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Contents

Foreword

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- x the first digit:
  - 1 presented to TSG for information;
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1 Scope

This document is a technical report of the 1.28Mcps TDD Home NodeB study item, which was approved in TSG RAN#41.

The goal of this study item is,

- To characterise the 1.28Mcps TDD Home NodeB environment.
- To determine the feasibility of a solution and to outline any obstacles for providing high data rate low cost services in home NodeB environment.
- High level HNB requirements are understood not to be complete; hence the report includes a description of the motivation of requirements needed to progress the work
- Whenever possible to offer recommendations for specifications

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*.

[1] RP-070767, Study Item on 1.28Mcps TDD Home NodeB, TD Tech, CMCC, RITT, Huawei, Spreadtrum, CATT, ZTE

[2] R4-082866, "1.28Mcps TDD Home NodeB Frequency Accuracy", TD Tech

[3] 3GPP TS 25.105 "Base Station (BS) radio transmission and reception (TDD)"

[4] R4-071025, "Consideration on frequency accuracy requirement for Home Node B " RAN1 43bis, Orlando, USA

[5] R4-090084, "Text Proposal on 1.28Mcps TDD Home NodeB RF Requirements" TD Tech

[6] R4-090086, "Text Proposal on Frequency Accuracy o f 1.28Mcps TDD Home NodeB" TD Tech

[7] R4-090675, "Text Proposal on 1.28Mcps TDD Home NodeB Deployment Configuration" TD Tech

[8] R4-090677, "Text proposal on Interference scenarios and Analysis on 1.28Mcps TDD Macro BS and Home NodeB" TD Tech

[9] R4-090987, "Text Proposal on Spurious Emission of transmitter of 1.28Mcps TDD Home NodeB" TD Tech

[10] R4-092114, "Text proposal on Simulation Assumption on 1.28Mcps TDD Macro BS and Home NodeB" TD Tech, Picochip Designs, CATT, CMCC

[11] R4-092145, "Text proposal on demodulation performance of 1.28Mcps TDD Home NodeB" TD Tech

[12] R4-092146, "Text proposal on Output Power of 1.28Mcps TDD Home NodeB" TD Tech

[13] R4-092936, “Text Proposal on Simulation results of maximum output power of 1.28Mcps TDD Home Node B” CATT

[14] R3-092133, “Text proposal to 25.866 on synchronization schemes for 1.28Mcps TDD Home Node B” TD Tech, CATT, ZTE

[15] R4-093487, “Text Proposal on Simulation results of Home NodeB and Macro BS” TD Tech

[16] R4-093492, “Text Proposal on intermodulation of 1.28Mcps TDD Home NodeB receiver” TD Tech

[17] R4-094371, “Text Proposal on sensitivity of 1.28Mcps TDD Home NodeB receiver” TD Tech

[18] R4-094854, “Simulation results for LCR Home NodeB receiver” CATT

[19] R4-094372, “Text Proposal on dynamic range of 1.28Mcps TDD Home NodeB receiver” TD Tech, CMCC

[20] R4-094373, “Text Proposal on ACS of 1.28Mcps TDD Home NodeB receiver” TD Tech, CMCC

[21] R4-094374, “Text Proposal on blocking of 1.28Mcps TDD Home NodeB receiver” TD Tech

[22] R4-094369, “Text Proposal on Simulation results of Home NodeB and Macro BS” Picochip Designs

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Symbols

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

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [x] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ACS Adjacent Channel Selection
CLPC Closed loop power control
CSG Closed Subscriber Group
DL Downlink
FOC Frequency Offset Correction
HNB Home NodeB
HO Handover
ISCP Interference Signal Code Power
MCL Min. Coupling Loss
MUD Multi User Detection
NF Noise Figure
PC Power Control
RX Receiver
TDD Time Division Duplexing
TX Transmitter
UE User Equipment
UL Uplink

UTRAN UMTS Terrestrial Radio Access Network

4 Introduction [1]

An increasing need for 1.28Mcps TDD Home NodeBs is observed to provide attractive services and data rates in home environments in China as a consequence of a large number of TD-SCDMA subscribers within recent years.

Whereas UTRAN is not optimally suited for this application, as it was developed and defined under the assumption of coordinated network deployment. Actually home NodeBs are typically associated with uncoordinated and large scale deployment.

The aim of this feasibility study is to investigate optimizations and amendments to the standard in order to fully support the application of 1.28Mcps TDD Home NodeBs.

This study includes but is not limited to the architecture aspect, HO scenario and interference consideration, etc.

New synchronization mechanism for 1.28Mcps TDD Home NodeB should be taken into consideration because there are more stringent synchronization requirements for 1.28Mcps TDD.

In order to minimize the impact on the existing overall network, the home NodeB concept for 1.28Mcps TDD shall operate with legacy terminal (from Release 4 onwards) and core network, and should minimize impact on protocol interfaces. So far no impact to terminal specifications is foreseen.

Once the feasibility study is finalized, a feasible solution regarding 1.28Mcps TDD Home NodeB deployment can be enabled.

4.1 Task description [1]

The purpose of this study item is to characterise the 1.28Mcps TDD Home NodeB environment and investigate the feasibility of optimisations and amendments to 1.28Mcps TDD mode to adapt it to fully support the Home NodeB.

In order to achieve this, studies should be carried out in at least the following areas:

For RAN4:

- Requirements
    - Identify any new, revised or missing RF requirements for 1.28Mcps TDD Home NodeB
    - Identify relevant deployment scenarios
- RF-related issues
    - Investigating RF related aspects such as interference scenarios and investigating RF performance requirements for 1.28Mcps TDD Home NodeB
- Frequency accuracy
    - How much the frequency accuracy can be relaxed in home environment
- Associated class definitions
    - Investigate (based on requirements and scenario coverage in the current specification) whether the local area class can be extended to cover scenarios for the 1.28Mcps TDD Home Node B, or a new class needs to be defined

For RAN1:

- Physical Layer
    - Investigation on if and which 1.28Mcps TDD physical layer specifications might be impacted

For RAN2 and RAN3:

- Architecture
  - Investigation on which UTRAN interfaces might be impacted for 1.28Mcps TDD Home NodeB
  - Investigate whether Home NodeBs need to be synchronized among each other or with the macro network and how synchronisation can be achieved in a scalable manner
- Implications of deployment and/or operational scenario for 1.28Mcps TDD Home NodeB
  - Potential for very high density of 1.28Mcps TDD Home NodeBs

    Note: for the investigation of this topic, it shall be taken into account that rigorous planning is not necessarily possible and/or desirable for consumer premise equipment
- Mobility and access control

Investigation on if and which 1.28Mcps TDD air interfaces might be impacted

5 RF Aspects (RAN WG4)

5.1 Requirements [5]

RF Requirements for 1.28Mcps TDD Home NodeBs will base on the local area 1.28Mcps TDD NodeB, with additional requirements as described in the following,

1) 1.28Mcps TDD Home NodeBs should not degrade significantly the performance of networks deployed in other channels. 5% performance degradation is acceptable to Macro BS.

   Adjacent channel co-existence should be considered as the worst case.

   Performance is quantified in terms of UE throughput, coverage and spectral efficiency, taking into account cell edge, average UE and close to the Home NodeB.

2) 1.28Mcps TDD Home NodeB configurations intended for deployment in the same carrier as an existing 1.28Mcps TDD network should ensure their combined performance is not significantly worse than that of the original network.

   This requirement is only applicable if it is deemed feasible to deploy Home NodeBs in the same channel as an existing network.

   Combined performance is equal to the addition of macro network and the Home NodeB network taking into account the open/closed access configuration. Performance is quantified in terms of UE throughput, coverage and spectral efficiency, taking into account cell edge, average UE and close to the Home NodeB same as 1).

3) 1.28Mcps TDD Home NodeBs should provide reasonable performance whether deployed in isolation or whether multiple Home NodeBs are deployed in the same area.

   Home NodeBs should provide a minimum level of performance, even when many are deployed near to each other, as would be the case in a housing estate. Furthermore, any interference mitigation techniques used to meet requirements 1 and 2 should do so without significantly compromising the performance of the Home NodeB. For example, a simple mechanism could switch off the Home NodeB when it causes interference. However, the Home NodeB itself would then be of no value.

   Performance is quantified in terms of UE throughput, coverage, and spectral efficiency, taking into account cell edge and average UE.

4) As 1.28Mcps TDD Home NodeBs may be owned privately and portable, it shall only radiate while it is confirmed that such an emission complies with regulatory requirements in force where that Home NodeB is operating.

   Radiation in licensed spectrum requires authorization from the license holder (i.e. an operator), who in turn is responsible for ensuring that emissions comply with the associated regulatory requirements. One key issue here is how the operator will verify that the is in the geographical region specified in their license. Whilst it is clear that a procedure is needed to support this requirement, it is considered to be beyond the scope of RAN WG4 to define it. Currently RAN4 assumes that the following aspects would need to be taken into account:

- HNB location
    1. Home NodeB must be within operator' license Area when they are operating.
    2. A more precise location may be required for other reasons, such as emergency service.
- communication link between HNB and HNB operator
    3. There must be a communication link to receive authorization
    4. The link may need to achieve minimum performance requirements for offered services.
- HNB identity.
    5. The Home NodeB operator must be able to verify the Home NodeB indentity.
- other FFS

5) 1.28Mcps TDD Home NodeB must support UE speeds up to 30 km/h.

Need to support UE speeds greater than 30 km/h is extremely unlikely. Further reductions in supported speed may be possible, but are not critical, since a limit of 30 km/h represents a significant and useful reduction from the current local area specification.

6) 1.28Mcps TDD Home NodeB must support existing 1.28Mcps TDD UEs.

Home NodeB must be backwards compatible with 1.28Mcps TDD UEs already in the field.

5.2 Deployment Configurations [7]

The following aspects are considered for Home NodeB deployment configuration:

- Open access or CSG (Closed Subscriber Group)
    - Open access Home NodeB makes no difference from a generic NodeB and can serve any UE.
    - CSG Home NodeBs only serve UEs belonging to a particular Closed Subscriber Group
- Dedicated channels, co-channels, sharing channel
    - Dedicated channels: Home NodeBs operate on their own separate channels which are not shared by macros cells.
    - Co-channels: Home NodeBs and macro cells operate on the same existing channels.
    - Full sharing channels: Home NodeB and macro cells share a set of channels. Home NodeBs can choose to operate on some channels from the set according to the channel interference measurement.
    - Partial Sharing Channels: macro cells can reside on all the channels of a channel set, while Home NodeB can only share part of the set.
- Fixed or adaptive (DL) maximum transmit power
    - Fixed: Home NodeBs transmit power levels are confined to a set fixed maximum values.
    - Adaptive: Home NodeB's sense interference to existing networks, and adjust maximum transmit power accordingly

Considering on the analysis of interference between the macro cells and Home NodeBs, the following configurations are considered and described in more detail in the following sections.

A. CSG, Dedicated channels, Fixed Power

B. CSG, Dedicated channels, Adaptive Power

C. CSG, Full sharing channels, Adaptive Power

D. CSG, Partial sharing channels, Adaptive Power

E. CSG, Co-channels, Adaptive Power

F. Open Access, dedicated or co-channel

5.2.1 Configuration A. CSG, Dedicated Channels, Fixed Power

Home NodeB is configured as a Closed Subscriber Group. Access to Home NodeB is controlled through an agreement between the Home NodeB owner and the network operator. Only the UEs allowed by the agreement are able to access the Home NodeB, other UEs do not have access to the Home NodeB.

The Home NodeBs are allocated to operate on dedicated channels which are not shared by the macro cells. The worst interference case is the adjacent channel interference between the neighboring Home NodeBs and this interference is especially severe when exactly the same channels are employed by the neighboring Home NodeBs.

Compared to the case Home NodeB and macro cell share the same channel, the dedicated channel configuration greatly reduces the interference between the macro cell and Home NodeB. However, the co-channel interference scenarios between Home NodeBs sharing the same channels still need analysis, especially, in the region where dense populations of Home NodeBs operate. In this configuration, the Home NodeB's maximum transmit power could potentially be fixed by the operator according to the deployment environment and interference level to/from adjacent Home NodeB or macro-cells. The fixed maximum transmit level shall not be set to too low for guaranteeing Home NodeB serving size.

5.2.2 Configuration B. CSG, Dedicated Channels, Adaptive Power

Home NodeBs are configured as a Closed Subscriber Group and operate on dedicated channels.

In this configuration, the maximum transmit power is adjustable for balancing the interference to/from macro-cells and adjacent Home NodeBs. The maximum transmit power may be set as high as the maximum capability of the Home NodeB. However, this adjustable power shall be confined to a suitable level regarding the interference to other Home NodeBs or Macro cells.

5.2.3 Configuration C. CSG, Full sharing channels, Adaptive Power

Home NodeBs are configured as a Closed Subscriber Group. Before a Home NodeB resides on channel(s), it shall listen to a set of available channels shared by Home NodeBs and macro cells and chooses the channels that have the least interference. The interference levels can be decided by the Home NodeB according to itself measurement or reports from the Home NodeB UE. The maximum transmit power level are adaptively configured according to the interference measurement. For lowering the interference to other Home NodeBs and macro cells at a reasonable level, the maximum transmit power can be set as low as possible, but shall guarantee provide the qualified service.

This configuration is a balance of the interference and the limited channels. In this configuration, the Home NodeBs can operate on any channel assigned, when they experience unacceptable interference on channels from adjacent home NodeBs or from macro cells, they can shift to the other channels with lower interference.

5.2.4 Configuration D. CSG, Partial sharing channels, Adaptive Power

Home NodeB is configured as a Closed Subscriber Group. Compared to the configuration C, Home NodeB only shares part of the channel set, while macro cells can reside on all the channels in the set as shown in Figure 1.

In this configuration, when macro cell UEs in the shared part experience interference from Home NodeB, they can move to the clear part only available to macro cells UE. Home NodeBs can also choose to work on some channels in the share part based on the channel interference measurement. Further, Home NodeB can decide on changing to another channel(s) in the shared part when they experience unacceptable interference from Home NodeB or macro cells.

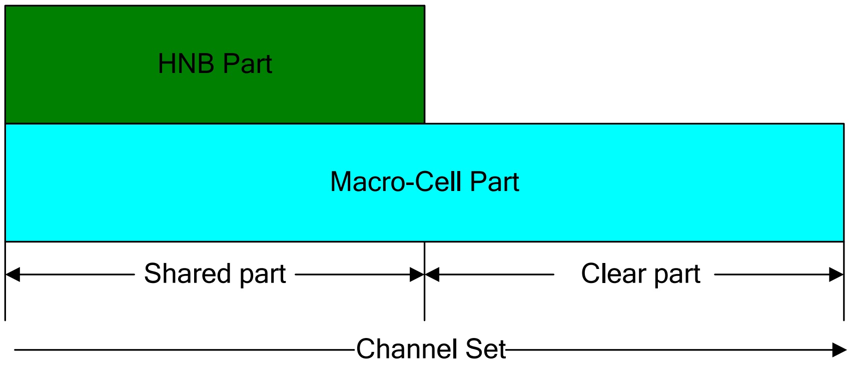


Figure 5.2.4.1-1: Partial channel sharing with Macro and Home NodeBs

5.2.5 Configuration E. CSG, Co-channel, Adaptive Power

Home NodeB is configured as a Closed Subscriber Group and shares the same channels as the macro network. This configuration introduces the worst interference case between the Home NodeB and macro cells. The transmit power levels of both macro-cell and Home NodeB share be controlled in an appropriate manner for balancing the interference between. This configuration envisages the highest risk.

5.2.6 Configuration F: Open Access, dedicated or co-channel

Open access Home NodeBs serve all UEs in the same way as a generic NodeB does. The Home NodeBs operate on dedicated channels or share the same channels with macro cells.

In this configuration, Home NodeB can be considered as an enhancement for the cell coverage and traffic load.

5.3 Interference Scenarios and Analysis

5.3.1 Interference Scenarios [8]

Considering interferences between Home NodeB and Macro BS and among Home NodeBs, all interference scenarios are listed in Table 5.3.1.

Scenario 1, scenario 2, scenario 3 and scenario 4 are interference scenarios considering Home NodeB and Macro Base station. To scenario 1 and 4, the worst case is that Home NodeB is close to Macro BS, and UE attached Home NodeB locates the cell border of Home NodeB. To scenario 2 and 3, the worst case is that the Macro UE is close to Home NodeB and Macro UE located at the cell edge of Macro BS.

There are 2 interference scenarios between a Home NodeB and the macro NodeB for protecting Macro NodeB. One is Home NodeB Uplink interfere with Maro NodeB Uplink i.e. Scenario 1, another is Home NodeB Downlink interfere with Macro NodeB Downlink i.e. Scenario 2. There are two aspects to evaluate Macro BS' performance, P-CCPCH receipt and Macro NodeB' HSDPA throughput.

Scenario 5 and Scenario 6 are interference between Home NodeB 1 and Home NodeB 2. In these two scenarios, any close distance between Home NodeB and UE attached to other Home NodeB can be cause to produce interference.

Table 5.3.1: Interference Scenarios

Number	Aggressor	Victim
1	UE attached to Home Node B (Uplink)	Macro Node B Uplink
2	Home Node B (Downlink)	Macro Node B Downlink (UE)
3	UE attached to Macro Node B (Uplink)	Home Node B Uplink
4	Macro Node B (Downlink)	Home Node B Downlink
5	UE attached to Home Node B (Uplink)	Home Node B Uplink (Home NodeB)
6	Home Node B (Downlink)	Other Home Node B Downlink (UE)

5.3.2 Interference Analysis

It is suggested that Monte Carlo method from TR 25.942 and determinative methods are applied on interference simulation of Home NodeBs and Macro BS.

5.3.2.1 Assumption [10]

Common simulation parameters of 1.28Mcps TDD Macro BS and Home NodeB are shown in Table 5.3.2.1-1.

Table5.3.2.1-1: 1.28Mcps TDD Macro BS and Home NodeB simulation assumptions

Parameter	UL value	DL value
SIMULATION TYPE	Snapshot	Snapshot
PROPAGATION PARAMETERS		
MCL macro (including antenna gain)	70 dB	70 dB
Antenna gain (including losses)	0 dBi (UE Tx) , 0 dBi (HomeNodeB, Rx)	0 dBi (HomeNodeB, Tx) 0 dBi(UE, Rx)
	0 dBi (UE Tx) 16 dBi (Macro Rx)	16 dBi (Macro Tx), 0 dBi(UE, Rx)
Log Normal fade margin	10 dB	10 dB
PC MODELLING[Note 1]		
# of snapshots	*800 for speech*	*800 for speech*
#PC steps per snapshot	> 150	> 150
Step size PC	perfect PC	perfect PC
PC error	0 %	0 %
Margin in respect with target C/I	0 dB	0 dB
Initial TX power	*Based on C/I target*	*Based on C/I target*
Outage condition	Eb/N0 target not reached due to lack of TX power	Eb/N0 target not reached due to lack of TX power
Satisfied user		measured Eb/N0 higher than Eb/N0 target - 0.5 dB
HANDOVER MODELING	*Not included*	*Not included*
NOISE PARAMETERS		
Noise figure	5 dB (Macro), [5] dB (HomeNodeB)	9 dB (UE)
Noise power	-108 dBm	-104 dBm
TX POWER		
Maximum BTS power		34 dBm macro
Maximum Home NodeB power		[20],[15],[13][10][5][0]dBm
Maximum UE power	21dBm	
Power control range	70 dB (UE)	30 dB (Home NodeB and Marco)
ADMISSION CONTROL	Not included	Not included
USER DISTRIBUTION		Random and uniform across the network
INTERFERENCE REDUCTION		
MUD	*On*	*On*
Non orthogonality factor macrocells	*0*	*0*
COMMON CHANNEL ORTHOGONALITY		Orthogonal
DEPLOYMENT SCENARIO		
BTS type		directional
Cell radius macro		[333]，[500] m macro
Inter-site single operator		[1000]，[1500] macro
Min. of macro cells		*[57]* with wrap around technique
Home NodeB Type		Omnidirectional
Home NodeB Indoor Scenario [Note 2]		
SIMULATED SERVICES		
bit-rate speech	12.2 kbps	12.2 kbps
Multipath environment macro	Vehicular macro	Vehicular macro
Eb/N0 target	*[ ]* dB	*[ ]* dB
HSDPA		
Multipath environment macro	Vehicular macro	Vehicular macro
Throughput		

Note1: When HSDPA service is analyzed, Downlink power control is turned off.

Note 2: Detailed indoor scenario refer to Section 4

The following propagation models are suggested.

- Path loss model between Macro BS and UE[1]

1. UMTS 30.03

If distance of Macro BS and UE is less than 100m, free space model is used. Or following Path loss Model for Vehicular in UMTS 30.03 is used. When Macro UE is indoor, penetration loss of wall should be considered.

$$L_{BS-UE} = \left(40\left(1-4\times10^{-3}\Delta h_b\right)\right)\cdot\log\left(d\right)-18\cdot\log\left(\Delta h_b\right)+21\cdot\log\left(f\right)+80 \qquad (1)$$

Where,

f – carrier frequency MHz

Δh_b – the base station antenna height measure from average rooftop, 6m is assumed.

d – distance km $d \geq 0.1\ km$

2. Cost231-OH

The expression of COST231-OH for built-up areas is as follows:

$$L = 46.3 + 33.9\log(f) - 13.82\log(h_b) + (44.9 - 6.55\log(h_b)\log(d) - F(h_M) + C$$

$$F(h_M) = \begin{cases} (1.1\times\log(f)-0.7)\times h_M - (1.56\times\log(f)-0.8) & \text{medium to small cities} \\ 3.2\times(\log(11.75\times \mathrm{h_M}))^2 - 4.97 & \text{for large cities} \end{cases}$$

The clutter correction factor is given by:

$$C = \begin{cases} 0dB & \text{for medium - size cities and suburban areas} \\ 3dB & \text{for large cities} \end{cases}$$

The parameters in the above expressions stand for:

f : frequency [MHz]

h_b : base station height above ground level [m]

h_M : mobile station height above ground [m]

d : distance from base station [km]

3. ITU P.1238

The expression for the pathloss is provided below:

$$L_{total} = 20\log_{10} f + N\log_{10} d + L_f(n) - 28$$

where

N : distance power loss coefficient

f : frequency (MHz)

d : separation distance (m) between the base station and portable terminal (where d>1m)

L_f : floor penetration loss factor (dB)

n : number of floors between base station and portable terminal ($n \geq 1$)

In the frequency range 1.8-2GHz, ITU suggests using the following power loss coefficients N:

- Residential: 28
- Office: 30
- Commercial: 22

And the following values for the floor penetration loss factor L_f:

- Residential: 4 x n
- Office: 15 + 4 x (n – 1)
- Commercial: 6 + 3 x (n – 1)

4. ITU P.1411

The LoS-street canyon model provides an upper and a lower bound for the pathloss using the following expressions:

$$L_{LoS,l} = L_{bp} + \begin{cases} 20\log_{10}\left(\dfrac{d}{R_{bp}}\right) & \text{for} \quad d \leq R_{bp} \\ 40\log_{10}\left(\dfrac{d}{R_{bp}}\right) & \text{for} \quad d > R_{bp} \end{cases}$$

for the lower bound, with the breakpoint distance given by $R_{bp} \approx \dfrac{4 h_b h_m}{\lambda}$; and

$$L_{LoS,u} = L_{bp} + 20 + \begin{cases} 25\log_{10}\left(\dfrac{d}{R_{bp}}\right) & \text{for} \quad d \leq R_{bp} \\ 40\log_{10}\left(\dfrac{d}{R_{bp}}\right) & \text{for} \quad d > R_{bp} \end{cases}$$

for the upper bound, the basic transmission loss at the breakpoint distance is given by:

$$L_{bp} = \left| 20\log_{10}\left(\frac{\lambda^2}{8\pi h_b h_m}\right) \right|$$

The other parameters in the above expressions are:

- λ which is the wavelength (m)
- h_b *and* h_M which are the basestation and the mobile unit's height above street level
- d is the distance from base station (m)

● Path loss model between UE and Home NodeB

Indoor UMTS 30.03 pathloss model is used as following,

$$Pathloss = 37 + 30 \times \log 10(d) + 18.3 \times n^{\left(\frac{n+2}{n+1} - 0.46\right)}$$

Outdoor to indoor UMTS 30.03 pathloss model is also used as following:

$$L = 40\, Log_{10}(R) + 30\, Log_{10}(f) + 49$$

where:

R is the base station - mobile station separation in kilometres;

f is the carrier frequency of 2000 in MHz for UMTS band application.

NOTE: *L* shall in no circumstances be less than free space loss. This model is valid for non-line-of-sight (NLOS) case only and describes worse case propagation. Log-normal shadow fading with a standard deviation of 10 dB for outdoor users and 12 dB for indoor users is assumed.

Note1: other suitable path losses are not excluded.

5.3.2.1.1 Indoor Scenario

- UMTS 30.03 indoor scenario.

UMTS 30.03 indoor scenario is shown in Figure 5.3.2.1.1- 1.

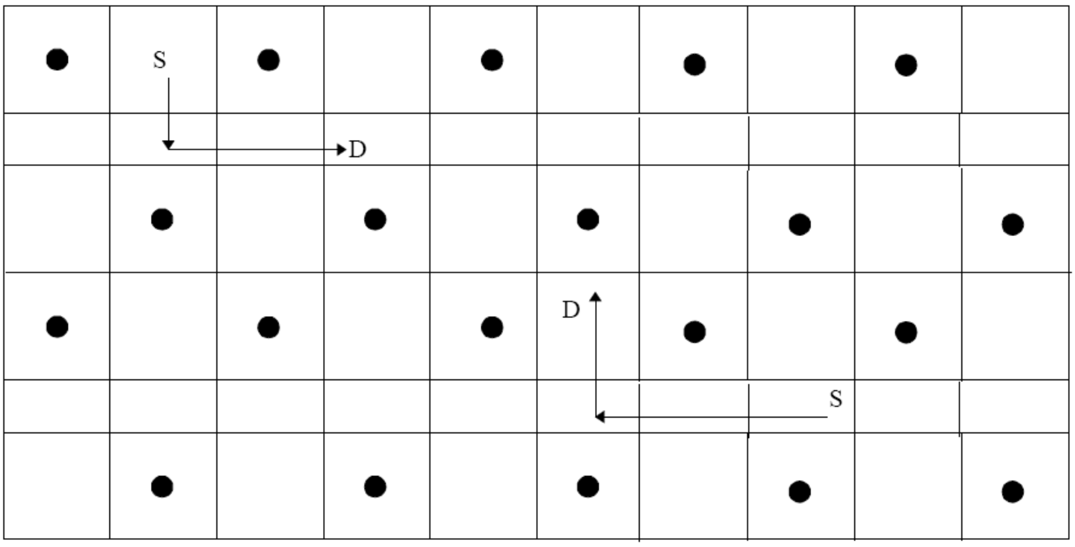


Figure5.3.2.1.1-1: UMTS 30.03 indoor scenario

Table 5.3.2.1.1-1: UMTS 30.03 Indoor parameters

Area (m^2)	5000（100*50）
Layer	3
Size of room and corridor（m^3）	Room：10*10*3
	Corridor：100*5*3

- 5x5 apartment.

This scenario consists of 25 apartments (5x5). Each apartment is of size 10x10 m (100 m2). In addition to indoor areas, the model contains also an outdoor area surrounding the building, see Figure 5.3.2.1.1-2.

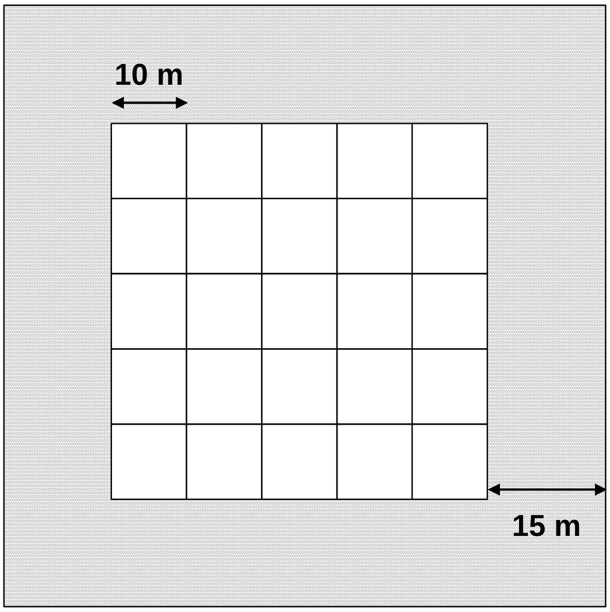


Figure5.3.2.1.1- 2: Reference [3] indoor apartment scenario

Typical apartment and house are also needed evaluation.

- Semi-detached house

The semi-detached building with 2 floors is shown in Figure 5.3.2.1.1-3. The semi detached building has two floors and a footprint of approximately 8.8m x 14.5m for both homes. Each floor is assumed to be 3m high. The HUE is assumed to be allowed to take up any position within its own home. In this scenario only one house, i.e. one side of the semi, has been studied in detail.

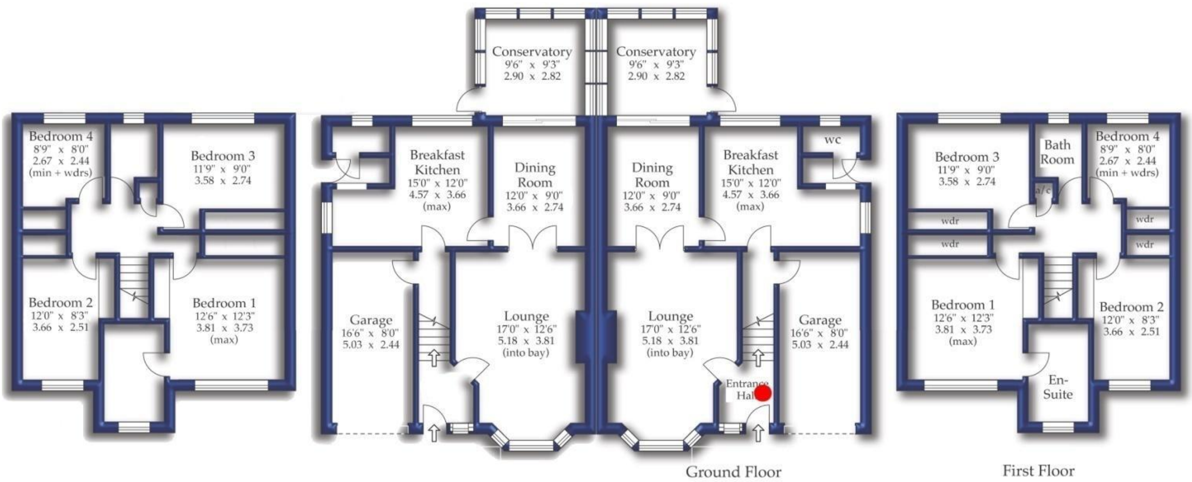


Figure 5.3.2.1.1-3: Floor plan of a semi-detached house

The penetration loss parameters of the obstructions in the houses are listed in Table 5.3.2.1.1-2.

Table 5.3.2.1.1-2 : Obstruction loss parameters

Obstruction	Loss (dB)
Heavy Internal Wall	8
Light Internal Wall	7
Floor	19
Brick	12
Brick with window	8
Wood	7

The external walls have been modelled as brick or brick with window where appropriate. The dividing wall between the two houses has been assumed to be a heavy internal wall and all other internal walls are assumed to be light. The external doors are made of wood and all doors inside the building are assumed to be open. The stairs are modelled as a heavy internal wall on the ground floor in order to simulate the obstacle they would present to radio signals and there is a void between the first and second floor to simulate the stairwell. Finally the conservatory has been modelled as all glass.

- Modern apartment building

The residential model used here is a modern apartment building. The block consists of identical floors of four flats on each floor in a North, South, East, West arrangement as shown in Figure 5.3.2.1.1-4. The building has a footprint of approximately 25m x 25m and each floor is assumed to be 3m high.

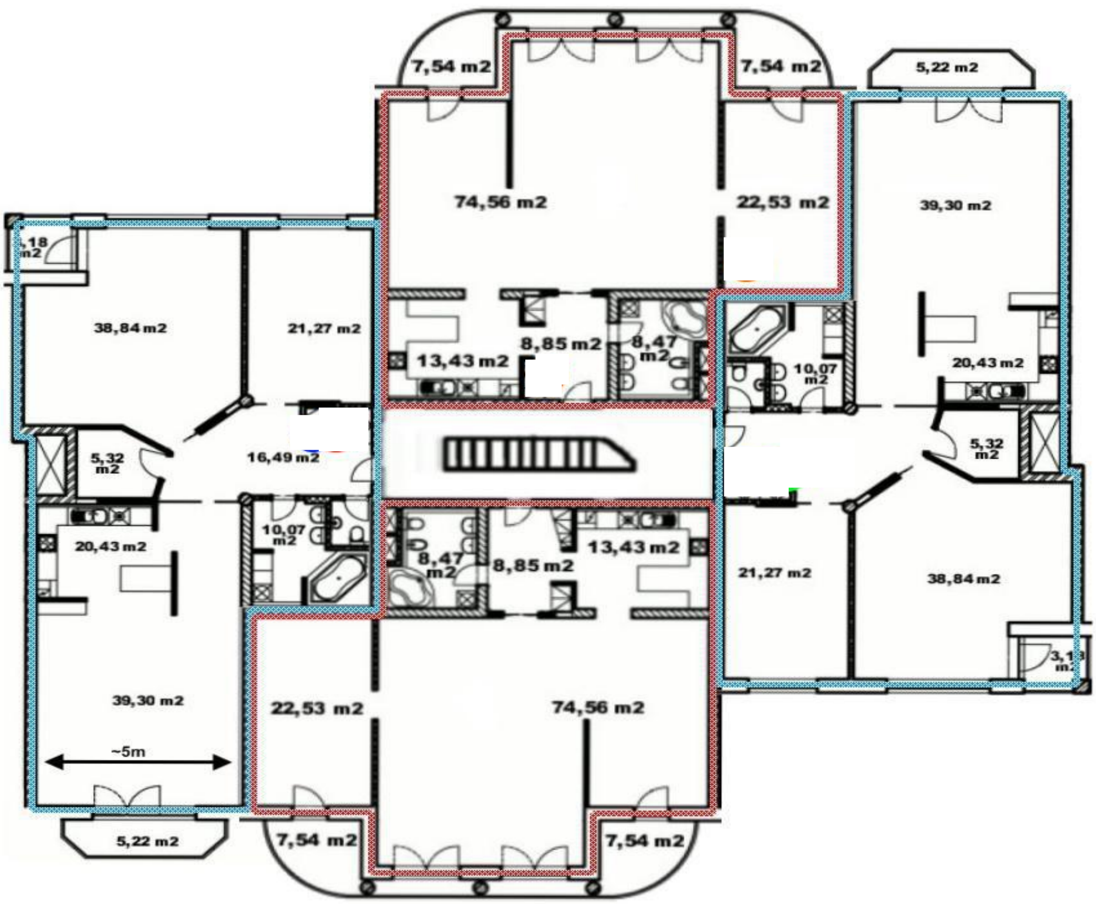


Figure 5.3.2.1.1-4: Floor plan of an apartment building

The penetration loss parameters of the obstructions in the houses are listed in Table 5.3.2.1.1-3.

Table 5.3.2.1.1-3: Obstruction loss parameters

Obstruction	Loss (dB)
Heavy Internal Wall	8
Light Internal Wall	7
Floor	19
Concrete	15
Concrete with window	10
Wood	7

The external walls and dividing walls between apartments in a north-south direction are assumed to be made of concrete (concrete with window where appropriate). The remaining dividing walls between apartments are assumed to be heavy internal walls. All internal walls are modelled as light walls. The external apartments doors are assumed to be made of wood and internal doors are assumed open

5.3.2.2 Simulation Results [15][13][22]

Specific simulation parameters of 1.28Mcps TDD Macro BS and Home NodeB are shown in Table 5.3.2.2-1.

Table 5.3.2.2-1: 1.28Mcps TDD Macro BS and Home NodeB simulation assumptions

Parameter	UL value	DL value
DEPLOYMENT SCENARIO		
Cell radius macro		333 m macro
Inter-site single operator		1000m macro
# of macro cells		*57* with wrap around technique
SIMULATED SERVICES		
Eb/N0 target	*[ ]* dB	*[ ]* dB
HSDPA	Full buffer FTP	Full buffer FTP
HSUPA	Full buffer FTP	Full buffer FTP
Throughput		
Frequency		
Macro NodeB<-> Macro NodeB	Same frequency	Same frequency
Macro NodeB<->Home NodeB	Adjacent frequency	Adjacent frequency
Home NodeB<->Home NodeB	Frequency reuse number 3	Frequency reuse number 3

Each building consists of 6 floors, and each floor has 25 apartments (5x5). Each apartment is of size 10x10 m (100 m2). In addition to indoor areas, the model contains also an outdoor area surrounding the building, shown in Figure 5.3.2.1.1-2.

The HNBs are placed in the middle of the rooms. The active HNB number in each building is 5, 10, 20 and 30; hence the total numbers of HNBs distributed in the victim sector are equal to 50, 100, 200, and 300.

For Uplink: Two PC control method are simulated in Scenario 1, 3, and 5:

1. ISCP control+ CLPC (Closed Loop PC): UE measure the SNPL of neighbor HNB, and report SNPL to the Control HNB. HNB control the Home UE's interference to other HNBs under the target of -102dBm.

2. CLPC: Closed Loop PC; UE does not report SNPL to the Control HNB. Only closed Loop PC is controlled by Control HNB.

In order to investigate the dependency on the strength of the macro cell, Home NodeBs located in different locations are also simulated in Scenario 1, 2, 3, and 4. In this case, one special building is constrained to be located in one of the following Location, and the Macro UE is located in the investigated building.

- Location A ("close to macro site, Distance between Macro BS and block is 0.2r").

- Location B ("middle of macro cell, Distance between Macro BS and block is 0.6r").

- Location C ("close to macro cell border, Distance between Macro BS and block is r").

Where: r is cell radium.

5.3.2.2.1 Scenario 1: UE attached to Home Node B (Uplink) → Macro Node B Uplink

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. The Macro UE is uniformly distributed in one sector of the central macro cell. Closed loop power control (CLPC) with or without ISCP control is used for Home Node B UL while CLPC with ISCP control is used for Macro Node B UL. The UL throughput of Macro Node B is given in Figure 5.3.2.2.1-1, and the ISCP is given in Figure 5.3.2.2.1-2. The throughput loss of CLPC+ ISCP is lower than CLPC.

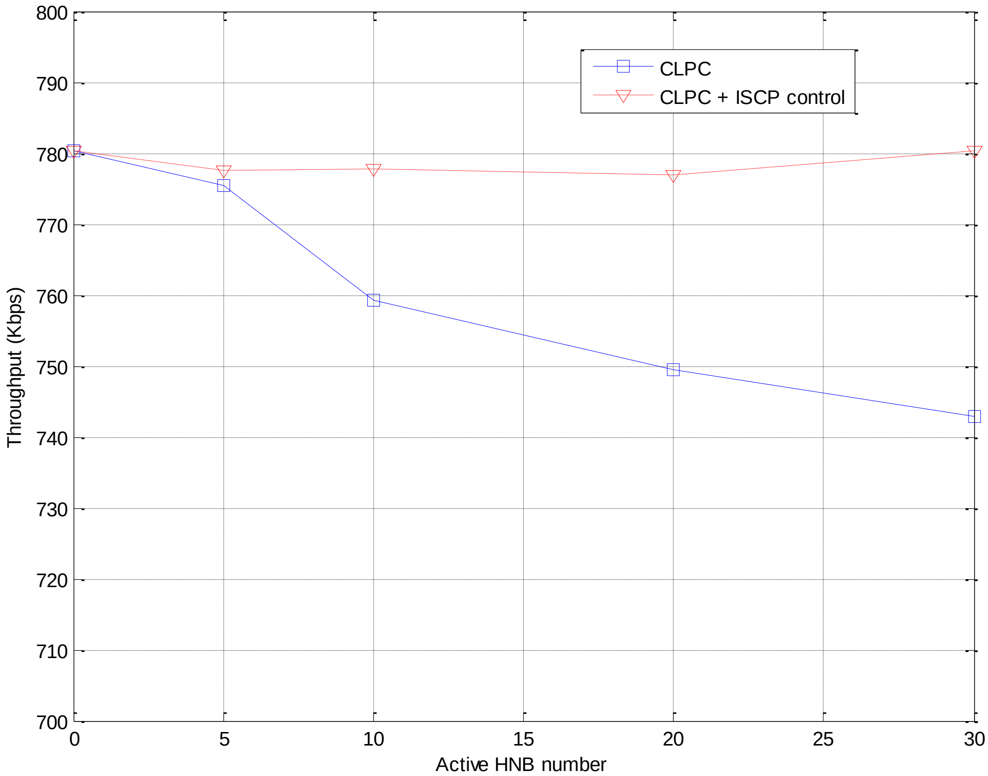


Figure 5.3.2.2.1-1: Macro NodeB UL throughput

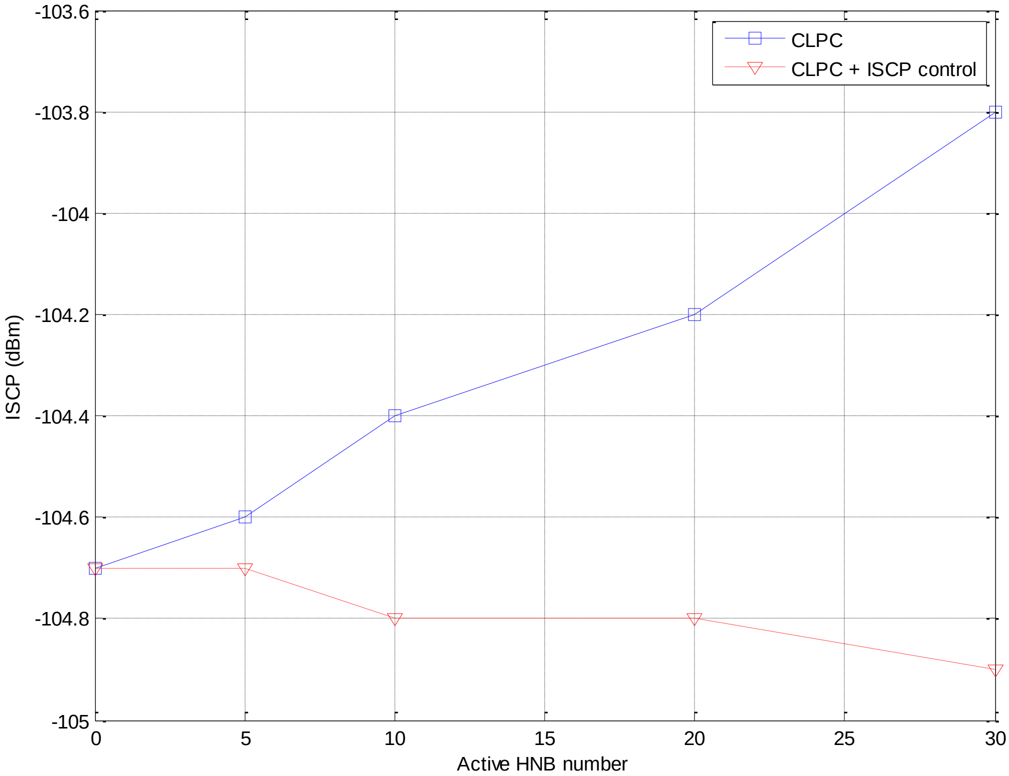


Figure 5.3.2.2.1-2: Macro NodeB ISCP

Home NodeB located in special Location: Ten building is located in sector 1. The investigated building is located in Location A, B or C. Macro UE is uniformly distributed in the special building. The other nine building is uniformly distributed in sector1. The Macro UE throughput results are depicted in Figure 5.3.2.2.1-3 when Macro UE is constrained in special location. When UE is located in Location A, the HNB without ISCP control has a significant impact on the throughput of Macro UE.

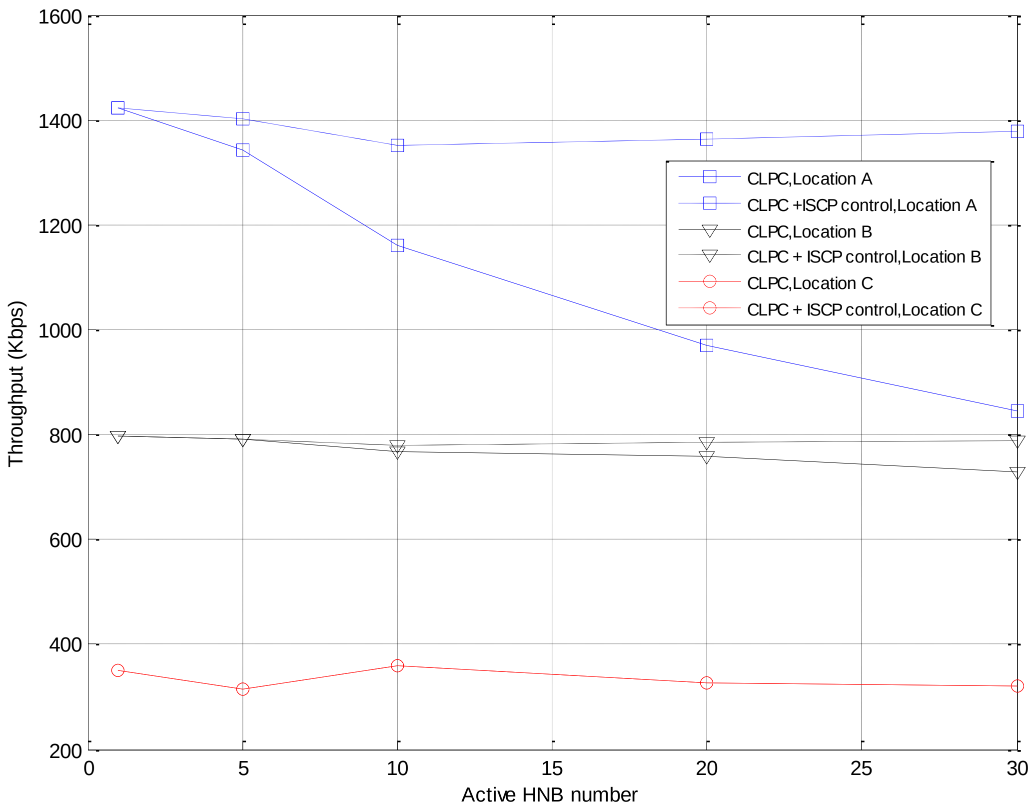


Figure 5.3.2.2.1-3: Macro NodeB UL throughput

5.3.2.2.2 Scenario 2: Home Node B（Downlink） → Macro Node B Downlink (UE）

5.3.2.2.2.1 Common simulation results

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. The Macro UE is uniformly distributed in one sector of the central macro cell.

The Throughput degenerations of Macro UE are presented in Table 5.3.2.2.2.1-1. With the increase of the active HNB in each building, the throughput of Macro UE increase accordingly. Generally speaking, the overall throughput degeneration caused by adjacent channel HNB interference is slight.

Table 5.3.2.2.2.1-1: simulation results Macro UE Throughput degeneration

HNB Output power	Active HNB =5	Active HNB =10	Active HNB =20	Active HNB =30
0dBm	0.01%	0.01%	0.07%	0.10%
13dBm	0.23%	0.28%	0.55%	0.60%

Home NodeB located in special Location: Ten building is located in sector 1. The investigated building is located in Location A, B or C. Macro UE is uniformly distributed in the special building. The other nine building is uniformly distributed in sector 1.

The Throughput degenerations of Macro UE are presented in Figure 5.3.2.2.2.1-1. It could be seen that the throughput degeneration is increased with the increment of the active HNB number in each building. The HNB output power has a significant effect on the downlink performance of Macro NodeB when the Macro UE is located in Location C.

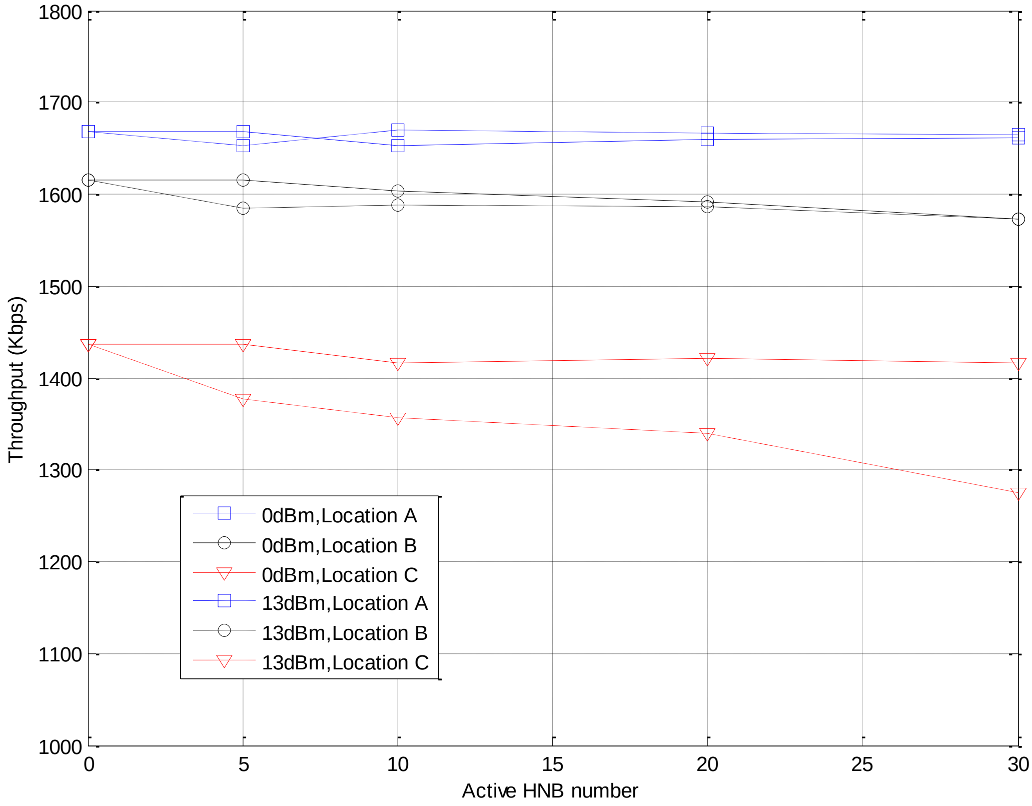


Figure 5.3.2.2.2.1-1: Macro NodeB DL throughput

5.3.2.2.2.2 Output Power of 1.28Mcps TDD Home NodeB Transmitter [13]

In this section, output power of 1.28Mcps TDD Home NodeB Transmitter are simulated. The extra simulation assumptions are shown in table 5.3.2.2.2.2-1.

Table 5.3.2.2.2.2-1: TD-SCDMA Macro BS and Home NodeB simulation assumptions

Parameter	UL value	DL value
TX POWER		
Maximum Home Node B power		0~20dBm(Adjust according to simulation condition)
Maximum PCCPCH power		37dBm
DEPLOYMENT SCENARIO		
Macro Cell Topology		Hexagonal grid ,19cell,3 sector per cell
Cell radius macro		[333] m macro
Inter-site single operator		[1000] macro
Total Home Node B number per cell		2400
Home Node B penetration rates [Note1]		[4%],[8%], [12%][16%]
SIMULATED SERVICES		
PCCPCH Ec/N0 target		[-6] dB

Note1: Home Node B penetration rates means the ratio of the power-on HNB number to all the HNB number

5.3.2.2.2.2.1 Propagation model

Table 5.3.2.2.2.2.1-1: Path loss models

Cases	Path Loss
Macro	$Pathloss = 15.3 + 37.6 \times \log_{10} d$ $Pathloss = 15.3 + 37.6 \times \log_{10} d + Lp$ (MUE is indoor)
Indoor	$Pathloss = 37 + 30 \times \log 10(d) + 18.3 \times n^{\left(\frac{n+2}{n+1} - 0.46\right)}$ n is number of penetrated floors

5.3.2.2.2.2.2 Co-channel scenario

Macro P-CCPCH outage

The Macro P-CCPCH channel outage probability for the case of different HNB penetration rate with fixed transmitted power under co-channel deployment are shown in Figure 5.3.2.2.2.2.2-1. As a result, the MUE downlink interference increases obviously with the increase of HNB output power and HNB penetration rate. The P-CCPCH outage probability is nearly 5%~9.5 % with 0dBm HNB transmit power.

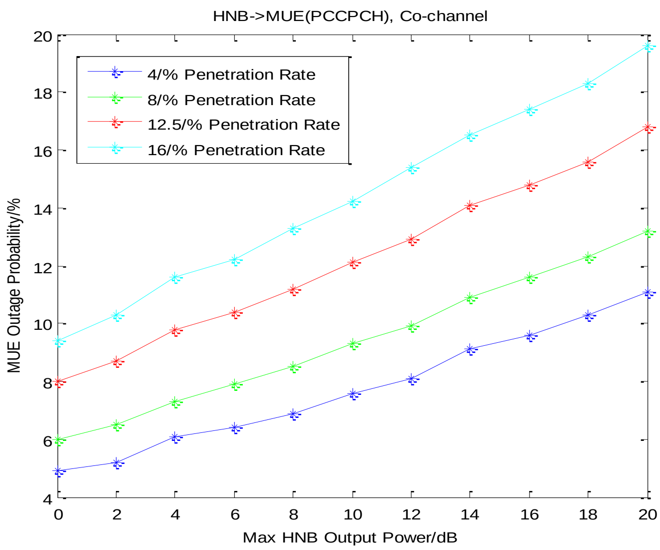


Figure 5.3.2.2.2.2.2-1: Macro P-CCPCH outage probability with fixed HNB output power

Macro HSDPA throughput loss

The impact of different HNB penetration rate with fixed transmitted power on the macro HSDPA throughput loss probability under co-channel is shown in figure 5.3.2.2.2.2.2-2. It can be noticed that, an average HNB density of 8% and 200 HNB/sector, the reduction in the throughput equal to 10.2% with P_{HNBmax} equal to 0dBm.

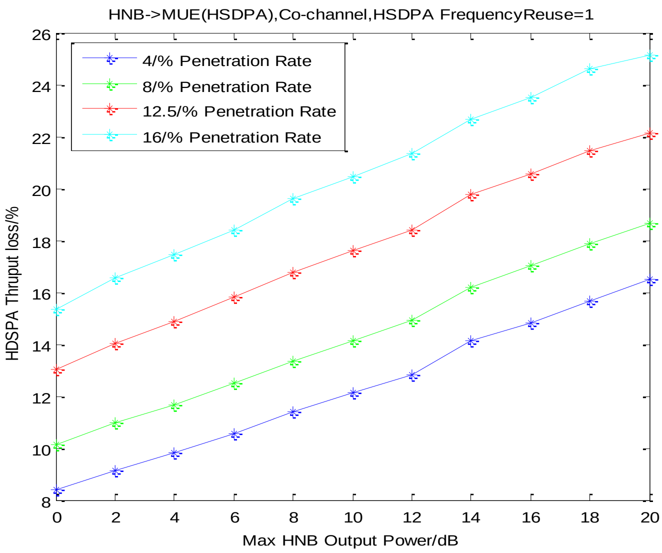


Figure 5.3.2.2.2.2.2-2: Macro HSDPA throughput losses with fixed HNB output power

5.3.2.2.2.2.3 Adjacent channel scenario

Macro P-CCPCH outage

The Macro P-CCPCH outage probability for the case of different HNB penetration rate with fixed transmitted power under adjacent channel deployment is shown in Figure 5.3.2.2.2.2.3-1. The result indicated that macro P-CCPCH performance is much better than co-channel scenario, an average HNB density of 16% and 200 HNB/sector, the macro P-CCPCH outage probability becomes equal to 0.5%, 1.3%, 3.5% with P_{HNBmax} equal to 5, 10 and 20dBm, respectively.

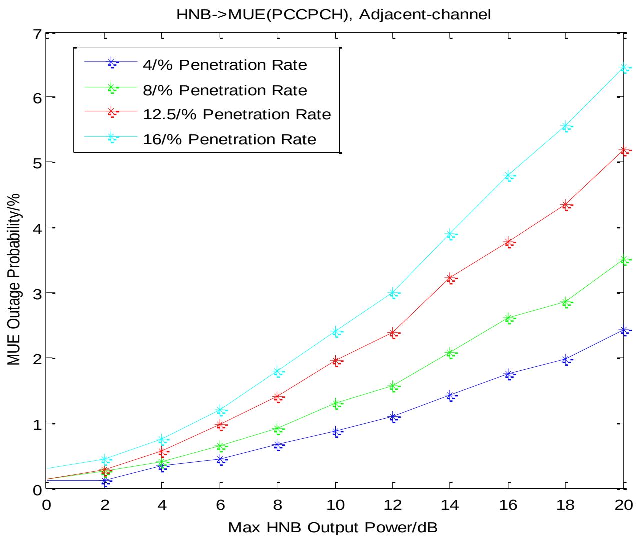


Figure 5.3.2.2.2.2.3-1: Macro P-CCPCH outage probability with fixed HNB output power

Macro HSDPA throughput loss

The impact of different HNB penetration rate with fixed transmitted power on the macro HSDPA throughput loss probability under adjacent channel is shown in figure 5.3.2.2.2.2.3-2. It can be noticed that, an average HNB density of 8% and 200 HNB/sector, the macro throughput loss probability becomes equal to 2.2%, 3%, 5% with P_{HNBmax} equal to 5, 10 and 17dBm, respectively.

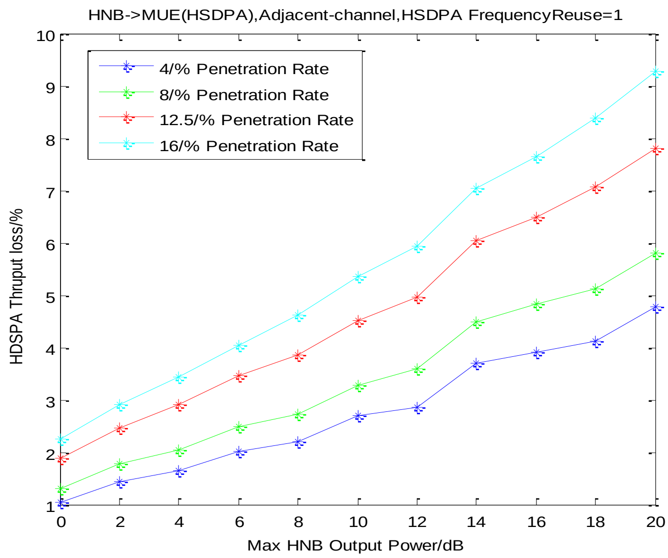


Figure 5.3.2.2.2.2.3-2: Macro HSDPA throughput loss with fixed HNB output power

5.3.2.2.2.2.4 Conclusion

Downlink co-existence between Home NodeBs (aggressor) and Macro UEs (victim) is analyzed. Both the impact of the HNB density as well as the maximum HNB output power has been considered. Furthermore, the study has been performed for both co-channel and adjacent channel deployment scenarios.

The results for the co-channel deployment indicate considerable interference problems at locations where the macro P-CCPCH and HSDPA are fairly weak, which results in high outage probability and throughput loss around the HNBs. The interference can be reduced for example by lowering the HNB maximum output power. According to the simulation results, there is a need to set the maximum HNB output power to lower than 0dBm, or in some cases even below that, in order to obtain an acceptable "coverage vs. interference" trade-off.

The adjacent channel deployment is found to work much better. The HNB maximum output power could be much higher than the co-channel deployment scenario. However, assuming some form of downlink interference control also for the adjacent channel scenario could further improve the HNB performance.

5.3.2.2.3 Scenario 3: UE attached to Macro Node B（Uplink） → Home Node B Uplink

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. The Macro UE is uniformly distributed in one sector of the central macro cell.

The throughput when using CLPC with ISCP control is a little higher than without ISCP control, this could be seen from Figure 5.3.2.2.3-1. Compared with the throughput of same active HNB number in Figure 5.3.2.2.3-1 and Figure 5.3.2.2.5-2, we can see that Macro NB has little influence to the uplink throughput of HNB UE.

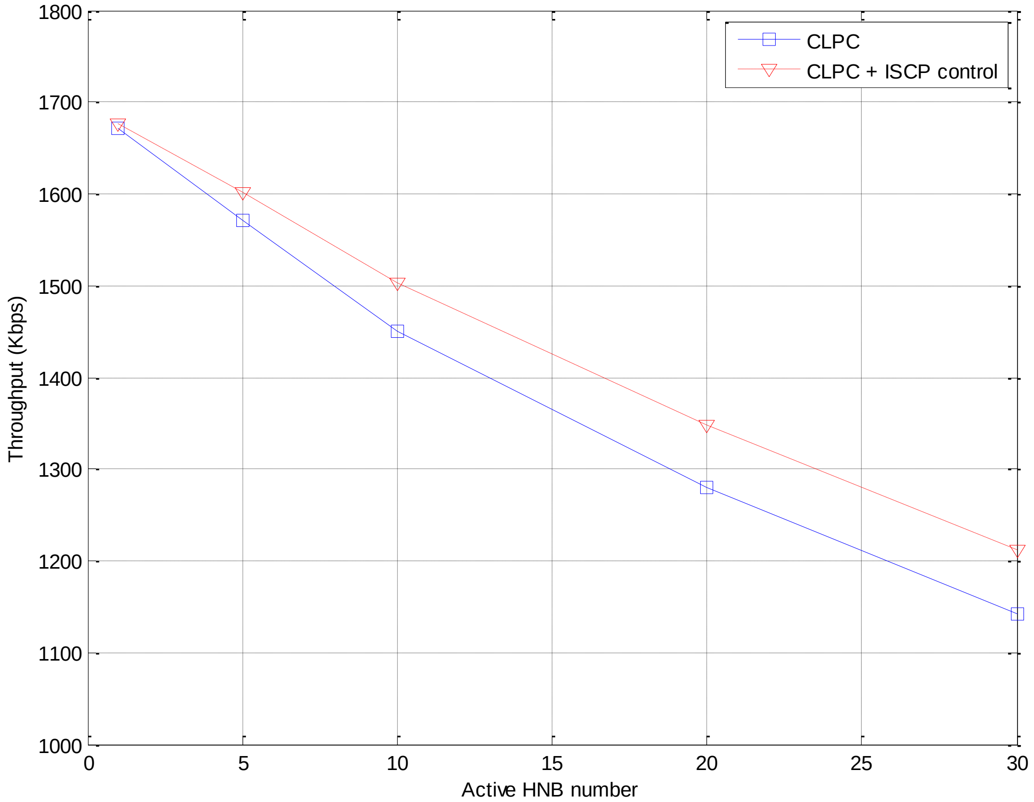


Figure 5.3.2.2.3-1: HNB NodeB UL throughput

In Figure 5.3.2.2.3-2, we could see that when using ISCP control, the HNB ISCP can be maintained in a lower level compare with no ISCP control.

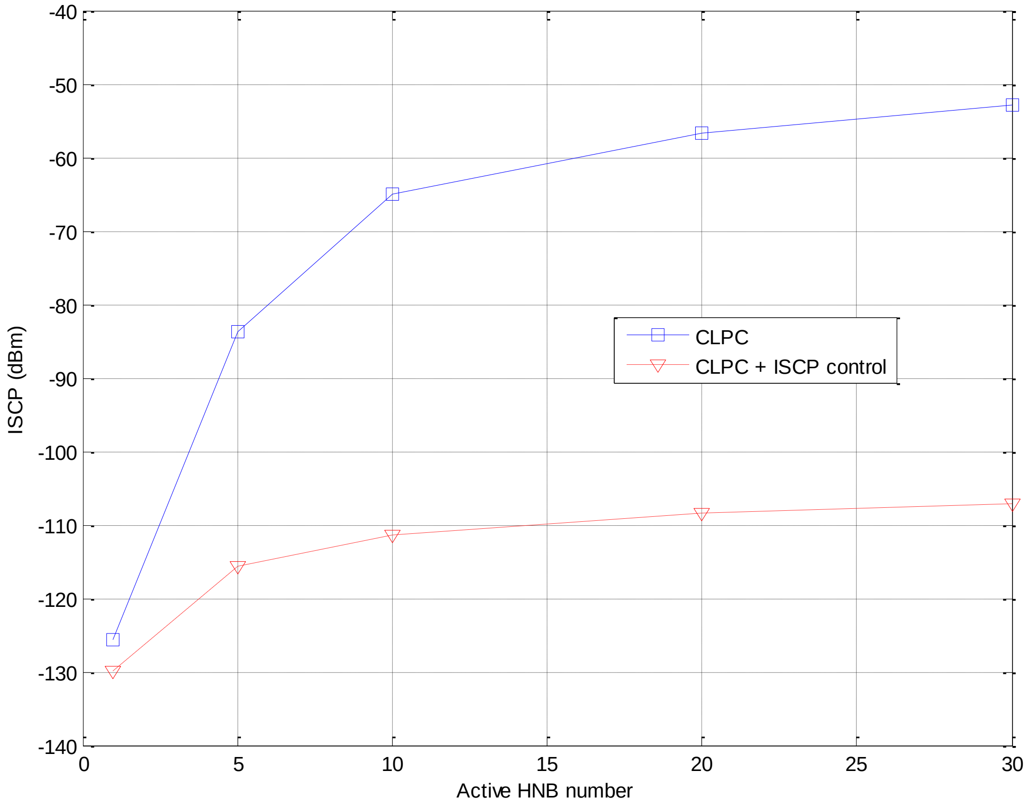


Figure 5.3.2.2.3-2: Home NodeB ISCP

5.3.2.2.4 Scenario 4: Macro Node B（Downlink） → Home Node B Downlink

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. The Macro UE is uniformly distributed in one sector of the central macro cell.

The HNB throughput could be seen from Figure 5.3.2.2.4-1. It could be seen that the HNB output power has almost no influence to the downlink throughput in this case. Compared with the throughput of the blue line in Figure 5.3.2.2.4-1 and the dashed red line in Figure 5.3.2.2.6-1, it is shown that Macro NB has little influence to the uplink throughput of HNB UE.

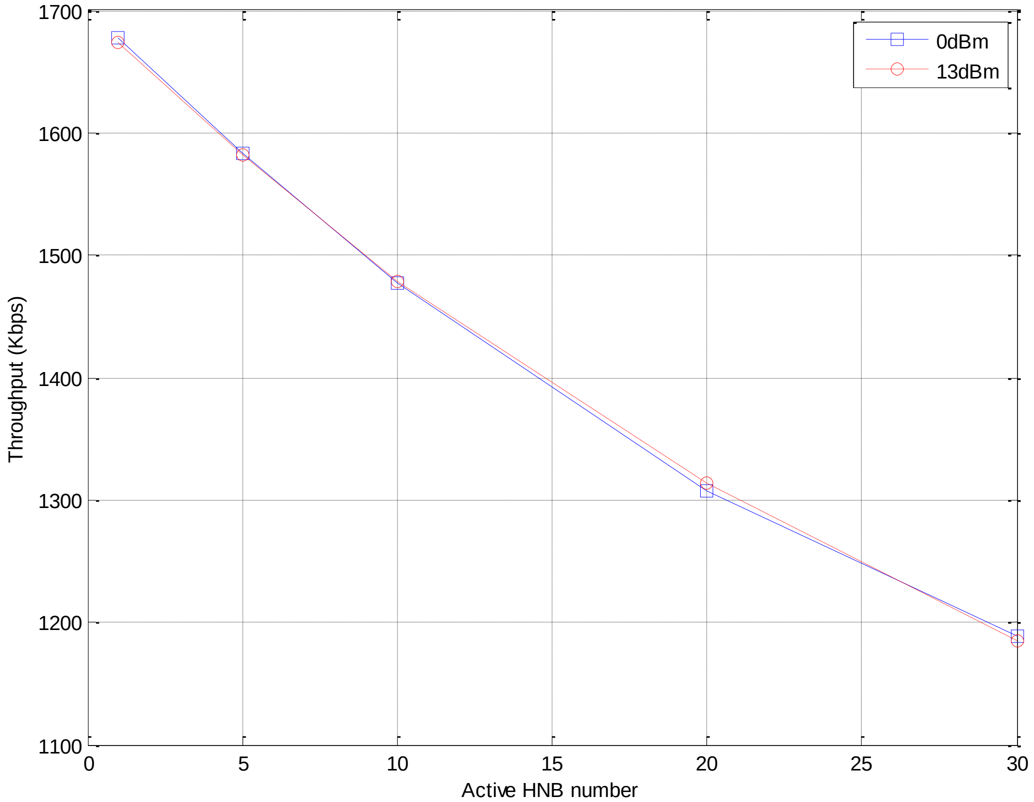


Figure 5.3.2.2.4-1: Home NodeB DL throughput

Simulations are also conducted in a semi-detached house environment as depicted in Figure 5.3.2.1.1-3. It is assumed that the HUE can roam arbitrarily in the house. Four macro-HNB distances are studied in this section: 30m, 60m, 120m and 200m.

The macro interference to HUE is discussed for 4 cases:

- Case 1: HUE in the 1st floor and macro NB to the south
- Case 2: HUE in the 1st floor and macro NB to the northwest.
- Case 3: HUE in the 2nd floor and macro NB to the south
- Case 4: HUE in the 2nd floor and macro NB to the northwest.

For co-channel deployment, the HNB DL deadzone statistics are given in Figure 5.3.2.2.4-2 ~ 5.3.2.2.4-7.

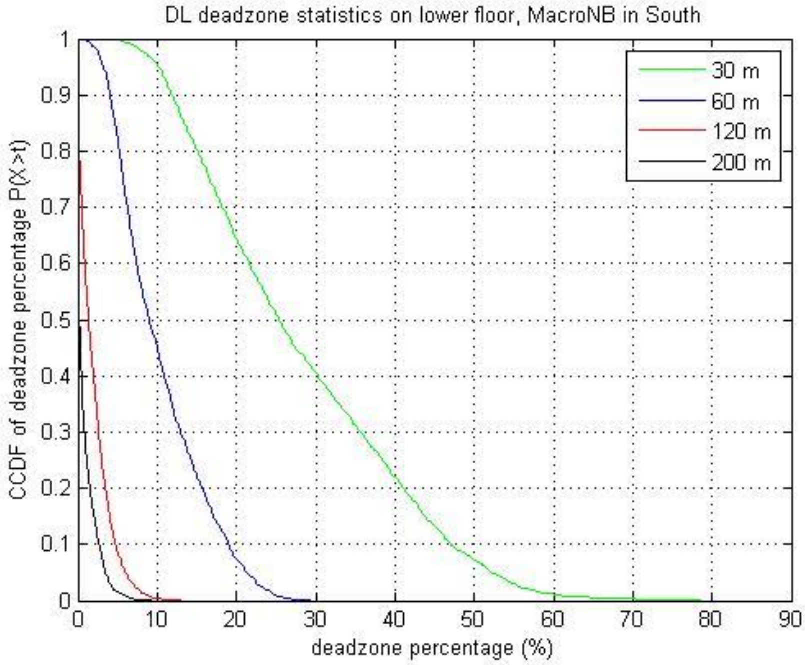


Figure 5.3.2.2.4-2: CCDF of dead zone ratio on lower floor, macro NB in South

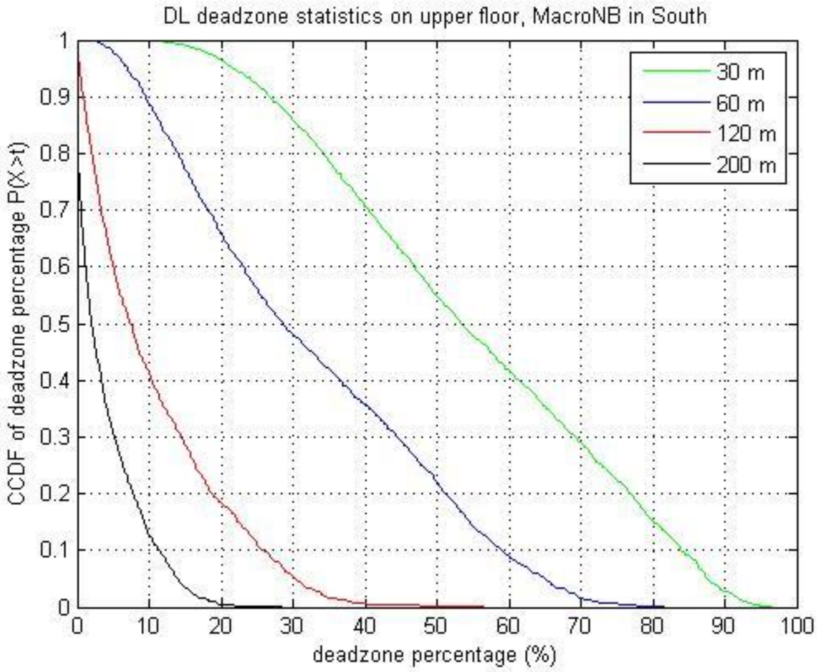


Figure5.3.2.2.4-3: CCDF of dead zone ratio on upper floor, macro NB in South

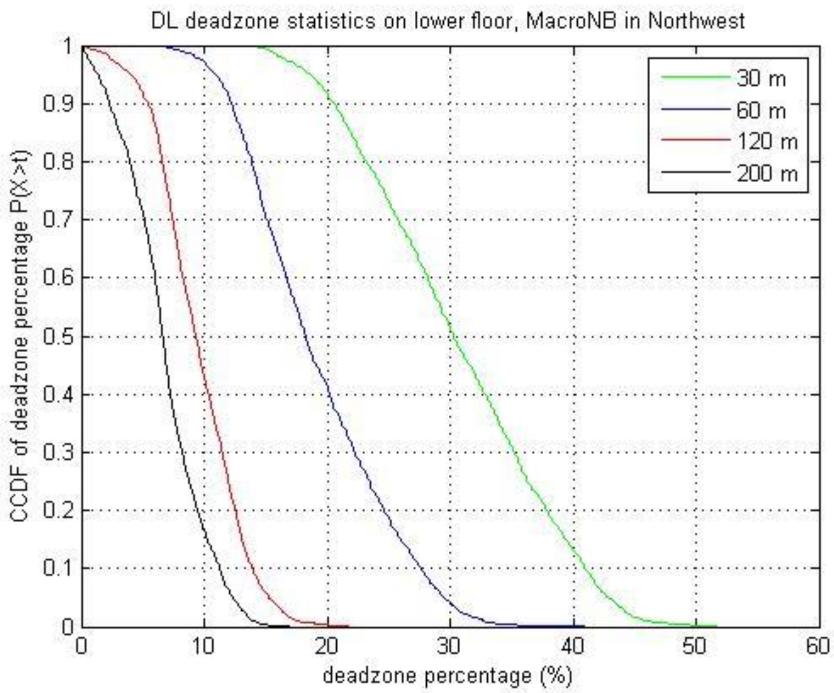


Figure 5.3.2.2.4-4: CCDF of dead zone ratio on lower floor, macro NB in Northwest

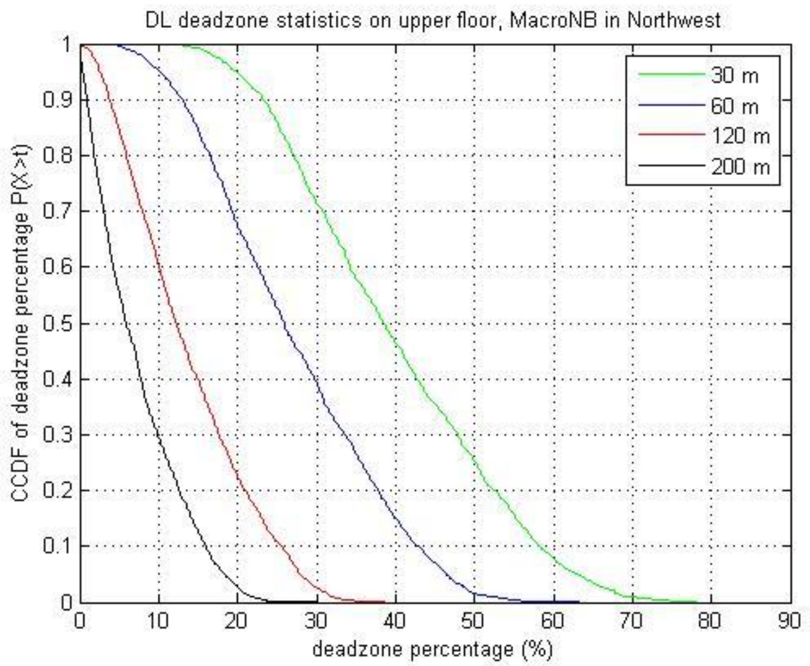


Figure 5.3.2.2.4-5: CCDF of dead zone ratio on upper floor, macro NB in Northwest

The 95-percentile of the dead zone ratios, i.e., Pr(dead zone ratio<y%) = 0.95 for the 4 cases are summarized in Table 5.3.2.2.4-1.

Table 5.3.2.2.4-1: Dead zone ratio of 95-percentile, co-channel deployment

	1st floor MNB to south	2nd floor MNB to NW	1st floor MNB to south	2nd floor MNB to NW
30 m	<52.3%	<87.5%	<42.8%	<63.1%
60 m	<21.4%	<65.1%	<29.5%	<46.4%
120 m	<6.1%	<30.2%	<15.3%	<28.1%
200 m	<3.5%	<14.0%	<12.4%	<18.4%

It can be seen that in certain co-channel deployment scenarios a nearby macro NB can impose a high level of interference, resulting in DL deadzone areas for the HUE.

For adjacent channel deployment the HNB DL deadzone statistics are given in Figure 5.3.2.2.4-6 ~ 5.3.2.2.4-9

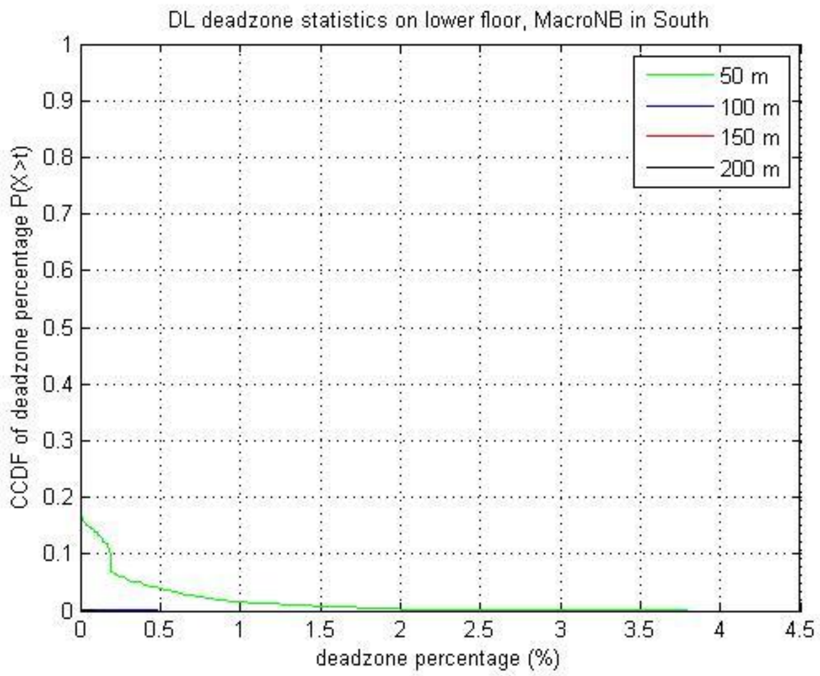


Figure5.3.2.2.4-6: CCDF of dead zone ratio on lower floor, macro NB in South

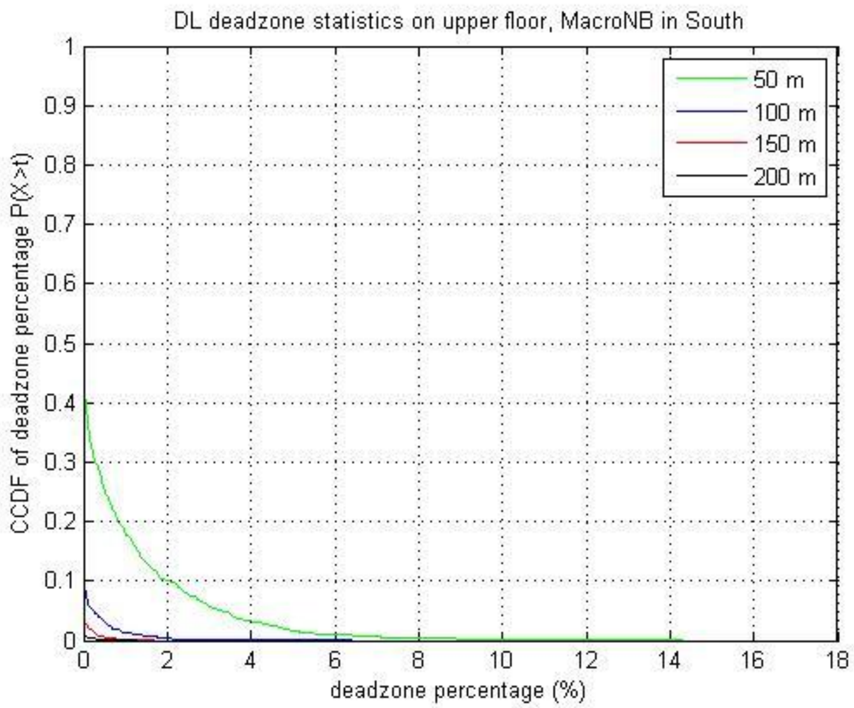


Figure 5.3.2.2.4-7: CCDF of dead zone ratio on upper floor, macro NB in South

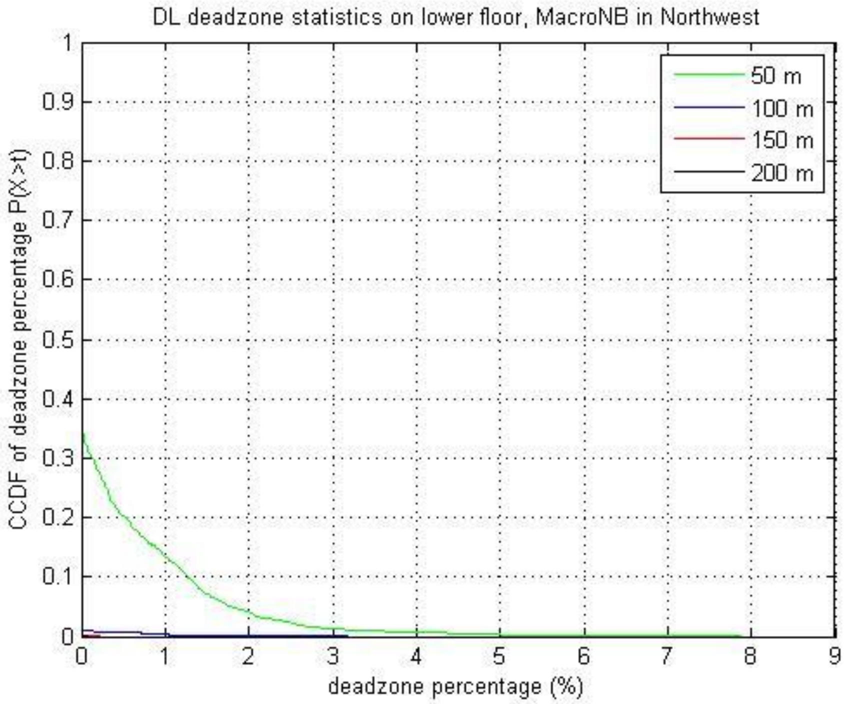


Figure 5.3.2.2.4-8: CCDF of dead zone ratio on lower floor, macro NB in Northwest

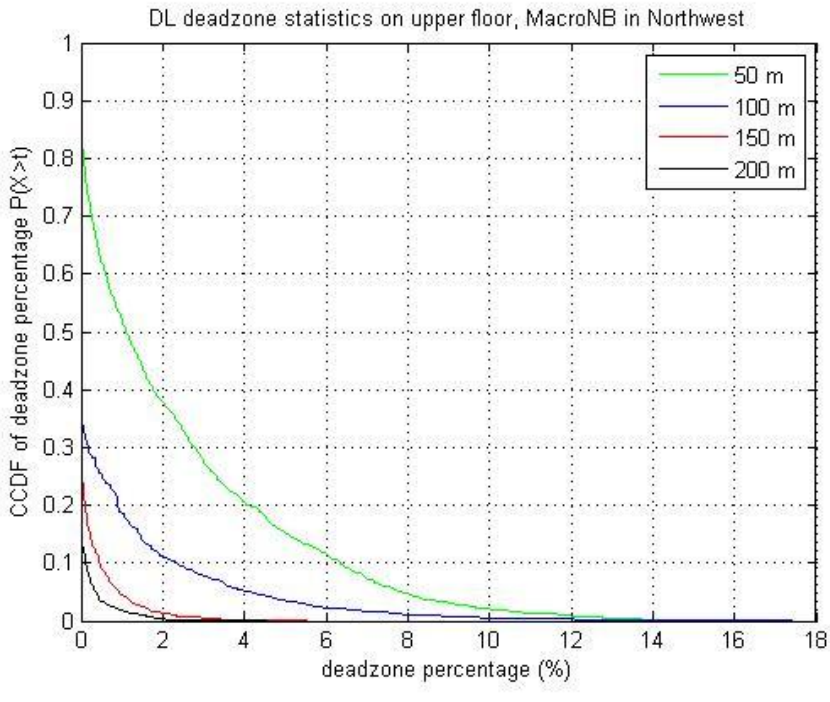


Figure 5.3.2.2.4-9: CCDF of dead zone ratio on upper floor, macro NB in Northwest

The 95-percentile of the dead zone ratios, i.e., Pr(dead zone ratio <y%) = 0.95 for the 4 cases are summarized in Table 5.3.2.2.4-2.

Table5.3.2.2.4-2: Dead zone ratio of 95-percentile, adj-ch deployment

	1st floor MNB to south	2nd floor MNB to NW	1st floor MNB to south	2nd floor MNB to NW
50 m	<0.4%	<3.3%	<1.8%	<7.8%
100 m	<0.0%	<0.2%	<0.0%	<4.2%
150 m	<0.0%	<0.0%	<0.0%	<0.9%
200 m	<0.0%	<0.0%	<0.0%	<0.4%

Based on the above study, the adjacent-channel downlink interference from the macro layer in this particular deployment (semi-detached house) has been found to be very insignificant.

These findings highlight the ability of a Network Monitor Mode, or "sniffer", in the HNB to help provide improved coverage –scanning the RF environment will allow for the HNB to self-configure to the best available channel.

5.3.2.2.5 Scenario 5: UE attached to Home Node B（Uplink） → Home Node B Uplink（Home NodeB）

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. Only intra HNB interference is simulated.

HNB UL throughput of ISCP control+ Closed Loop PC and Closed Loop PC are given in this section. When the active HNB number in each building is 5, 10, 20, and 30, the throughput of ISCP control+ Closed Loop PC and Closed Loop PC are almost the same. Frequency reuse 3 can increase the HNB UL throughput.

The ISCP can be controlled in ISCP control + Closed Loop PC case, while the ISCP in Closed Loop Power control case is not under control. For the simulation case of frequency reuse number is 1, when the active HNB number in each building is 5, 10, 20 and 30, the ISCP of ISCP control + Closed Loop PC are -102.8dBm, -100.0 dBm, -98.1 dBm, and -97.3 dBm, respectively. The ISCP of Closed Loop Power control is not under control, the ISCP are -58.6dBm, -52.9 dBm,-47.7 dBm, -45.2 dBm, respectively.

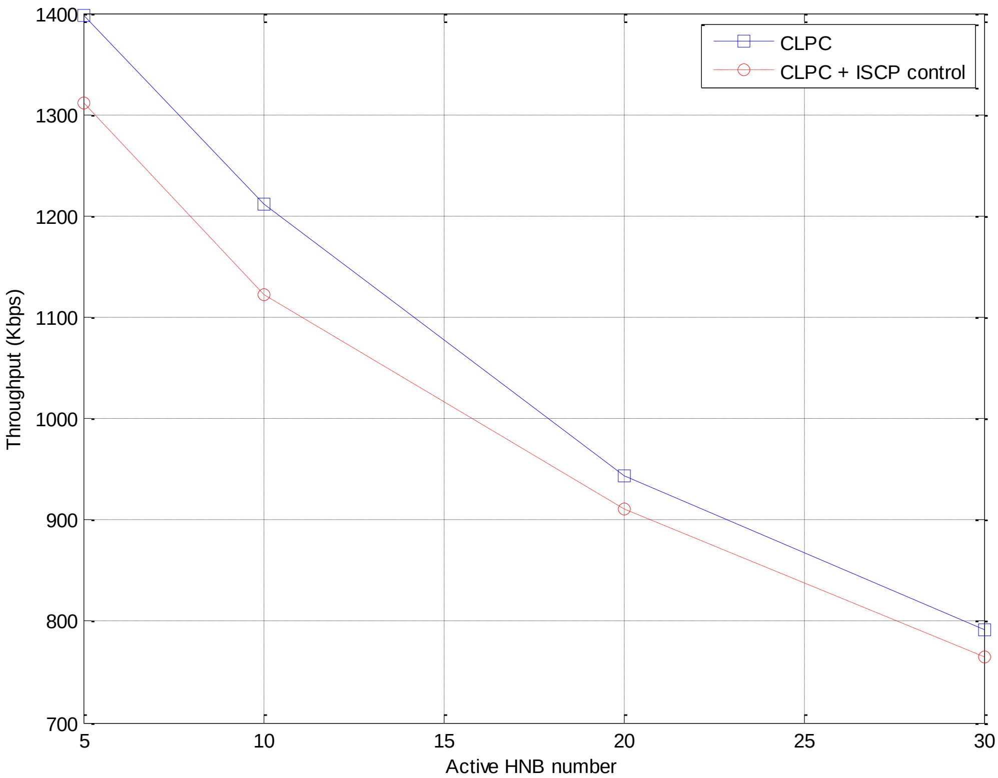


Figure 5.3.2.2.5-1: Home NodeB UL Throughput with Frequency reuse 1

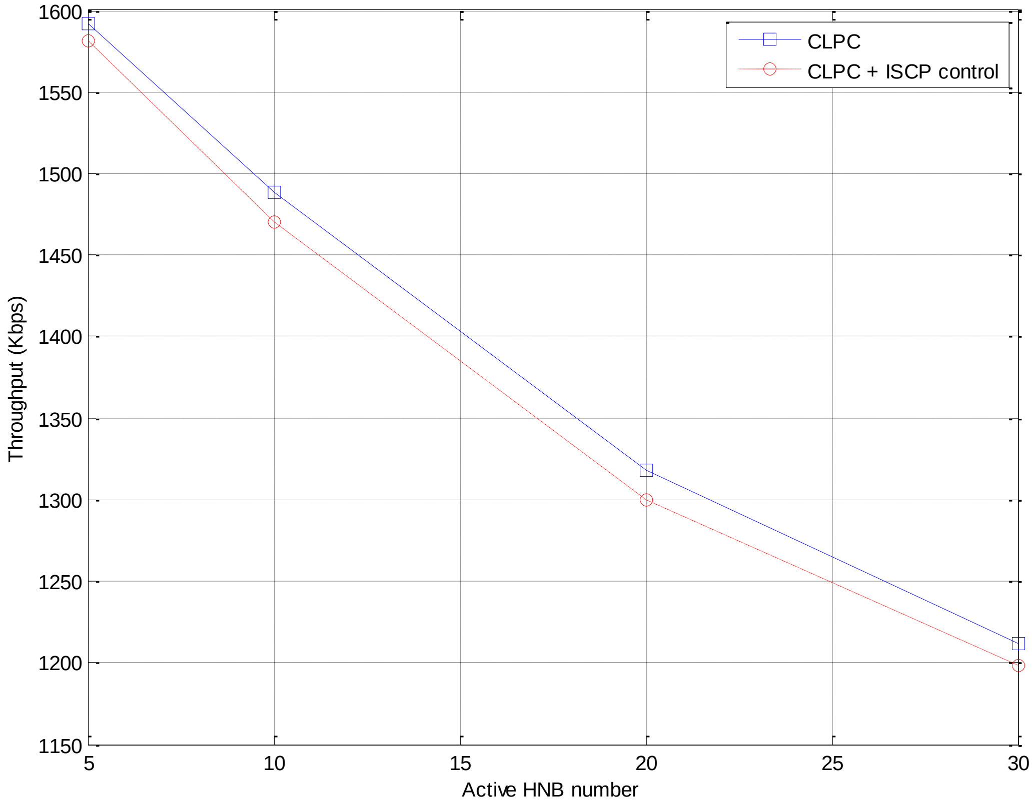


Figure 5.3.2.2.5-2: Home NodeB UL Throughput with Frequency reuse 3

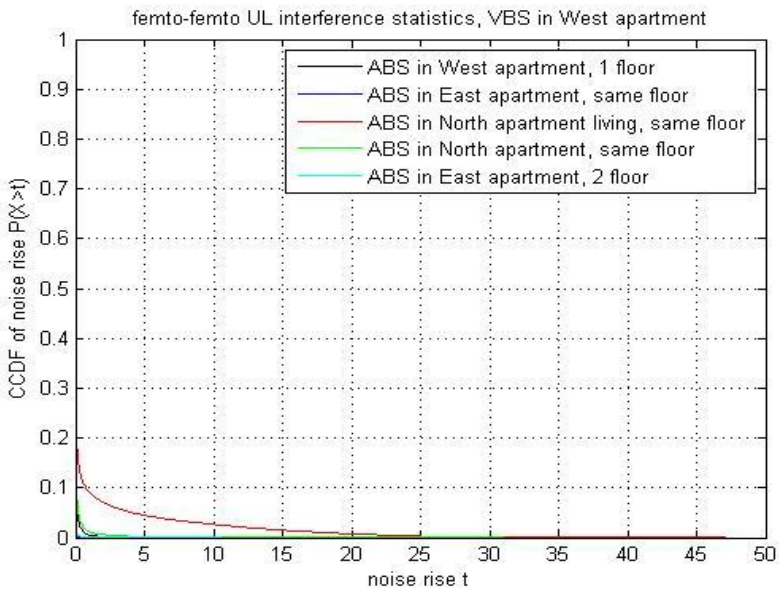
It is shown that frequency reuse 3 can increase the UL throughput of Home NodeB. In order to enhance the throughput of HNB, more frequency band should be reserved for HNB.

If SNPL is not reported by Home UE, the ISCP of HNB can not be controlled. Some ISCP control method should be introduced in Home NodeB environment. E.g. the same ISCP control method as Macro NodeB or the maximum UL output power of Home UE should be limited by the self optimization process of Control HNB according to the neighbor Home Node B number and distance.

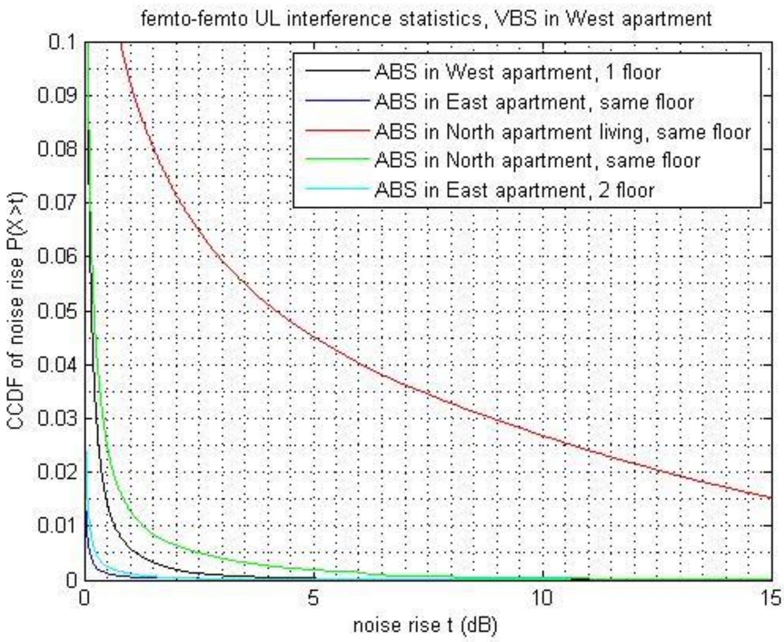
Simulations are also conducted in the modern apartment building depicted in Figure 5.3.2.1.1-4. The victim HNB is located at the door way of the western apartment. The UL HNB-HNB interference is studied in 5 cases:

- Aggressor HNB in East, 2 floor separation
- Aggressor HNB in East, 1 floor separation
- Aggressor HNB in West, 1 floor separation
- Aggressor HNB in North, living room, same floor
- Aggressor HNB in North, same floor

The complementary cumulative distribution functions (CCDFs) of the noise rise from different ABS is given in Figure 5.3.2.2.5-3.



(a) full plot



(b) zoomed plot

Figure 5.3.2.2.5-3: CCDFs of noise rise at VBS. (a) full plot (b) zoomed plot

It can be seen co-channel HNB-HNB UL interference is only significant when the aggressor HNB is far away from the victim apartment, and the victim HNB is close to the aggressor apartment.

Adaptive noise figure (NF) is an effective mean to mitigate UL interference for such cases. When VBS experiences an noise rise that is large enough to block the uplink connection, it can adjust its NF so that the associated HUE can power up to maintain the connection.

Monte-Carlo runs are also conducted to obtain the CCDF of noise rise at ABS, assuming 12 dB extra NF at VBS. The result is given in Figure 5.3.2.2.5-4.

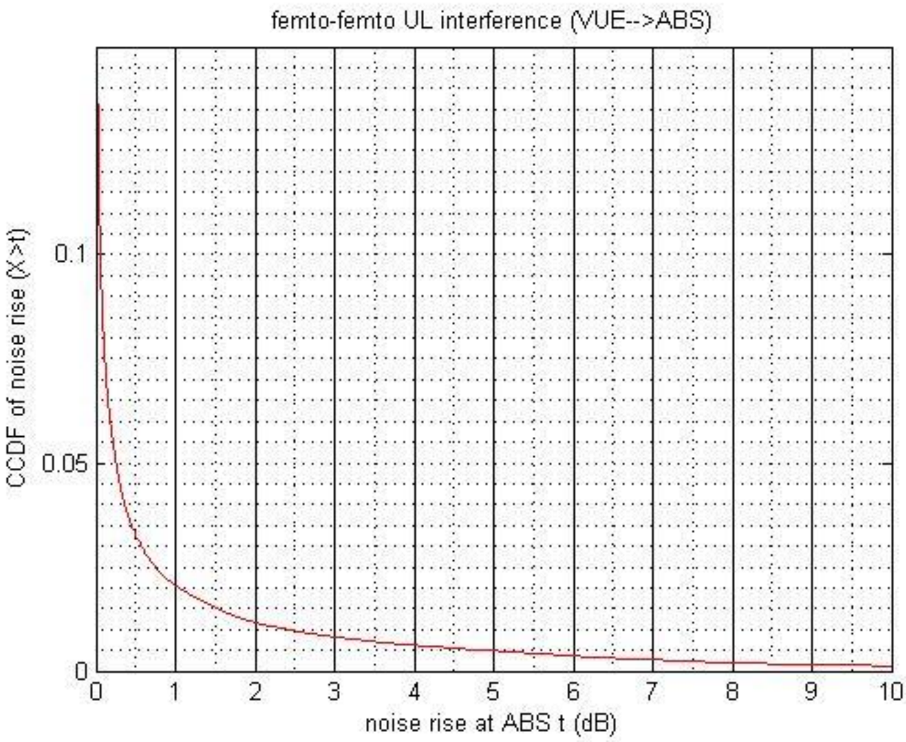


Figure 5.3.2.2.5-4: Noise rise statistics at ABS with VBS NF+12 dB

Based on the above simulation results we can have the following findings:

- The co-channel HNB-HNB UL interference is insignificant in most cases.
- The co-channel HNB-HNB UL interference can be significant if VBS is close to the aggressor apartment and ABS is far away from the victim apartment (e.g., VBS in West, door way and ABS in North, living room, same floor).
- Adaptive NF technique is an effective method to tackle HNB-HNB UL interference.

5.3.2.2.6 Scenario 6: Home Node B (Downlink) → Other Home Node B Downlink (UE)

This simulation is run at 5X5 apartment. Home NodeB randomly distributed in one Macro cell: 10 building are uniformly distributed in Sector 1. Only intra HNB interference is simulated.

DL interferes among HNB with Frequency reuse number 1 and 3 are given in this section. When the active HNB number in each building is 5, 10, 20, and 30, the throughput gains of frequency reuse number 3 are 186kbps, 281kbps, 360kbps, and 402kbps, respectively.

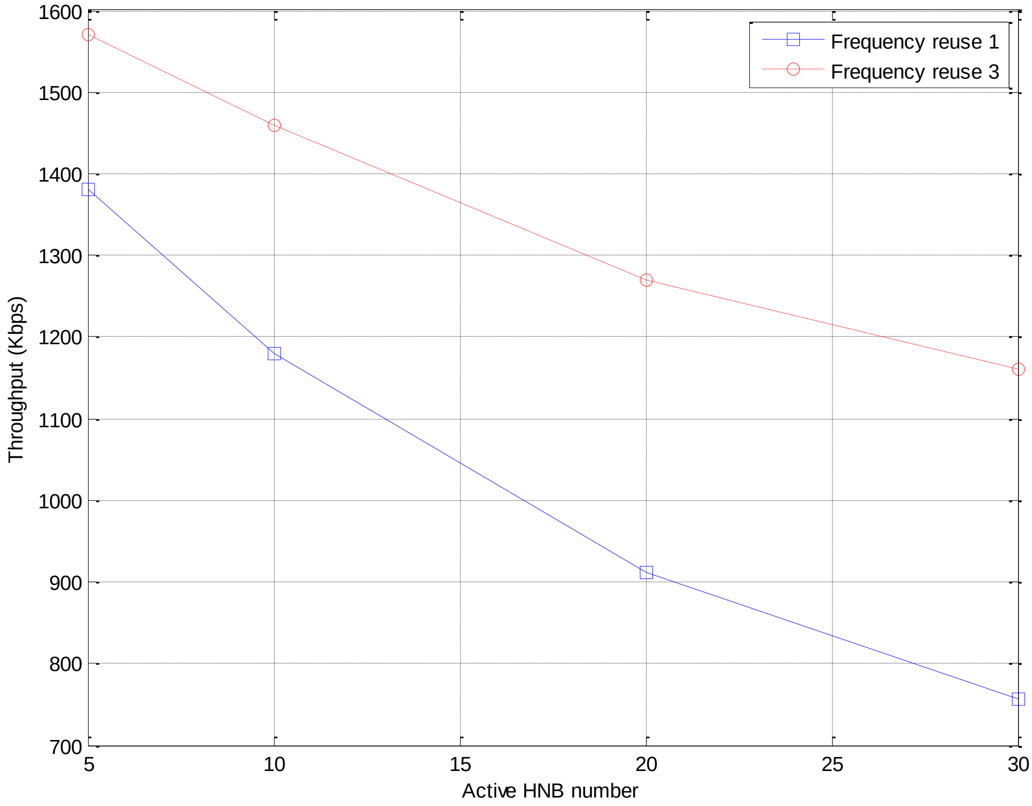


Figure 5.3.2.2.6-1: Home NodeB DL Throughput with output power 0dBm

It is shown that frequency reuse 3 can increase the throughput of Home NodeB. In order to enhance the throughput of HNB, more frequency band should be reserved for HNB.

The HNB to HNB DL interference simulations are also conducted in the modern apartment building as depicted in Figure 5.3.2.1.1-4. Both single carrier frequency and multiple carrier frequencies are used for this study.

For single carrier frequency, we assume the aggressor HNB located at the western apartment doorway, and the following 4 victim HNB positions are considered:

- Victim (serving) HNB in East, same floor
- Victim (serving) HNB in North, same floor
- Victim (serving) HNB in West, 1 floor separation
- Victim (serving) HNB in North living room, same floor

In Figure 5.3.2.2.6-2 we give the HNB DL deadzone statistics. It can be seen:

- If the ABS-VBS deployment is non-adjacent on the same floor or has floor separation the resulting DL deadzone is insignificant.
- HNB DL interference and the resulting deadzone can be significant for adjacent apartments in the same floor.
- The case of north apartment with HNB in the living room suffers most due to the near-far effect between ABS and VBS.

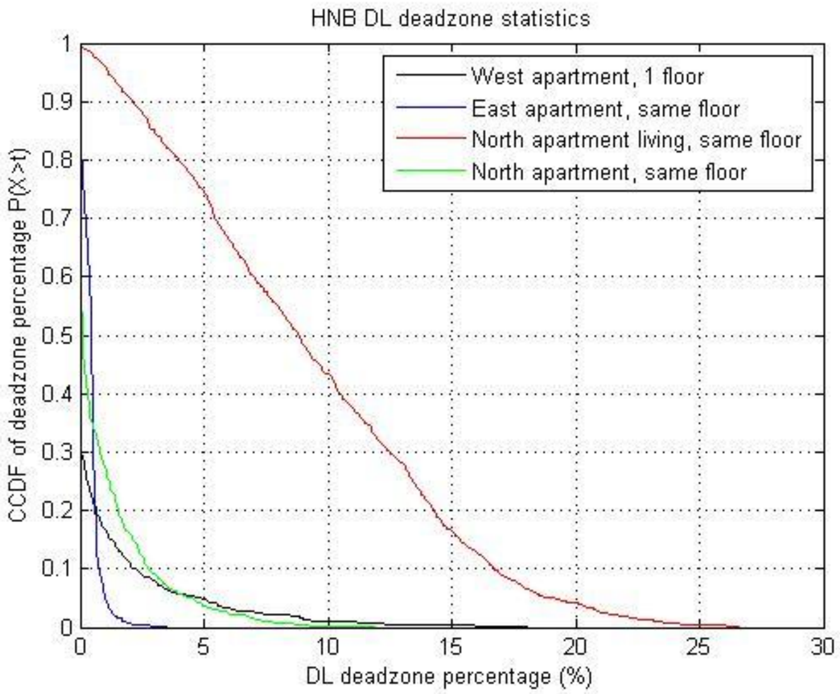


Figure 5.3.2.2.6-2: CCDF of deadzone coverage area (ABS in West)

Increasing the number of carrier frequencies of HNBs can be an effective method to mitigate DL interference. Using the worst case above (ABS in West, VBS in North, living room, same floor), we assign 1, 3 and 6 carrier frequencies respectively and study the DL deadzone statistics. The HNBs are assumed to randomly choose one from the multiple carrier frequencies. The deadzone statistics is given in Figure 5.3.2.2.6-3.

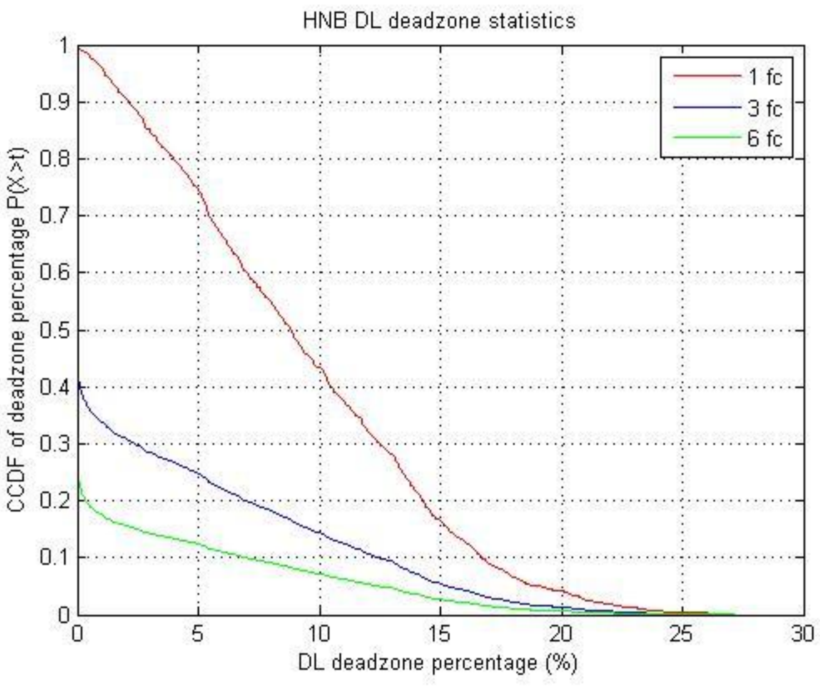


Figure 5.3.2.2.6-3: CCDF of deadzone with ABS in West, VBS in North living room, same floor.

From Figure 5.3.2.2.6-3 it can be seen that even with random carrier configuration (the simplest and dumbest approach), increasing frequency reuse number can effectively mitigate HNB-HNB DL interference.

A natural question that can be raised is: how many carrier frequencies are necessary to mitigate HNB-HNB DL interference? In the analysis below we aim to determine the number of carrier frequencies needed for HNB DL interference mitigation. To make the study in a more realistic framework, we use RSSI based carrier configuration scheme as follows:

1. There are a total of *K* carrier frequencies available for HNBs: fc, fc+fs, … fc+(K-1)fs.
2. Once power on, an HNB scans the K frequencies and picks the one that has least interference.
3. If multiple carrier frequencies are legitimate candidates, an HNB selects the one with lowest index.

To analyze the HNB-HNB DL interference, we consider an extreme deployment case: Every apartment in the building has an HNB activated, i.e., 100% HNB density. Since interference from aggressors with ≥2 floor separation is negligible, we only have to study 3 floors of the apartment building. As depicted in Figure5.3.2.2.6-4, we assume the serving HNB is in the south apartment and there is an aggressor HNB in each of the apartments on the same floor, upper floor and lower floor.

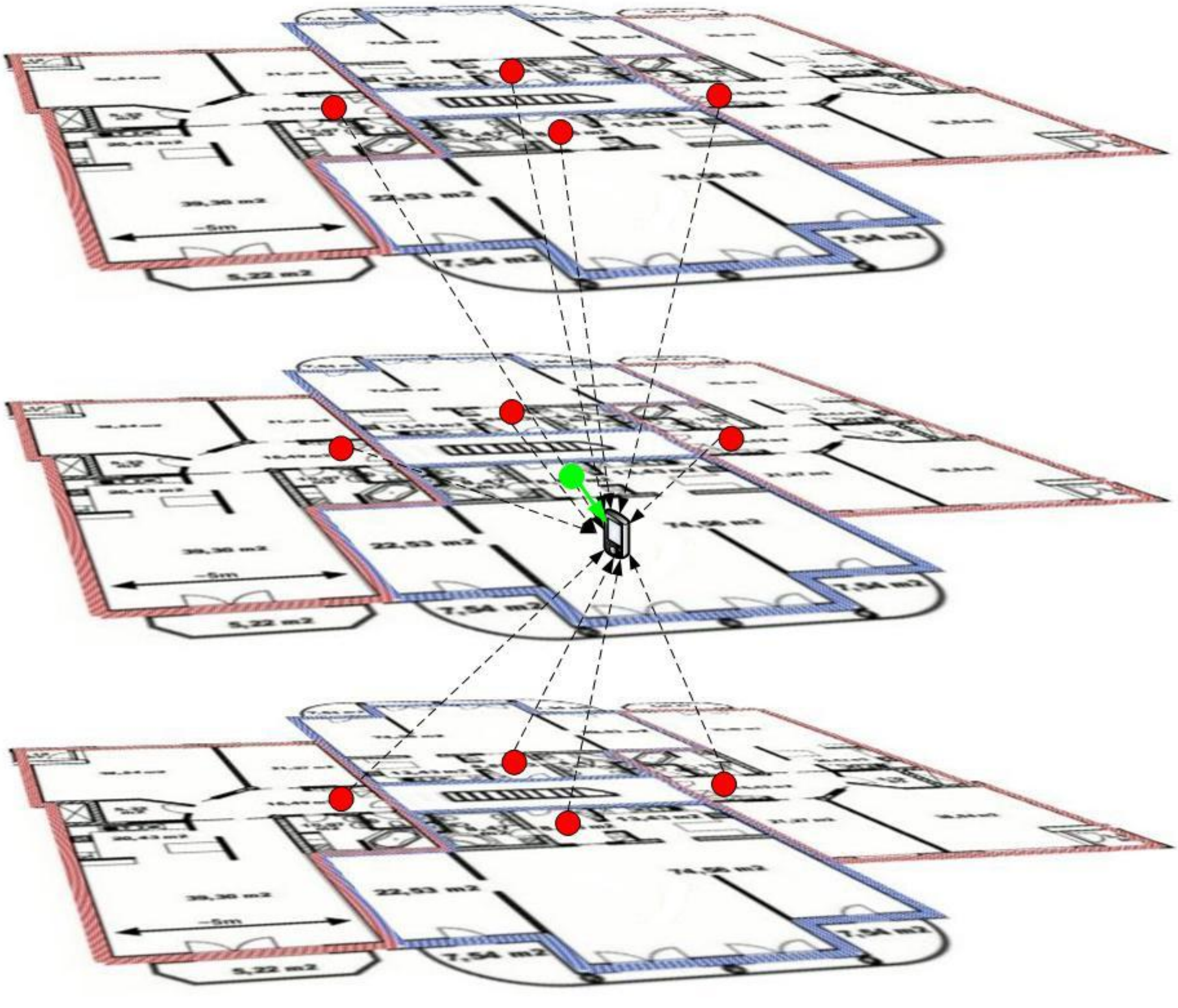


Figure 5.3.2.2.6-4: Modern apartment building with 100% HNB loading

We allocate 4 carrier frequencies to HNB and follow the self-configuration scheme described above. The deadzone statistics hence obtained are given in Figure 5.3.2.2.6-5.

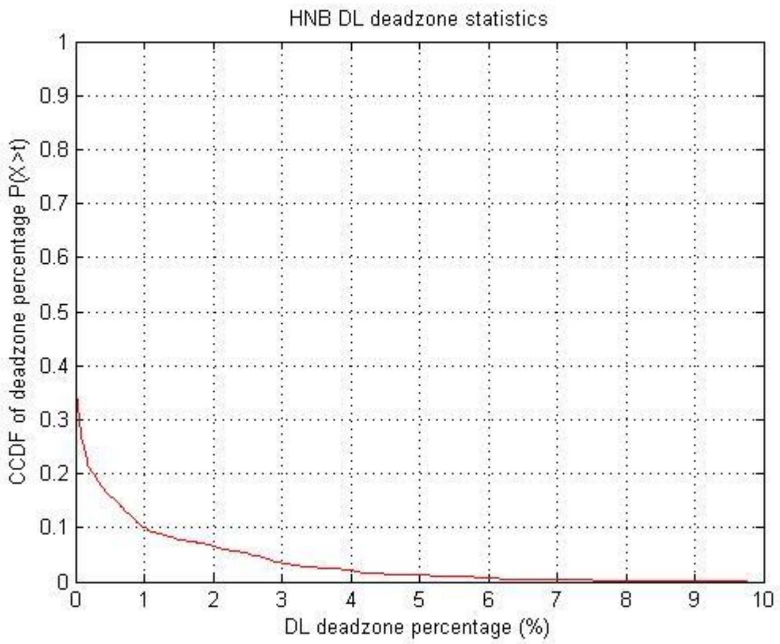


Figure 5.3.2.2.6-5: HNB DL deadzone statistics with VBS in South, 4 fc's, 100% HNB density

It can be seen with 95% probability the DL deadzone area is ≤2.7% of the southern apartment area, which is negligible. Therefore in this model 4 carrier frequencies are enough to mitigate HNB DL interference, even with 100% deployment density.

Since 4 carrier frequencies can be an overkill if the HNB density is relatively low, it would also be of interest to know the deployment density that is suitable for 3 carrier frequencies without causing significant DL interference.

Based on the findings above we can estimate (conservatively) the percentage of the "significantly interfered" HNBs as below:

$$\text{Pr(HNBs with significant DL interference)}= \frac{L * p^4 * 2}{4 * L * p} = 0.5p^3$$

Based on the above equation we plot the curve of Pr(HNBs with significant DL interference) vs. the HNB density in Figure 5.3.2.2.6-6. It can be seen the 5-percentile HNB density is ~0.47.

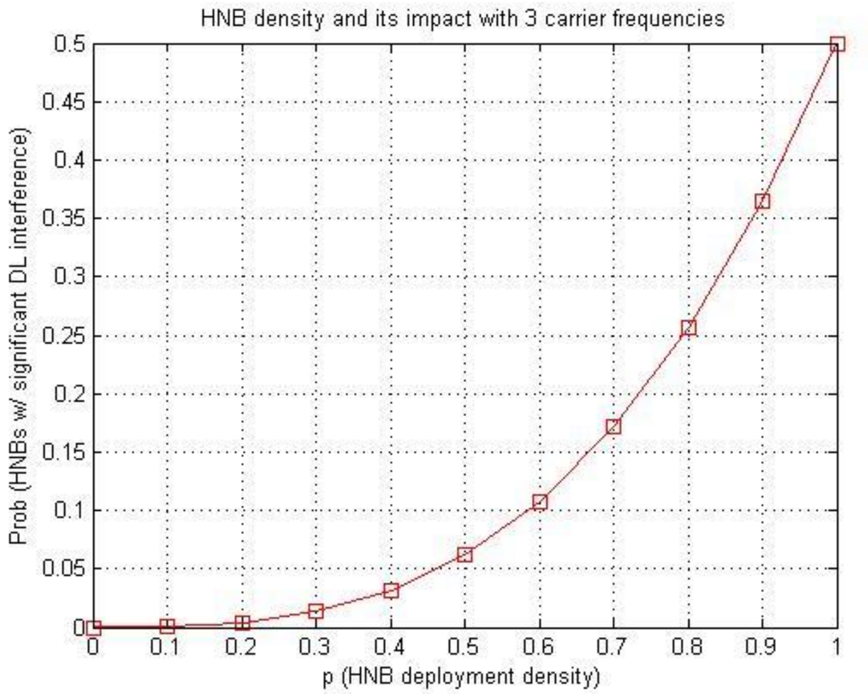


Figure 5.3.2.2.6-6: HNB-HNB DL interference vs. deployment density, 3 carrier frequencies

Based on the above study conducted in a modern apartment building, we can draw the following conclusions:

- Co-channel HNB DL interference and the resulting deadzone can be significant in certain cases.
- Increasing the frequency reuse number for HNBs can effectively mitigate DL interference.
- 4 carrier frequencies can provide sufficient DL interference mitigation, even with 100% HNB density.

With 3 carrier frequencies the HNB density should be ≤0.47 without causing significant DL interference.

5.3.2.3 Conclusion

With the increase of active HNB number, the throughput loss of Closed Loop Power control without ISCP control become higher. When HNB is deployed in a place near Macro NB, without the ISCP control, the throughput of Macro UE has been significant impacted. Also, without ISCP control, the ISCP value of HNB is unacceptable. So, HNB should deploy some mechanism to limit the UE power.

When the Macro UE is uniform distributed, the downlink throughput degeneration is slight. But under some special scenario (Macro UE located in cell edge), the downlink throughput degeneration of Macro UE is significant when HNB power is 13dBm. So, interference mitigation technique is necessary, e.g. adjust the output power adaptively according to the distance between HNB and Macro NB.

Macro UE has little influence to the DL/UL throughput of HNB UE, the DL/UL throughput of HNB UE mainly restricted by the intra-interference.

Frequency reuse can increase the DL and UL throughput of HNB. In order to enhance the throughput of HNB, more frequency band is suggested to be reserved for HNB.

5.4 Home NodeB Class Definition

5.4.1 Introduction

Void

5.4.2 Base station classes

Void

5.4.3 Transmitter characteristics

Void

5.4.3.1 Control of NodeB output power

Void

5.4.3.2 Maximum NodeB output power [12]

The Maximum Output power of a Home NodeB should be able to provide adequate coverage for a full range of supported HNB deployment scenarios, while not exceeding the HNB interference limits. Considering two common Home NodeB scenarios (Home and small-scale corporation), the following two Max. output power level are recommended in table 5.4.3.2.

Table 5.4.3.2: Recommended power of Home NodeB

Power class	Max. output Power	Scenario
1	20 mW (13dBm)	Home
2	100 mW (20dBm)	Small-scale Corporation

5.4.3.3 Frequency Accuracy [6]

This section includes the investigation of frequency accuracy requirements in the home environment.

The modulated carrier accuracy for local area NodeB is required to be equal to 0.1ppm as in [3] with consideration on the high speed mobility of UE, but the same frequency accuracy requirement is not necessary for Home NodeB in terms of deployment scenarios considering Home NodeBs are usually deployed at home and office, it is most likely that the serving UEs are in slow mobility profile and 30Km/h speed should be the reasonable assumption for defining minimum performances for Home NodeB frequency. Taking the conformance of frequency accuracy in the radio interface with the maximum mobility into account, the Home NodeB modulated carrier frequency can be relaxed to 0.25 PPM in [2]. Furthermore, as Home NodeB is a cost-sensitive home device and the low accurate crystal is much more expensive than the high accurate crystal, the 0.25ppm crystal can reduce the cost of the Home NodeB compared to the 0.1ppm crystal.

Two issues have been taken into concern in [2] regarding the 0.25ppm relaxation, one is timing synchronization and the other is the impact of the inaccuracy on the HomeNodeB performance.

Two alternative approaches are analyzed in [2][4]regarding timing synchronization: one is to provide timing and synchronization via GPS and the other is through Precision Timing Protocol (PTP, IEEE 1588). According the analysis in [2], the GPS-based solution envisages a great risk as Home Node B is usually installed indoors, the signals are greatly degraded by roofs and walls and this makes the synchronization quite unstable, furthermore, the GPS device and maintaining the GPS antennas may be beyond some customers' affordability. The second approach IEEE 1588 is prospective since it needs no device maintenance and the embedded software implementation of 1588 protocol can meet the Home NodeB timing synchronization requirement.

For assessing the impact of the 0.25ppm frequency offset on the system performance, some link level simulations were conducted in [2]. The simulation demonstrates that when the frequency offset correction (FOC) is employed at UE, compared with the 0.1ppm frequency offset without any frequency offset correction, 0.25ppm only suffers about 0.85dB performance loss at BLER 10^{-1}. Consider the walls indoors usually can cause about 10dB loss, the loss from 0.25ppm frequency accuracy is acceptable and this loss can be balanced by downlink power control.

The assumptions for the simulation are listed in the Table 5.4.3.3-1 and simulation results are shown in and Table 5.4.3.3-2 respectively.

Table 5.4.3.3-1: Simulation Parameters

Carrier frequency	2GHz
Traffic	PS64K
Number of User	1 (with 1 antenna)
Power control	No
Number of Antenna at NodeB	1
Channel Mode	OTIA 3km/h
Frequency offset	0/0.1/0.25ppm

Table 5.4.3.3-2: Simulation Result at BLER=0.1

	0ppm	0.1ppm without FOC	0.25ppm with FOC
C/I（dB）	-0.6	0.3	1.15

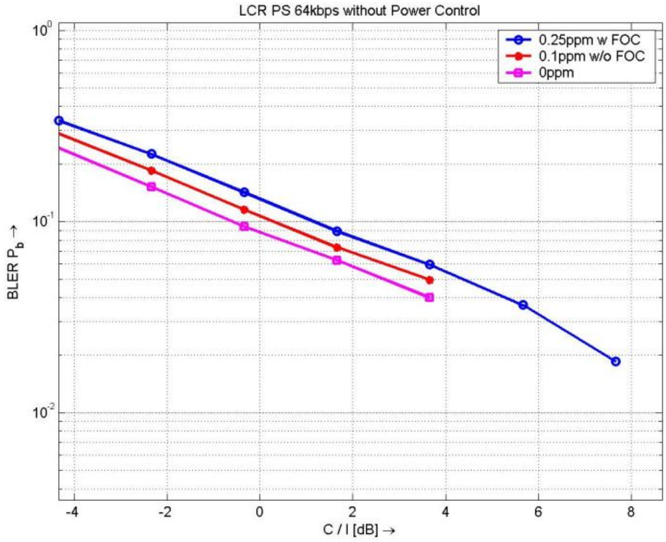


Figure 5.4.3.3-1: Comparison of the performance of Home NodeB with the 0.25ppm(w FOC at UE), 0.1ppm (w/o FOC at UE) and 0ppm

5.4.3.4 Spurious emissions [9]

Keep same requirements as the local area base station class.

5.4.3.4.1 Protection of the BS receiver of own or different BS

Keep same requirements as the local area base station class.

5.4.3.4.2 Co-existence with co-located and co-sited base stations

Keep same requirements as the local area base station class.

5.4.3.4.3 Co-existence with unsynchronised TDD and UTRA-FDD

Keep same requirements as the local area base station class.

5.4.3.4.4 Co-existence with Home NodeB in other bands

[This section need FFS]

5.4.4 Receiver characteristics

5.4.5.1 Reference sensitivity level[17][18]

5.4.5.1.1 The Theoretical Analysis the Noise Rise in Home NodeB

The sensitivity level for FDD local area BS was derived by analysing the noise rise for UL in Picocell, which is interfered by a micro cell operating in adjacent frequency channel. The same analytical methods used in sub-clause A2.2 of 25.951 can be employed for 1.28Mcps TDD Home NodeB receiver sensitivity level derivation as well. In 1.28Mcps TDD Home NodeB deployment, the macro NodeB is usually employed for local area coverage instead of a micro NodeB, therefore modelling the Macro UE as interference source to the 1.28Mcps TDD Home NodeB is reasonable. Figure 5.4.5.1.1-1 depicts the scenario model used.

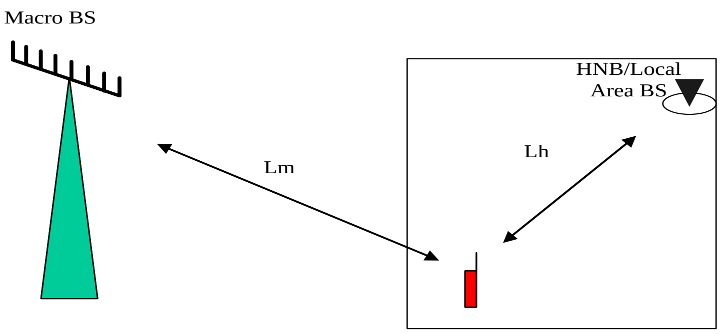


Figure 5.4.5.1.1-1: Local BS or Home NodeB operating at Macro-cell adjacent frequency channel.

Denote the ***I*** as the interference level in the Home NodeB with an interfering Macro UE located in the same room as 1.28Mcps TDD Home NodeB, use the method in sub-clause A2.2 of 25.951, the interference ***I*** can be obtained as

$$I = \frac{P_{P-CCPCH}}{\chi \cdot R_{ref} \rho_{ref} P_h} \cdot \frac{\rho_{UL} I_{UL} R_{UL} \cdot ACIR\_DL}{ACIR\_UL}$$

Where R_{ref} is the reference channel data rate, P_h is the Home NodeB or Micro cell transmit power, ρ_{ref} and ρ_{UL} are the E_b/N_0 requirements for reference channel and uplink dedicated channel respectively. I_{UL} is macro cell uplink interference level, *ACIR_DL* and *ACIR_UL* are the adjacent channel interference ratio in downlink and uplink respectively. R_{UL} is the dedicated channel uplink data rate. χ is the power adjustment parameter; when χ=1 (0 dB), if the reference service is given the same power as for the P-CCPCH, and χ=2 (3 dB) indicates the reference service is given 3 dB less power than for the P-CCPCH. Notice that the interference in UL in Home NodeB is independent on the pathloss between macro and Home NodeB.

For 1.28Mcps TDD, the parameters used for obtaining ***I*** is listed in Table 5.4.5.1.1-1.

Table 5.4.5.1.1-1: Analysis parameters for interference analysis

$P_{P-CCPCH}$ =25dBm	PCCPCH channel
χ=1	Dedicated and P-CCPCH power level is same.
R_{ref} =12.2 kbps	Reference channel data

ρ_{UL} =6.0dB, for 64kbps,	Eb/N0 requirement for decoding the 64kbps data
ρ_{ref} =8dB	Eb/N0 requirement for decoding the reference channel data.
R_{UL} =64kbps	dedicated channel uplink data rate,
P_h =20 dBm	Home NodeB or Local Area Base Station transmit power
ACIR_DL/ACIR_UL=-3 dB	DL and UL adjacent channel interference ratio

Applying in table the values in ***I*** equation, the noise rise compared to the macro-cell interference level I_{UL} is

$$I = \frac{P_{P-CCPCH}}{\chi \cdot R_{ref}\rho_{ref}} \frac{1}{P_h} \cdot \frac{\rho_{UL} I_{UL} R_{UL} \cdot ACIR\_DL}{ACIR\_UL} = \frac{316}{1\cdot} \frac{1}{100} \cdot \frac{I_{UL}}{2} \cdot \frac{64}{12.2} \cdot \frac{3.98}{6.3} = 5.23 \cdot I_{UL} = I_{UL}(dB) + 7.2$$

From the analytical study and numerical computation above shows that compared to a macro cell, noise rise in 1.28Mcps TDD Home NodeB due to the interfering macro cell is about 7.2dB with 64kbps bit rate for the worst case.

5.4.5.1.2 Simulation for Evaluating the Noise Rise in Home NodeB

The reference sensitivity power level is the minimum mean power received at the antenna connector at which a throughput requirement shall be met for a specified reference measurement channel. It is seen as a measure of the RF receiver's noise figure and base band demodulation capability. Since the difference in reference sensitivity between MNB and HNB is only depending on the noise figure. The Home Node B reference sensitivity level can be determined by desensitization based on the MNB, for which the tolerable noise figure should be determined based on simulation.

In Evaluating the Noise Rise in Home NodeB，Some simulations are conducted to study the impact of the noise rise in 1.28Mcps TDD Home NodeB when it coexists with Macro cell scenario and two different simulation methods are applied. And the two simulations derived the similar results on the noise rise level in Home NodeB. Clause 5.4.5.1.2.1 and 5.4.5.1.2.2 outline these two different simulation methods and results on the sensitivity level in Home NodeB.

5.4.5.1.2.1 Simulation method 1

In simulation method 1, the most important and typical scenario captured for evaluating the adjacent channel interference is by setting a macro UE at the edge of a macro-cell transmitting high power in UL close to a Home NodeB. In this scenario, the Macro UE receives not only the data from the anchored macro-cell but also the interference from the Home NodeB. The used simulation parameters can be found in Table 5.4.5.1.2-1 and modulation and code rate choice is in Table 5.4.5.1.2-2.

Table 5.4.5.1.2-1: Simulation Parameters

Parameter	Value	Comments
Number of BSs	57 Macro BSs, 120 Home NodeBs	
ACIR	ACIR 45dB	
UE max transmission powers:	21dBm	
Simulated services	Full buffer ftp	
Modulation and coding rate	Refer to Table 3	
UL Noise rise target	6 dB	Same for both Macro and HomeNodeB
Propagation Model	According to UMTS30.03	
UE Tx power limits	Min: -50 dBm Max: 21 dBm	
Slow fading deviation (Mean: 0 dB)	Macro: 10 dB HomeNodeB: 10dB	
Number of HomeNodeB users per BS	Data: 1	The numbers of users were selected such that 6 dB noise rise target (-102dBm) was controlled by NodeB.
Number of Macro cell users per BS	Data: 1 (only indoors)	The numbers of users were selected such that 6 dB noise rise target (-102dBm) was controlled by NodeB.

Table 5.4.5.1.2-2: Modulation & Code Rate

QPSK	Code Rate	1/6	1/3	1/2	2/3	3/4	7/8	1
16QAM	Code Rate	1/2	2/3	3/4	7/8	1		

Simulation results show when the macro-cell users are located inside the rooms with Home NodeB, UL noise rise in HomeNodeB is growing by 6.6 -7.1dB according to different number of users activated as listed in Table 5.4.5.1.2-3. With all the Home NodeBs, only the 5 worst Home NodeBs noise rise were picked out for averaging. Table 5.4.5.1.2-3 and Figure 5.4.5.1.2-1 indicate when the macro-cell users are located indoors as interfering source for Home NodeB, the UL noise rise in 1.28Mcps TDD Home NodeB is around 7dB and does not increase or decrease monotonously as the number of active Home NodeB does.

Table 5.4.5.1.2-3: ISCP level rise with and without interference from Marocell

The number of active HomeNodeB	30	50	70	100	120
ISCP(dBm) w Macro UE interfering	-98.7	-99	-98.7	-98.7	-99
ISCP(dBm) w/o Macro UE interfering	-105.8	-105.7	-105.4	-105.4	-105.6
ISCP increased (dB)	7.1	6.7	6.7	6.7	6.6

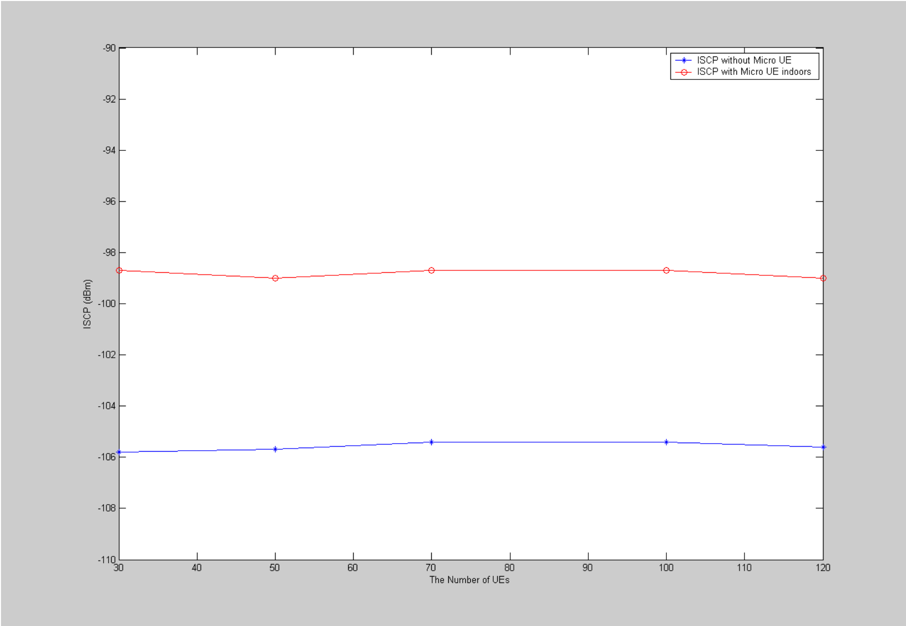


Figure 5.4.5.1.2-1: UL noise rise versus the number of UE

The simulations show the worst case noise rise in Home NodeBs is about 7 dB, which matches the analytical studies in section 5.4.5.1.2. If the implementation margin is considered to be 1.5dB, about 9dB sensitivity degradation is proposed for Home NodeB or Local area BS class, which means -110dBm+9dB = -101dBm sensitivity level for 1.28Mcps TDD Home NodeB.

5.4.5.1.2.2 Simulation method 2

5.4.5.1.2.2.1 Simulation Assumption

We evaluated both the impact of Home Node B noise rise on MNB capacity loss and the impact of MUE interference on Home eNodeB noise rise. The simulation assumptions are described in Table 5.4.5.1.2.2.1-1 and table 5.4.5.1.2.2.1-1.

Table 5.4.5.1.2.2.1-1: System simulation parameters

Parameter	Macro cell	Home NodeB
Simulated Services	HSUPA	HSUPA
Cellular Layout	Hexagonal grid, 3 sectors per site, reuse 1	Urban Dual-strip
Inter-site distance	1000m	-
Number sites	19 (=57 cells) with wrap-around	-
Carrier Frequency	2000 MHz	2000 MHz (HNB deployed on a difference carrier other than that used for MNB)
UL Noise rise target	12dB	18dB
Shadowing standard deviation	8 dB	4 dB
Auto-correlation distance of Shadowing	50 m	3 m
Penetration Loss (assumes UEs are indoors)	10dB	
Antenna pattern	Smart Antenna	Omni-directional
BS antenna gain after cable loss	16.3 dBi	0 dBi
BS noise figure	5 dB	8 dB
Number of BS antennas	8 Rx, 8 Tx	1 Rx, 1 Tx
UE Antenna gain	0 dBi	
UE Noise Figure	9dB	
Number of UE antennas	1 Rx, 1 Tx	
Total BS TX power (Ptotal)	34dBm	Vary between 0-20 dBm
UE power class	21dBm	
Minimum distance between UE and cell	35 m	1 m
Carrier bandwidth	1.6 MHz	1.6 MHz

Table 5.4.5.1.2.2.1-2: Urban dual-strip parameters

Parameter	Urban
Apartment/House size	10m(X)×10m(Y)
N (number of cells per row)	10
M (number of blocks per sector)	10
L (number of floors per block)	1
R (deployment ratio)	1
P (activation number of HNB)	40，100，200，300
Number of active femto UEs per femto-cell	1
Allow Femto blocks to overlap	No

In the case of "the impact of Home Node B noise rise on MNB capacity loss", we consider the worst situation, Home Node B located in special Location: Ten building is located in one sector. The investigated building is located in Location A[Note]. Macro UE is uniformly distributed in the special building. The other nine building is uniformly distributed in one sector.

Note: Location A ("close to macro site, Distance between Macro BS and block is 0.1r").

Where: r is cell radium.

In the other hand, the case of "the impact of MUE interference on HNB noise rise", we consider two deployment scenario. Scenario 1 is MUE located in cell edge at a distance D=R, which is the worst case. Scenario 2 is MUE located in R/2 of the radius of Macro cell.

5.4.5.1.2.2.2 Simulation Result

The noise rise of HNB will cause the increase of UE output power to maintain communication quality. Then the increased UE transmission power will cause interference to a nearby MNB, thus degrading the performance of the MNB in terms of throughput loss or coverage decrease. Figure 5.4.5.1.2.2.2-1 gives the simulation results on the impact of HNB noise rise on MNB capacity loss.

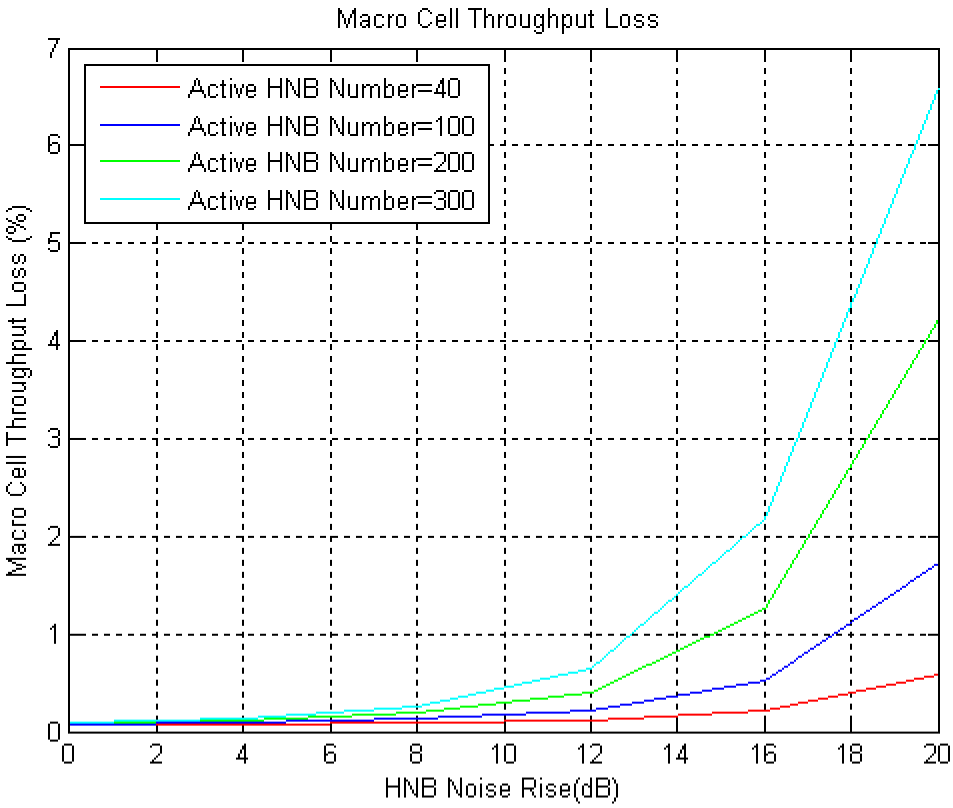


Figure 5.4.5.1.2.2.2-1: MNB uplink throughput loss VS HNB noise rise

The simulation results are summarized in table5.4.5.1.2.2.2-1. The maximum tolerable noise rise depends on the criterion of MNB throughput loss.

Table 5.4.5.1.2.2.2-1: Noise rise of HNB under different MNB throughput loss

MNB throughput loss	Active HNB =40	Active HNB =100	Active HNB =200	Active HNB =300
3%	-	-	18.352dB	16.738dB
5%	-	-	-	18.549dB

Also the HNB will receive interference from a MUE. Figure 5.4.5.1.2.2.2-2 gives CDF of HNB noise rise in two deployment scenario.

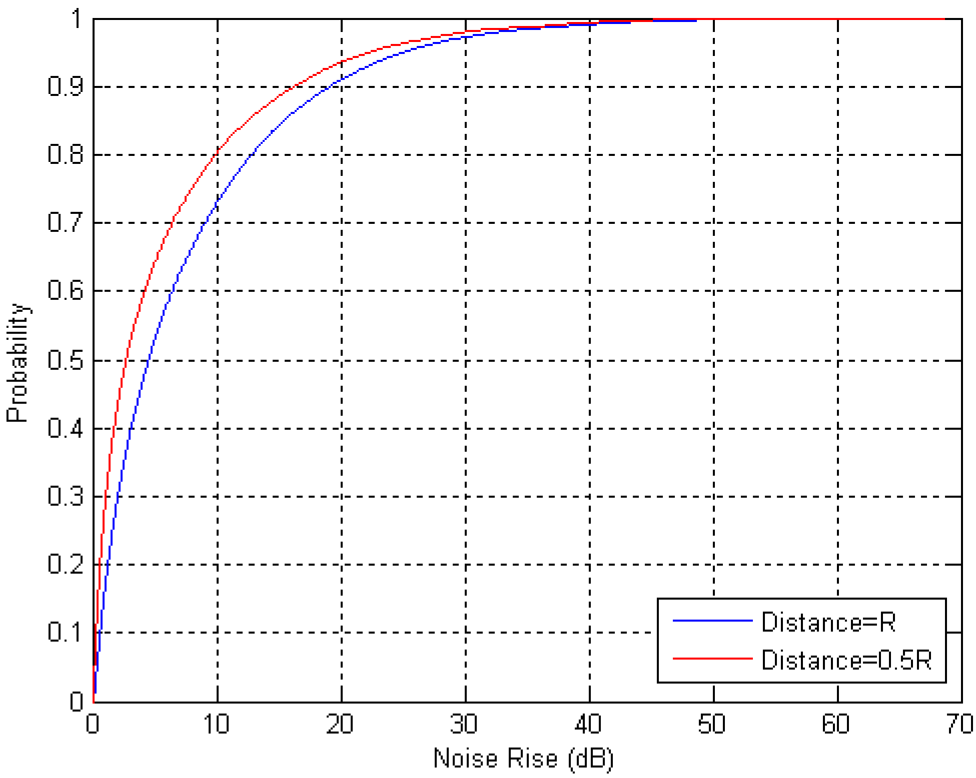


Figure 5.4.5.1.2.2.2-2: HNB noise rise CDF, MUE distance from MNB

Table 5.4.5.1.2.2.2-2: Summary of HNB noise rise due to MUE interference

Probability of HNB that observe highest interference	MUE distance from MNB, D=R/2	MUE distance from MNB, D=R(worst case)
40%	4.214 dB	6.424 dB
30%	6.408 dB	9.093 dB
20%	9.948 dB	12.867 dB

It is seen from table 5.4.5.1.2.2.2-2, the choice of HNBs that receive the highest interference from MUE has big impact on the maximum tolerable noise rise.

5.4.5.1.3 Sensitivity Level

Using the reference measurement channel specified in 25.105 Annex A, the reference sensitivity level and performance of the BS shall be as specified in table Table5.4.5.3-1.

Table5.4.5.3-1: 1.28Mcps TDD Home NodeB reference sensitivity level

BS Class	Reference measurement channel data rate	BS reference sensitivity level	BER
1.28Mcps TDD Home NodeB	12.2 kbps	-101 dBm	BER shall not exceed 0.001

5.4.5.2 Dynamic range [19]

Receiver dynamic range is the receiver ability to handle a rise of interference in the reception frequency channel. The receiver shall fulfil a specified BER requirement for a specified sensitivity degradation of the wanted signal in the presence of an interfering AWGN signal in the same reception frequency channel.

Considering impact of co-channel uplink interference on the Home NodeB, it is possible that Home NodeB receiver will be exposed to strong interference signals from un-coordinated UEs. It was shown that the Home NodeB dynamic range requirement needs to be extended by 20dB to protect the HNB from the strong interference signal of an un-coordinated UE. This conclusion can be reused in 1.28Mcps TDD Home NodeB.

The BER shall not exceed 0.001 for the parameters specified in Table 5.4.5.2-1.

Table 5.4.5.2-1: Dynamic Range of 1.28Mcps TDD Home NodeB Receiver

Parameter	Level	Unit
Reference measurement channel data rate	12.2	kbps
Wanted signal mean power	-51	dBm
Interfering AWGN signal	-47	dBm/1.28 MHz

5.4.5.3 Adjacent channel selectivity (ACS)[20]

Adjacent channel selectivity (ACS) is defined as a measure of the receiver ability to receive a wanted signal at its assigned channel frequency in the presence of a single code CDMA modulated adjacent channel signal at a given frequency offset from the center frequency of the assigned channel. ACS is the ratio of the receiver filter attenuation on the assigned channel frequency to the receiver filter attenuation on the adjacent channel(s).

The BER shall not exceed 0.001 for the parameters specified in Table 5.4.5.3-1.

Table 5.4.5.3-1: Adjacent channel selectivity of 1.28Mcps TDD Home NodeB Receiver

Parameter	Level	Unit
Reference measurement channel data rate	12.2	kbps
Wanted signal mean power	-77	dBm
Interfering AWGN signal	-28	dBm

5.4.5.4 Blocking characteristics [21]

The blocking characteristics are a measure of the receiver ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the adjacent channels. The blocking performance requirement applies to interfering signals with center frequency within the ranges specified in the tables below, using a 1MHz step size.

5.4.5.4.1 Minimum requirement

The static reference performance as specified in clause 5.4.5.1 shall be met with a wanted and an interfering signal coupled to BS antenna input using the parameters as specified in table 5.4.5.3.1-1 to 5.4.5.3.1-6 for 1.28Mcps TDD Home NodeB.

Table 5.4.5.4.1-1: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
1900 - 1920 MHz, 2010 - 2025 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1880 - 1900 MHz, 1990 - 2010 MHz, 2025 - 2045 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1920 - 1980 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1 - 1880 MHz, 1980 - 1990 MHz, 2045 - 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

Table 5.4.5.4.1-2: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
1850 - 1990 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1830 - 1850 MHz, 1990 - 2010 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1 - 1830 MHz, 2010 - 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

Table 5.4.5.4.1-3: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
1910 - 1930 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
1890 - 1910 MHz, 1930 - 1950 MHz	-30 dBm	-90 dBm	3.2 MHz	Narrow band CDMA signal with one code
1 - 1890 MHz, 1950 - 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

Table 5.4.5.4.1-4: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
2570 - 2620 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
2500 - 2570 MHz, 2620 - 2690 MHz	-30 dBm	-90 dBm	3.2 MHz	Narrow band CDMA signal with one code
1 - 2500 MHz, 2690 - 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

Table 5.4.5.4.1-5: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
2300 - 2400 MHz	-30 dBm	-90 dBm	3.2MHz	Narrow band CDMA signal with one code
2280 - 2300 MHz, 2400 - 2420MHz	-30 dBm	-90 dBm	3.2 MHz	Narrow band CDMA signal with one code
1 - 2280 MHz, 2420 – 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

Table 5.4.5.4.1-6: Blocking requirements for 1.28Mcps TDD Home NodeB

Center Frequency of Interfering Signal	Interfering Signal mean power	Wanted Signal mean power	Minimum Offset of Interfering Signal	Type of Interfering Signal
1880-1920 MHz	-30 dBm	-90 dBm	3.2 MHz	Narrow band CDMA signal with one code
1860 - 1880 MHz, 1920 - 1940MHz	-30 dBm	-90 dBm	3.2 MHz	Narrow band CDMA signal with one code
1 - 1860 MHz, 1940 – 12750 MHz	-15 dBm	-90 dBm	—	CW carrier

5.4.5.4.2 Minimum Requirement - Co-location with GSM900, DCS 1800, PCS1900, GSM850 and/or UTRA FDD

Keep same requirement as local area BS.

5.4.5.4.3 Minimum Requirement - Co-location with UTRA-TDD

Keep same requirement as local area BS.

5.4.5.5 Intermodulation characteristics [16]

Third and higher order mixing of the two interfering RF signals can produce an interfering signal in the band of the desired channel. Intermodulation response rejection is a measure of the capability of the receiver to receiver a wanted signal on its assigned channel frequency in the presence of two or more interfering signals which have a specific frequency relationship to the wanted signal.

The static reference performance as specified in sensitivity performance should be met when the following signals are coupled to BS antenna input.

- A wanted signal at the assigned channel frequency, with mean power 6 dB above the static reference level.
- Two interfering signals with the following parameters.

Using the reference measurement channel specified in Annex A of 3GPP TS 25.105, the reference sensitivity level and performance of the Home NodeB shall be as specified in table 5.4.5.5-1.

Table 5.4.5.5-1: Intermodulation requirement of Home NodeB Receiver

Interfering Signal Mean Power	Offset	Type of Interfering Signal
- 38 dBm	3.2 MHz	CW signal
- 38 dBm	6.4 MHz	1,28 Mcps TDD Option signal with one code

5.4.6 Performance requirement [11]

To Multi-path Fading environment shown in Table B.2 of 25.105, case 1 and case 2 are considered for 1.28Mcps TDD Home NodeB performance requirements. However to case 2, considering 16chips（12.5ms）detection window, 12ms delay seems too much. So, just case 1 is recommended for 1.28Mcps TDD Home NodeB demodulation.

To Propagation Conditions for Multipath Fading Environments for E-DCH Performance Requirements for 1,28 Mcps TDD shown in Table B.2A of 25.105 , ITU Pedestrian A speed 3km/h (PA3)，ITU Pedestrian B speed 3km/h (PB3) and ITU vehicular A speed 30km/h (VA30) are suitable to 1.28Mcps TDD Home NodeB.

To Parameters in static propagation conditions and multipath Case 1 channel, Ioc will be changed according to sensitivity changes of local area Base station and Home NodeB.

5.4.7 Summary

This section summarises the investigation of whether the local area class can be extended to cover scenarios for the 1.28Mcps TDD Home Node B, or a if new class needs to be defined.

6 Physical Layer (RAN WG1)

6.1 Physical Layer Requirements

This section includes the investigation of physical layer requirements in the home environment

No change is predicted in RAN1 Specifications.

7 Radio Interface Architecture and protocols (RAN WG2)

7.1 Mobility scenarios

This section includes the investigation Home NodeB mobility scenarios.

Keep same as FDD Home NodeB issue.

7.2 Access control scenarios

This section includes the investigation how to manage access control for the Home NodeB

Keep same as FDD Home NodeB issue.

8 UTRAN Architecture and Application Protocol (RAN WG3)

This section includes the investigation of whether any UTRAN interfaces might be impacted and investigation of whether 1.28Mcps TDD Home NodeBs need to be synchronized among each other or with the macro network and how synchronization can be achieved in a scalable manner.

8.1 Synchronization [14]

8.1.1 V1588 synchronization scheme

IEEE PTP 1588V2 is an improved and optimized version with shortened form relative to 1588, a precise time synchronization protocol.

IEEE 1588V2 calculates time shift and resident time introduced by intermediate network equipment through information transmitted between principal and subordinate equipments. It may decrease the effect of timing packet suffering by saving and transmitting, thereby can realize precise synchronization between principal and subordinate equipments.

Figure 8.1.1-1 describes the procedure calculating path delay and time shift of principal and subordinate equipments.

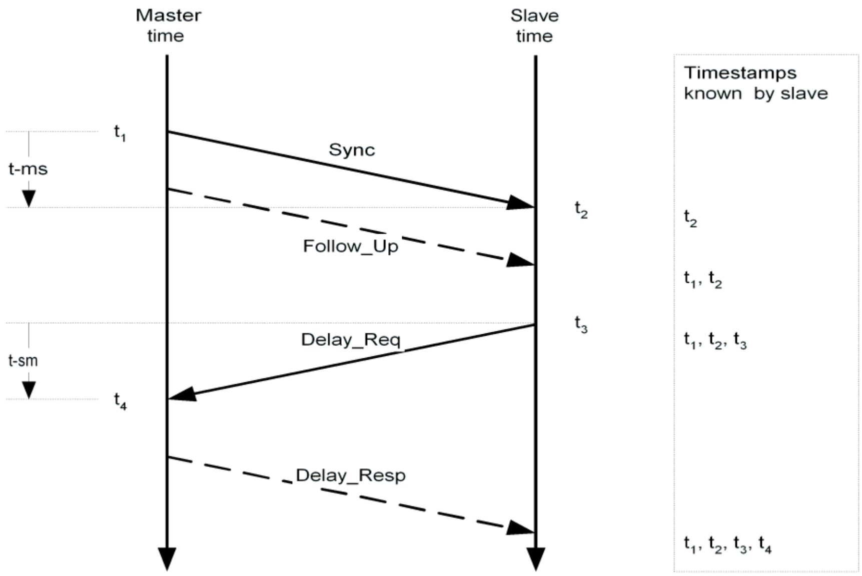


Figure 8.1.1-1: The procedure calculating path delay and time shift of principal and subordinate equipments

Subordinate equipment obtains t_1, t_2, t_3 and t_4 according to the procedure above and calculates path delay between principal and subordinate equipments using t_1, t_2, t_3 and t_4 , and further comes out time shift. It will correct local time by this time shift.

a) Path delay:

$$Delay = [(t_4 - t_1) - (t_3 - t_2)]/2$$

Then

$$t_2 = t_1 + Delay + Offset = t_1 + [(t_4 - t_1) - (t_3 - t_2)]/2 + Offset$$

b) Time shift：

$$offset = [(t_2 - t_1) + (t_3 - t_4)]/2$$

Subordinate equipment calculates time shift and corrects local time, and synchronizes to principal equipment.

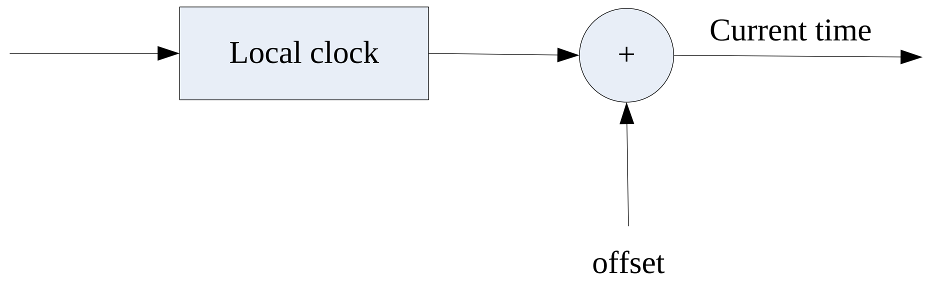


Figure 8.1.1-2 Principle of time correct

In real network, timing information between principal and subordinate equipments involves several nodes. So each node in network is required to maintain and correct path delay. Based on 1588V2 protocol, timing precision can be in ns, some synchronization network may realize phase difference within +/-1uS relative to datum reference source, which may make terrestrial synchronization network meet or exceed the synchronization requirement of TDD Home Node B network.

8.1.2 GPS synchronization scheme

GPS is an alternative Home Node B synchronisation scheme for it has already been endorsed as an important local clock signal source for TD-SCDMA base stations. GPS receives signal from more than one satellite and deciphers an UTC time info.

Actually, the accuracy tightly depends on the propagation quality between GPS receiver device and source satellites. The quality may be deteriorated when GPS receiver is located in a closed building or with a long cable between GPS antenna and receiver. Thereby on top of additional cost for GPS receiver, the timing accuracy may not be adequate for a Home Node B synchronisation for indoor coverage is a large percentage of its usage.

8.1.3 Air interface synchronization scheme

The concentration of TDD Home Node B air interface synchronization is how to select the timing benchmark. Once the timing benchmark is selected, all Home Node Bs in one location should automatically adjust their timing to this benchmark.

The handover between Home Node B and Macro Node B must be supported, such that Home Node B synchronizing with Marco Node B is a straight method without additional complexity.

TDD Home Node B detects Macro Node B’s DwPCH, and defines its timing benchmark according to Macro Node B’s DwPCH.

Considering the complex deployment scenario of TDD Home Node B network and least impact on macro cellular deployment, Macro Node Bs and TDD Home Node Bs are preferably deployed on different frequency. Home Node B should select the best suitable macro cell from all candidates Macro Node Bs if it can detect signal of multiple Macro Node Bs. The timing could be set using one reference in figure 8.1.3-1.

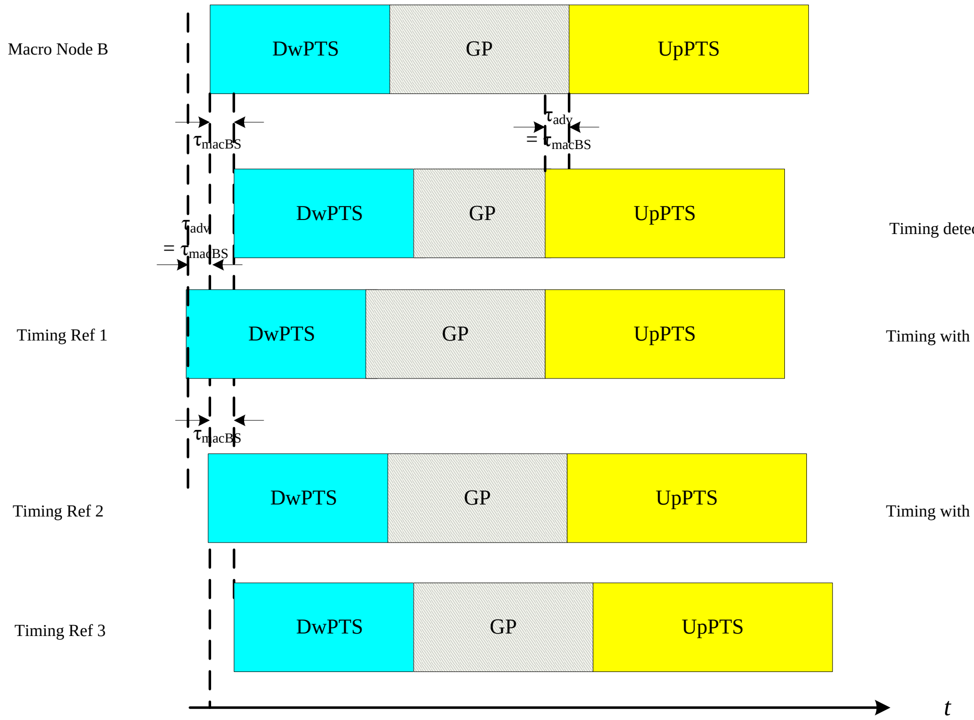


Figure 8.1.3-1: TDD Home Node B Timing according to Macro Node B's DwPCH

Figure 8.1.3-1 gives three candidate TDD Home Node B air interface timing adjust methods:

- Reference 1: The frame boundary of Home Node B precedes anchored macro one with one τ_{adv}, which is given by macro Node B via a uplink synchronisation procedure;
- Reference 2: The frame boundary of Home Node B is exactly aligned with anchored macro one via uplink synchronisation procedure;
- Reference 3: Home Node B sets its frame boundary at the time point when it detects a downlink synchronisation peak, which in principle lag τ_{adv} behind anchored macro one.

If reference 1 or 2 is selected, Home Node B shall behave as a regular TD-SCDMA UE and perform a 'fake' random access in its synchronisation.

If Home Node B can not detect Macro Node Bs' DwPCH, according to its SON characters, Home Node B may apply the following schemes but not necessarily be restricted to the followings, to select its working frequency and timing.

- When Home Node B is power on, it searches the best suitable Home Node B from Home Node B available frequency list, and gets its timing advance.
- Apply any type of Home Node B timing reference as shown in figure 8.1.3-1

If Home Node B can neither detect signal from Macro Node B nor from other Home Node B, the timing rule is not needed to specify.

Due to cost concern, oscillators with loose timing accuracy and stability requirement are preferred for Home Node B device. Therefore Home Node B needs to periodically perform a synchronisation corroboration to amend impact incurred by low stability and enable working frequency and timing accuracy in an interference mitigated purpose.

The above synchronisation principle could be also used for multi-frequency TD-SCDMA Home Node B because the timing reference signal, i.e. DwPTS, is only located on primary frequency and one multiple-frequency Home Node B only adopts one unique timing.

9 Conclusions

9.1 RAN4 Conclusions

- 1.28Mcps TDD Home NodeBs should not degrade significantly the performance of networks deployed in other channels.
- Frequency reuse can increase the DL and UL throughput of 1.28Mcps TDD Home NodeBs. More effective interference mitigation schemes should be studied to enhance the throughput of both macro cell and home BS.
- 1.28Mcps TDD Home NodeBs should provide reasonable performance whether deployed in isolation or whether multiple Home NodeBs are deployed in the same area. However, in high density environments, techniques may be needed to mitigate inter-HNB interference.
- It is ensured that such an emission complies with regulatory requirements in force where that 1.28Mcps TDD Home NodeB is operating.
- 1.28Mcps TDD Home NodeB must support UE speeds up to 30 km/h.

9.2 RAN1 Conclusions

- No change is predicted in RAN1 Specifications.

9.3 RAN2 summary, conclusions and recommendations

- Keep same as FDD Home NodeB

9.4 RAN3 Conclusions

- Synchronization is needed to 1.28Mcps TDD Home NodeB.

Annex A (informative): Change history

Table A.1: Change history

Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2008-10	RAN4#48bis	R4-082518			Report skeleton		0.0.1
2009-01	RAN4#49bis	R4-090083 R4-090084 R4-090086			Revised Report skeleton Text Proposal on 1.28Mcps TDD Home NodeB RF Requirements Text Proposal on Frequency Accuracy of 1.28Mcps TDD Home NodeB	0.0.1	0.0.2
2009-02	RAN4#50	R4-090675 R4-090677 R4-090987			Text Proposal on 1.28Mcps TDD Home NodeB Deployment Configuration Text proposal on Interference scenarios and Analysis on 1.28Mcps TDD Macro BS and Home NodeB Text Proposal on Spurious Emission of transmitter of 1.28Mcps TDD Home NodeB	0.0.2	0.1.0
2009-05	RAN4#51	R4-092114			Text proposal on Simulation Assumption on 1.28Mcps TDD Macro BS and Home NodeB	0.1.0	0.2.0
2009-06	RAN4#51bis	R4-092145 R4-092146			Text proposal on demodulation performance of 1.28Mcps TDD Home NodeB Text proposal on Output Power of 1.28Mcps TDD Home NodeB	0.2.0	0.3.0
2009-08	RAN4#52	R4-092936			Text Proposal on Simulation results of maximum output power of 1.28Mcps TDD Home Node B	0.3.0	0.4.0
	RAN3#65	R3-092133			Text proposal to 25.866 on synchronization schemes for 1.28Mcps TDD Home Node B		
2009-10	RAN4#52bis	R4-093487			Text Proposal on Simulation results of Home NodeB and Macro BS	0.4.0	0.5.0
		R4-093492			Text Proposal on intermodulation of 1.28Mcps TDD Home NodeB receiver		
2009-11	RAN4#53	R4-094371			Text Proposal on sensitivity of 1.28Mcps TDD Home NodeB receiver	0.5.0	1.0.0
		R4-094854			Simulation results for LCR Home NodeB receiver		
		R4-094372			Text Proposal on dynamic range of 1.28Mcps TDD Home NodeB receiver		
		R4-094373			Text Proposal on ACS of 1.28Mcps TDD Home NodeB receiver		
		R4-094374			Text Proposal on blocking of 1.28Mcps TDD Home NodeB receiver		
		R4-094369			Text Proposal on Simulation results of Home NodeB and Macro BS		
2009-12	RAN#46	RP-091232			Approved at RAN	1.0.0	9.0.0