are averaged to find an average throughput gain. The set of DIP ratios closest to this average is then selected as the interference profile. Two profiles were ultimately defined, one for 0 dB geometry, and the other for

-3 dB geometry. The remainder of this clause describes the methodology used to define these two interference profiles along with their associated values. Note since the initial link level gains were negligible for the higher geometries (5 and 10 dB), the group agreed to focus on performance at the lower geometries, which is intuitively where an IC receiver is going to provide benefit.

6.3.1 0 dB geometry

The 0 dB geometry profile based on weighted average throughput gain was defined based on a methodology presented in [8] and explained further as follows. In the static system simulator, UEs were randomly placed throughout the simulated cells of interest. All of the randomly placed UEs with a geometry of near I_{or1}/I_{oc} = 0dB (±0.2 dB) were chosen and their DIP values were saved. This process was repeated for multiple realizations, until a significant number of samples were obtained. Then, the saved DIP values were sorted by DIP_1 and then binned in 5-percentile bands. One random sample was drawn from each 5-percentile band to obtain a total of 20 representative DIP ratio sets. Table 6.2 shows the 20 representative DIP ratio sets that were used to define the interference profile for the 0 dB case.

Table 6.2: DIP ratios for I_{or1}/I_{oc} = 0dB [8]

#	I_{or1}/I_{oc}	DIP_1	DIP_2	DIP_3	DIP_4	DIP_5	I_{oc}
1	-0.08	-8.22	-9.39	-9.99	-10.11	-10.73	-61.62
2	0.07	-6.35	-7.85	-8.09	-8.61	-9.47	-68.37
3	-0.01	-5.74	-6.41	-10.70	-11.19	-11.50	-54.74
4	0.05	-5.38	-7.48	-7.57	-7.68	-15.79	-60.59
5	-0.01	-4.94	-5.30	-8.05	-13.64	-14.11	-65.75
6	-0.09	-4.68	-5.73	-8.11	-12.38	-15.16	-57.44
7	-0.09	-4.40	-5.38	-8.73	-13.72	-13.80	-49.08
8	0.01	-4.14	-9.26	-10.12	-11.85	-13.54	-54.25
9	-0.06	-3.93	-8.89	-10.65	-11.50	-12.78	-65.95
10	0.09	-3.65	-7.36	-9.25	-12.49	-13.58	-63.34
11	0.02	-3.43	-8.55	-8.72	-11.52	-15.01	-63.50
12	-0.04	-3.17	-4.33	-14.32	-15.99	-18.96	-58.68
13	0.04	-3.00	-4.66	-13.34	-17.61	-20.61	-56.81
14	0.00	-2.75	-7.64	-8.68	-13.71	-14.59	-41.51
15	-0.05	-2.40	-4.99	-12.37	-18.32	-18.70	-47.09
16	-0.01	-2.12	-8.97	-9.13	-15.77	-17.90	-63.01
17	-0.03	-1.79	-11.42	-12.07	-14.54	-14.95	-65.39
18	0.04	-1.37	-9.47	-15.28	-16.42	-17.83	-69.25
19	0.07	-0.84	-14.86	-15.80	-16.01	-17.27	-51.90
20	0.08	-0.50	-11.39	-19.44	-21.55	-24.07	-53.99

Link level simulations were conducted for each of the above 20 representative sets of DIP ratios to obtain link level throughputs for each set. The average throughput gain over all 20 sets was then calculated. The DIP ratio set whose individual throughput gain was closest to the average throughput gain was then chosen as the DIP ratio set for the interference profile. For the data in Table 6.2, the DIP ratio set corresponding to row #14 was found to be the one with throughput gain closest to the average. The corresponding DIP values for this row are repeated in Table 6.3. These values were used in a second round of link level characterization for the 0 dB geometry case as described in clause 8.

Table 6.3 Interference Profile Based on Weighted Average Throughput for 0 dB Geometry [8]

DIP_1 [dB]	DIP_2 [dB]	DIP_3 [dB]	DIP_4 [dB]	DIP_5 [dB]
-2.75	-7.64	-8.68	-13.71	-14.59

6.3.2 -3 dB geometry

In the methodology used to define the interference profile for the 0 dB geometry case in clause 6.3.1 a random sample was drawn from each of the 20 5-percentile bins to obtain the 20 sets of representative DIP ratios. It was pointed out in [18] that due to this random draw, the interference profile defined in clause 6.3.1 was not repeatable by other companies. If repeatability is desired, an alternative method of obtaining 20 representative DIP ratio sets based on bin-averaging was proposed in [18]. According to this alternative method the DIP values calculated for each 5 percentile interval are based on the average of all of the values that fall within that bin. For example, for the I_{or1}/I_{oc} = -3 dB case, all UEs whose DIP_1 value is equal to -3 dB (±0.2 dB) are sorted according to DIP_1 and sampled at 5 percentile intervals to yield 20 groups. The 20 representative DIP values are the average of the DIP values observed by all UEs that fall within each of these 20 groups. The 20 sets of DIP values, calculated using the bin-averaging method for the -3 dB geometry case are shown in Table 6.4.

Table 6.4 DIP values for Ior/Ioc = -3 dB, sorted on 5th percentile increments. [19]

Bin #	Ior/Ioc	DIP_1	DIP_2	DIP_3	DIP_4	DIP_5
1	-2.998	-6.937	-7.659	-8.454	-9.608	-10.972
2	-2.994	-6.135	-7.058	-8.320	-9.880	-11.729
3	-3.007	-5.755	-6.761	-8.203	-10.258	-12.123
4	-3.003	-5.481	-6.616	-8.414	-10.446	-12.231
5	-3.016	-5.238	-6.392	-8.339	-10.864	-12.762
6	-2.992	-5.043	-6.398	-8.617	-10.961	-12.975
7	-3.003	-4.866	-6.498	-8.647	-11.006	-12.908
8	-3.001	-4.697	-6.423	-8.928	-11.357	-13.136
9	-2.983	-4.524	-6.180	-8.960	-11.626	-13.544
10	-2.993	-4.370	-6.210	-9.245	-11.654	-13.750
11	-2.984	-4.218	-6.148	-9.594	-11.979	-13.862
12	-2.996	-4.088	-6.202	-9.508	-12.007	-14.064
13	-3.001	-3.959	-6.205	-9.537	-12.151	-14.229
14	-3.002	-3.830	-6.435	-10.064	-12.304	-13.839
15	-2.996	-3.699	-6.537	-9.879	-12.378	-14.146
16	-2.994	-3.556	-6.362	-10.123	-12.648	-14.409
17	-3.007	-3.423	-6.515	-10.314	-12.788	-14.436
18	-2.998	-3.300	-6.598	-10.454	-12.785	-14.702
19	-2.975	-3.174	-6.772	-10.619	-12.882	-14.717
20	-2.897	-3.003	-7.078	-10.791	-13.061	-14.689

It was shown in [18], that both the random draw and bin-averaging methods produce the same throughput gains for the 0 dB geometry case and thus, either method was deemed acceptable for this case. However, this was not found to be the case for the -3 dB geometry condition, where in [19] there was shown to be a significant difference between the throughput gains for the two methods. A significant difference was also observed in [20] where throughput gains were compared using just the random draw method. Based on all of this, the group decided [21] to adopt the alternative method based on bin-averaging for the -3 dB geometry case, but to leave the interference profile defined for the 0 dB case in clause 6.3.1 unchanged since there was no significant difference in link level throughput results for this latter case.

Applying the "weighted average throughput gain" method to the data of Table 6.4 results in the selection of row #10 as the interference profile for the -3 dB geometry case. For clarity, the selected DIP values of row #10 are repeated in Table 6.5 below. Note in [19] the DIP ratio set is actually selected based on the weighted average throughput as opposed to the weighted average throughput gain, but the two methods were found to be nearly equivalent for the data analyzed, and in fact the former method gave a more consistent answer.

Table 6.5: Interference Profile based on Weighted Average Throughput for I_{or1}/I_{oc} = -3 dB [19]

DIP_1 [dB]	DIP_2 [dB]	DIP_3 [dB]	DIP_4 [dB]	DIP_5 [dB]
-4.37	-6.21	-9.25	-11.65	-13.75

6.4 Interference profiles based on field data

The interference profiles defined in clauses 6.3 and 6.4 are all based on the use of static system level simulators. These simulators are based on a homogeneous layout of hexagonal cells with uniformly distributed users. Thus, they fail to capture a number of real-world effects including non-homogeneity of cells, buildings/terrain, and non-uniform distribution of users, just to name a few. Even with these shortcomings, system level simulations are still extremely valuable since the results developed are typically repeatable and one can precisely control the environment. However, it is also very important to consider actual field data when attempting to determine the feasibility of an advanced UE receiver that is attempting to cancel interference from other cells as is being considered in this study item. To this end, several contributions were submitted during this effort, which describe a number of field measurements [9] [22] [23] [24]. These measurements provide additional insight into how well an IC receiver might actually perform in a real network. In addition, interference profiles conditioned on geometry were defined based on one of the sets of field data. Link level characterization using this latter set is described in clause 8. The following briefly describes some of the main observations that can be drawn from the field data plus the specifics of the field-based interference profiles.

In [22] interference data collected in a live UMTS network in Paris is described. The major observations from these measurements are as follows:

- For mobiles at the cell edge, there are in general no more than 3 interfering cells seen by the UE. In about 65% of the time, there are only 2 interferers detected.
- DIP 1 values are fairly high (when compared to other DIP values) and not too spread out, ranging between 0 and -4 dB, at geometry Ior/Ioc = 0.
- DIP 2 and DIP 3 values are more spread out.
- There are not enough 4[th] interferers detected to include in a meaningful statistical analysis.
- A 3-D representation of data confirmed the spread of DIP 2 in particular over a large range of values: from -2dB to about -13 dB.

In [23] field measurements are provided for an operational UMTS/HSDPA network in parts of greater and downtown Chicago. The results from these measurements indicate that for the 0 dB geometry case that most of the interfering energy when measured at the median points of the DIP CDF curves is contained in the first two interfering cells (78%). For -3 dB geometry, most of the interfering energy is in the first three interfering cells (coincidentally 78%).

Field measurements of DIP values recorded in central London are presented in [24]. DIP measurements were taken conditioned on the following values of geometry: -3, 0, 5, and 10 dB. Based on these measurements, DIP profiles were defined as shown in Table 6.6. These values are based on taking the median value of each respective DIP value for each of the geometries considered. Even though this approach (taking the median value) is thought to be conservative, the values in Table 6.6 are still more optimistic from an IC performance perspective than the other profiles previously defined, see clause 6.6. If one were to apply the "weighted average throughput gain" method to this field data, the results would be even more optimistic. Link level results based on the DIP ratios corresponding to -3 and 0 dB geometries are provided in clause 8.

One of the conclusions that can be drawn from all of the field measurements is that most of the interference is contained in the first two interfering cells with some energy in the third depending upon geometry. Very little energy was detected in the fourth and beyond, and thus, the use of five interfering cells in the simulation-based profiles may be bit of an over kill. The second conclusion is that field-based profiles are more optimistic than the simulation-based profiles and thus, performance in the real world (at least in those locations where the field data was collected) should be better than that predicted by the simulations.

Table 6.6: Interference Profiles Based on Field Data [24]

	$\hat{I}_{or1}/I_{oc}$			
DIP_i	**-3dB**	**0dB**	**5dB**	**10dB**
DIP_1	-4.1	-1.9	-1.8	-1.8
DIP_2	-6.3	-8.7	-8.5	-9.4
DIP_3	-9.1	-14.6	-15.8	-14.9
DIP_4	-12.1	-20.6	-21.7	-20.2
DIP_5	-15.3	-29.8	-31	-31

6.5 Summary

In summary, Table 6.7 shows the interference profiles that have been defined as part of this feasibility study to assess link level performance of IC receivers. The top entry reflects the median DIP values, which are to be used for all geometries considered. The next entry defines the two DIP profiles that were defined based on the weighted average throughput gain method for the 0 dB and -3 dB geometries, respectively. The last entry shows the DIP entries based on field data where we have limited the geometries to 0 and -3 dB once since there is where gain for IC receivers is expected. It is interesting to note when comparing these profiles that the median profile is actually quite close to both of the profiles conditioned on -3 dB geometry, and how really close the latter two are to each other. This suggests that the median profile probably should have only been used for the -3 dB geometry condition, and that it is important to condition the DIP ratios on geometry to obtain meaningful results. Link level performance results based on these interference profiles are presented in clause 8.

Table 6.7: Summary of Defined Interference Profiles

Profile	DIP1	DIP2	DIP3	DIP4	DIP5
Based on median values	-4.2	-7.5	-10.5	-12.6	-14.4
Based on weighted average throughput gain					
0 dB geometry	-2.75	-7.64	-8.68	-13.71	-14.59
-3 dB geometry	-4.37	-6.21	-9.25	-11.65	-13.75
Based on field data					
0 dB geometry	-1.9	-8.7	-14.6	-20.6	-29.8
-3 dB geometry	-4.1	-6.3	-9.1	-12.1	-15.3

7 Transmitted code/power characteristics

7.0 General

This clause describes the modelling methods and assumed characteristics of desired and interfering signals for this study.

7.1 Transmitted code and power characteristic in case of HSDPA

In the following clauses the modelling of code and power characteristics for serving and interfering cells is presented. The text is based on [29] aiming to merge the proposals presented in documents [25][26][27][28] accounting also the discussions held during RAN4#39. Also additional changes proposed in [30] and [31] were accounted as agreed in interim teleconference held between RAN4 meetings #41 and #42 [21].

For modelling the transmitted code and power domain characteristics in case of HSDPA, two difference scenarios are determined; the "HSDPA-only" and "HSDPA+R"99". The scenarios described in this clause are separated by the used HS-PDSCH power allocation and modelling of the associated dedicated channels. For "HSDPA-only", 66% HS-PDSCH power allocation is assumed with associated channels modeled as F-DPCH, and for "HSDPA+R"99" 50% and 25% allocations are assumed together with dedicated channels assumed as DPCH.

7.1.1 Common channels for serving and interfering cells

The common downlink channels and corresponding powers used in RAN4 HSDPA demodulation requirements with single transmit antenna are listed in the Table C.8 of TS25.101 [2]. Similar definitions exist also for open and closed loop transmit diversity requirements in Tables C.9 and C.10 in [2]. Table 7.1 below summarizes the common downlink physical channels for single transmit antenna case. As these figures can be considered to be quite representative, it is seen that these could be used also for the evaluation, for both, serving cell and interfering cells, in case of single transmit antenna.

Table 7.1: Downlink Physical Channels transmitted during a connection for HSDPA

Physical Channel	Power ratio	NOTE
P-CPICH	P-CPICH_Ec/Ior = -10 dB	Use of P-CPICH or S-CPICH as phase reference is specified for each requirement and is also set by higher layer signalling.
P-CCPCH	P-CCPCH_Ec/Ior = -12 dB	When BCH performance is tested the P-CCPCH_Ec/Ior is test dependent
SCH	SCH_Ec/Ior = -12 dB	This power shall be divided equally between Primary and Secondary Synchronous channels
PICH	PICH_Ec/Ior = -15 dB	

7.1.2 Serving cell

In this clause the definition of transmitted code and power characteristics are given for the serving cell.

7.1.2.1 Transmitted code and power characteristics for HSDPA+R"99 scenario

The assumed downlink physical channel code allocations for HSDPA+R"99 scenario is given in Table 7.2. Table 7.3 summarizes the power allocations of different channels for the serving cell in "HSDPA+R"99" scenario for 50 % or 25 % HS-PDSCH power allocation.

Ten HS-PDSCH codes have been reserved for user of interest in Table 7.2. Depending on the used fixed reference channel definition, H-SET3 or H-SET6, part of these may be left unused.

In total 46 SF=128 codes have been reserved for other users channels (OCNS). For HSDPA+R"99 scenario the (associated) dedicated channels of other users are modeled as DPCH. The amount of users present is dependent on the power remaining available after HSDPA allocation. For HSDPA power allocation of 50%, 18 users were fitted to cell. Correspondingly with HSDPA allocation of 25%, 34 users were fitted to the cell. The definition of the other user orthogonal channels and channel powers are given in Table 7.4 and Table 7.5. Power control behavior of the other users is introduced as described in Clause 7.1.4.

Table 7.2: Downlink physical channel code allocation for HSDPA+R"99

Channelization Code at SF=128	Note
0, 1	P-CPICH, P-CCPCH and PICH on SF=256
2…7	6 SF=128 codes free for OCNS
8…87	10 HS-PDSCH codes at SF=16
88…127	40 SF=128 codes free for OCNS

Table 7.3: Summary of modelling approach for the serving cell in HSDPA+R"99 scenarios

	Serving cell	
Common channels	0.195 (-7.1dB) As given in Table 7.1	
HS-PDSCH transport format	H-SET3 or H-SET6	
HS-PDSCH power allocation [E_c/I_{or}]	0.5 (-3dB)	0.25 (-6dB)
Other users channels	0.305 (-5.16dB) Set as given in Table 7.4	0.555 (-2.58dB) Set as given in Table 7.5

NOTE: The values given in decibel are only for information.

Table 7.4: Definition of 18 other users orthogonal channels on downlink scenario with 50% HS-PDSCH power allocation

Channelization Code Cch,SF,k	Ec/Ior	Channelization Code Cch,SF,k	Ec/Ior	Channelization Code Cch,SF,k	Ec/Ior
Cch,128,2	0.0204	Cch,128,98	0.0269	Cch,64,58	0.0294
Cch,128,4	0.0105	Cch,128,100	0.0170	Cch,128,121	0.0269
Cch,128,6	0.0115	Cch,128,102	0.0091	Cch,128,123	0.0204
Cch,128,88	0.0110	Cch,64,52	0.0232	Cch,128,125	0.0069
Cch,128,91	0.0112	Cch,128,109	0.0129		
Cch,128,93	0.0110	Cch,128,111	0.0178		
Cch,128,95	0.0316	Cch,128,114	0.0072		

Table 7.5: Definition of 34 other users orthogonal channels on downlink scenario with 25% HS-PDSCH power allocation

Channelization Code Cch,SF,k	Ec/Ior	Channelization Code Cch,SF,k	Ec/Ior	Channelization Code Cch,SF,k	Ec/Ior
$C_{ch,128,2}$	0.0229	$C_{ch,128,98}$	0.0129	$C_{ch,128,114}$	0.0110
$C_{ch,128,3}$	0.0182	$C_{ch,128,99}$	0.0162	$C_{ch,128,115}$	0.0110
$C_{ch,128,4}$	0.0076	$C_{ch,128,100}$	0.0170	$C_{ch,128,116}$	0.0110
$C_{ch,128,5}$	0.0155	$C_{ch,128,101}$	0.0102	$C_{ch,128,118}$	0.0316
$C_{ch,128,6}$	0.0245	$C_{ch,128,103}$	0.0182	$C_{ch,128,119}$	0.0269
$C_{ch,64,44}$	0.0304	$C_{ch,64,52}$	0.0379	$C_{ch,64,60}$	0.0261
$C_{ch,128,90}$	0.0081	$C_{ch,128,106}$	0.0132	$C_{ch,128,123}$	0.0120
$C_{ch,128,91}$	0.0065	$C_{ch,128,108}$	0.0229	$C_{ch,128,124}$	0.0115
$C_{ch,128,93}$	0.0069	$C_{ch,128,109}$	0.0145	$C_{ch,128,125}$	0.0132
$C_{ch,128,94}$	0.0110	$C_{ch,128,110}$	0.0115	$C_{ch,128,126}$	0.0110
$C_{ch,128,95}$	0.0135	$C_{ch,128,111}$	0.0200		
$C_{ch,128,96}$	0.0200	$C_{ch,128,113}$	0.0102		

7.1.2.2 Transmitted code and power characteristics for HSDPA-only scenario

The assumed downlink physical channel code allocations for the HSDPA-only scenario is given in Table 7.6. In the Table 7.7 power allocations for the serving cell is presented for HSDPA-only scenario.

For HSDPA-only scenario, as in Table 7.6, 14 codes are made available for the HS-DSCH as all the associated dedicated channels use F-DPCH. Depending on the used fixed reference channel definition, H-SET3 or H-SET6, part of these may be left unused. In order to permit comparable simulations to be performed using existing FRC definitions, an additional code multiplexed user is introduced to the serving cell of HSDPA-only scenario. As H-SET6 requires a maximum of 10 codes and H-SET3 requires 5 codes, additional code multiplexed user is defined in case of the serving cell. This additional code multiplexed user utilizes the rest of the available codes assumed to be available for HSDPA. The code channels intended for the additional code multiplexed user shall have equal power and common modulation. The power per code for H-SET6 shall be either 0.04 (-14 dB) when HS-DSCH Ec/Ior allocated for the DUT is 50%, or 0.1025 (-9.9 dB) when HS-DSCH Ec/Ior allocated for the DUT is 25%. The respective per code power allocations for H-SET3 are 0.01777 (-17.5 dB) and 0.04555 (-13.4 dB), see Tables 7.8 and 7.9. Used common modulation (QPSK or 16QAM) should be randomly selected with equal probability.

The definition of other users orthogonal channels is given in Table 7.10. The channelization code indices, $C_{ch,256,x}$ and $C_{ch,256,y}$ given at same row are considered as pair. At any given symbol instant, only symbol from either code channel is transmitted with the Ec/Ior given in the last column of the same row. The other code channel is DTX"ed. The code channel transmitted is selected randomly with even probability. This is done to account the structure of the F-DPCH.

Table 7.6: Downlink physical channel code allocation for HSDPA-only scenario

Channelization Code at SF=128	Note
0	P-CPICH, P-CCPCH and PICH on SF=256
1	
2…7	6 SF=128 codes free for OCNS
8…119	14 HS-PDSCH codes at SF=16
120…127	8 SF=128 codes free for OCNS

Table 7.7: Summary of the modelling approach for the serving cell in HSDPA-only scenarios

	Serving cell
Common channels	0.195 (-7.1dB) As given in Table 7.1
HS-PDSCH transport format	H-SET3 or H-SET6 for user of interest. Additional other HSDPA users code allocation is based on Table 7.8 for H-SET3 or Table 7.9 for H-SET6.
Total HS-PDSCH power allocation [E_c/I_{or}]	0.66 (-1.8dB)
HS-PDSCH power allocation for DUT (of the total) [E_c/I_{or}]	[0.5, 0.25] ([-3dB, -6dB])
Other users dedicated channels	0.14 (-8.54dB) Set according to Table 7.10.
NOTE: The values given in decibel are only for information.	

Table 7.8: Definition of additional code multiplexed users orthogonal channel for HSDPA-only scenario (H-SET3)

Channelization Code Cch,SF,k	Ec/Ior [dB]	Channelization Code Cch,SF,k	Ec/Ior [dB]	Channelization Code Cch,SF,k	Ec/Ior [dB]
Cch,16,6	Note1	Cch,16,7	Note1	Cch,16,8	Note1
Cch,16,9	Note1	Cch,16,10	Note1	Cch,16,11	Note1
Cch,16,12	Note1	Cch,16,13	Note1	Cch,16,14	Note1
NOTE 1: Used common modulation should be randomly selected for codes with equal probability. The code channels shall have equal power, either 0.01777 (-17.5 dB) when HS-DSCH E_c/I_{or} allocated for the DUT is -3dB or 0.04555 (-13.4 dB) when HS-DSCH E_c/I_{or} allocated for the DUT is -6dB.					

Table 7.9: Definition of additional code multiplexed users orthogonal channel for HSDPA-only scenario (H-SET6)

Channelization Code Cch,SF,k	Ec/Ior [dB]	Channelization Code Cch,SF,k	Ec/Ior [dB]	Channelization Code Cch,SF,k	Ec/Ior [dB]
Cch,16,11	Note2	Cch,16,12	Note2	Cch,16,13	Note2
Cch,16,14	Note2				
NOTE 2: Used common modulation should be randomly selected for codes with equal probability. The code channels shall have equal power, either 0.04 (-14 dB) when HS-DSCH E_c/I_{or} allocated for the DUT is -3dB or 0.1025 (-9.9 dB) when HS-DSCH E_c/I_{or} allocated for the DUT is -6dB.					

Table 7.10: Definition of other users orthogonal channels on downlink for HSDPA-only scenario

Channelization Code Cch,SF,x	Channelization Code Cch,SF,y	Ec/Ior
Cch,256,4	Cch,256,243	0.0135
Cch,256,5	Cch,256,244	0.0200
Cch,256,249	Cch,256,246	0.0129
Cch,245,8	Cch,256,247	0.0166
Cch,256,9	Cch,256,6	0.0170
Cch,256,11	Cch,256,250	0.0102
Cch,256,240	Cch,256,253	0.0182
Cch,256,242	Cch,256,255	0.0316

7.1.3 Interfering cells

In this clause the definition of transmitted code and power characteristics are given for the interfering cells.

7.1.3.1 Transmitted code and power characteristics for HSDPA+R"99 scenario

For the interfering cells in HSDPA+R"99 scenario, same downlink physical channel code allocations are assumed as given in Table 7.2. The modelling is summarized in Table 7.11 for HSDPA+R"99 scenario for interfering cells.

Table 7.11: Summary of modelling approach for the interfering cells in HSDPA+R"99 scenarios with power allocation of 50% and 25%

	Interfering cell(s)
Common channels	0.195 (-7.1dB) As given in Table 7.1
HS-PDSCH transport format	Selected randomly from Table 7.12. Independent for each interferer.
HS-PDSCH power allocation [E_c/I_{or}]	0.5 (-3dB)
Other users channels	0.305 (-5.16dB) Set according to Table 7.4.
NOTE: The values given in decibel are only for information.	

The HS-PDSCH transmission for interfering cells is modelled to have randomly varying modulation and number of codes to model the actual dynamic system behaviour to some extent. The predefined modulation and code allocations are given in Table 7.12. The transmission from each interfering cell is randomly and independently selected every HSDPA sub-TTI among the four options given in the table.

Table 7.12: Predefined interferer transmission for HSDPA+R"99 scenario

#	Used modulation and number of HS-PDSCH codes
1	QPSK with 5 codes
2	16QAM with 5 codes
3	QPSK with 10 codes
4	16QAM, with 10 codes

The modelling of the other users dedicated channels is done in same way as in the case of the serving cell. The definition of the other users" orthogonal channels and channel powers are given in Table 7.4. As fixed HSDPA power allocation (50%) is assumed for interfering cells, only one definition set is enough.

7.1.3.2 Transmitted code and power characteristics for HSDPA-only scenario

Same downlink physical channel code allocations as for serving cell, given Table 7.6, are used for the interfering cells in HSDPA-only scenario. The modelling of the transmission of the interfering cells for HSDPA-only scenario is summarized in Table 7.13.

Table 7.13: Summary of modelling approach for the interfering cells in HSDPA-only scenarios

	Interfering cell(s)
Common channels	0.195 (-7.1dB) As given in Table 7.1
HS-PDSCH transport format	Selected randomly from Table 7.14. Independent for each interferer.
Total HS-PDSCH power allocation [E_c/I_{or}]	0.66 (-1.8dB)
Other users channels	0.14 (-8.54 dB) Set according to the Table 7.10
Note: The values given in decibel are only for information.	

Similarly as in case of HSDPA+R"99 scenario the HS-PDSCH transmission is modeled as having varying modulation and allocation of codes. This is done by selecting a code and modulation format from a group of predefined sets, as given in Table 7.14. Three different options are determined, with one option including code multiplexing. In case of the code multiplexing for the interfering HS-DSCH transmission (e.g. option #3) the power is divided equally between the two assumed users having different modulation.

Table 7.14: Predefined interferer transmission for HSDPA-only scenario

#	Used modulation and number of HS-PDSCH codes
1	QPSK with 14 codes
2	16QAM, with 14 codes
3	QPSK with 7 codes and 16QAM with 7 codes

7.1.4 Model for the power control sequence generation

In this clause the modelling of power control behavior for the other users channels is given. In the assumed approach the power of each user, *i* at slot *n*, equals P_n^i in dB. The power is varied randomly, either by increasing or decreasing it by 1dB steps in each slot, i.e. $P_n^i = P_{n-1}^i + \Delta$, where $\Delta \in \{-1,+1\}$. The probability of Δ having a value of +1 for the i^{th} user at time instant *n* can be determined as

$$\Pr_n^i(\Delta = +1) = 0.5 - (P_{n-1}^i - P_0^i)\frac{0.5}{L}, \qquad (1)$$

where, P_{n-1}^i is the transmitted power at time instant *n*-1 and P_0^i is the initial value of the i^{th} users power in dB. The initial transmit power values P_0^i for different users are given in Tables 7.4 and 7.5 in absolute values. *L* is a scaling factor which can be used to determine the range to which the variation of power is confined. The value of *L* is set to10, leading to variance of 5 dB.

In order to minimize the impact to test equipment due to power control modelling the total OCNS power is intended to be normalized. Thus the power control sequence for each user is generated as described above. The actual applied transmit power $\hat{P}_n^i$ (in linear domain) for the i^{th} user would still be normalized by the total sum power of different users, defined as

$$\hat{P}_n^i = \frac{P_{lin,n}^i}{\sum_i P_{lin,n}^i} \sum_i P_{lin,0}^i . \qquad (2)$$

where $P_{lin,n}^i$ is the transmitted power at time instant n and $P_{lin,0}^i$ is the initial value of the i^{th} user"s power in linear domain. The normalization has implications to the power variation of each user.

8 Link performance characterization

8.0 General

The purpose of this clause is to summarize the link-level simulation results that were provided by the companies that supported this study item. Emphasis is on results that were based on agreed set of simulation parameters. However, a complete list of results is given in the appendix of this clause.

8.1 Overview

This overview is meant to be a brief synopsis of the framework in which link-level simulations were performed. More detailed information regarding such topics as code modelling, system scenarios, and interference modelling are available elsewhere in this report. As described in clause 6 system simulations were performed by participating companies in order to reach an agreement on link-level simulation parameters. The main focus of this work was determining the number of interfering Node-Bs and associated set of DIP values and geometries to be used. Based on these simulation studies it was decided to set the number of interfering Node-Bs to five. Also, a single set of median DIP values would be used for selected geometries. See Table 8.1 for these and other referenced DIP values. In the course of this study it was proposed that median DIP values might give a pessimistic assessment of the potential gain that a LMMSE receiver with interference cancellation capability might provide. It was decided that the DIP values should be modified to take into account the potential gains at low geometries. Consequently a 2nd set of DIP values were accepted for link-level simulation purposes. In this case the DIP values are a function of the operating geometry; 0 or -3 dB. Afterwards, there was discussion regarding the method of generation of these DIP values. Subsequently it was decided to accept a modified DIP for geometry -3 dB. Contributions that investigated the DIP issue based on field measurements were also presented; simulations using these derived values were presented.

Table 8.1: DIP values (dB) used during progression of SI

Evolution	DIP1	DIP2	DIP3	DIP4	DIP5	Status
Median	-4.2	-7.5	-10.5	-12.6	-14.4	Obsolete
Weighted G=0	-2.75	-7.64	-8.68	-13.71	-14.59	Active
Weighted G=-3	-3.21	-5.56	-10.01	-12.67	-15.53	Obsolete
Revised Weighted G=-3	-4.37	-6.21	-9.25	-11.65	-13.75	Active
Field Measurement G=0	-1.9	-8.7	-14.6	-20.6	-29.8	Information
Field Measurement G=-3	-4.1	-6.3	-9.1	-12.1	-15.3	Information

8.2 Simulation results

The following clauses 8.2.1 - 8.2.3 show the average relative gains as demonstrated by a type 2i over a type 2 receiver or a type 3i over a type 3 receiver. (As noted in clause 8.2.1, it was eventually decided that this SI would concentrate on the type 3 / 3i configuration. However, the type 2 / 2i results are given for completeness; similarly like simulation results for the obsolete DIP sets.) For a given simulation condition, average relative gain is defined as the ratio of the FRC throughput of the type 2i or 3i receiver to the throughput of the type 2 or 3 receiver, respectively. This "normalized" numerical result allows for a readily discernable evaluation of the efficacy of the type 2i / 3i receiver. However, this single quantity may not tell the complete story. If for example, the relative gain for a given channel condition is shown to be 7.0 for a 16QAM configuration, while the relative gain is 1.3 for QPSK under the same condition, the utility of the 16QAM value is of little practical importance if the actual throughput values are 7 Kb/s and 1 Kb/s for the type i and non type i receivers. Whereas, if for the same channel condition the QPSK throughput values are 195 Kb/s and 150 Kb/s for the different receivers, these values might be considered substantial and useful gains. Therefore, the corresponding average FRC throughput values are shown - expressed as ratio of integers - for all relative gains[2].

8.2.1 Types 2 and 2i - median DIP values

Tables 8.2 and 8.3 show the relative average gains and throughputs of the type 2i / 2 receivers for the various signal levels and channel conditions as indicated for the HSet-6 HSDPA+R99 QPSK and 16QAM scenarios, respectively. These sets of statistics are based on the contributions of six companies; see Appendix, Tables 8.A1 - 8.A2[3]

Table 8.2: HSet-6 QPSK gains and throughputs for types 2i / 2 receivers for HSDPA+R99 with median DIP values

QPSK HSet6	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	1.22 179 / 146	1.04 973 / 933	1.01 1645 / 1635	1.44 130 / 91	1.05 1040 / 992	1.01 1707 / 1693
-3	1.08 785 / 728	1.03 1626 / 1583	1.00 2594 / 2587	1.10 838 / 764	1.02 1636 / 1600	1.00 2505 / 2493

[2] It should be noted that the relative gains and ratio of throughput values may not be equal. This is due to the fact that average of a set of ratios, is not equal to the average of the numerators divided by the average of the denominators.

[3] Due to the nature of this section, where a considerable number of contributions are condensed into a single statistic, direct reference is not made to the contribution(s). Rather, the "raw data" of the contributions are given in a set of tables in the appendix; the tables give the RAN4 TD numbers for the individual values, this TD may be cross-referenced in the Reference section for the complete title and date.

Table 8.3: HSet-6 16 QAM gains and throughputs for types 2i / 2 receivers for HSDPA+R99 with median DIP values

16QAM HSet6	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	2.03 7 / 5	1.09 394 / 362	1.01 1375 / 1363	1.00 1 / 1	1.19 373 / 312	1.02 1560 / 1490
-3	1.22 247/202	1.04 1355 / 1303	1.01 2188 / 2176	1.30 166 / 132	1.04 1422 / 1360	1.01 2288 / 2260

Tables 8.4 and 8.5 give simulation results similar to above but for HSet-3. In this case the statistics are based on two contributing companies; see Appendix, Table 8.A4 and 8.A5.

Table 8.4: HSet-3 QPSK gains and throughputs for types 2i / 2 receiver for HSDPA+R99 with median DIP values

QPSK HSet3	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	1.06 407 / 382	1.02 809 / 825	0.99 1301 / 1311	1.06 435 / 410	1.01 735 / 728	1.00 1277 / 1270
-3	1.04 738 / 712	1.01 1305 / 1294	0.96 1520 / 1579	1.03 732 / 712	1.00 1097 / 1094	1.00 1546 / 1546

Table 8.5: HSet-3 16QAM Gains and throughputs for types 2i / 2 receiver for HSDPA+R99 with median DIP values

16QAM HSet3	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	1.23 146 / 120	1.02 725 / 712	1.01 1150 / 1138	1.46 127 / 89	1.05 770 / 735	1.01 1217 / 1200
-3	1.07 599 / 562	1.02 1124 / 1104	1.01 1724 / 1707	1.07 618 / 576	1.02 1148 / 1127	1.01 1795 / 1682

From the above tables it can be observed that for geometries of 5 or 10 dB the gains are generally small, with all gains less than 1.10 except for one case where the gain is 1.19. The average of the gains for geometries 5 and 10 dB is 1.02. This average is based on all modulation types, signal levels, channels, and scenarios. The average relative gain for geometry 0 dB is 1.10 when the average is computed only over the better performing modulation scheme for a given channel and signal level; this is always QPSK in these cases.

8.2.2 Types 3 and 3i - median DIP values

Tables 8.6 and 8.7 give the relative gains and absolute ratios for receiver types 3 and 3i for HSet-6 and the indicated modulation with the use of the median DIP values. These statistics are based on appendix Tables 8.A10 and 8.A11.

Table 8.6: HSet-6 QPSK gains and throughputs for types 3i / 3 receivers for HSDPA+R99 with median DIP values

QPSK HSet6	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	1.16 1001/861	1.04 1865 / 1790	1.00 3005 / 2994	1.15 1042 / 908	1.05 1845 / 1759	1.01 2880 / 2850
-3	1.09 1630 / 1490	1.03 2941 / 2854	1.00 3218 / 3217	1.09 1619 / 1485	1.04 2771 / 2660	1.00 3212 /3209

Table 8.7: HSet-6 16QAM gains and throughputs for types 3i / 3 receivers for HSDPA+R99 with median DIP values

16QAM HSet6	PB3			VA30		
Signal Level	G (dB)	G(dB)	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	0	5	10	0	5	10
-6	1.66	1.05	1.03	2.41	1.06	1.02
	360 / 217	1643 / 1560	2541 / 2469	311 / 128	1673 / 1577	2530 / 2466
-3	1.16	1.03	1.01	1.17	1.04	1.02
	1393 / 1201	2384 / 2303	3915 / 3862	1436 / 1230	2409 / 2320	3676 / 3607

From the tables for types 3i and 3 receivers simulated under the median DIP set, the average gain computed over geometries 5 and 10 dB is 1.03. Based on these results, including the type 2i / 2 receivers, it was decided to limit the study item to lower geometries, specifically -3 and 0 dB.

The average relative gain for geometry 0 dB is 1.13 when the average is computed only over the better performing modulation scheme for a given channel and signal level; like the types 2i / 2 case, this is for QPSK modulation. It was decided that only the type 3i / 3 case would be further studied. This decision was not based solely on the gain of 1.13 of the type 3i / 3 compared to the 1.10 gain of the type 2i / 2, as the performance gains are somewhat comparable. However, when the absolute throughput values at geometry 0 dB are compared for both receiver groups, the larger throughputs of the 3i receiver influenced the decision to limit the study item to the 3i / 3 case.

8.2.3 Weighted DIPS: geometries -3 & 0 dB

As indicated in the Overview of this clause the study group decided to use a set of weighted DIP values rather than median DIP values in order to more realistically determine the potential gain of the type 3i receiver under low geometry conditions. Tables 8.8 and 8.9 show the results when these weighted DIPs were used for simulation. In this case these tables represent the combined results of the HSDPA+R99 and HSDPA only scenarios. Specifically, there were 6 independent contributions for the HSDPA+R99 scenario, and 2 to 4 independent contributions, dependent upon the channel condition and geometry, for the HSDPA only scenario. In order to maximize the number of samples for averaging the results of both scenarios were combined. However, if a company contributed to HSDPA+R99 and HSDPA scenario, then just the HSDPA only scenario was used in the averaging. Because of the very close values for HSDPA+R99 and HSDPA only scenarios as observed when a given company submitted for both sets - this and prior simulations - it is believed that this is valid statistic. See appendix Tables 8.A16 through 8.A21

Tables 8.8 and 8.9 show the substantial relative gain that a type 3i receiver may realize over a type 3 at the low geometries of 0 and -3 dB. Also, it should be noted that these gains are at very useful throughput values. Again QPSK shows the better performance, though at geometry 0 dB and Ec/Ior = -3 dB, the difference between QPSK and 16QAM is fairly close.

Table 8.8: HSet-6 QPSK gains and throughputs for types 3i / 3 receivers with weighted DIP values

QPSK HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	2.79	1.32	3.81	1.30
	508 / 209	1113 / 852	618 / 177	1171 / 904
-3	1.38	1.18	1.31	1.20
	1224 / 894	1780 / 1509	1292 / 983	1805 / 1498

Table 8.9: HSet-6 16QAM gains and throughputs for types 3i / 3 receivers with weighted DIP values

16QAM HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	5.46	2.51	30.50	4.54
	34 / 7	439 / 189	16 /1	480 / 106
-3	2.58	1.32	4.14	1.30
	721 / 297	1516 / 1147	837 / 229	1590 / 1225

8.2.4 Revised DIP: geometry -3 dB

As discussed in Clause 6.3.2 it was decided to use a revised weighted DIP value for geometry -3 dB. Tables 8.10 and 8.11 show the average throughput and gain values based on the contributions that incorporated this modified DIP set. Again, these statistics are based on a combined set of HSDPA and HSDPA+R99 results. These simulations also include the modified set of OCNS codes that were concurrently agreed to when the revised DIP for geometry -3 dB was established. The tables show that for geometry -3 dB there is a small reduction in the average relative gains due to the revised DIP; compare to Tables 8.8 and 8.9.Whereas for a geometry of 0 dB there is a lesser degradation in the gains, especially for the QPSK values which tend to represent the more useful modulation scheme for these signal levels and geometries. (Only at geometry 0 dB and Ec/Ior = - 3 dB does 16QAM approach the QPSK average throughput values.) Because the DIP value was not changed for 0 dB it is to be expected that there should be little change in the prior results as shown in Tables 8.8 and 8.9 compared to those of 8.10 and 8.11 at 0 dB. Probably most of the change is due to the sample size for geometry 0 dB. In this case there were only 3 and 2 sets of independent simulation results for PB3 and VA30, respectively. Whereas for geometry - 3 dB there are 7 and 6 sets for PB3 and VA30. See appendix Tables 8.A22 - 8.A31 for the complete set of simulation results, which include similar contributions for H-Set 3.

Table 8.10: HSet-6 QPSK gains and throughputs for types 3i / 3 receivers with revised DIP values

QPSK HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	2.05	1.36	3.02	1.30
	406 / 201	1216 / 889	409 / 142	1177 / 911
-3	1.24	1.20	1.22	1.20
	1159 / 932	1857 / 1542	1175 / 964	1811 / 1514

Table 8.11: HSet-6 16QAM gains and throughputs for types 3i / 3 receivers with revised DIP values

16QAM HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	3.98	2.18	5.00	4.14
	20 / 5	570 / 262	4 / 1	571 / 144
-3	2.01	1.31	3.15	1.29
	537 / 269	1641 / 1239	567 / 185	1613 / 1254

8.2.5 Power control

As explained in Clause 7 it was decided to investigate two methods to model the effects of power control. These two methods are referred to "normalized" and "un-normalized" power control. Based on the contributions by participating companies the simulation results showed that power control had relatively little effect on the average throughput and relative gains; see appendix Table 8.A32 - 8.A39, For example, based on appendix Table 8.A32, for H-Set 6 QPSK HSDPA+R99 scenario with geometry -3 dB and propagation channel PB3 the average un-normalized throughput relative to no power control was 0.93, and for normalized it was 1.04. For the same conditions for geometry 0 dB the relative un-normalized throughput is 0.97, while the normalized is 1.00. Note: this is based on only two independent sets of simulation results, but there is a strong similar consistency throughout the submitted data[4]. Consequently the relative throughput gains due to interference cancellation are only negligibly modified by power control. This is due to the structure of the reference receiver, the LMMSE. This statement of course may not hold in general when other types of receivers may be subjected to power controlled signals. Finally, it is reasonable to conjecture that the un-normalized power control induces instances of larger interference compared to the normalized power control. Therefore, there is somewhat greater degradation due to un-normalized power control.

8.2.6 Field based DIP

As outlined in clause 6.4 there were contributions addressing the modelling of DIP values based on field measurements. Subsequently, simulation results utilizing these field measurements were contributed. Table 8.1 gives the DIP sets for geometries 0 and -3 dB based on certain field measurements. Tables 8.12 and 8.13 give the simulated average throughput and relative gains for the stated conditions using these DIP values. The relative gain results for the QPSK H-

[4] The reason for the small sample size of averaged data is due to the lack of multiple data sets that share the same set of conditions.

Set 6 in Table 8.12 are within 15% or less of the similar values for the weighted revised DIP values shown in Table 8:10. The same comment is true regarding the corresponding 16QAM values shown in Tables 8.13 and 8.11. The results in this clause are based on appendix Tables 8.A40 and 8.A41.

Table 8.12: QPSK gains and throughputs for types 3i / 3 receivers with field based DIP values for propagation channel PB3 and HSDPA only scenario

QPSK	H-Set 6		H-Set 3	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	2.33	1.50	1.31	1.28
	511 / 220	1388 / 928	675 / 514	1033 / 808
-3	1.31	1.26	1.16	1.24
	1331 / 1013	2030 / 1608	954 / 821	1505 / 1217

Table 8.13: 16QAM gains and throughputs for types 3i / 3 receivers with field based DIP values for propagation channel PB3 and HSDPA only scenario

16QAM	H-Set 6	H-Set 3
Signal Level	G (dB)	G (dB)
Ec/Ior (dB)	0	0
-6	NA	1.38
		939 / 678
-3	1.41	1.24
	1855 / 1313	1346 / 1085

8.2.7 Types 2i / 2 receivers: weighted & revised DIPS

As this SI progressed there was a group decision to limit this SI to types 3i and 3 receivers [R4-061080]. However, there was one set of simulation results that reported throughput values and relative gains for types 2i / 2 receivers using the revised DIP for geometry -3 dB, and the weighted DIP for geometry 0 dB. Tables 8.14 and 8.15 show the results for H-Set 6 under the stated conditions. A comparison of these tables with Tables 8.10 and 8.11 show similar relative gains for conditions that lead to non-negligible throughput values; that is primarily corresponding to QPSK and Ec/Ior = -3dB conditions. See appendix Tables 8.A42 - 8.A45 for the complete set of data.

Table 8.14: HSet-6 QPSK gains and throughputs for types 2i / 2 receivers with revised DIP values

QPSK HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	1.55	1.97	4.00	2.79
	17 / 11	333 / 169	4 / 1	243 / 87
-3	1.36	1.33	1.64	1.35
	367 / 269	942 / 707	275 / 168	1023 / 757

Table 8.15: HSet-6 16QAM gains and throughputs for types 2i / 2 receivers with revised DIP values

16QAM HSet6	PB3		VA30	
Signal Level	G (dB)	G (dB)	G (dB)	G (dB)
Ec/Ior (dB)	-3	0	-3	0
-6	NA	1.69	NA	NA
	0 / 0	22 / 13	0 / 0	1 / 0
-3	1.06	1.98	NA	2.98
	17 / 16	441 / 223	3 / 0	295 / 99

8.3 Appendix

The tables contained in this appendix represent the totality of the simulations results contributed by the participating parties. It also shows the values that were used for computing the statistics in clauses 8.2. The following tables are contained herein:

Table 8.A1 Type 2i / 2, HSDPA + R99, PB3, H-Set6, Median DIP
Table 8.A2 Type 2i / 2, HSDPA + R99, VA30, H-Set 6, Median DIP

Table 8.A1: Type 2i / 2, HSDPA + R99, PB3, H-Set6, Median DIP

Rx Type	2	2	2i	2i	2	2	2i	2i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Motorola	9	198	11	244	0	12	0	14	1.22	1.23	NA	1.17	R4-060841
Average	9	198	11	244	0	12	0	14	1.22	1.23	NA	1.17	
G = 0 dB													
Ericsson	157	749	186	792	0	278	0	323	1.18	1.06	NA	1.16	R4-060884
Fujitsu	134	745	177	781	1	167	5	222	1.32	1.05	5.00	1.33	R4-060954
Intel	137	712	142	740	5	175	6	185	1.04	1.04	1.20	1.06	R4-060981
Motorola	131	692	156	763	5	161	6	194	1.19	1.10	1.20	1.20	R4-060841
Nokia	158	743	206	833	5	229	8	302	1.30	1.12	1.60	1.32	R4-060909
Tensorcomm	160	725	205	803	12	203	14	258	1.28	1.11	1.17	1.27	R4-070282
Average gain	146	728	179	785	5	202	7	247	1.22	1.08	2.03	1.22	
G= 5 dB													
Ericsson	959	1585	1007	1632	428	1446	454	1497	1.05	1.03	1.06	1.04	R4-060884
Fujitsu	939	1602	959	1618	304	1269	352	1302	1.02	1.01	1.16	1.03	R4-060954
Intel	890	1556	905	1569	289	1224	288	1224	1.02	1.01	1.00	1.00	R4-060981
Motorola	908	1578	965	1633	306	1191	342	1269	1.06	1.03	1.12	1.07	R4-060841
Nokia	960	1633	1005	1676	407	1372	452	1440	1.05	1.03	1.11	1.05	R4-060909
Tensorcomm	940	1544	998	1629	440	1313	474	1396	1.06	1.06	1.08	1.06	R4-070282
Average gain	933	1583	973	1626	362	1303	394	1355	1.04	1.03	1.09	1.04	
G = 10 dB													
Ericsson	1661	2554	1699	2593	1493	2255	1514	2290	1.02	1.02	1.01	1.02	R4-060884
Fujitsu	1630	2659	1624	2640	1344	2170	1350	2175	1.00	0.99	1.00	1.00	R4-060954
Intel	1543	2453	1545	2465	1201	2060	1198	2064	1.00	1.00	1.00	1.00	R4-060981
Motorola	1661	2610	1691	2656	1313	2138	1357	2168	1.02	1.02	1.03	1.01	R4-060841
Nokia	1680	2658	1664	2616	1464	2256	1456	2244	0.99	0.98	0.99	0.99	R4-060909
Average gain	1635	2587	1645	2594	1363	2176	1375	2188	1.01	1.00	1.01	1.01	

Table 8.A2: Type 2i / 2, HSDPA + R99, VA30, H-Set 6, Median DIP

Rx Type	2	2	2i	2i	2	2	2i	2i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Motorola	3	137	4	177	0	3	0	4	1.33	1.29	NA	1.33	R4-060841
Average gain	3	137	4	177	0	3	0	4	1.33	1.29	NA	1.33	
G = 0 dB													
Ericsson	140	888	199	956	2	213	2	297	1.42	1.08	1.00	1.39	R4-060884
Fujitsu	73	717	110	739	1	167	0	123	1.51	1.03	NA	0.74	R4-060954
Intel	105	755	105	774	1	123	1	133	1.00	1.03	1.00	1.08	R4-060981
Motorola	84	720	116	797	2	98	2	128	1.38	1.11	1.00	1.31	R4-060841
Nokia	81	754	152	920	0	114	0	212	1.88	1.22	NA	1.86	R4-060909
Tensorcomm	65	748	96	841	0	74	0	104	1.48	1.12	NA	1.41	R4-070282
Average gain	91	764	130	838	1	132	1	166	1.44	1.10	1.00	1.30	
G= 5 dB													
Ericsson	1102	1696	1166	1746	557	1586	669	1663	1.06	1.03	1.20	1.05	R4-060884
Fujitsu	929	1548	934	1552	224	1228	257	1252	1.01	1.00	1.15	1.02	R4-060954
Intel	971	1574	977	1577	285	1307	286	1312	1.01	1.00	1.00	1.00	R4-060981
Motorola	960	1581	1032	1635	255	1271	323	1354	1.08	1.03	1.27	1.07	R4-060841
Nokia	995	1605	1079	1675	305	1402	409	1525	1.08	1.04	1.34	1.09	R4-060909
Tensorcomm	996	1596	1051	1631	248	1364	291	1425	1.06	1.02	1.17	1.04	R4-070282
Average gain	992	1600	1040	1636	312	1360	373	1422	1.05	1.02	1.19	1.04	
G = 10 dB													
Ericsson	1879	2673	1915	2702	1808	2543	1865	2602	1.02	1.01	1.03	1.02	R4-060884
Fujitsu	1573	2395	1565	2368	1305	2105	1301	2118	0.99	0.99	1.00	1.01	R4-060954
Intel	1608	2389	1605	2396	1386	2150	1378	2155	1.00	1.00	0.99	1.00	R4-060981
Motorola	1692	2485	1738	2527	1396	2173	1458	2232	1.03	1.02	1.04	1.03	R4-060841
Nokia	1713	2523	1712	2532	1553	2327	1580	2334	1.00	1.00	1.02	1.00	R4-060909
Average gain	1693	2493	1707	2505	1490	2260	1516	2288	1.01	1.00	1.02	1.01	

Table 8.A3: Type 2i / 2, HSDPA + R99, PA3, H-Set 6, Median DIP

Rx Type	2	2	2i	2i	2	2	2i	2i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Fujitsu	378	834	422	893	113	486	161	547	1.12	1.07	1.42	1.13	R4-060954
G= 5 dB													
Fujitsu	1181	1914	1197	1892	782	1476	823	1535	1.01	0.99	1.05	1.04	R4-060954
G = 10 dB													
Fujitsu	2173	2633	2113	2596	1806	2878	1816	2852	0.97	0.99	1.01	0.99	R4-060954

Table 8.A4: Type 2i / 2, HSDPA + R99, PB3, H-Set 3, Median DIP

Rx Type	2	2	2i	2i	2	2	2i	2i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Ericsson	380	714	413	745	143	581	166	631	1.09	1.04	1.16	1.09	R4-060884
Fujitsu	384	710	400	730	96	543	125	567	1.04	1.03	1.30	1.04	R4-060954
Average gain	382	712	407	738	120	562	146	599	1.06	1.04	1.23	1.07	
G= 5 dB													
Ericsson	810	1277	831	1301	740	1107	755	1129	1.03	1.02	1.02	1.02	R4-060884
Fujitsu	808	1311	819	1309	683	1101	695	1118	1.01	1.00	1.02	1.02	R4-060954
Average gain	809	1294	825	1305	712	1104	725	1124	1.02	1.01	1.02	1.02	
G = 10 dB													
Ericsson	1285	1582	1301	1586	1142	1706	1166	1725	1.01	1.00	1.02	1.01	R4-060884
Fujitsu	1337	1576	1300	1454	1133	1708	1134	1723	0.97	0.92	1.00	1.01	R4-060954
Average gain	1311	1579	1301	1520	1138	1707	1150	1724	0.99	0.96	1.01	1.01	

Table 8.A5: Type 2i / 2, HSDPA + R99, VA30, H-Set 3, Median DIP

Rx Type	2	2	2i	2i	2	2	2i	2i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Ericsson	451	733	486	763	129	653	179	708	1.08	1.04	1.39	1.08	R4-060884
Fujitsu	369	690	384	700	49	499	75	528	1.04	1.01	1.53	1.06	R4-060954
Average gain	410	712	435	732	89	576	127	618	1.06	1.03	1.46	1.07	
G= 5 dB													
Ericsson	676	1001	685	1015	815	1180	845	1211	1.01	1.01	1.04	1.03	R4-060884
Fujitsu	780	1187	784	1178	654	1073	695	1085	1.01	0.99	1.06	1.01	R4-060954
Average gain	728	1094	735	1097	735	1127	770	1148	1.01	1.00	1.05	1.02	
G = 10 dB													
Ericsson	1335	1563	1365	1575	1293	1786	1324	1830	1.02	1.01	1.02	1.02	R4-060884
Fujitsu	1205	1528	1189	1516	1107	1577	1110	1579	0.99	0.99	1.00	1.00	R4-060954
Average gain	1270	1546	1277	1546	1200	1682	1217	1705	1.00	1.00	1.01	1.01	

Table 8.A6: Type 2i / 2, HSDPA + R99, PA3, H-Set 3, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Fujitsu	424	771	458	773	260	569	299	614	1.08	1.00	1.15	1.08	R4-060954
G= 5 dB													
Fujitsu	964	1232	955	1213	787	1289	814	1303	0.99	0.98	1.03	1.01	R4-060954
G = 10 dB													
Fujitsu	1317	1468	1300	1454	1484	1856	1467	1837	0.99	0.99	0.99	0.99	R4-060954

Table 8.A7: Type 3i / 3, HSDPA + R99, PB3, H-Set 3, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Ericsson	781	1264	890	1408	703	1075	817	1164	1.14	1.11	1.16	1.08	R4-060884
Fujitsu	747	1272	799	1337	632	1058	705	1105	1.07	1.05	1.12	1.04	R4-060953
Average gain	764	1268	845	1373	668	1067	761	1135	1.10	1.08	1.14	1.06	
G= 5 dB													
Ericsson	1455	1600	1524	1601	1272	1957	1379	2102	1.05	1.00	1.08	1.07	R4-060884
Fujitsu	1452	1597	1461	1597	1163	1877	1190	1879	1.01	1.00	1.02	1.00	R4-060953
Average gain	1454	1599	1493	1599	1218	1917	1285	1991	1.03	1.00	1.05	1.04	
G = 10 dB													
Ericsson	1601	1601	1601	1601	2137	2332	2218	2332	1.00	1.00	1.04	1.00	R4-060884
Fujitsu	1600	1601	1599	1601	1960	2324	1972	2323	1.00	1.00	1.01	1.00	R4-060953
Average gain	1601	1601	1600	1601	2049	2328	2095	2328	1.00	1.00	1.02	1.00	

Table 8.A8: Type 3i / 3, HSDPA + R99, VA30, H-Set 3, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Ericsson	788	1182	890	1315	740	1116	845	1214	1.13	1.11	1.14	1.09	R4-060884
Fujitsu	734	1154	781	1212	626	1038	701	1093	1.06	1.05	1.12	1.05	R4-060953
Average gain	761	1168	836	1264	683	1077	773	1154	1.10	1.08	1.13	1.07	
G= 5 dB													
Ericsson	1113	1524	1168	1547	1299	1850	1402	2012	1.05	1.02	1.08	1.09	R4-060884
Fujitsu	1329	1586	1327	1586	1158	1701	1184	1718	1.00	1.00	1.02	1.01	R4-060953
Average gain	1221	1555	1248	1567	1229	1776	1293	1865	1.02	1.01	1.05	1.05	
G = 10 dB													
Ericsson	1601	1601	1601	1601	2084	2322	2211	2332	1.00	1.00	1.06	1.00	R4-060884
Fujitsu	1594	1601	1591	1601	1705	2293	1761	2288	1.00	1.00	1.03	1.00	R4-060953
Average gain	1598	1601	1596	1601	1895	2308	1986	2310	1.00	1.00	1.05	1.00	

Table 8.A9: Type 3i / 3, HSDPA + R99, PA3, H-Set 3, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Fujitsu	845	1240	947	1293	652	1092	754	1242	1.12	1.04	1.16	1.14	R4-060953
G= 5 dB													
Fujitsu	1404	1554	1420	1554	1397	1932	1502	1977	1.01	1.00	1.08	1.02	R4-060953
G = 10 dB													
Fujitsu	1578	1599	1576	1598	2093	2276	2084	2276	1.00	1.00	1.00	1.00	R4-060953

Table 8.A10: Type 3i / 3, HSDPA + R99, PB3, H-Set 6, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Motorola	188	886	336	1079	1	233	5	440	1.79	1.22	5.00	1.89	R4-060842
Average gain	188	886	336	1079	1	233	5	440	1.79	1.22	5.00	1.89	
G = 0 dB													
Fujitsu	873	1476	968	1583	148	1179	267	1314	1.11	1.07	1.80	1.11	R4-060953
Ericsson	928	1537	1095	1751	349	1373	594	1612	1.18	1.14	1.70	1.17	R4-060884
Intel	836	1490	927	1561	207	1129	252	1251	1.11	1.05	1.22	1.11	R4-060981
Motorola	821	1471	982	1609	167	1102	293	1302	1.20	1.09	1.75	1.18	R4-060842
Nokia	848	1475	1032	1645	216	1222	393	1485	1.22	1.12	1.82	1.22	R4-060909
Panasonic													
Average gain	861	1490	1001	1630	217	1201	360	1393	1.16	1.09	1.66	1.16	
G= 5 dB													
Fujitsu	1713	2890	1709	2906	1504	2245	1527	2267	1.00	1.01	1.02	1.01	R4-060953
Ericsson	1911	2899	2120	3052	1750	2466	1911	2672	1.11	1.05	1.09	1.08	R4-060884
Intel	1774	2796	1744	2832	1492	2273	1487	2244	0.98	1.01	1.00	0.99	R4-060981
Motorola	1778	2825	1878	2966	1451	2221	1586	2312	1.06	1.05	1.09	1.04	R4-060842
Nokia	1772	2858	1876	2950	1601	2311	1704	2423	1.06	1.03	1.06	1.05	R4-060909
Panasonic													
Average gain	1790	2854	1865	2941	1560	2303	1643	2384	1.04	1.03	1.05	1.03	
G = 10 dB													
Fujitsu	2978	3218	2950	3215	2279	3700	2315	3777	0.99	1.00	1.02	1.02	R4-060953
Ericsson	3092	3219	3145	3219	2859	4225	3107	4370	1.02	1.00	1.09	1.03	R4-060884
Intel	2874	3207	2875	3209	2387	3650	2352	3617	1.00	1.00	0.99	0.99	R4-060981
Motorola	3018	3226	3073	3229	2400	3850	2427	3962	1.02	1.00	1.01	1.03	R4-060842
Nokia	3007	3217	2983	3219	2418	3885	2504	3850	0.99	1.00	1.04	0.99	R4-060909
Panasonic													
Average gain	2994	3217	3005	3218	2469	3862	2541	3915	1.00	1.00	1.03	1.01	

Table 8.A11: Type 3i / 3, HSDPA + R99, VA30, H-Set 6, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Motorola	97	885	218	1040	0	108	0	252	2.25	1.18	NA	2.33	R4-060842
Average gain	97	885	218	1040	0	108	0	252	2.25	1.18	NA	2.33	
G = 0 dB													
Fujitsu	886	1453	981	1542	73	1178	176	1321	1.11	1.06	2.41	1.12	R4-060953
Ericsson	1000	1600	1152	1765	278	1434	683	1670	1.15	1.10	2.46	1.16	R4-060884
Intel	895	1481	1020	1589	126	1198	233	1364	1.14	1.07	1.85	1.14	R4-060981
Motorola	883	1428	967	1536	69	1096	122	1284	1.10	1.08	1.77	1.17	R4-060842
Nokia	876	1461	1088	1663	96	1243	341	1539	1.24	1.14	3.55	1.24	R4-060909
Panasonic													
Average gain	908	1485	1042	1619	128	1230	311	1436	1.15	1.09	2.41	1.17	
G= 5 dB													
Fujitsu	1679	2634	1698	2615	1478	2226	1510	2270	1.01	0.99	1.02	1.02	R4-060953
Ericsson	1902	2748	2106	2952	1816	2541	2026	2721	1.11	1.07	1.12	1.07	R4-060884
Intel	1745	2641	1809	2744	1542	2301	1615	2370	1.04	1.04	1.05	1.03	R4-060981
Motorola	1708	2612	1737	2712	1436	2175	1478	2220	1.02	1.04	1.03	1.02	R4-060842
Nokia	1759	2664	1875	2834	1615	2356	1738	2465	1.07	1.06	1.08	1.05	R4-060909
Panasonic													
Average gain	1759	2660	1845	2771	1577	2320	1673	2409	1.05	1.04	1.06	1.04	
G = 10 dB													
Fujitsu	2654	3202	2670	3196	2218	3229	2283	3372	1.01	1.00	1.03	1.04	R4-060953
Ericsson	3036	3214	3137	3219	2915	4071	3156	4342	1.03	1.00	1.08	1.07	R4-060884
Intel	2799	3206	2826	3209	2406	3534	2392	3547	1.01	1.00	0.99	1.00	R4-060981
Motorola	2840	3215	2862	3223	2289	3473	2269	3437	1.01	1.00	0.99	0.99	R4-060842
Nokia	2920	3210	2904	3214	2500	3726	2549	3684	0.99	1.00	1.02	0.99	R4-060909
Panasonic													
Average gain	2850	3209	2880	3212	2466	3607	2530	3676	1.01	1.00	1.02	1.02	

Table 8.A12: Type 3i / 3, HSDPA + R99, PA3, H-Set 6, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = 0 dB													
Fujitsu	906	1664	1080	1870	443	1213	649	1418	1.19	1.12	1.47	1.17	R4-060953
G= 5 dB													
Fujitsu	2119	2806	2230	2838	1669	2660	1790	2869	1.05	1.01	1.07	1.08	R4-060953
G = 10 dB													
Fujitsu	2990	3170	2972	3165	2950	4120	3149	4123	0.99	1.00	1.07	1.00	R4-060953

Table 8.A13: Type 3i / 3, HSDPA only, PB3, H-Set 6, Median DIP

Rx Type: 3:3:3i:3i:3:3:3i:3i:Gain:Gain:Gain:Gain:Reference

Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	220	1027	449	1273					2.04	1.24			R4-070044
Motorola	189	889	342	1083	1	238	4	443	1.81	1.22	4.00	1.86	R4-060984
Average gain	205	958	396	1178	1	238	4	443	1.93	1.23	4.00	1.86	
G = 0 dB													
AT&T	920	1561	1156	1719		1281		1538	1.26	1.10		1.20	R4-070044
Motorola	822	1473	983	1606	167	1108	290	1312	1.20	1.09	1.74	1.18	R4-060984
Average gain	871	1517	1070	1663	167	1195	290	1425	1.23	1.10	1.74	1.19	
G= 5 dB													
Motorola	1778	2824	1885	2970	1453	2228	1585	2306	1.06	1.05	1.09	1.04	R4-060984
Average gain	1778	2824	1885	2970	1453	2228	1585	2306	1.06	1.05	1.09	1.04	
G = 10 dB													
Motorola	3016	3226	3076	3229	2397	3862	2418	3958	1.02	1.00	1.01	1.02	R4-060984
Average gain	3016	3226	3076	3229	2397	3862	2418	3958	1.02	1.00	1.01	1.02	

Table 8.A14: Type 3i / 3, HSDPA only, VA30, H-Set 6, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Motorola	100	889	221	1046	0	111	0	254	2.21	1.18	NA	2.29	R4-060984
Average gain	100	889	221	1046	0	111	0	254	2.21	1.18	NA	2.29	
G = - 2dB													
InterDigital	310	1089	484	1206	0.5	336	28	576	1.56	1.11	56.00	1.71	
Average gain	310	1089	484	1206	1	336	28	576	1.56	1.11	56.00	1.71	
G = 0 dB													
Motorola	839	1434	970	1538	69	1097	121	1288	1.16	1.07	1.75	1.17	R4-060984
InterDigital	986	1579	1112	1711	180	1264	332	1441	1.13	1.08	1.84	1.14	
Average gain	913	1507	1041	1625	125	1181	227	1365	1.14	1.08	1.80	1.16	
G= 5 dB													
Motorola	1703	2615	1737	2714	1437	2182	1484	2226	1.02	1.04	1.03	1.02	R4-060984
Average gain	1703	2615	1737	2714	1437	2182	1484	2226	1.02	1.04	1.03	1.02	
G = 10 dB													
Motorola	2843	3214	2811	3214	2289	3474	2271	3446	0.99	1.00	0.99	0.99	R4-060984
Average gain	2843	3214	2811	3214	2289	3474	2271	3446	0.99	1.00	0.99	0.99	

Table 8.A15: Type 3i / 3, HSDPA only, PB3, H-Set 3, Median DIP

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	518	819	643	911					1.24	1.11			R4-070044
G = 0 dB													
AT&T	783	1215	859	1367	657	1069	785	1153	1.10	1.13	1.19	1.08	R4-070044

Table 8.A16: Type 3i / 3, HSDPA + R99, PB3, H-Set 6, Weighted DIPS

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Agere	63	758	314	1127	0	142	17	535	4.98	1.49	NA	3.77	R4-061246
Intel	254	952	538	1229	19	329	45	736	1.28	1.14	1.96	1.27	R4-061279
Average gain	159	855	426	1178	10	236	31	636	3.13	1.32	1.96	2.52	
G = 0 dB													
Agere	674	1446	1016	1776	93	1026	395	1423	1.51	1.23	4.25	1.39	R4-061246
Fujitsu	873	1476	1111	1753	148	1179	479	1527	1.27	1.19	3.24	1.30	R4-061260
Intel	868	1512	1108	1730	245	1177	481	1490	1.28	1.14	1.96	1.27	R4-061279
Nokia	850	1496	1133	1798	251	1299	575	1621	1.33	1.20	2.29	1.25	R4-061185
Average gain	816	1483	1092	1764	184	1170	483	1515	1.35	1.19	2.93	1.30	

Table 8.A17: Type 3i / 3, HSDPA + R99, VA30, H-Set 6, Weighted DIPS

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Agere	68	932	412	1202	0	89	1	596	6.06	1.29	NA	6.70	R4-061246
Intel	234	1018	696	1322	1	288	35	924	2.97	1.30	35.00	3.21	R4-061279
Average gain	151	975	554	1262	1	189	18	760	4.52	1.29	35.00	4.95	
G = 0 dB													
Agere	871	1480	1141	1763	68	1212	402	1512	1.31	1.19	5.91	1.25	R4-061246
Fujitsu	886	1453	1111	1715	73	1178	419	1521	1.25	1.18	5.74	1.29	R4-061260
Intel	956	1538	1235	1855	210	1274	708	1680	1.29	1.21	3.37	1.32	R4-061279
Nokia	875	1473	1179	1796	114	1238	623	1674	1.35	1.22	5.46	1.35	R4-061185
Average gain	897	1486	1167	1782	116	1226	538	1597	1.30	1.20	5.12	1.30	

Table 8.A18: Type 3i / 3, HSDPA, PB3, H-Set 6, Weighted DIPS

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Agere	63	758	303	1135	0	142	15	526	4.81	1.50	NA	3.70	R4-061247
Ericsson	276	993	671	1316		452		1032	2.43	1.33	NA	2.28	R4-061176
InterDigital	179	801	419	1143	3	215	18	512	2.34	1.43	6.00	2.38	R4-061234
Motorola	271	968	611	1299	7	345	56	797	2.25	1.34	8.00	2.31	R4-061356
Average gain	197	880	501	1223	3	289	30	717	2.96	1.40	7.00	2.67	
G = 0 dB													
Agere	665	1444	1022	1774	93	1016	395	1425	1.54	1.23	4.25	1.40	R4-061247
Ericsson	904	1571	1230	1982		1355		1822	1.36	1.26	NA	1.34	R4-061176
InterDigital	789	1458	1054	1695	178	1009	344	1370	1.34	1.16	1.93	1.36	R4-061234
Motorola	894	1545	1150	1830	261	1180	543	1507	1.29	1.18	2.08	1.28	R4-061356
Nokia	854	1496	1134	1794	251	1228	573	1624	1.33	1.20	2.28	1.32	R4-061186
Panasonic	969	1571	1094	1685	144	1033	261	1360	1.13	1.07	1.81	1.32	R4-061198
Average gain	846	1514	1114	1793	185	1137	423	1518	1.33	1.18	2.47	1.34	

Table 8.A19: Type 3i / 3, HSDPA, VA30, H-Set 6, Weighted DIPS

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Agere	68	932	394	1198	0	89	1	597	5.79	1.29	NA	6.71	R4-061247
Ericsson	241	1057	864	1428		384		1235	3.59	1.35	NA	3.22	R4-061176
InterDigital	132	901	458	1194	0	133	2	539	3.47	1.33	#DIV/0!	4.05	R4-061234
Motorola	208	1006	676	1320	1	252	26	892	3.25	1.31	26.00	3.54	R4-061356
Average gain	162	974	598	1285	0	215	10	816	4.02	1.32	#DIV/0!	4.38	
G = 0 dB													
Agere	871	1480	1124	1744	68	1212	435	1495	1.29	1.18	6.40	1.23	R4-061247
Ericsson	999	1560	1335	2006		1434		1916	1.34	1.29	NA	1.34	R4-061176
InterDigital	897	1500	1115	1719	106	1151	344	1442	1.24	1.15	3.25	1.25	R4-061234
Motorola	945	1554	1173	1835	167	1258	521	1550	1.24	1.18	3.12	1.23	R4-061356
Nokia	871	1472	1179	1794	117	1236	627	1669	1.35	1.22	5.36	1.35	R4-061186
Panasonic	805	1425	1094	1685	0	1060	308	1449	1.36	1.18	NA	1.37	R4-061198
Average gain	898	1498.5	1170	1797.167	91.6	1225.167	447	1586.833	1.30	1.20	4.53	1.30	

Table 8.A20: Type 3i / 3, Combined HSDPA, & HSDPA+R99 PB3, H-Set 6, Weighted DIPS

Rx Type	Scenario	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation		QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)		-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB														
Agere	H	63	758	303	1135	0	142	15	526	4.81	1.50	NA	3.70	R4-061247
Ericsson	H	276	993	671	1316		452		1032	2.43	1.33	NA	2.28	R4-061176
Intel	R99	254	952	538	1229	19	329	45	736	2.12	1.29	2.37	2.24	R4-061279
InterDigital	H	179	801	419	1143	3	215	18	512	2.34	1.43	6.00	2.38	R4-061234
Motorola	H	271	968	611	1299	7	345	56	797	2.25	1.34	8.00	2.31	R4-061356
Average gain		209	894	508	1224	7	297	34	721	2.79	1.38	5.46	2.58	
G = 0 dB														
Agere	H	665	1444	1022	1774	93	1016	395	1425	1.54	1.23	4.25	1.40	R4-061247
Ericsson	H	904	1571	1230	1982		1355		1822	1.36	1.26	NA	1.34	R4-061176
Fujitsu	R99	873	1476	1111	1753	148	1179	479	1527	1.27	1.19	3.24	1.30	R4-061260
Intel	R99	868	1512	1108	1730	245	1177	481	1490	1.28	1.14	1.96	1.27	R4-061279
InterDigital	H	789	1458	1054	1695	178	1009	344	1370	1.34	1.16	1.93	1.36	R4-061234
Motorola	H	894	1545	1150	1830	261	1180	543	1507	1.29	1.18	2.08	1.28	R4-061356
Nokia	H	854	1496	1134	1794	251	1228	573	1624	1.33	1.20	2.28	1.32	R4-061186
Panasonic	H	969	1571	1094	1685	144	1033	261	1360	1.13	1.07	1.81	1.32	R4-061198
Average gain		852	1509	1113	1780	189	1147	439	1516	1.32	1.18	2.51	1.32	

Table 8.A21: Type 3i / 3, Combined HSDPA & HSDPA+R99, VA30, H-Set 6, Weighted DIPS

Rx Type		3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation		QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)		-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB														
Agere	H	68	932	394	1198	0	89	1	597	5.79	1.29	NA	6.71	R4-061247
Ericsson	H	241	1057	864	1428		384		1235	3.59	1.35	NA	3.22	R4-061176
Intel	R99	234	1018	696	1322	1	288	35	924	2.97	1.30	35.00	3.21	R4-061279
InterDigital	H	132	901	458	1194	0	133	2	539	3.47	1.33	NA	4.05	R4-061234
Motorola	H	208	1006	676	1320	1	252	26	892	3.25	1.31	26.00	3.54	R4-061356
Average gain		177	983	618	1292	1	229	16	837	3.81	1.31	30.50	4.14	
G = 0 dB														
Agere	H	871	1480	1124	1744	68	1212	435	1495	1.29	1.18	6.40	1.23	R4-061247
Ericsson	H	999	1560	1335	2006		1434		1916	1.34	1.29	NA	1.34	R4-061176
Fujitsu	R99	886	1453	1111	1715	73	1178	419	1521	1.25	1.18	5.74	1.29	R4-061260
Intel	R99	956	1538	1235	1855	210	1274	708	1680	1.29	1.21	3.37	1.32	R4-061279
InterDigital	H	897	1500	1115	1719	106	1151	344	1442	1.24	1.15	3.25	1.25	R4-061234
Motorola	H	945	1554	1173	1835	167	1258	521	1550	1.24	1.18	3.12	1.23	R4-061356
Nokia	H	871	1472	1179	1794	117	1236	627	1669	1.35	1.22	5.36	1.35	R4-061186
Panasonic	H	805	1425	1094	1685	0	1060	308	1449	1.36	1.18	NA	1.37	R4-061198
Average gain		904	1498	1171	1794	106	1225	480	1590	1.30	1.20	4.54	1.30	

Table 8.A22: Type 3i / 3, HSDPA + R99, PB3, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Electronics	200	1006	434	1229	2	249	19	555	2.17	1.22	9.5	2.23	R4-070074
Marvell	248	948	426	1143	13	318	23	563	1.72	1.21	1.77	1.77	R4-070232
Motorola	236	959	438	1182	5	284	17	557	1.86	1.23	3.4	1.92	R4-070334
Average gain	228	971	433	1185	7	284	20	558	1.92	1.22	4.89	1.97	
G = 0 dB													
AT&T	919	1577	1346	1941		1300		1781	1.46	1.24		1.37	R4-070045
Motorola	886	1551	1149	1835	240	1172	506	1501	1.30	1.18	2.11	1.28	R4-070334
Average gain	903	1564	1248	1888	240	1236	506	1641	1.38	1.21	2.11	1.33	

Table 8.A23: Type 3i / 3, HSDPA + R99, VA30, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Electronics	139	1024	497	1277	0	169	2	580	3.58	1.25	NA	3.43	R4-070074
Marvell	221	1018	511	1215	1	275	6	675	2.31	1.19	6.00	2.45	R4-070232
Motorola	182	1001	460	1200	0	206	5	580	2.53	1.20	NA	2.82	R4-070334
Average gain	181	1014	489	1231	0	217	4	612	2.81	1.21	6.00	2.90	
G = 0 dB													
Motorola	934	1554	1169	1827	162	1234	495	1540	1.25	1.18	3.06	1.25	R4-070334
Average gain	934	1554	1169	1827	162	1234	495	1540	1.25	1.18	3.06	1.25	

Table 8.A24: Type 3i / 3, HSDPA + R99, PB3, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Electronics	512	836	622	959	145	682	304	859	1.21	1.15	2.10	1.26	R4-070074
Motorola	491	818	599	950	163	674	306	830	1.22	1.16	1.88	1.23	R4-070334
Average gain	502	827	611	955	154	678	305	845	1.22	1.16	1.99	1.25	
G = 0 dB													
Motorola	790	1268	933	1440	626	1056	808	1195	1.18	1.14	1.29	1.13	R4-070334
Average gain	790	1268	933	1440	626	1056	808	1195	1	1.14	1.29	1.13	

Table 8.A25: Type 3i / 3, HSDPA + R99, VA30, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Electronics	511	815	637	928	111	698	325	898	1.25	1.14	2.93	1.29	R4-070074
Motorola	511	815	610	933	126	697	323	846	1.19	1.14	2.56	1.21	R4-070334
Average gain	511	815	624	931	119	698	324	872	1.22	1.14	2.75	1.25	
G = 0 dB													
Motorola	790	1193	929	1366	657	1070	824	1217	1.18	1.15	1.25	1.14	R4-070334
Average gain	790	1193	929	1366	657	1070	824	1217	1.18	1.15	1.25	1.14	

Table 8.A26: Type 3i / 3, HSDPA only, PB3, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	219	1009	488	1317					2.33	1.25			R4-070044
Fujitsu	141	896	304	1054					2.16	1.18			R4-070089
InterDigital	155	804	297	1035		183		359	1.92	1.29		1.96	R4-070136
LG Electronics	204	1006	448	1219	0	249	20	552	2.20	1.21		2.22	R4-070073
Motorola	237	959	438	1181	4	291	18	560	1.85	1.23	4.5	1.92	R4-070061
Nokia	203	903	441	1166	3	304	17	652	2.18	1.29	5.67	2.16	R4-070271
Average gain	193	930	403	1162	2	257	18	531	2.11	1.24	5.09	2.07	
G = 0 dB													
AT&T	925	1581	1353	1940		1313		1786	1.46	1.23		1.31	R4-070044
Motorola	894	1545	1154	1827	261	1180	543	1507	1.29	1.18	2.08	1.28	R4-070061
Nokia	847	1500	1142	1805	262	1224	596	1630	1.34	1.20	2.27	1.33	R4-070271
Average gain	889	1542	1216	1857	262	1239	570	1641	1.36	1.20	2.18	1.31	

Table 8.A27: Type 3i / 3, HSDPA only, VA30, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Fujitsu	91	924	288	1085					3.17	1.17			R4-070089
InterDigital	104	875	258	1082		102		309	2.48	1.24		3.03	R4-070136
LG Electronics	139	1028	464	1272	0	169	2	573	3.34	1.24	NA	3.39	R4-070073
Motorola	186	1004	464	1201	1	211	4	581	2.49	1.20	4.0	2.75	R4-070061
Nokia	108	932	469	1197	0	169	2	695	4.35	1.28	NA	4.11	R4-070271
Average gain	126	953	389	1167	0	163	3	540	3.17	1.23	4.00	3.32	
G = 0 dB													
Motorola	945	1557	1173	1829	168	1261	518	1551	1.24	1.17	3.08	1.23	R4-070061
Nokia	877	1470	1181	1793	120	1246	623	1674	1.35	1.22	5.19	1.34	R4-070271
Average gain	911	1514	1177	1811	144	1254	571	1613	1.30	1.20	4.14	1.29	

Table 8.A28: Type 3i / 3, HSDPA only, PB3, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	515	820	666	946					1.29	1.15			R4-070044
Fujitsu	456	757	537	856					1.18	1.13			R4-070089
LG Electronics	511	831	614	966	140	700	306	857	1.20	1.16	2.19	1.22	R4-070073
Motorola	495	820	601	954	166	676	307	833	1.21	1.16	1.85	1.23	R4-070061
Average gain	494	807	605	931	153	688	307	845	1.22	1.15	2.02	1.23	
G = 0 dB													
AT&T	794	1227	977	1474	670	1078	914	1298	1.23	1.20	1.36	1.20	R4-070044
Motorola	787	1265	931	1438	628	1053	815	1192	1.18	1.14	1.30	1.13	R4-070061
Average gain	791	1246	954	1456	649	1066	865	1245	1.21	1.17	1.33	1.17	

Table 8.A29: Type 3i / 3, HSDPA only, VA30, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Fujitsu	469	750	548	849					1.17	1.13			R4-070089
LG Electronics	519	814	643	928	109	702	328	904	1.24	1.14	3.01	1.29	R4-070073
Motorola	513	817	609	933	126	702	328	847	1.19	1.14	2.60	1.21	R4-070061
Average gain	500	794	600	903	118	702	328	876	1.20	1.14	2.81	1.25	
G = 0 dB													
Motorola	791	1197	931	1366	666	1070	831	1216	1.18	1.14	1.25	1.14	R4-070061
Average gain	791	1197	931	1366	666	1070	831	1216	1.18	1.14	1.25	1.14	

Table 8.A30: Type 3i / 3, Combined HSDPA & HSDPA + R99, PB3, H-Set 6, Revised G= -3 DIP & Codes

Rx Type		3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation		QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)		-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB														
AT&T	H	219	1009	488	1317					2.33	1.25			R4-070044
Fujitsu	H	141	896	304	1054					2.16	1.18			R4-070089
Marvell	R99	248	948	426	1143	13	318	23	563	1.72	1.21	1.77	1.77	R4-070232
InterDigital	H	155	804	297	1035		183		359	1.92	1.29		1.96	R4-070136
LG Electronics	H	204	1006	448	1219	0	249	20	552	2.20	1.21		2.22	R4-070073
Motorola	H	237	959	438	1181	4	291	18	560	1.85	1.23	4.5	1.92	R4-070061
Nokia	H	203	903	441	1166	3	304	17	652	2.18	1.29	5.67	2.16	R4-070271
Average gain		201	932	406	1159	5	269	20	537	2.05	1.24	3.98	2.01	
G = 0 dB														
AT&T	H	925	1581	1353	1940		1313		1786	1.46	1.23		1.31	R4-070044
Motorola	H	894	1545	1154	1827	261	1180	543	1507	1.29	1.18	2.08	1.28	R4-070061
Nokia	H	847	1500	1142	1805	262	1224	596	1630	1.34	1.20	2.27	1.33	R4-070271
Average gain		889	1542	1216	1857	262	1239	570	1641	1.36	1.20	2.18	1.31	

Table 8.A31: Type 3i / 3, Combined HSDPA & HSDPA + R99, VA30, H-Set 6, Revised G= -3 DIP & Codes

Rx Type		3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation		QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)		-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB														
Fujitsu	H	91	924	288	1085					3.17	1.17			R4-070089
Marvell	R99	221	1018	511	1215	1	275	6	675	2.31	1.19	6.00	2.45	R4-070232
InterDigital	H	104	875	258	1082		102		309	2.48	1.24		3.03	R4-070136
LG Electronics	H	139	1028	464	1272	0	169	2	573	3.34	1.24	NA	3.39	R4-070073
Motorola	H	186	1004	464	1201	1	211	4	581	2.49	1.20	4.0	2.75	R4-070061
Nokia	H	108	932	469	1197	0	169	2	695	4.35	1.28	NA	4.11	R4-070271
Average gain		142	964	409	1175	1	185	4	567	3.02	1.22	5.00	3.15	
G = 0 dB														
Motorola	H	945	1557	1173	1829	168	1261	518	1551	1.24	1.17	3.08	1.23	R4-070061
Nokia	H	877	1470	1181	1793	120	1246	623	1674	1.35	1.22	5.19	1.34	R4-070271
Average gain		911	1514	1177	1811	144	1254	571	1613	1.30	1.20	4.14	1.29	

Table 8.A32: Type 3i / 3, HSDPA + R99, PB3, H-Set 6, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	200	1006	434	1229	2	249	19	555	2.17	1.22	9.5	2.23	R4-070074
LG Elec. (Un PC)	179	955	401	1194	0	215	12	500	2.24	1.25	NA	2.33	R4-070074
LG Elec. (Nm PC)	203	995	445	1226	0	245	18	535	2.19	1.23	NA	2.18	R4-070074
Motorola (No PC)	236	959	438	1182	5	284	17	557	1.86	1.23	3.4	1.92	R4-070334
Motorola (Un PC)	208	922	397	1147	3	252	16	508	1.91	1.24	5.33	2.02	R4-070334
Motorola (Nm PC)	234	958	441	1178	4	290	18	551	1.88	1.23	4.5	1.90	R4-070334
Nokia (Un PC)	195	859	426	1137	2	268	13	594	2.18	1.32	6.5	2.22	R4-070272
Nokia (Nm PC)	204	899	444	1164	10	303	18	656	2.17	1.29	1.80	2.17	R4-070272
G = 0 dB													
AT&T (No PC)	919	1577	1346	1941		1300		1781	1.46	1.24		1.37	R4-070045
AT&T (Un PC)	876	1550	1309	1885		1260		1744	1.49	1.22		1.38	R4-070045
AT&T (Nm PC)	917	1583	1346	1934		1295		1783	1.46	1.23		1.38	R4-070045
Motorola (No PC)	886	1551	1149	1835	240	1172	506	1501	1.30	1.18	2.11	1.28	R4-070334
Motorola (Un PC)	847	1512	1108	1792	202	1120	453	1461	1.31	1.19	2.24	1.30	R4-070334
Motorola (Nm PC)	887	1551	1149	1832	236	1172	511	1502	1.30	1.18	2.17	1.28	R4-070334
Nokia (Un PC)	803	1459	1103	1758	215	1161	531	1588	1.37	1.20	2.47	1.37	R4-070272
Nokia (Nm PC)	849	1490	1143	1804	259	1227	593	1633	1.35	1.21	2.29	1.33	R4-070272

Table 8.A33: Type 3i / 3, HSDPA + R99, VA30, H-Set 6, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	139	1024	497	1277	0	169	2	580	3.58	1.25	NA	3.43	R4-070074
LG Elec. (Un PC)	103	990	432	1235	0	139	0	542	4.19	1.25	NA	3.90	R4-070074
LG Elec. (Nm PC)	132	1040	487	1262	0	178	2	594	3.69	1.21	NA	3.34	R4-070074
Motorola (No PC)	182	1001	460	1200	0	206	5	580	2.53	1.20	NA	2.82	R4-070334
Motorola (Un PC)	149	968	415	1177	0	170	3	516	2.79	1.22	NA	3.04	R4-070334
Motorola (Nm PC)	182	1000	461	1200	0	207	5	577	2.53	1.20	NA	2.79	R4-070334
Nokia (Un PC)	104	892	450	1174	0	131	2	622	4.33	1.32	NA	4.75	R4-070272
Nokia(Nm PC)	111	925	471	1196	0	163	2	690	4.24	1.29	NA	4.23	R4-070272
G = 0 dB													
Motorola (No PC)	934	1554	1169	1827	162	1234	495	1540	1.25	1.18	3.06	1.25	R4-070334
Motorola (Un PC)	899	1518	1142	1788	130	1183	433	1504	1.27	1.18	3.33	1.27	R4-070334
Motorola (Nm PC)	939	1551	1172	1826	161	1239	497	1541	1.25	1.18	3.09	1.24	R4-070334
Nokia (Un PC)	823	1435	1149	1752	86	1183	536	1636	1.40	1.22	6.23	1.38	R4-070272
Nokia (Nm PC)	875	1472	1178	1790	117	1240	628	1675	1.35	1.22	5.37	1.35	R4-070272

Table 8.A34: Type 3i / 3, HSDPA + R99, PB3, H-Set 3, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	512	836	622	959	145	682	304	859	1.21	1.15	2.10	1.26	R4-070074
LG Elec. (Un PC)	488	817	605	942	120	660	273	828	1.24	1.15	2.28	1.25	R4-070074
LG Elec. (Nm PC)	506	838	619	961	144	698	325	898	1.22	1.15	2.09	1.22	R4-070074
Motorola (No PC)	491	818	599	950	163	674	306	830	1.22	1.16	1.88	1.23	R4-070334
Motorola (Un PC)	469	799	583	929	140	647	281	810	1.24	1.16	2.01	1.25	R4-070334
Motorola (Nm PC)	490	819	599	950	164	676	307	829	1.22	1.16	1.88	1.23	R4-070334
G = 0 dB													
Motorola (No PC)	790	1268	933	1440	626	1056	808	1195	1.18	1.14	1.29	1.13	R4-070334
Motorola (Un PC)	767	1239	909	1418	598	1035	781	1176	1.19	1.14	1.31	1.14	R4-070334
Motorola (Nm PC)	789	1266	933	1440	628	1056	807	1197	1.18	1.14	1.29	1.13	R4-070334

Table 8.A35: Type 3i / 3, HSDPA + R99, VA30, H-Set 3, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	511	815	637	928	111	698	325	898	1.25	1.14	2.93	1.29	R4-070074
LG Elec. (Un PC)	503	803	632	911	76	684	300	873	1.26	1.13	3.95	1.28	R4-070074
LG Elec. (Nm PC)	517	822	639	931	100	706	329	890	1.24	1.13	3.29	1.26	R4-070074
Motorola (No PC)	511	815	610	933	126	697	323	846	1.19	1.14	2.56	1.21	R4-070334
Motorola (Un PC)	494	797	595	916	103	673	286	825	1.20	1.15	2.78	1.23	R4-070334
Motorola (Un PC)	512	814	608	935	124	697	322	844	1.19	1.15	2.60	1.21	R4-070334
G = 0 dB													
Motorola (No PC)	790	1193	929	1366	657	1070	824	1217	1.18	1.15	1.25	1.14	R4-070334
Motorola (Un PC)	769	1167	906	1342	631	1045	803	1197	1.18	1.15	1.27	1.15	R4-070334
Motorola (Nm PC)	790	1194	927	1364	657	1067	824	1217	1.17	1.14	1.25	1.14	R4-070334

Table 8.A36: Type 3i / 3, HSDPA only, PB3, H-Set 6, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	204	1006	448	1219	0	249	20	552	2.20	1.21		2.22	R4-070073
LG Elec. (Un PC)	192	987	432	1205	0	226	18	503	2.25	1.22	NA	2.23	R4-070073
LG Elec. (Nm PC)	204	1009	441	1209	0	243	22	547	2.16	1.20	NA	2.25	R4-070073
G = 0 dB													
AT&T (No PC)	925	1581	1353	1940		1313		1786	1.46	1.23		1.31	R4-070045
AT&T (Un PC)	906	1568	1329	1922		1292		1759	1.47	1.23		1.36	R4-070045
AT&T (Nm PC)	930	1583	1351	1941		1315		1787	1.45	1.23		1.36	R4-070045

Table 8.A37: Type 3i / 3, HSDPA only, VA30, H-Set 6, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	139	1028	464	1272	0	169	2	573	3.34	1.24	NA	3.39	R4-070073
LG Elec. (Un PC)	116	1019	482	1254	0	162	2	559	4.16	1.23	NA	3.45	R4-070073
LG Elec. (Nm PC)	142	1022	506	1256	0	171	2	568	3.56	1.23	NA	3.32	R4-070073

Table 8.A38: Type 3i / 3, HSDPA only, PB3, H-Set 3, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	511	831	614	966	140	700	306	857	1.20	1.16	2.19	1.22	R4-070073
LG Elec. (Un PC)	507	825	608	957	135	688	295	855	1.20	1.16	2.19	1.24	R4-070073
LG Elec. (Nm PC)	506	833	614	966	142	683	305	859	1.21	1.16	2.15	1.26	R4-070073

Table 8.A39: Type 3i / 3, HSDPA only, VA30, H-Set 3, Revised G= -3 DIP & Codes with Power Control

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
LG Elec. (No PC)	519	814	643	928	109	702	328	904	1.24	1.14	3.01	1.29	R4-070073
LG Elec. (Un PC)	511	809	629	924	99	696	327	892	1.23	1.14	3.30	1.28	R4-070073
LG Elec. (Nm PC)	519	820	635	928	104	699	330	893	1.22	1.13	3.17	1.28	R4-070073

Table 8.A40: Type 3i / 3, HSDPA only, PB3, H-Set 6, Field Derived DIP Values

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	220	1013	511	1331					2.33	1.31			R4-070044
G = 0 dB													
AT&T	928	1608	1388	2030		1313		1855	1.50	1.26		1.41	R4-070044

Table 8.A41: Type 3i / 3, HSDPA only, PB3, H-Set 3, Field Derived DIP Values

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
AT&T	514	821	675	954					1.31	1.16			R4-070044
G = 0 dB													
AT&T	808	1217	1033	1505	678	1085	939	1346	1.28	1.24	1.38	1.24	R4-070044

Table 8.A42: Type 2i / 2, HSDPA+R99, PB3, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Tensorcomm	11	269	17	367	0	16	0	17	1.55	1.36	NA	1.06	R4-070282
G = 0 dB													
Tensorcomm	169	707	333	942	13	223	22	441	1.97	1.33	1.69	1.98	R4-070282

Table 8.A43: Type 2i / 2, HSDPA+R99, VA30, H-Set 6, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Tensorcomm	1	168	4	275	0	0	0	3	4.00	1.64	NA	NA	R4-070282
G = 0 dB													
Tensorcomm	87	757	243	1023	0	99	1	295	2.79	1.35	NA	2.98	R4-070282

Table 8.A44: Type 2i / 2, HSDPA+R99, PB3, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Tensorcomm	140	433	187	494	8	185	11	259	1.34	1.14	1.38	1.40	R4-070282
G = 0 dB													
Tensorcomm	358	659	475	781	124	490	234	663	1.33	1.19	1.89	1.35	R4-070282

Table 8.A45: Type 2i / 2, HSDPA+R99, VA30, H-Set 3, Revised G= -3 DIP & Codes

Rx Type	3	3	3i	3i	3	3	3i	3i	Gain	Gain	Gain	Gain	Reference
Modulation	QPSK	QPSK	QPSK	QPSK	16QAM	16QAM	16QAM	16QAM	QPSK	QPSK	16QAM	16QAM	
Ec/Ior (dB)	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	-6	-3	
G = -3 dB													
Tensorcomm	91	466	150	531	0	107	1	176	1.65	1.14	NA	1.64	R4-070282
G = 0 dB													
Tensorcomm	389	701	517	805	58	521	159	710	1.33	1.15	2.74	1.36	R4-070282

9 System performance characterization

9.0 General

This chapter discusses the benefits of Type 3i receivers from a system performance perspective. Two different simulation studies were made within the Study Item, both showing significant benefit when using interference cancellation for users at cell borders [66]. Details concerning the two studies that were made can be found in clauses 9.1 and 9.2. Conclusions can be found in clause 9.3.

9.1 First system-level study (Ericsson)

9.1.1 Simulation setup

We model a macro-cell environment, where the site deployment consists of a uniform hexagonal pattern containing 19 base station sites, each serving 3 cells. The site-to-site distance is 3000 m. We use a 2-D sectorization antenna model which has antenna gains as shown in Fig.1. Antenna tilting is not considered in our simulations. The transmit power of the base station is 20 watt per carrier per cell. The path loss model is 128.1+37.6*log(*r*) in dB, where *r* is the distance in km from the mobile to the base station. The shadowing loss is log-normal with a standard deviation of 8 dB. The receiver is assumed to operate at 9 dB noise figure. To simplify our analysis, we assume that all the radio links have the same power delay profile. All the mobiles in the system are moving at 3 km/h. Two multipath models are considered, a heavily dispersive model and a mildly dispersive model. The heavily dispersive model consists of four chip-spaced rays with exponential power delay profile. The average relative powers for the four paths are 0, -3, -6 and -9 dB, respectively. This power delay profile is identical to the power delay profile of the Case3 channel specified in [67]. Hence, we will refer to this channel as simply the Case3 channel. The mildly dispersive model has three chip-spaced paths with average relative power of 0, -12.5, and -24.7 dB. This channel model resembles the Pedestrian A channel model in [67].

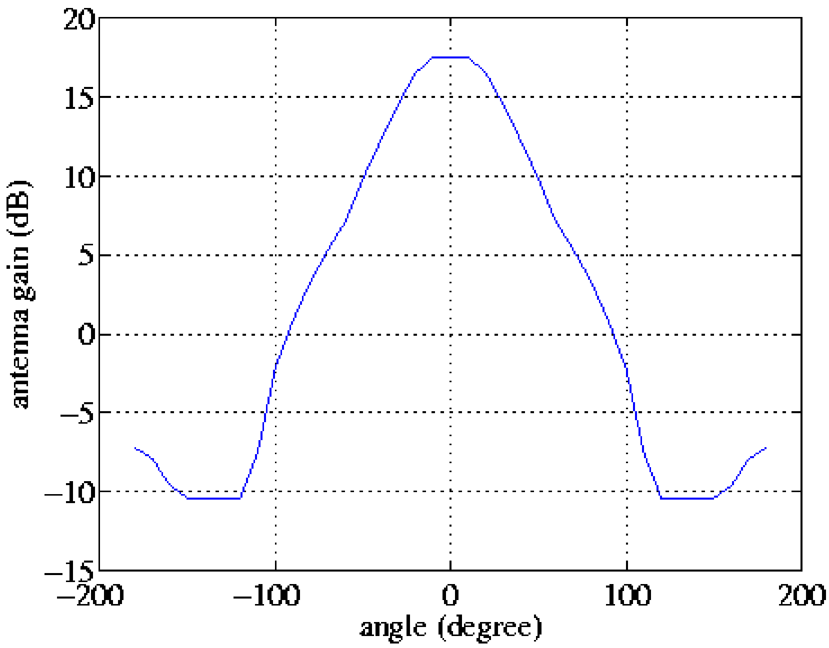

Figure 9.1: 2-D sectorization antenna pattern used in our simulations

For link adaptation, we use a MCS table based on link simulation results of an ideal receiver in AWGN. The MCS table is shown in Table 1. The SINR in Table 1 is for every HS-PDSCH symbol (16 chips) per code. The SINR range is determined to achieve less than 10% block error rate for the 1st transmission. In system-level simulations however, we include a 2 dB implementation loss for both Type 3 and Type 3i receivers. We use the same finger positions for Type 3 and Type 3i receivers.

In our simulations, we further assume that 15 codes and 75% of base station power are available for serving the desired user"s HS-DPDCH. Code and power allocations however do not impact the relative performance between Type 3 and Type 3i receivers.

Table 9.1: MCS table used for link adaptation

SINR (dB) range	bits/HS-PDSCH symbol/code
[-11.5, -10.5]	0.0626
[-10.5, -9.5]	0.0758
[-9.5, -8.5]	0.0990
[-8.5, -7.5]	0.1253
[-7.5, -6.5]	0.1516
[-6.5, -5.5]	0.1980
[-5.5, -4.5]	0.2506
[-4.5, -3.5]	0.3032
[-3.5, -2.5]	0.3958
[-2.5, -1.5]	0.5011
[-1.5, -0.5]	0.6063
[-0.5, 0.5]	0.7116
[0.5, 1.5]	0.8814
[1.5, 2.5]	1.0427
[2.5, 3.5]	1.2041
[3.5, 4.5]	1.3654
[4.5, 5.5]	1.5267
[5.5, 6.5]	1.6881
[6.5, 7.5]	1.8494
[7.5, 8.5]	2.0108
[8.5, 9.5]	2.5135
[9.5, 10.5]	2.7659
[10.5, 11.5]	3.0182
[11.5, 12.5]	3.2705
[12.5, 13.5]	3.5228
[13.5, 14.5]	3.7751
14.5 and above	4.0000

9.1.2 Simulation results

We evaluate distributions of achievable data rates over fading realizations for users at a certain distance from the serving base station. Each of these distributions is equivalent to the distribution of CQI reports collected from users at the same distance away from the base station. Simulation results for the Case 3 (heavily dispersive) channel are shown in Fig. 9.2 and Fig. 9.3, for 10^{th} percentile and median data rate, respectively. The 10^{th} percentile data rate is achieved by 90% of the users, and it is an important indicator for coverage. From Fig. 9.2, we see that Type 3i receiver improves coverage significantly. The improvement is around 25-35% in data rate depending on the user location. It is interesting to see that Type 3i also improves the 10^{th} percentile data rate when users are close to the base station. In fact, the gains of Type 3i are higher for users close to the base station. This is because those users close to the base station experience other-cell interference mainly due to inter-sector interference, and Type 3i is effective in suppressing few (most likely one) inter-sector interference. From Fig. 9.3, we observe the gains for median data rates are moderate.

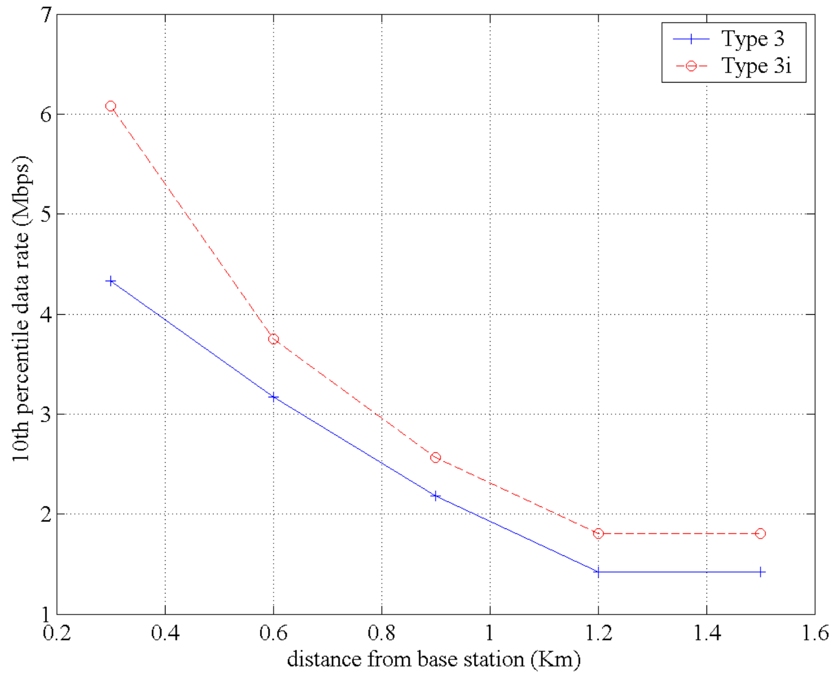

Figure 9.2: 10th percentile data rate for users in a highly dispersive channel

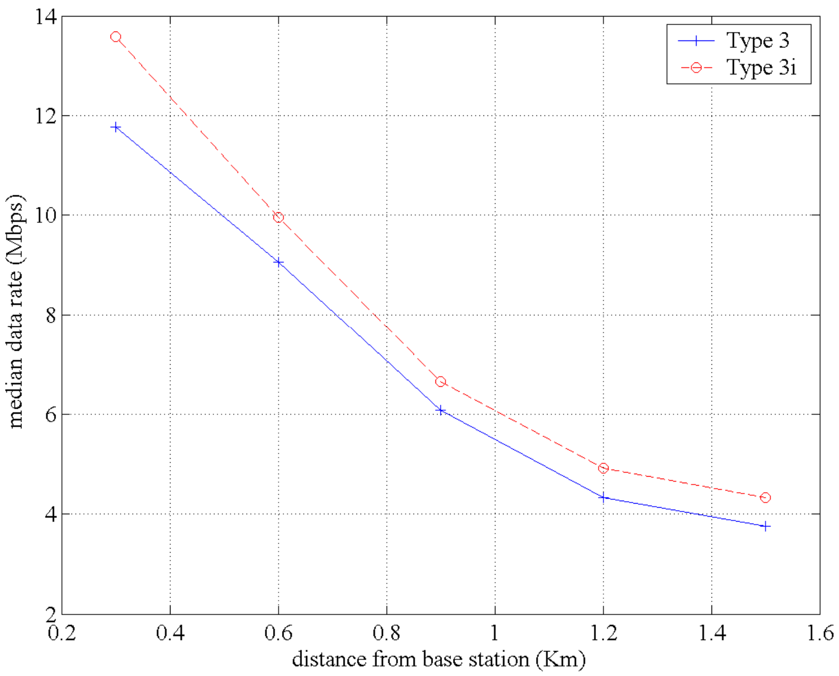

Figure 9.3: Median data rate for users in a highly dispersive channel

Simulation results for the mildly dispersive channel are shown in Fig. 9.4 and Fig. 9.5, for 10th percentile and median data rate, respectively. The improvement for the 10th percentile data rate is in the range of 20-55% throughout the cell coverage area. On the other hand, we observe that the gains for median data rates are moderate.

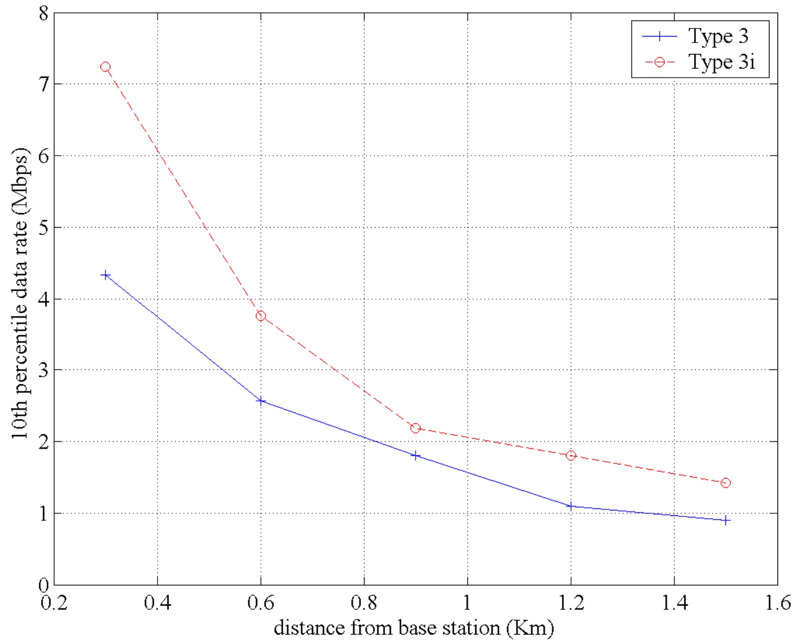

Figure 9.4: 10th percentile data rate for users in a mildly dispersive channel

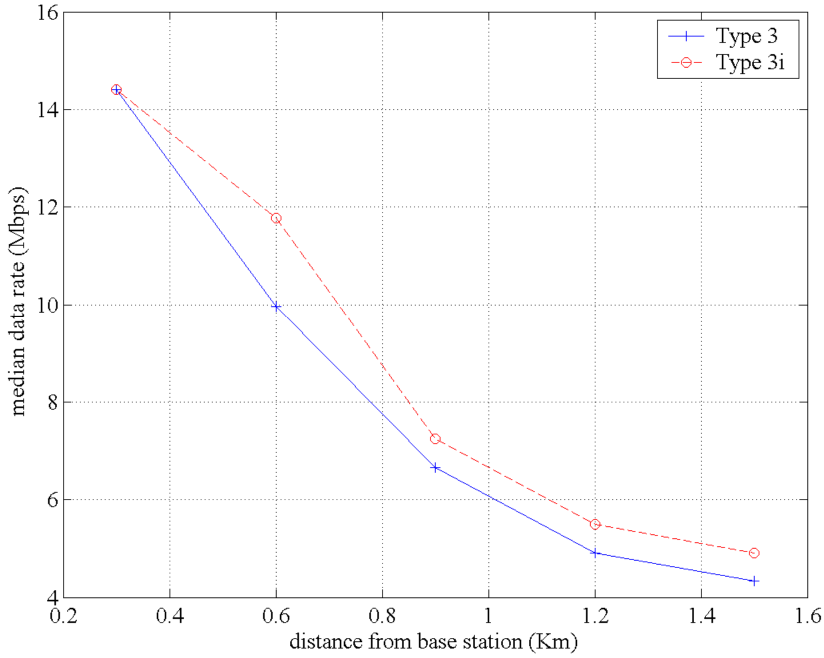

Figure 9.5: Median data rate for users in a mildly dispersive channel

9.2 Second system-level study (Nokia)

9.2.1 Simulation setup for second study

The simulations were performed in a macro cell scenario, which consists of 7 Node Bs and 21 hexagonal cells (sectors) of radius of 933 meters. Thus the site-to-site distance was 2800 m, which differs from the 1000 m, used in [4]. Propagation model was based on [7] and log-normally distributed slow fading with an 8 dB standard deviation and a spatial correlation distance of 50 meters were assumed. The evaluated channel profiles was modified Vehicular A. The power delay profiles were modified from the original ITU power delay profiles so that the tap delays are integer chips. Average path powers were [-3.1, -5.0, -10.4, -13.4, -13.9, -20.4] dB in Vehicular A channel.

MAC-hs packet scheduling based on Proportional Fair scheduling algorithms was used without code-multiplexing, i.e. only one UE is scheduled per TTI. The maximum numbers of HS-DSCH codes was 10 with spreading factor 16. HS-DSCH power allocation was 14 W, which is 70% of the total base station transmission power. One code was allocated for HS-SCCH with spreading factor of 128. HS-SCCH was power controlled so that the power follows the average power over the last TTI of the associated DCH with an offset. Realistic reception of HS-SCCH was considered. Six parallel stop-and-wait (SAW) channels were used for the Hybrid ARQ. At the maximum 4 retransmissions were allowed per transport block. Chase Combining was used for the retransmissions [68].

HS-DSCH link adaptation was based on the UE reported channel quality indicators (CQI's) (inner loop) and UE reported Ack/Nacks from past retransmissions (outer loop). Aimed residual block error rate (BLER) after the second transmission was 1% and link adaptation outer loop was used to control the BLER target. The MCS tables used in Node B were throughput optimized. CQI reporting granularity of 1dB was accounted. CQI reporting error, which was modeled as log-normally distributed with standard deviation of 1 dB, was included in the simulations. The CQI"s reported by UE"s were always based on normal (or noninterference aware) LMMSE chip level equalizer. The link adaptation outer loop was set to account the difference between normal LMMSE and interference aware LMMSE equalizer in SINR calculation.

Mobility and traffic models were based on UMTS 30.03 [69]. UE velocity was 3km/h. Modified web browsing traffic model, in which the users do not have a reading time during a download session i.e. they only have one packet call per session, was used. The total simulation time was 6 minutes. The call arrival rate in the network was 140 calls per second and the average packet call size was 112 kilobytes. Thus, the total average offered load per cell can be calculated as A * B / C, where A is the call arrival rate, B is the average packet call size and C is the number of cells in the network. In these simulations the average offered load per cell was approximately 6 Mbps. New calls were generated according to homogeneous Poisson process. The offered traffic was high enough to have almost 100 % utilization of the HS-DSCH. Admission control allowed up to 16 HSDPA users per cell.

The LMMSE equalizer and interference aware LMMSE equalizer were used for HS-DSCH with and without Rx diversity. For determining the SINR used with the interference aware LMMSE equalizer under study (i.e. either Type 2i or Type 3i) the interference seen from strongest interfering cells was explicitly accounted by modelling the actual channel matrices of the cells [2]. The calculation of noise covariance matrix in SINR calculation was thus done in the assumption that the channel matrices of the strongest interfering cells are ideally known at the receiver. Three strongest interfering other cells were accounted in the calculation as it was noticed that considering fourth strongest interferer or lower did not affect the results significantly. The main simulation parameters are also listed in Table 9.2 below.

Table 9.2: System Simulation Parameters

Parameter	Explanation/Assumption	Comments
Cellular layout	Hexagonal cell grid, wrap-around	7 Node-Bs and 21 sectors
Cell radius	933 m	Corresponds to a Node-B to Node-B distance of 2800 m.
Propagation Model	$L = 128.1 + 37.6 Log_{10}(R_{km})$	
Radio propagation condition	Vehicular A with 3 km/h	
Std. deviation of slow fading	8 dB	
Correlation between sectors	1.0	The correlation in the slow fading between the sectors. The UE experiences the same kind of slow fading in the area of the correlating sectors, i.e. the fading is not entirely random.
Correlation between Node-Bs	0.5	The correlation in the slow fading between the Node-Bs.
Correlation distance of slow fading	50 m	This parameter defines the maximum distance within which the UE experiences correlated slow fading to a sector.
Minimum path loss	70 dB	
BS antenna gain	18 dB	
Antenna front to back ratio	-20 dB	
Node-B total Tx power	43 dBm	Corresponds to 20 W.
Power resource for HS-DSCH	14 W	
HSDPA packet scheduling algorithm	Proportional fair	
Used Redundancy Version	Chase Combining	
Maximum number of retransmissions	4	Maximum number of retransmission before the corresponding HARQ channel is cleared
Traffic model	Web browsing without reading time	Average packet call size was 112 kbytes
HSDPA RLC PDU size	320 bits	
Code resource for HS-DSCH	10	SF=16
UE HS-DSCH receiver	LMMSE equalizer or interference aware LMMSE equalizer with and without receiver diversity.	Type2/3 and Type2i/3i
Number Of HARQ channels in UE	6	

9.2.2 Simulation results for second study

In Figure 9.6 the CDF of cell throughput obtained with different receivers is presented. In Figure 9.7 the scheduled user E_s/N_0 is depicted.

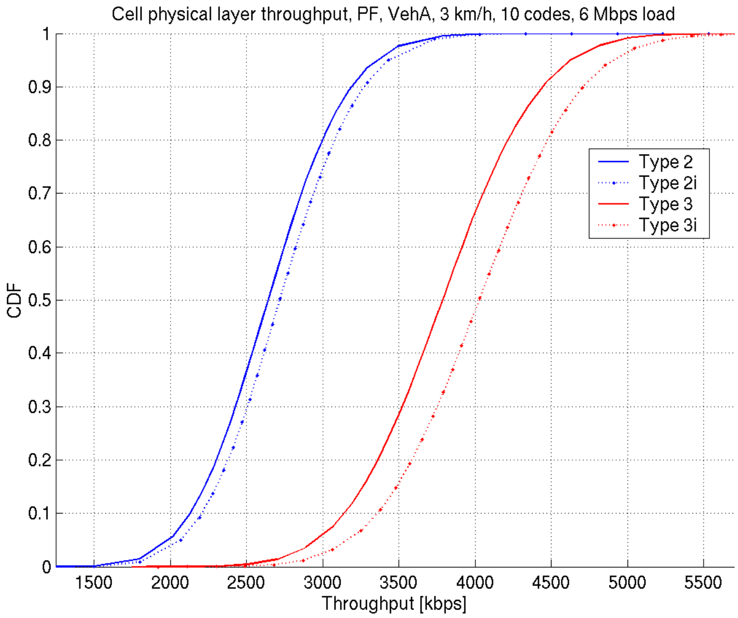

Figure 9.6: Cell throughput

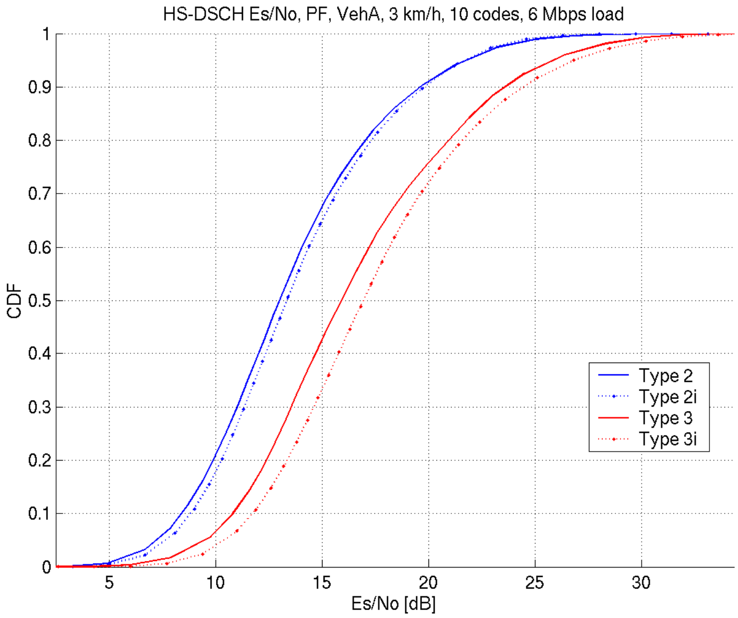

Figure 9.7: HS-DSCH E_s/N_0 distribution of scheduled user

In order to more accurately evaluate the receiver gains and the effect of different network situations to them, more specific throughput statistics were gathered. As interference aware LMMSE equalizer is assumed to provide gain specifically when a strong interferer is present, this effect was attempted to be captured by collecting statistics from UEs with cells of different strength in their vicinity. As the existence of a cell in UEs active set is a good measure of the strength of the cell, the throughput statistics were gathered from UEs in different DCH soft handover states. Statistics for two different handover states were considered. First, the statistics were collected separately for users in DCH soft handover e.g. UEs that have more than one cell in active set and all the cells do not belong to the same Node B. Second state consisted of users that were in softer handover e.g. UEs that have exactly two cells (sectors) in their active set and both are from the same Node B.

Figure 9.8 presents the spatial distribution of users in DCH soft handover and in Figure 9.9 the distribution of users in softer handover is depicted. The terms "soft handover" and "softer handover" refer to DCH handover states and they are only used to refer to the area of interest in the cell.

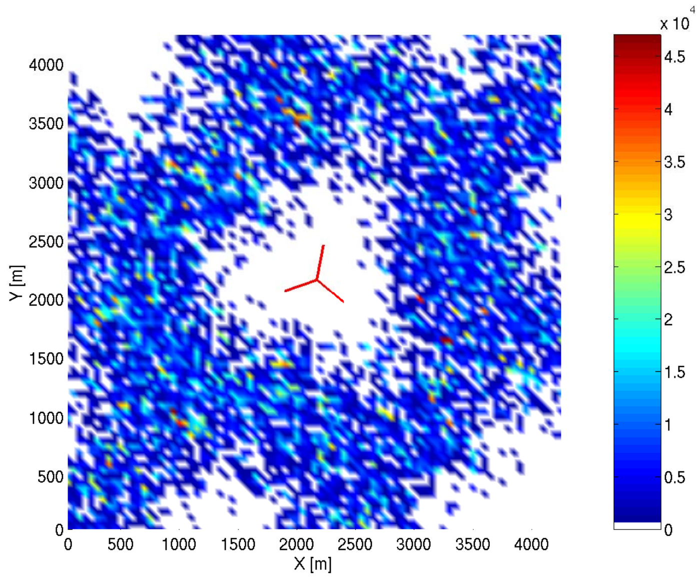

Figure 9.8: Spatial distribution of users in DCH soft handover in respect to the serving Node B

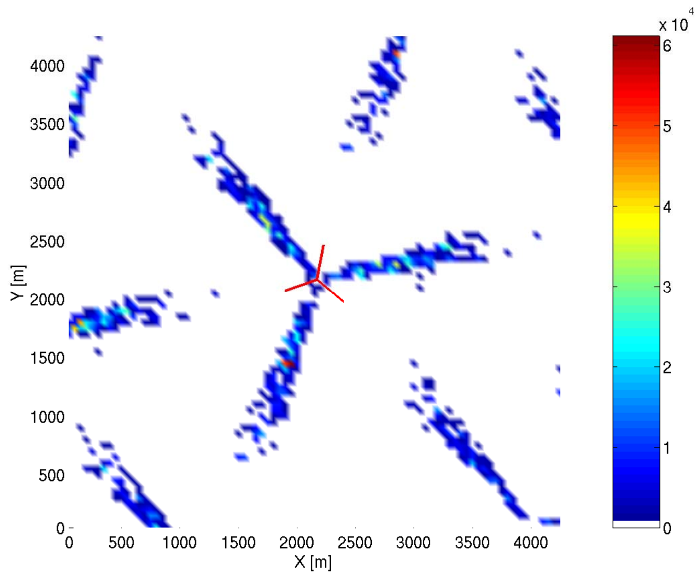

Figure 9.9: Spatial distribution of users in DCH softer handover in respect to the serving Node B

In Table 9.3 the average call throughputs of users in different DCH soft handover states is presented. It can be observed that the benefit of Type 3i receivers is largest at the border regions, the largest gains observed for the soft and softer handover ranging from 22% to 21%. Thus the Type 3i interference aware receivers seems to provide some benefits for the cell edge users, roughly increasing the obtained user throughput by 50kbps. For Type 2i receiver some gain can be seen also for the cell border regions, but for all users a slight loss is seen. As the performance of the cell border users is improved, leading to increased scheduling probability, resulting slight decrease in overall user throughput. The DCH soft handover state of the user used in statistics collecting is determined at the end of the call to be the one in which UE has been longest time during a whole call, thus there may be some variance in the observed call throughputs.

In Table 9.4 the average instantaneous HS-DSCH TTI throughputs of users in the aforementioned states are presented for different receivers evaluated. It can be seen that similarly as in case of the call throughputs, the gain of Type 2i and Type 3i receivers is the highest in the border regions between two cells of a three sector Node B. As the overall gain, considering all users, is 3 % with Type 2i and 6 % with Type 3i, the corresponding gains in the border regions between two sectors is 4 % and 19 %.

The small effect of the higher gains to the total average gains is due to low percentage of the users in the given regions. Only 3-4 % of the scheduled users are located between sector borders, as can be seen in Table 9.5. It should be noted that the percentages shown in Table 9.5 do not necessarily reflect the actual percentage of scheduled users in the different handover areas. There could be also users being scheduled in the same geographical area with only one cell in the active set. The values given in Table 9.5 do however give an insight of the actual percentages.

The users in the outer border regions of the cell realize 5 % and 13 % gains using Type 2i and Type 3i receivers, respectively. Their portion of all users is much larger compared to the users in sector borders. Approximately one of four users is at this region. The significance of these users in overall observed gains is therefore much greater than the users between two sectors of the same Node B.

Table 9.3: Average call throughput of UEs in different DCH SHO states

	All UEs		UE DCH is in soft handover		UE DCH in softer handover	
	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]
Type 2	569	0%	99	0%	130	0%
Type 2i	565	-1%	103	4%	136	5%
Type 3	875	0%	196	0%	247	0%
Type 3i	975	11%	240	22%	297	21%

Table 9.4: Average instantaneous HS-DSCH TTI throughput of UEs in different DCH SHO states

	All UEs		UE DCH is in soft handover		UE DCH in softer handover	
	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]	Throughput [kbps]	Gain over LMMSE [%]
Type 2	2659	0%	1485	0%	1897	0%
Type 2i	2737	3%	1560	5%	1968	4%
Type 3	3795	0%	2223	0%	2705	0%
Type 3i	4037	6%	2513	13%	3209	19%

Table 9.5: Percentage of user in different SHO states

	Pct of scheduled users in DCH soft handover [%]	Pct of scheduled users in DCH softer handover [%]
Type 2	24.2 %	3.6 %
Type 2i	23.8 %	3.6 %
Type 3	23.8 %	3.7 %
Type 3i	23.5 %	3.5 %

9.3 Conclusions

Two different system level simulation studies have been conducted within the study item, both trying to evaluate the benefits of the Type 3i receiver.

The first study concluded that there is indeed an increase in throughput to be seen for the 10th percentile users, which is in the order of 20-55% for mildly dispersive channels and 25-35% for heavily dispersive channels. The second study divided the users into two different groups depending on their DCH handover states, where the first group collected users in soft handover (between cells), and the second group collected users in softer handover (between sectors of the same cell). It was concluded that the Type 3i receiver would seem to provide benefits for the users in these two groups, increasing their throughput by slightly over 20%.

In summary, two different system level simulation studies have been made, both showing benefit for the cell edge users through use of Type3i receivers.

10 Receiver implementation issues

In this clause, receiver implementation issues are discussed that are relevant to the type 3i receiver along with the impact these issues might have on the feasibility of realizing an actual UE implementation. The main issues discussed are the requirement for two "receive" paths or branches, and the complexity of the LMMSE processing as described in clause 4.

With regards to the requirement for two branches, this is an issue that has had quite a bit of history in the evolution of mobile terminals. The main concerns have been the physical realization of two branches (where does one find the space for a second path), and performance issues due to correlation and gain mismatch between paths. 3GPP has already defined performance requirements for two types of enhanced receivers, which require two branches: the type 1 which is based on a conventional rake, and the type 3, which is equalizer based. Thus, there is no need to justify the feasibility of implementing two branches since it is generally accepted that this can be accomplished as further evidenced by the commercial availability of a two-branch, equalized receiver [70]. Certainly, wireless data or PC cards are potentially more amenable to two branch solutions because of additional space that may be available to implement two branches with low amounts of correlation and path mismatch between paths. However, improvements in antenna and RF front-end design are also paving the way for solutions in conventional handsets as well. Even though there might be higher levels of correlation and mismatch between paths in these latter solutions, it seems reasonable to assume that there will still be sufficient gain particularly in interference-limited environments. Thus, though there may be issues with including the second antenna and associated RF front-end electronics, it appears that advancements in technology are enabling both data card and mobile handset implementations.

The LMMSE reference receiver defined for the type 3i receiver is described in detail in clause 4 and [2]. The processing is nearly identical to that defined for the type 3 as defined in [71] except that the type 3i calculates an additional "interference aware" term. What this means is that the received signal covariance matrix for the type 3i is given by

$$C_{rr} = M^0 M^{0H} + \sum_{j=1}^{N_{BS}} P_j M^j (M^j)^H + \sigma_n^2 I \qquad (1)$$

where the first term is the contribution from the desired signal (serving cell), the second term is the contribution from the interfering base stations, and the third term accounts for any residual interference plus thermal noise collectively modeled as AWGN. Note all of these terms have been previously defined in clause 4 and [2]. The presence of the second term is what makes the type 3i interference aware.

The corresponding equation for the Type 3 receiver is

$$C_{rr} = M^0 M^{0H} + \sigma_{N+I}^2 I \qquad (2)$$

where now all of the interference is accounted for in the second term, which is an estimate of the variance of the total interference plus any thermal noise.

The remaining processing to calculate the weights of the equalizer filters is identical for both receiver types. Thus, the only additional processing performed by the type 3i receiver is the calculation of the interference aware term. To calculate this latter term, the type 3i receiver must estimate the channel response matrix and the average power for each of the interfering node Bs (see clause 4), which in this study was assumed to be a maximum of five. Note in an actual receiver implementation the channel response matrix will only be calculated for those interfering cells that are determined to have sufficient energy. Data from field measurements would tend to indicate that the signals from only three interfering node Bs might need to be processed, but a conservative implementation might over bound that with the value of five used in the study. Be that as it may, the processing required to calculate each of the interfering cell channel matrices is identical to the CPICH-based channel estimation processing that the type 3 currently performs for the serving cell. But now in addition to processing the serving cell CPICH, the type 3i receiver will also have to process the CPICHs from each of the interfering cells. Note there may be other methods used to perform channel estimation, but processing the CPICH is one of the most common. Thus, we can conclude that the processing required for the type 3i reference receiver is incremental over that required for a type 3, and thus, quite doable with existing processing capabilities.

11 Conclusions

In this technical report we have documented the work that was accomplished by RAN4 as part of the feasibility study on interference cancellation for UTRA FDD UE. Receiver methods and structures based on an LMMSE sub-chip level equalizer were defined for interference-aware receivers for both two-branch and one-branch implementations. This type of receiver attempts to cancel the interference that arises from users operating outside the serving cell, which is also referred to as other-cell interference. Interference models/profiles were developed for this other-cell interference in terms of the number of interfering Node Bs to consider, and their powers relative to the total other cell interference power, the latter ratios referred to as Dominant Interferer Proportion (DIP) ratios. For the purposes of this study it was determined that five interfering Node Bs should be taken into account in the interference models. DIP ratios were defined based on three criteria; median values of the corresponding cumulative density functions, weighted average throughput gain, and field data. Of these criteria, the one based on the "weighted average" was felt to offer a compromise between the conservative, median value criteria and the more optimistic field data criteria. In addition, two network scenarios were defined, one based solely on HSDPA traffic (HSDPA-only), and the other based on a mixture of HSDPA and Rel. 99 voice traffic (HSDPA+R99).

HSDPA throughput estimates were then developed using link level simulations, which included the other-cell interference models plus OCNS models for the serving and interfering cells based on the two network scenarios considered. The two-branch reference receiver, referred to as a type 3i receiver, was found to offer significant gains in throughput primarily at or near the cell edge. Link level results were developed for a wide range of operating conditions including such factors as transport format, network scenario, modulation, and channel model. For example, the gains for the DIP ratios based on the weighted average ranged from a factor of 1.2 to 2.05 for QPSK H-SET6 PB3, and from 1.2 to 3.02 for VA30 for network geometries of -3 and 0 dB. This complements the performance of existing two-branch equalizers (type 3), which typically provide gain at high geometries, and thus, the combination of the two will lead to a much better user experience over the entire cell.

In addition, a system level study was conducted that indicated that a type 3i receiver provided gains in coverage ranging from 20-55% for mildly dispersive channels, and 25-35% for heavily dispersive channels, the exact value of which depends upon user location. A second system level study divided the users into two different groups depending on their DCH handover states, where the first group collected users in soft handover (between cells), and the second group collected users in softer handover (between sectors of the same cell). The results of this second study indicate that the Type 3i receiver will provide benefits for users in these two groups, increasing their throughput by slightly over 20%. With regards to implementation issues, it was felt that the type 3i receiver is based upon known and mature signal processing techniques, and thus, the complexity is minimized. With two-branch, equalizer-based receivers already available in today"s marketplace, it appears quite doable to develop a two-branch equalizer with interference cancellation/mitigation capabilities. Given all of the above, RAN4 has concluded that two-branch interference cancellation receivers are feasible for HSDPA. However, no such conclusion has yet been reached for the type 2i one-branch receiver.

Annex A: Change history

Change history								
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History

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