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Foreword

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1 Scope

This document is a technical report of the study item on Home NodeB/eNodeB [1]. The goal of this study item is,

- To characterise the 3G Home NodeB environment. Whenever possible the scenarios defined as part of this study shall be of benefit to the LTE Home eNodeB investigation.
- To determine the feasibility of a solution and to outline any obstacles
- 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*.

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3 Definitions, symbols and abbreviations

For the purposes of the present document, the terms and definitions given in TR 21.905 [128] 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 [128].

3G HNB	3rd Generation Home NodeB
3G HNB GW	3G HNB Gateway
ACIR	Adjacent Channel Interference Rejection, can be translated to receiver selectivity when the emission mask of the interfering signal is accounted for.
BS	Cellular system base station
BC	Broadcast
CN	Core Network
CS	Circuit Switched
CSG	Closed Subscriber Group
DL	Downlink, the RF path from BS to UE
eHNB	evolved Home Node B
GSM	Mobile cellular system (throughout this document, this acronym is generally to also means the services GPRS and EDGE, both enhancements to GSM, unless not applicable to the discussion.)
HNB	Home NodeB
HNBAP	HNB Application Application Protocol
MBSFN	Multicast/Broadcast over a Single Frequency Network
NNSF	NAS Node Selection Function
PPI	Payload Protocol Identifier
PS	Packet Switched
RANAP	Radio Access Network Application Part
RNL	Radio Network Layer
RUA	RANAP User Adaptation
RX	Receiver
SCCP	Signalling Connection Control Part
SCTP	Stream Control Transmission Protocol
TX	Transmitter
UE	User Equipment, also cellular terminal
UL	Uplink, the RF path from UE to BS
UTRAN	UMTS Terrestrial Radio Access Network
UMTS	Universal Mobile Telecommunications System, often used synonymously with WCDMA
WCDMA	Wideband Code Division Multiple Access, a type of cellular system meeting ITU-2000 requirement

4 General

As agreed in the study item proposal [1]:

“Within the course of increasing UMTS terminal penetration and fixed-mobile convergence, an upcoming demand for 3G Home NodeBs to provide attractive services and data rates in home environments is observed.

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

Aim of this feasibility study is to investigate optimization and amendments to the UTRAN standard in order to fully support the application of Home NodeBs. The scope of this study item is limited to FDD mode.

This study includes but is not limited to the architecture aspect, handover scenarios and interference considerations.

In order to minimize the impact on the existing overall network, the home NodeB concept for WCDMA shall operate with legacy terminals (from Release 99 onwards) and core network and minimize impact on UTRAN interfaces. No impact to terminal specifications is foreseen.

Once the feasibility study is finalized, an optimised solution for the 3G Home NodeB environment should be available.

Work for the LTE home eNodeB (as part of the on-going LTE work item) should benefit from the scenarios defined as part of this study. The intention is to base the interference analysis on the same scenario for both UTRAN and EUTRAN as the deployment scenarios are expected to be the same."

4.1 Task description

The purpose of this study item is to characterise the 3G Home NodeB environment and investigate the feasibility of optimisations and amendments to UTRAN FDD mode to adapt it to fully support the 3G Home NodeB.

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

1) TSG RAN WG4

Requirements

Identify any new, revised or missing RF requirements for 3G Home NodeB

Identify relevant deployment scenarios

RF-related issues

Investigate RF related aspects such as interference scenarios and RF performance requirements for 3G Home NodeB

Frequency accuracy

Investigate the frequency accuracy required for the 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 3G Home Node B, or a new class needs to be defined.

2) TSG RAN WG2 and TSG RAN WG3

Architecture

Investigation on if and which UTRAN interfaces might be impacted

Implications of deployment and/or operational scenario for 3G Home NodeB

Potential for very high density of 3G Home NodeBs

Rigorous planning is not necessarily possible and/or desirable for consumer premise equipment

Mobility scenarios

Management of neighbor cell information

Restriction of handover in one or both directions.

Frequency reuse within overlapping/ hierarchical cell layout

Access control scenario

Control of 3G Home NodeB access and managing unwanted access

5 RF Aspects (RAN WG4)

5.1 Requirements

RF Requirements for Home (e)NodeBs will be the same as for the local area (e)NodeB, with additional requirements as described in the following sections.

5.1.1 New Requirements Affecting RF Aspects

1) Home (e)NodeBs should not degrade significantly the performance of networks deployed in other channels.
2) Home (e)NodeB configurations intended for deployment in the *same* channel as an existing (e)UTRAN network should ensure their combined performance is not significantly worse than that of the original network.
3) Home (e)NodeBs should provide reasonable performance whether deployed in isolation or whether multiple Home (e)NodeBs are deployed in the same area.
4) As a Home (e)NodeBs may be privately owned 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.
5) The Home NodeB must support UE speeds up to 30 km/h.
6) Home NodeB must support existing UTRAN UEs.

5.1.2 RF Requirements analysis

1) *Adjacent* channel co-existence should be considered as this is the worst case.

1 & 2) Performance is quantified in terms of UE throughput, coverage and spectral efficiency, taking into account cell edge, average UE and close to the HNB.

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

Combined performance is equal to the addition of macro network and the HNB network taking into account the open/closed access configuration.

3) 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. HNB system requirements are currently discussed in SA1, as illustrated by [119]; performance requirements will align with the outcome of this work.

4) 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 HNB 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
- communication link between HNB and HNB operator
- HNB identity.
- other FFS

The events and frequency on which the above conditions must be verified is an open issue.

HNB location:

- HNB must be within operator's license area when transmitting on the radio path.
- A more precise location may be required for other reasons, such as: emergency services, lawful interception, or restricting operation to a specific location (open issue)

Communication link between HNB and HNB operator:

- There must be a communication link to receive authorisation
- The communication link may need to achieve minimum performance requirements for offered services (open issue)

HNB identity:

- The HNB operator must be able to verify the HNB identity

5) Discussions in [5,6,7,8,] have demonstrated that the 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) HNB must be backwards compatible with UTRAN UEs already in the field.

Note. The support of UE location for emergency calls is being handled by other 3GPP groups and is not believed to impact RAN WG4.

5.2 Deployment Configurations

A number of different deployment configurations have been considered for Home (e)NodeB. The aspects which define these are as follows:

- Open access or CSG (Closed Subscriber Group)
  - Open access HNBs can serve any UE in the same way as a normal NodeB
  - CSG HNBs only serve UEs which are a member of a particular Closed Subscriber Group
- Dedicated channel or co-channel
  - Whether HNBs operate in their own separate channel, or whether they share a channel with an existing (e)UTRAN network
- Fixed or adaptive (DL) maximum transmit power
  - Fixed: HNBs have a set fixed maximum transmit power
  - Adaptive: HNB's sense interference to existing networks, and adjust maximum transmit power accordingly

The following configurations are considered and are described in more detail in the following sections.

A. CSG, Dedicated channel, Fixed Power

B. CSG, Dedicated channel, Adaptive Power

C. CSG, Co-channel, Adaptive Power

D. Partial Co-Channel

E. Open Access, dedicated or co-channel

5.2.1 Configuration A. CSG, Dedicated Channel, Fixed Power

HNB is configured as a Closed Subscriber Group. Access to HNB is controlled through an arrangement between the HNB owner and by the network operator. Access is restricted to a very limited number of UE; the majority of UE do not have access to the HNB. Therefore, a CSG covers the partially open system, as discussed in [89].

The HNB is deployed on a dedicated channel; i.e. a channel that is not used within the macro layer. The worst case dedicated channel deployment is the adjacent channel. The worst case adjacent channel deployment is when the adjacent channel is owned by a different operator.

Although the HNB is deployed on the dedicated frequency with respect to the macro network, a co-channel interference scenario remains between HNB's. HNB's must share the same frequency, hence co-channel coexistence must be analysed within a dense population of HNB.

In this configuration, the Home NodeB's maximum transmit power could potentially be fixed by the operator to be lower than the Maximum Transmit power capability. As analysed in detail in [63], the reduced power limit ensures the dominance of the HNB with respect to a macro cell is appropriately bounded. Therefore, the HNB cell size is limited with respect to a weak macro signal. Consequently, the HNB can operate with a fixed maximum power level even at the edge of a macro cell.

5.2.2 Configuration B. CSG, Dedicated Channel, Adaptive Power

HNB is configured as a Closed Subscriber Group.

The HNB is deployed on a dedicated channel.

Maximum transmit power may be set as high as the maximum capability of the HNB class of basestation. However, higher maximum power level than the acceptable "fixed" maximum power for dedicated channel deployment, Section 0 shall only be used when appropriate for the deployed environment, and when the resulting interference is acceptable.

5.2.3 Configuration C. CSG Co-channel, Adaptive Power

HNB is configured as a Closed Subscriber Group.

The HNB is deployed on the same channel as the macro network. This is considered the worst case interference scenario; consequently this is the highest risk deployment. Power levels used by the Home Node B and all attached UE's must be set as appropriate for the deployed environment.

The fixed maximum transmit power limit is not considered feasible for co-channel deployment and has been removed from further analysis.

5.2.4 Configuration D. Partial Co-Channel

Partial co-channel is proposed for CSG operation for HNBs. This works by limiting frequencies which are shared by the "macro layer" and the HNB, as shown in Figure 1. The macro layer uses the all available frequencies, whereas the home NodeB only uses a subset – the shared part. Macro UEs can operate on any frequency. Macro UEs in the shared part experiencing "pathological" interference from home NodeBs can move to the clear part.

Whist this configuration is indented as a solution for CSG operation, it may also be applicable to Open access in order to limit the influence of the HNB in the overall network and allow more control over mobility.

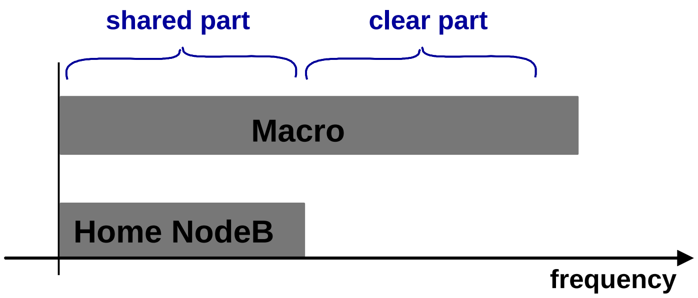

Figure 1. Spectrum arrangement for Macro and Home Node Bs

Figure 2 shows how this could be implemented in UTRAN. Two channels are needed, one for Macro+HNB, the other for Macro only. Macro-only UEs experiencing HNB interference in channel 1 would handover to channel 2.

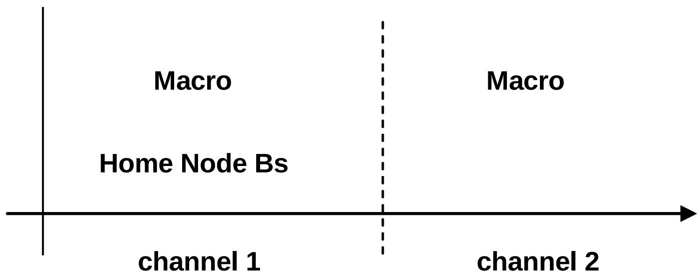

Figure 2. Spectrum arrangement for UTRAN

Figure 3 shows how this could be implemented for EUTRAN. Since it has scalable bandwidth, it does not necessarily require two channels as with UTRAN. Provided the HENB sub-band does not overlap the central 6 RBs of the macro's channel, then it will not prevent UEs receiving the BCH and SCH and connecting to the macro layer. Frequency hopping and Frequency dependent scheduling will ensure UEs experiencing HNB interference on part of the band will still be able to function.

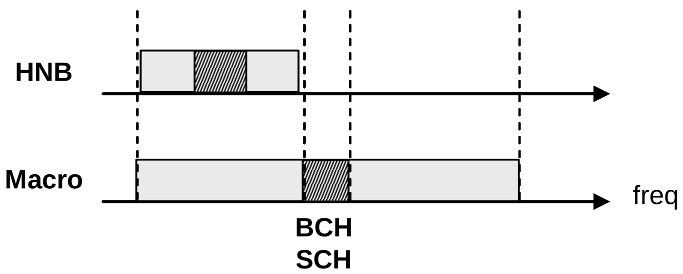

Figure 3. Spectrum arrangement for EUTRAN

Providing UEs hand over to the clear channel when experiencing HNB interference , the performance of this configuration should be similar to that of configuration A (dedicated channel, fixed power)

5.2.5 Configuration E: Open Access, dedicated or co-channel

Open access Home NodeBs serve all UEs, in the same way as other NodeBs do [33,34,55].

The results referenced in Section 0 explain the level of openness supported by a HNB deployment when explaining the model and assumptions used.

A completely open system is already covered by the existing classes of Node B.

5.3 Interference Scenarios

Home Node B's are intended to enhance the coverage of a UMTS Radio Access Network in the home environment. However, it is not feasible to completely control the deployment of the HNB layer within the UMTS RAN. Therefore, interference due to the HNB is a concern and interference mitigation techniques may be required. Interference mitigation techniques will impact the HNB performance, which will present the HNB with challenges in managing its radio resources and maintaining Quality of Service to its attached users. In the following sections the interference scenarios that exist between a HNB and the macro layer, and among HNBs, are discussed in more detail.

Priority of the interference scenario investigations has been established as shown in Table 1

Table 1. Interference Scenarios

Number	Aggressor	Victim	Priority
1	UE attached to Home Node B	Macro Node B Uplink	yes
2	Home Node B	Macro Node B Downlink	yes
3	UE attached to Macro Node B	Home Node B Uplink	yes
4	Macro Node B	Home Node B Downlink	
5	UE attached to Home Node B	Home Node B Uplink	yes
6	Home Node B	Home Node B Downlink	yes
7	UE attached to Home Node B and/or Home Node B	Other System	
8	Other System	UE attached to Home Node B and/or Home Node B	

In addition to the above scenarios, we also addressed the scenario of a HNB mobile operating very close to its serving HNB, simulation results are referred to in Section 0.

Additionally, possible methods for assessing HNB performance in the different interference scenarios were proposed in [102].

5.3.1 Coexistence Simulation Parameters

Simulation results are encouraged from a range of parameters to ensure a robust and diverse analysis of the problem. The results in this section were generated over a range of simulation assumptions. Simulation models are described for different HNB deployment scenarios in [50, 55, 57, 63, 88].Models for the dense urban apartment building, HNB-Macro are provided in [57] and [103].

5.3.2 Interference scenario 1 UL HNB UE → Macro

Noise rise on the macro layer will significantly reduce macro performance; consequently, the transmit power of the UE should be controlled. The following mechanisms are investigated to limit the interference cause by an HNB attached UE:

- HNB receiver performance will have an impact on UE transmit power; therefore any relaxation of the BS receiver required must be carefully investigated.
- UE power limitations such as maximum transmit power limits, and strict scheduling limits and noise rise limitation for HSUPA
- Open access; UEs are permitted to move easily between the macro and HNB layers, thereby ensuring each uplink connection requires the least amount of UE transmit power and generates the least amount of interference [55].

Table 2. Directory of Results for interference scenario 1 UL HNB UE → Macro

Requirements Affected	Refer-ences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[26,27, 88]	CSG Performance analysis	
	[34,55]	Performance analysis of open system	
	[59,102]	Need to address trade-off between macro and HNB performance. Adaptive uplink attenuation can improve performance.	
Base station Requirements			
Receiver Sensitivity (for CSG HNB)	[26,102]	As per Local Area BS class spec. Acknowledgement that desensitisation of the CSG HNB receiver will potentially increase HNB UE interference on Macro	RAN4
Receiver Performance (for HNB)	[26]	As per Local Area BS class spec. Acknowledgement that poor performance of the HNB receiver will potentially increase HNB UE interference on Macro. However, testing for high speed mobile may no longer be required, if lower maximum UE speed is adopted	RAN4
In band blocking tests	[27,32]	As per Local Area BS class spec, (but may change if a different Minimum Coupling Loss is chosen)	RAN4
HNB system Requirements			
UE power limits	[55]	No protocol changes required. A limit is required to protect macro performance. Note: this is operator implementation specific; no need to standardise.	
		Deployment Scenario B will see highest UE power levels; hence most likely to require a limit.	

5.3.3 Interference scenario 2 DL HNB → Macro UE

In a CSG, downlink interference from an HNB will result in coverage holes in the macro network. In co-channel deployment the coverage holes are considerably more significant than when the HNB is deployed on a separate carrier. Several mechanisms are considered to reduce the impact of the macro coverage:

- fixed HNB transmit power. (this is only applicable to dedicated channel deployment)
- control of HNB behaviour with respect to setting its maximum transmit power
- open access systems.

Deployment scenario C reduces the impact on the macro layer by automatically adjusting the HNB transmit power. The algorithm used to control the HNB transmission power will be left as an implementation detail; consequently a variety of models are explored when setting the HNB transmission power. Some options are as follows:

• In [63], the maximum output power for each HNB is set based on a fixed limit in the "dead zone" (out-of-coverage area) that would be caused by any adjacent channel macro UE.

• In [50], the transmit power for each HNB is set based on the inverted power control scheme used for macro/macro coexistence simulation (power control set 1, power control set 2)

• In [55], the average transmit power for both the HNB and the macro are balanced at the HNB cell edge.

Deployment scenario B, where the HNB output power is controlled and the HNB's are deployed on an adjacent carrier to the macro layer, is shown to be of limited use [64], since the reduced power limit of Deployment Scenario A is adequate for coverage of the majority of homes. An increase in power may be desirable when a large coverage area is desired, or when coverage within the home is difficult. However, when the density of HNB is very high, inter-HNB interference dominates, and an increase in HNB power beyond Deployment scenario A does not result in performance gains.

Open access provides an alternative solution, as illustrated in [34] and [55].

When specifying HNB behaviour, it is the goal of this study item to avoid any RAN1 impact if possible. If possible, RAN4 will determine the framework to allow a range of implementation to set the maximum transmit power. For example, a framework may consist of requirements and tests for a suitable target power level, but will not specify the algorithm.

It is acknowledge that no single mechanism alone provides a definitive solution. Any solution will likely involve a combination of methods, and will certainly have to reach a suitable compromise between macro layer and HNB layer performance.

Table 3. Directory of Results for interference scenario 2 DL HNB → Macro UE

Requirements Affected	Refer-ences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[42,63,88]	CSG Performance analysis, Deployment Configuration A	
	[42,50,64, 88,102]	CSG Performance analysis, Deployment Configuration B,C	
	[34,55]	Performance analysis of open system, Deployment Configuration E	
	[23,42,63, 102]	CSG deployment of HNB's using fixed HNB transmit power results in unacceptable performance for co-channel deployments	

Requirements Affected	References	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
	[102]	CSG deployment of HNB's using fixed HNB transmit power results in unacceptable performance both for co-channel and dedicated channel deployments	
Base station Requirements			
Maximum transmit power	[102,104]	**Deployment Configuration A:** agreement that Adjacent Channel interference still exists without some control or reduction of power.	RAN4, RAN2
Maximum transmit power dynamic range	[33,42,54, 90]	General agreement that CSG HNB performance may benefit from the ability to set the maximum transmit power to lower values. This will require a change to Primary CPICH Tx Power in TS 25.331, section 10.3.6.61 and is currently under discussion with RAN2 via LS, [77].	RAN4, RAN2,
Electromagnetic Field protection. Need for Radiated Power Tests	[30]	Raised in [30], no recorded objections	
HNB system Requirements			
Need for BS to set transmit power appropriate for macro environment.	[104,102]	**Deployment Configuration B,C:** Acknowledged that interference in closed system is too high, **interference management mechanism required.**	RAN4, RAN2,
Definition of transmit power level	[37]	**Deployment Configuration B,C:** Multiple possibilities exist to define HNB power level: - Relative to macro CPICH RSCP - Relative to macro CPICH Ec/Io - Relative to total RSSI Could be defined as: - HNB dominance level - Size of dead zone caused.	RAN4, RAN2,
Hand In requirement for Interference mitigation	[37]	**Deployment Configuration A,B,C:** General consensus that aspects of open system help in managing HNB interference scenarios. interference mitigation is required in a closed system; hand in should be permitted as an option.	RAN2, RAN4

5.3.4 Interference scenario 3 UL Macro UE → HNB

As described in interference scenario 1, the HNB attached UE is constrained in its transmit power. Consequently, the HNB attached UE is especially susceptible to interference from the macro UE. The HNB receiver must reach a compromise between protecting itself against uncoordinated interference from the macro UEs, while controlling the interference caused by its own UE's towards the macro layer.

Table 4. Directory of Results for interference scenario 3 UL Macro UE → HNB

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
High Level Requirement			
System Performance	[59,102]	Need to address trade-off between macro and CSG HNB performance. Adaptive uplink attenuation can improve performance.	RAN2, RAN4
	[88]	CSG performance analysis	
Base station Requirements			
Receiver Sensitivity	[26]	In general can be the same as local area BS	RAN4
	[19][26]	**Deployment Scenario B,C:** In a CSG, co-channel deployment, HNB must manage noise rise of other UE's. It is noted that HNB desensitisation has an impact of system performance, eg. a reduction on UE battery life.	RAN4
Receiver Dynamic Range		In general can be the same as local area BS	RAN4
	[19]	**Deployment Scenario B,C:** In a CSG, co-channel deployment, HNB must manage noise rise of other UE's. Local Area BS class spec is sufficient.	RAN4
Adjacent Channel Selectivity		As per Local Area BS class spec.	RAN4
Receiver Performance (fading)	[100]	general consensus on max user speed < 30 km/h;	RAN4
Receiver Performance (delay spread)		50 m cell radius	RAN4
In band blocking tests		As per Local Area BS class spec (dependent on MCL).	RAN4

5.3.5 Interference scenario 4 DL Macro → HNB UE

A trade off exists between the HNB coverage and the impact on the macro network coverage (discussed in 5.3.3). The HNB downlink transmit power can be adjusted to maintain coverage if the dynamic range of the HNB power is large enough [103]. Additional performance analysis in a closed system is provided in [88].

No changes to UE. This is expected to hold for LTE as well. The Wide Area Basestation defines the UE RF performance. The UE will then be expected to work with all other classes of eNodeB

5.3.6 Interference scenario 5 HNB ←→ HNB (UL)

With respect to other HNB, co-channel interference must be considered. This is especially important to deployment option A, where a strong macro presence is not available on the same frequency to act as a reference level to determine UE power limits.

It is difficult to avoid co-channel interference between CSG HNB's, which limits the interference reductions achieved by deploying a CSG HNB on an separate carrier from the macro network, as shown in [27][64][58]. Interference management techniques are required to manage HNB to HNB interference.

Table 5. Directory of Results for interference scenario 5 HNB ←→ HNB (UL)

Requirements Affected	**References**	**Summary of analysis provided;** **Recommendation endorsed by cited reference**	**WG affected**
High Level Requirement			
System Performance	[58,102]	The performance of CSG HNBs is degraded unless interference mitigation techniques are used.	RAN4
	[106]	Without interference mitigation techniques, there is a clear impact on CSG HNB performance. However, the significant of the impact must be judged by the operator in the context of the desired system performance.	
Base station Requirements			
Receiver Sensitivity	[58,102]	Acknowledgement that a large number of HNB could be located very close together	RAN4
Receiver Dynamic Range	[58,102]	Acknowledgement that a large number of HNB could be located very close together	RAN4
Adjacent Channel Selectivity		Acknowledgement that a large number of HNB could be located very close together	RAN4
In band blocking tests		Acknowledgement that a large number of HNB could be located very close together	RAN4
HNB system Requirements			
UE power limits		No protocol changes required	RAN4

5.3.7 Interference scenario 6 HNB ←→ HNB (DL)

With respect to other HNB, co-channel interference must be considered. This is especially important to deployment option A where a strong macro presence is not available on the same frequency to act as a reference to determine HNB transmit power settings.

Table 6. Directory of Results for interference scenario 6 HNB ←→ HNB (DL)

Requirements Affected	**Ref-erences**	**Summary of analysis provided;** **Recommendation endorsed by cited reference**	**WG affected**
High Level Requirement			
System Performance	[58,102]	The performance of CSG HNBs is significantly degraded unless interference mitigation techniques are used.	
	[103, 104]	CSG DL performance analysis including apartment blocks and macro layer.	
HNB system Requirements			
Need for HNB to set transmit power based on neighbouring HNB power.		**Deployment Scenario B,C:** Acknowledged that interference in closed system is too high, **interference management mechanism required.**	RAN4, RAN2,

5.3.8 Interference scenarios 7,8 HNB ←→ Other systems

Table 7. Directory of Results for interference scenarios 7 and 8

Requirements Affected	**Ref-erences**	**Summary of analysis provided;** **Recommendation endorsed by cited reference**	**WG affected**
Base station Requirements			
Out of band blocking	[19]	Need for new out of band blocking requirements due to different transceivers on top of each other in the home. [30][31] recommends a 15 dB MCL, 20 cm minimum spacing should be considered for investigations in RAN4 Status: An LS reply [73] was sent to ETSI TC DECT, stating that inter-operation studies are best done in ECC PT1	RAN4
Spurious Emissions	[19]	As above.	

5.3.9 HNB mobile operating very close to serving HNB

Table 8. Directory of Results for HNB mobile operating very close to serving HNB

Requirements Affected	Ref-erences	Summary of analysis provided; Recommendation endorsed by cited reference	WG affected
Base station Requirements			
Maximum output power	[109]	Possible impact on a HNB mobile operating very close its serving HNB is addressed. Indicates that power levels lower than 20dBm may be recommended to ensure correct mobile operation.	RAN4

5.4 Home NodeB Class Definition

5.4.1 Introduction

5.4.2 Fixed parameters

[Void]

5.4.3 Base station classes

5.4.4 Transmitter characteristics

5.4.4.1 Control of NodeB output power

Evaluation based on co-channel interference considerations

Analysis of interference scenarios has shown that a fixed maximum power setting value does not provide acceptable performance in many scenarios. Hence, a capability to have a settable power limit is required. Suggestions for the minimum value of this power setting have varied from -10dBm to – 30dBm. A minimum value of -10 dBm P-CPICH is currently supported within [125][1].

The description of any algorithm to control the power is outside scope of this document.

Notes

(1) A liaison has been sent to RAN2 to request information about potential impacts on legacy mobiles if P-CPICH power levels lower than -10dBm are used.

Control of NodeB output power overview

The output power of the NodeB should be settable from the maximum power to a level of [0dBm].

5.4.4.2 Maximum NodeB output power

Evaluation based on emitted power limitations

During the study of Home NodeB Home eNodeB feasibility the question of whether maximum Home NodeB power might be set by emitted power density limits was raised. This section seeks to analyse this issue and confirm that this is not a limiting factor.

The US FCC sets limits for emitted power density at 1mW/cm2 for general population exposure to frequencies in the range 1500-100,000 MHz [133].

If we consider a HNB operation at 2.1GHz, the wavelength is 14cm so a ½ wave dipole would be 7cm long, as a starting point for our calculation we assume emission by a HNB may be characterised by such an antenna. The gain of such an antenna is 2.1dBi. The Tdocs in reference [30] and [31] suggest a minimum spacing of 20cm. To calculate the field strength we need to determine if the measurement will be made in the near-field or far-field. The minimum far-field distance, d, for the antenna is,

$$d = {2D^2}/{\lambda}$$

where D is the length of the antenna and λ is the wavelength.

At 2.1 GHz λ is 14cm, D is 7cm and the far-field distance is 7cm, thus it is reasonable to assume that calculations may be made in the far-field. Free-space propagation loss, L, is given by,

$$L = 20\log d + 20\log f + 32.44$$

where, d is measured in km and f is measured in MHz.

This gives a free-space propagation loss of 24.9 dB. Accounting for the gain of the dipole antenna, and assuming a similar one is used to measure the radiated power, the propagation loss is 20.7dB. To calculate the power density we need to know the effective area of the receiving dipole antenna A

$$A = \frac{G_a}{4\pi}\lambda^2$$

where, G_a is the antenna gain as a linear factor

This gives the effective surface area of a 2.1dB gain antenna as 25.3 cm2. Thus, the input power to the antenna to give a power density of 1mW/cm2 at 20cm is 35dBm.

The largest gain that size-wise might reasonably be considered for a HNB would be that corresponding to a that a ½ wave square patch antenna, which with a small ground plane would be of the order of 20cm x 20cm. The maximum gain is about 9dBi [132], which would suggest the maximum input power to keep the radiated power density at 1mW/cm2 at 20cm would be 28dBm.

Therefore, given that the maximum power being considered for the HNB is of the order of 20dBm, radiated power density limits at 20cm from the HNB are not a limiting factor.

<u>Evaluation based on MCL</u>

During the study of Home NodeB Home eNodeB feasibility MCL[1] was considered for uncoordinated mobiles near to the Home NodeB attached to the macro system. This produced the same pragmatic arguments that resulted in an effective MCL value of 45dB for the local area base station class[2], and while rare cases of MCL smaller than this are possible they are typically negated by the interference of the HNB to the interfering mobile, eg, [27]. This would suggest the power limit the same may be the same as the local area class.

Notes

(1) Additionally, MCL to other co-located systems such as DECT was considered. MCL in this case could be as low as 15dB. However, control of this scenario, which involves legacy systems deployed in licence exempt spectrum, falls outside of the influence of 3GPP. Consequently, it is likely that any action will be limited to operator recommendations on siting of Home NodeB with relation to other indoor systems.

(2) MCL values of [20dB] for mobiles attached to the Home NodeB should also be considered as effective system operation should be ensured.

<u>Evaluation based on coverage considerations</u>

The Maximum Output power of a HNB should be able to provide adequate coverage for a full range of supported HNB deployment scenarios, while not exceeding the HNB interference limits. Moreover, the power level of the HNB should not create unnecessary difficulties in meeting thermal requirements, or in meeting power density limits especially should high gain antennas be used[1]. During various scenario investigations a consensus of 20dBm was achieved being sufficient to provide adequate coverage in all reasonable interference conditions.

Notes

(1) Any reduction in power will help address the radio interference, thermal power, and power density level of an HNB. Deployment and Interference scenarios are currently for further study. Home equipment antennas may have significant gain in which case exclusion zones around them may be required to meet power density limits. Also, practical lower limits due to thermal requirements means an exclusion zone for powers above 21dBm is large compared with the equipment size. These are considered implementation issues; nevertheless it is considered prudent at this time to consider a limit in the maximum output power of approximately 20 dBm.

Maximum power overview

Therefore, the working assumption for Maximum Output Power is [20 dBm], since this level is sufficient to achieve coverage over a wide range of deployment scenarios

5.4.4.3 Frequency Error

This section includes the investigation of frequency accuracy requirements in the home environment. [19][28][29]

A formal derivation of the frequency accuracy from vehicular speeds is still required to finalise the following working assumption. Moreover, the consequences of MBSFN support in HNB has not yet been investigated.

The working assumption is that frequency accuracy can be relaxed to 250ppb.

Start of rapporteur's comments

250 ppb is identified as a safe value to use as a working assumption. This level of relaxation is considered to be a worthwhile goal, as it would reduce synchronisation related traffic, and may have additional benefits for implementation of the home NodeB. On the other hand, the potential risks regarding demodulation and handover performance are considered low, given the likely user speeds and resultant Doppler frequency offsets. Nevertheless, it is acknowledge that more work is required in this area, as the work in identifying scenarios is not complete

The possible question of the frequency stability based on tolerable time to achieve base station synch to the network [15][16] has been dealt with in RAN3.

End of rapporteur's comments

5.4.4.4 Spurious emissions

No changes expected from the local area base station class.

5.4.4.4.1 Protection of the BS receiver of own or different BS

No changes expected from the local area base station class.

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

No changes expected from the local area base station class.

5.4.4.4.3 Co-existence with UTRA-TDD

No changes expected from the local area base station class.

5.4.5 Receiver characteristics

5.4.5.1 Reference sensitivity level

The analysis in [27] indicates that sensitivity equivalent to that of the local area base station is recommended to minimise interference. Correspondingly, no changes are expected from the local area base station class [125].

Notes

(1) Some analysis shows there may be benefits to varying the sensitivity, thus the capability to vary the sensitivity should not be precluded so long as compliance to radio performance requirements is not affected.

5.4.5.2 Dynamic range

Potential for change given the requirement to provide a settable power limit for the Home NodeB.

5.4.5.3 Adjacent channel selectivity (ACS)

No changes expected from the local area base station class.

5.4.5.4 Blocking characteristics

No changes expected from the local area base station class.

5.4.5.4.1 Minimum requirement

No changes expected from the local area base station class.

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

No changes expected from the local area base station class.

5.4.5.4.3 Minimum Requirement - Co-location with UTRA-TDD

No changes expected from the local area base station class.

5.4.5.4.4 Minimum Requirement – Co-location with DECT and WiFi/WLAN

This is a possible new requirement.

5.4.5.5 Intermodulation characteristics

No changes expected from the local area base station class.

5.4.6 Performance requirement

Some of the propagation conditions may not be relevant for the HNB.

5.4.7 Summary

This section summarises the investigation of whether the local area class can be extended to cover scenarios for the 3G Home Node B, or a if new class needs to be defined.

List of changes identified with respect to the current definition of a local area class:

Minimum coupling loss

Table 9. Summary of Changes to Transmitter Characteristics

Specification	Proposed Value	Current Value	Status
Maximum Output Power	[20 dBm]	24 dBm	Working assumption
Control of output power	[~~20 dBm~~ Maximum power - 0 dBm]		Mechanisms to control max allowed power are being investigated
Frequency Error	[250 ppb]	100 ppb	Working assumption
Spurious emissions Protection of the BS receiver of own or different BS	[same]	-82dBm	
Spurious emissions Co-existence with co-located and co-sited base stations	[same] [same]	- 70dBm (pico 900/850) - 82dBm	
Spurious emissions Co-existence with UTRA-TDD	[same]	- 55dBm	

Table 10. Summary of Changes to Receiver Characteristics

Specification	Proposed Value	Current Value	Status
Reference sensitivity level	[same]	-107dBm	
Dynamic range	[potential impacts]	-59dBm (wanted -77dBm)	
ACS	[same]	-38dBm (wanted -101dBm)	
Blocking characteristics Minimum requirement	[same]	-101 dBm (interferer various)	
Blocking characteristics Minimum Requirement - Co-location with GSM900, DCS 1800, PCS1900, GSM850 and/or UTRA FDD	[same]	- 115 dBm (interferer various)	
Blocking characteristics Minimum Requirement - Co-location with UTRA-TDD	[same]	- 101 dBm (-4dBm)	
Blocking characteristics Minimum Requirement - Co-location with DECT,	[new value]		

WiFi/WLAN			
Intermodulation	[same]	- 38dBm (wideband) - 37dBm (narrowband)	

6 Radio Interface Architecture and protocols (RAN WG2)

6.1 Mobility scenarios

This section includes the investigation Home NodeB mobility scenarios.

6.1.1 Scenarios

For mobility, the following deployment scenarios have been identified.

1. Home NodeB is out of coverage from any macro cells of GSM/UMTS
2. Home NodeB is in coverage of macro GSM (not specifically studied).
3. Home NodeB is in coverage of the macro of UMTS (Home NodeB uses the same frequency as the macro)
4. Home NodeB is in coverage of the macro of the UMTS (Home NodeB uses a different frequency as the macro)

6.1.2 UEs to find and prioritize Home NodeB Cell

In deployment case 1, when the mobile performs a cell selection it will find the Home NodeB Cell (no problem). In case 2 and 4, when/if the macro coverage is good, a UE would not normally trigger a search for the Home NodeB.

6.1.3 Cell Reselection Parameters

Reference [121] shows some principles for how cell reselection parameters could be set to make a UE find Home NodeB cells and stay there once camped.

Pros: It is possible by simple configuration to set cell reselection parameters so

1) UEs that are camped on a macro layer can automatically find Home NodeB cell(s).

2) once camped on the Home NodeB cell, UEs prioritize this cell

Cons: All UE will follow the cell reselection parameterisation towards the Home NodeB and attempt to register. After being actively rejected the cell remains unsuitable and UE might continue measuring the highest ranked cell (unless the 300s timer is implemented), assuming access control by mobility management signalling, see later chapter. This has negative impact on battery consumption and adds to mobility management signalling load on the CN. These results assume that dedicated Neighbour cell list parameters are used. The limit of maximum 32 intra -frequency and 32 inter-frequency neighbours can be a limiting factor for Macro-> Home NodeB mobility.

6.1.4 Cell Reselection using HCS

Hierarchical Cell Structure (HCS) can be used as an additional means of better distinguishing between Home NodeB cells and macro cells. It allows different cell reselection rules and thus more flexibility:

- UEs can measure for Home NodeB cells even when UE is in good macro coverage, still limiting the measurement burden on those UEs, as only either High priority cells or Low priority cells need to be considered.
- The number of unwanted UEs selecting to Home NodeB, and thus doing mobility management signalling, can be limited, by two methods:
  - Using the HCS penalty timer. It can be used to avoid selecting to a certain cell for the duration of the timer. UE has to measure Q > Qhcs for the duration of the timer to stop using the penalty offset. Thus it can be avoided that passing-by UEs select to this cell.
  - Parameters for "high mobility" can be set so most moving UEs would select to macro cells, and only UEs that are quite stationary would use the Home NodeB layer.

Pros: Same as previous chapter:

Cons: Same as previous chapter, except that the negative impact on UE battery consumption and mobility management signalling can be less severe, as the number of UEs measuring on and selecting to the Home Node B can be reduced.

6.1.5 Separate Home NodeB PLMN ID

6.1.5.1 General

Home NodeB Cells would have a separate PLMN ID different from the PLMN ID of the macro cells.

Assignment of the separate PLMN ID has the following benefits and drawback regardless if enhanced with one of the other configurations:

Pros: UEs not allowed to use a Home Node B could be configured to not access the Home NodeB PLMN, resulting in better battery performance for them, and less signalling load towards the core Network (compared to only relying on Cell Reselection parameters). Also, a separate PLMN ID allows to make UE displaying the right network identifier, indicating to the user that he camps on a Home NodeB cell, but requires some updates of the SIM/UICC and might not work with older SIM cards.

Cons: Operators might not have additional PLMN IDs. Introduction of additional PLMN ID might be costly as PLMN IDs have impact on existing business infrastructure (billing, roaming agreements etc).

For older SIM cards the correct Operator PLMN ID display might not be available.

Separate access control is needed in addition for all the cases.

6.1.5.2 Manual Selection

Relying more on manual PLMN selection, the macro network does not need to provide any cell reselection parameters to bring the UE to the Home NodeB.

Pros: No cell reselection parameter settings in the macro cells lead to better UE battery performance for all UEs, also for UEs not allowed on a Home NodeB, and less signalling load towards the core network created from those UEs. Manual Selection is a robust mechanism.

Cons: Manual selection of the macro PLMN might be needed when moving out of the Home NodeB. This might not be acceptable for the user.

6.1.5.3 Equivalent PLMN

Equivalent PLMN feature was introduced as a means to enable cell reselection between PLMNs. The equivalent PLMNs are considered equivalent to the registered PLMN regarding PLMN selection, cell selection, cell re-selection and handover.

The list of equivalent PLMNs of a UE can be updated at location registration. UEs not allowed to use a Home NodeB would never have the Home NodeB PLMN as an equivalent PLMN, thus such UEs would never try to access a Home NodeB cell. Furthermore, UEs allowed to use Home NodeB could be configured with Home NodeB PLMN ID (as an equivalent PLMN) only in registration areas overlapping the geographical location of the Home NodeB cell.

Pros: Additional PLMN ID for Home NodeB cells can be introduced without modifying UE SIM. UEs allowed to use Home NodeB could be configured to not access the Home NodeB PLMN outside the macro registration area overlapping their Home NodeB cell, resulting in better battery performance for them, and less signalling load towards the core Network

Cons: This mechanism does not provide any help for UEs to find their Home NodeB cell.

Additional effort for configuration and execution of selective signaling of ePLMN list, depending on LA and UE.

6.1.5.4 National Roaming

National roaming is a feature where when the mobile is not roaming in its HPLMN, but on a VPLMN of the same country as the HPLMN. In automatic PLMN selection mode it could be set in a mode where it searches periodically for it HPLMN [126].

Proposed solution:

UEs allowed to use Home NodeB are national roaming when in macro cell layer. The PLMN id of the Home NodeB is the HPLMN of the UE and is different from the Macro cells PLMN identity. The Macro PLMN is thus a VPLMN. In this case the UE performs a background PLMN search depending on the configuration of the SIM timer field. By configuring the background PLMN search timer to the minimum of every 6 min. So the average time to finding the Home NodeB when in coverage would be around 3 min.

As a refinement to this scheme (and save UE power) the timer can be reconfigured when moving outside its "home" macro LA for example using SIM tool kit details are FFS and need to be studied.

Pros: UEs allowed to use Home NodeB could find Home NodeB cells irrespective of Macro Layer Cell Reselection parameters. Thus, the impact to UEs not allowed to use Home NodeB of introducing Home NodeB cells would be minimal/zero, regarding battery consumption and signaling load towards the core network. There would be no need to include Home NodeB cells in macro layer neighbor cell lists. This mechanism is robust. There would be no need to rely on manual selection.

Cons: Need to update SIM and IMSI for UEs allowed to use Home NodeB. Might not work with older SIM cards. Changing/updating SIM and or IMSI is an issue for operators.

6.2 Access control scenarios

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

6.2.1 Access Control by mobility management signalling

A common assumption is that Access Control is done by mobility management signalling. Each Home NodeB is assigned a Home NodeB specific Location area. UEs not allowed in a certain Home NodeB receives negative response at location registration, having the effect that UEs not allowed in this Home NodeB are not allowed to camp normally.

Reject causes, depending on use case, could be:

- LA Not allowed
- Roaming not allowed in LA.

A side-effect of using registration area update rejects, is that a UE would not reattempt to reselect to this frequency for the next 300s (unless there is no alternative), if the UE is Rel-5 UE and the procedure is implemented.

To reduce time in out-of-service or limited camped state there should always be a frequency available with cells where LA is allowed, i.e. there should be a non- Home NodeB frequency layer.

Pro: Access Control is immediate, simple solution.

Con: This method involves quite much mobility management signalling. Also, if a UE slips outside the coverage of his Home NodeB cell, and tries to register to a neighbour Home NodeB cell, he cannot re-register with his own Home NodeB cell until after 300s timer expiry.

6.2.2 Access Control by redirection and handover

An alternative approach is to allow UEs that are allowed to use a Home NodeB to roam and camp also on Home NodeB cells, where they are not allowed. Access Control would then be done by redirecting or handing over non-allowed UEs to a macro cell, when data transmission service is requested.

In this approach a number of Home NodeB would be configured in to one LA. Mobiles would perform cell reselection between these cells without the need to perform location update (for example all Home NodeB in a building are configured as one LA) so as long as coverage is more or less constant no LA update is needed when moving from one Home NodeB to another Home NodeB in the same local vicinity.

An issue with this network configuration is that hand-over or redirection might not always work, e.g. in case there is no macro cell in coverage. In this situation, a non-allowed UE camping on a Home NodeB cell would “erroneously” indicate to the user that it is in-service.

A possible way of handling this could be that Home NodeB that are out of service of macro cell would be handled by access control by mobility management signalling according to the previous chapter.

Pros: Reduced mobility management signaling, and corresponding battery saving, especially in dense Home NodeB deployments.

Cons: Configuration of location area for a Home NodeB cell might need to depend on coverage / deployment scenario, i.e. if deployment case 1 applies or not. Another side effect could be increased session setup times, or increased handover signaling

7 UTRAN Architecture and Application Protocol (RAN WG3)

7.1 Architectural support of 3G Home NodeB

The support of the 3G Home NodeB is ensured within the framework provided in the UTRAN architecture as described in [127], with support of legacy UEs and legacy core networks. Possible enhancements to the Iu interface architecture to cater with scalability issues are described in section 7.3.

7.2 Deployment option(s)

The UTRAN architecture supports different deployment options, in particular an Iub deployment and an Iu deployment option.

The preferred deployment option is with Iu or Iu-based termination at the 3G Home NB.

Different deployment options based on Iu has also been discussed, all relying on an access concentrator or gateway between 3G Home NB and core network:

- GAN –based Home NB Gateway without impact on Iu specifications ([129]),
- Femto Gateway without impact on Iu specifications ([130]),
- Iu –based Home NB Gateway ([131]),

7.3 Impact to the UTRAN interfaces

7.3.1 Iu Interface Architecture

The overall UMTS architecture and UTRAN architectures are described in [137]. This subclause specifies only the architecture of the Iu interface when applied for 3G HNB access.

Whereas the I_u interface is specified at the boundary between the Core Network and UTRAN, the I_{uh} interface is specified between the 3G HNB GW and the 3G HNB. Figure 7.3.1-1 depicts the logical division of the I_u interface and the I_{uh} interface. From the I_u interface perspective, the UTRAN access point is an 3G HNB GW.

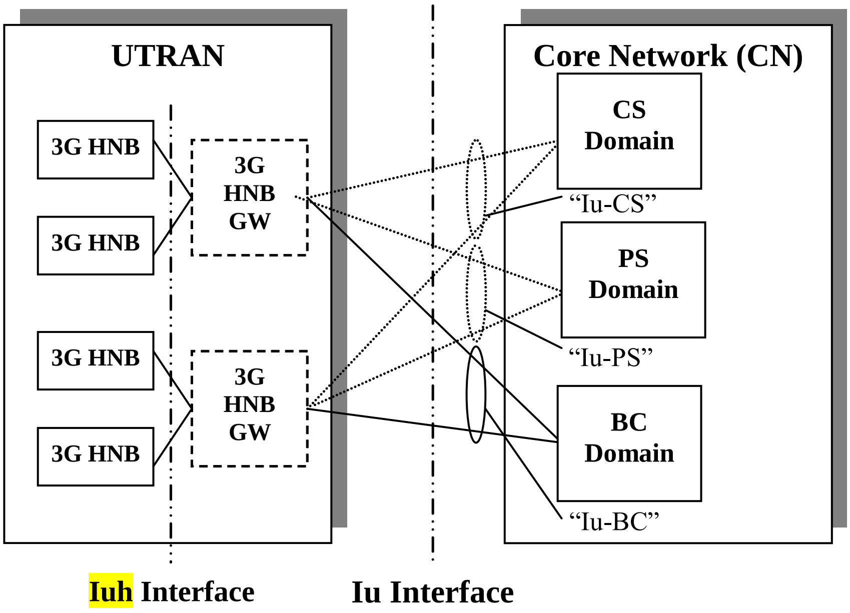

Figure 7.3.1-1. I_u and I_{uh} Interface Architecture.

The 3G HNB and 3G HNB GW in combination supports all of the UTRAN functions, as described in section 4 of [135]. The legacy UTRAN functions in the 3G HNB are supported by RANAP, whereas the functions 3G HNB Registstration, UE Registration and 3G HNB GW discovery (FFS) are supported by the new protocol Home NodeB Application Protocol (HNBAP) between the 3G HNB and the 3G HNB GW. These functions are described in section 7.3.4.2. The 3G HNB GW provides concentration function for the control plane and may provide concentration function for the user plane.

There can be several 3G HNB GWs within UTRAN, and each 3G HNB GW may have several 3G HNBs, and so UTRAN may have several I_u access points towards the Core Network. As a minimum, each Iu access point (in UTRAN or CN) shall independently fulfil the requirements of the relevant Iu specifications (25.41x series).

7.3.1.2 Implementation of the NAS Node Selection Function

The optional NAS Node Selection Function (NNSF) is described in [136].

If the NAS Node Selection Function is deployed with in the UTRAN, it resides within the RNC or 3G HNB GW.

7.3.2 I_{uh} Interface Characteristics

Alternative means to provide connection oriented services for RANAP and connectionless services for RANAP and HNBAP are under discussion

Three alternatives are under consideration for the mapping of RANAP to underlying protocols. The target is to reduce the number of alternatives.

7.3.2.1 Use of SCCP (Alternative 1)

Section 4.5 of [135] shall apply for UTRAN for 3G HNB access as well.

The only difference is that the 3G HNB GW will terminate the SCCP stack towards the 3G HNB and towards the CN and therefore in total two SCCP signalling bearers exist between the CN and the 3G HNB.

7.3.2.2 Use of SCTP with UE context indicated through PPI (Alternative 2)

For the deplyoment of 3G HNBs SCTP as specified in [134] is defined as an alternative transport network user plane layer for the signalling bearer. For connection-oriented procedures as defined to be supported by RANAP, the PPI field of the SCTP payload header is used to denote a dedicated Iu signalling connection. The 3G HNB and the 3G HNB GW respectively, are responsible for the allocation of unique Iu signalling connection identifications within the PPI field.

Note: For connectionless procedures as defined to be supported by RANAP and the HNB Application Protocol, no specific method as for connection oriented procedures are necessary on SCTP level.

Typically, two single SCTP streams are allocated, one for conveing Iu-cs protocol services, the other for conveing Iu-ps protocol services.

7.3.2.3 Use of SCTP with Lightweight Adaptation Layer (Alternative 3)

For the deployment of 3G HNBs, SCTP as specified in [134] is defined as the transport network user plane layer for the signalling bearer. For connection-oriented procedures as defined to be supported by RANAP, an adaptation layer i.e. RANAP User Adaptation (RUA) is introduced to denote a dedicated Iu signalling connection. The RUA contains information necessary for UE connection management at the 3G HNB and 3G HNB GW as well as the necessary information to support NNSF functionality.

Note: For connectionless procedures as defined to be supported by RANAP a single pair of stream identifiers shall be reserved.

Domain indicator (i.e. CS/PS) is also provided by the RUA layer.

7.3.3 Use of Transport Network User Plane as User Data Bearer

On the Iuh interface only TNL stack options for the IP transport option are used.

7.3.4 Functions of the I_{uh} Interface Protocols & Functional Split

7.3.4.1 Support of Legacy UTRAN functions

Legacy UTRAN functions are supported through the RANAP control plane on Iuh. The division of functions between 3G HNB and 3G HNB GW are FFS.

7.3.4.2 Agreed new functions for support of 3G HNB deployment

New functions have been identified as necessary to allow the 3G HNB deployment in UTRAN. The following lists the agreed functions.

7.3.4.2.1 3G HNB Registration Function

The 3G HNB Registration Function provides means to register the 3G HNB at the 3G HNB GW on RNL level and resides in the 3G HNB and the 3G HNB GW.

7.3.4.2.2 UE Registration Function for 3G HNB

The UE Registration Function for 3G HNB provides means for the 3G HNB to convey UE identification data to the 3G HNB GW in order to perform access control for the UE in the 3G HNB GW. The UE Registration also informs the 3G HNB GW of the specific 3G HNB where the UE is located.

7.3.4.3 New functions under discussion for support of 3G HNB deployment

The following lists the new functions under discussions for 3G HNB deployment in UTRAN.

7.3.4.3.1 3G HNB GW Discovery Function (FFS)

The 3G HNB Discovery Function provides the means for a designated “Provisioning HNB GW” to provide the address for the Serving 3G HNB GW for the 3G HNB. The 3G HNB will use the Serving 3G HNB GW address to Register with the Serving 3G HNB GW.

8 Summary

This report contains considerable analysis of the impact on Home Node B on the macro layer, with a strong emphasis on the downlink.

This study has prioritized the interference scenarios shown in Table 11, and illustrated in Figure 4.

Table 11. Schedule for Interference Scenarios analysis

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

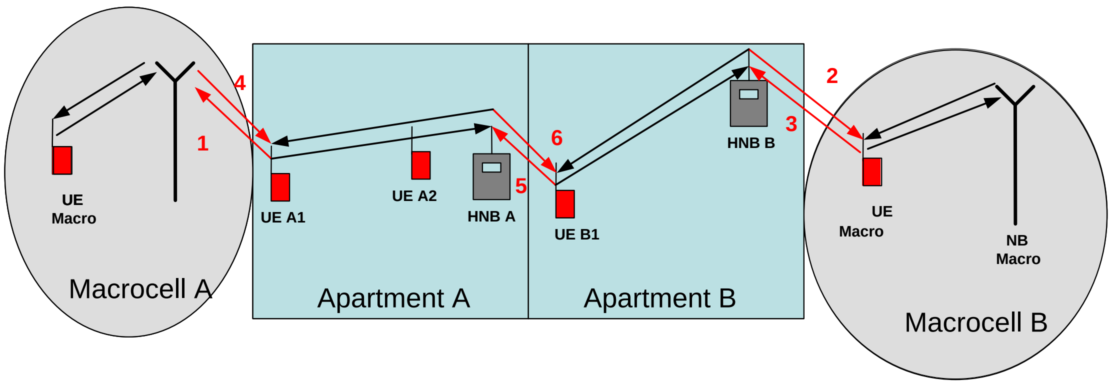

Figure 4. Interference scenarios

The diverse input to this study item on Home Node B / eNode B has revealed that a wide range of possible deployment configurations are envisioned for the HNB. This study uses interference scenarios to investigate the impact on Home Node B deployment on the existing basestation requirements. However, the interference scenarios are dependent on the deployment configurations. Specifically, the most important deployment characteristics are as follows

- Open access or CSG (Closed Subscriber Group)
  - Open access HNBs can serve any UE in the same way as a normal NodeB
  - CSG HNBs only serve UEs which are a member of a particular Closed Subscriber Group
- Dedicated carrier or co-channel
  - Whether HNBs operate in their own separate channel, or whether they share a carrier with an existing (e)UTRAN network

Furthermore, how an operator chooses to manage Home Node B power has a strong impact on the interference analysis. Therefore, this study distinguished between the following methods of managing the HNB transmit power

- Fixed: HNBs have a set fixed maximum transmit power.
- Adaptive: HNBs sense interference to existing networks, and adjust maximum transmit power accordingly

Home Node B's enhance the coverage of a UMTS Radio Access Network in the home environment. However, it is not feasible to completely control the deployment of the HNB layer within the UMTS RAN. Therefore, interference due to the HNB is a concern and this report concludes that interference mitigation techniques are required in the case of closed access. No single method has been identified that completely eliminates interference while maintaining HNB performance for closed access. It is not the intention of this report to recommend a set of specification or an algorithm that ensures feasibility of the Home Node B. Rather, this report evaluates the effectiveness of interference control with an acceptable trade-off between macro layer and HNB performance over a set of deployment configurations.

The analysis of the various configurations resulted in the following observations:

- Open access configuration will result in lower interference levels than Closed Subscriber Group Operation.
- Dedicated carrier deployment results in much lower interference levels than co-channel deployment.
- A CSG HNB deployment (whether dedicated or co-channel) requires interference mitigation techniques in order to control the inter-HNB interference for both the downlink and uplink.
- It is not possible to control the downlink co-channel interference through fixed maximum HNB transmit power setting in case of co-channel CSG HNB deployment.
- A "partial co-channel" approach for UTRAN operating on two channels can provide higher spectral efficiency than obtained with a dedicated carrier approach while maintaining the same cell edge performance.
- In case of CSG co-channel HNB deployment it is possible to control the uplink and downlink interference levels to the macro layer through appropriate use of interference mitigation techniques and thus maintain a suitable performance trade-off between the HNB and Macro layers.

For a successful Home Node B deployment, minimum performance requirements are needed for all scenarios in Table 11, for both dedicated and co-channel deployments.

9 Conclusions

9.1 RAN4 Conclusions

In its study of the feasibility of the Home (e)NodeB RAN4 has identified new requirements affecting RF aspects. The feasibility of meeting these is addressed in the following numbered items,

1) Home (e)NodeBs should not degrade significantly the performance of networks deployed in other channels. Feasible. Dedicated carrier deployment of Home Node B's is feasible for both open and closed subscriber group systems in a wide range of deployment configurations. Co-existence between HNB and UTRAN networks in adjacent channels is comparable with co-existence for local area bases stations.

2) Home (e)NodeB configurations intended for deployment in the same channel as an existing (e)UTRAN network should ensure their combined performance is not significantly worse than that of the original network. Feasible, however, especially in the case of CSG there will be an increased level of interference relative to dedicated deployment; interference mitigation techniques have been studied to reduce this.

3) Home (e)NodeBs should provide reasonable performance whether deployed in isolation or whether multiple Home (e)NodeBs are deployed in the same area. Feasible. However, in high density deployments, techniques may be needed to mitigate inter-HNB interference.

4) As a Home (e)NodeBs may be privately owned 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. Feasible. (SA1, SA2, SA3 response)

5) The Home NodeB must support UE speeds up to [30] km/h. Feasible

6) Home NodeB must support existing UTRAN UEs. Feasible (RAN2 response)

9.2 RAN2 summary, conclusions and recommendations

RAN2 has studied intra-frequency and inter-frequency mobility solutions and access control for UMTS Home-NodeBs. Different solutions taken the requirement to be based on current Rel-7 status have been studied. No quantitative results have been presented.

The conclusion from a RAN2 point of view is that there is not one good solution. There are a few solutions but they all have their drawbacks/limitations. It can be made to work but with some restrictions on deployment. The operator would have to decide whether he is happy with the restrictions.

For release 8 UEs, some mechanisms that optimise mobility and access control have already been presented.

Recommendation for Rel-8 UMTS Home NodeB

1) Solutions to optimise the mobility and access control should be specified;

2) Solution for UMTS Home-NodeB aligned with the ones decided for E-UTRAN Home-eNBs ("CSG cells") should be analysed first;

3) The removal of constraints in the procedures for the (macro) cell reselection in order to efficiently support Home-NodeB cells should also be investigated (e.g. removal of cell barring for 300 s for reselection if highest ranked cell is a CSG cell).

9.3 RAN3 Conclusions

RAN3 concludes that the support of deployment of 3G Home NBs, with legacy UEs and legacy core network nodes, is feasible. Further enhancements for improved support of 3G Home NBs were proposed and can be further considered.

Annex A: (informative) Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2007-08	RAN4#44				TR created based on content in **R4-071254**		0.1.0
2007-10	RAN4#44 bis	R4-071548			Agreed TPs in RAN4#44: **R4-071255** "Text proposal for Maximum Transmit power in section TR 25.820", **R4-071460** "Text proposal for HNB specific Emissions Requirements in TR 25.820"	0.1.0	0.2.0
2007-11	RAN4#45	R4-072230			Agreed TPs in RAN4#44: **R4-071921** "TR skeleton based on revised structure in TR 25.820" **R4-072203** "Home NodeB Requirements TP for TR 25.820" **R4-072196** "Home NodeB Deployment Configurations TP for TR 25.820" **R4-071923** "Text proposal for Interference scenarios in TR 25.820", RAN4#45 **R4-071924** "Text proposal for Home Node B Class Definitions in TR 25.820", RAN4#45 **R4-072180** "Text proposal for Conclusions in TR 25.820", RAN4#45	0.2.0	1.0.0
2008-02	RAN4#46				**R4-080451** "TR 25.820: TP for Conclusions (9)" **R4-080098** "TR 25.820: TP for Requirements (5.1)" **R4-080485** "TR 25.820: TP for Deployment Configurations (5.2)" **R4-080523** "TR 25.820: TP for Home Node B Class Definitions (5.4)" **R4-080103** "TR 25.820: TP for Radio Interface Architecture and Protocols (6)" **R4-080525** "TR 25.820: TP for Interference Scenarios (5.3)" **R4-080524** "Proposal for the summary and conclusion of the HNB study item" **R3-080556,** LS Source RAN3, to RAN4, "Text Proposal for TR 25.820", RAN3#59.	1.0.0	1.1.0
2008-04	RAN # 39	RP-080170			Specification presented for Approval	1.1.0	8.0.0
2008-05	RAN #40	RP-080331	01		Support of 3G HNB	8.0.0	8.1.0
2008-05					Editorial Correction: restores original references deleted due to unclear CR	8.1.0	8.1.1
2008-09	RAN #41	RP-080634	1		Correction on the reference list	8.1.0	8.2.0