TSG-RAN Meeting #13 **RP-010638**
Beijing, PRC, September 18–21, 2001

Agenda item: 9.9.9

Source: Tekmar Sistemi

Title: Status Report of Study Item “UTRA Wide-band Distribution System”

Document for: Status Report

This contribution contains a brief summary of the contributions made to date to RAN 4 on the subject of the UTRA Wide-band Distribution System.
It details the input made to RAN 4 #19 in Edinburgh, summarises the discussion points and suggests a way forward from the current status.

Document R4-011045 WDS Study Item Report presented at RAN 4 #19 is attached for information.

Summary of RAN 4 Activities for WDS

RAN 4 Meeting #17, Goteborg, Sweden (21-25 May 2001)

R4- 010559 Technical justification and overall advantages of WDS

Discussion document explained the concept and the benefits of a WDS. A hardware description and RF performance attributes were discussed in relation to the current TS25.104 specification.

It was agreed to proceed with a feasibility study to prove that the system was applicable and feasible. Feasibility study should be complete by September 2001.

RAN Plenary Meeting #12, Stockholm, Sweden (12-15 June 2001)

RP-010488 Study Item description sheet for feasibility study on UTRA WDS

Document detailed the justification for the system and set out the criteria which must be satisfied in order to proceed. This included addressing RF multi-carrier performance, end to end system performance and consideration of location service and O&M aspects.

RAN 4 Meeting #18, Berlin, Germany (9-13 July 2001)

R4-010935 WDS Study Item Status

Document presented for information to update RAN 4 of the programme of tasks that were underway. This was in order that there was agreement over the correct way to proceed and also to highlight any new concerns that needed to be addressed in the final feasibility study.

Concerns were raised regarding the impact on the system performance due to the inclusion of the new device. Ericsson opposed setting any requirements for a low level interface (LLI) between the Node B and the WDS as they were not clear about the concept.

RAN 4 Meeting #19, Edinburgh, Scotland (3-7 September 2001)

R4-011045 WDS Study Item Report

Feasibility Study presented for decision which covered the following subjects

a. End to end system performance improvements shown through major simulation work.
b. RF up-link and down-link parameters for LLI, WDS and compliance to TS25.104 at antenna connection point.
c. Addressing all questions raised at previous RAN 4 meetings with detailed explanations of LLI concept, system degradation, LCS and O&M impact.

It was noted by Ericsson and a number of operators that there were no doubt of the benefits of WDS, specifically in order to give the operators the ability to share resources in indoor environments.
Ericsson did not see the need to standardise such a system whilst Vodafone/Omnitel believed that this was a requirement in order protect the network and its performance.
Ericsson had further concerns over their understanding of the LLI, how it physically interfaces with variable Node B configurations and also questioned its technical feasibility.

Due to the obvious benefits of WDS agreed by all it was recommended that the study item phase was continued in order to close out the points raised.

It is believed that major offline discussion work is required involving WDS suppliers, OEMs and operators in achieve a solution which would satisfy all parties.
This work will initially attempt to agree on the LLI concept as this is envisaged as the best method to maintain conformance to current TS25.104 specs.
Given the recognised benefits that WDS may bring to networks, other strategies may be identified if there is no agreement on LLI, in order that WDS is standardised and not fitted as a rogue network device. A proposed route forward should be available for RAN 4 #20

In order to identify the requirements of a communication interface between WDS and other network elements work will be required with RAN3 and SA5.
R3-0119333 [Ref. 1] and R5-010481 [Ref. 2] were input to RAN 3 and SA5 respectively with no formal objections.

References

[1] R3-011933 Impact and assessment for study item on WDS into O&M aspects of Node B

[2] S5-010481 Impact assessment for study item on WDS into O&M aspects

TSG-RAN Working Group 4 (Radio) meeting #19 **R4-011045**
Edinburgh, Great Britain, 3rd – 7th September 2001

Source: Tekmar Sistemi / Mikom

Title: WDS Study item report

Agenda item: **9.2**

Document for: Discussion and Decision

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1 Introduction

This document sets out to summarise the work carried out in the feasibility study of the Wide band Distribution System (WDS). One of the important objectives of the study item, the end-to-end system performance with the application scenarios for WDS has been investigated by simulations. The simulations highlight the system performance improvements to be gained by the WDS. This document shows the key RF performance parameters as a first proposal and will address the concerns raised at previous RAN 4 meetings.

The report will demonstrate that WDS is a feasible system, completing the defined study item work and as such enable the decision to be made to move to a Work Item at the RAN4 Plenary

2 Technical Aspects

2.1 Addition of WDS to Node B without performance degradation

Agreed that it is not possible to add an ancilliary device and not have some impact on performance of the connection to the Node B.

Therefore the aim is to define the WDS as a new network device, creating an interface between the WDS and the Node B known as an LLI (low level interface). [Ref. 1]

The parameters of this interface would be specified on uplink and downlink in order to facilitate connection to the Node B.

The key points to note from this are:

a. Although the LLI would have a reduced spec, WDS would comply with the 3GPP TS25.104 at the antenna therefore having no negative impact on overall system performance.

b. There would no requirement for the system parameters to change from what is currently in place.

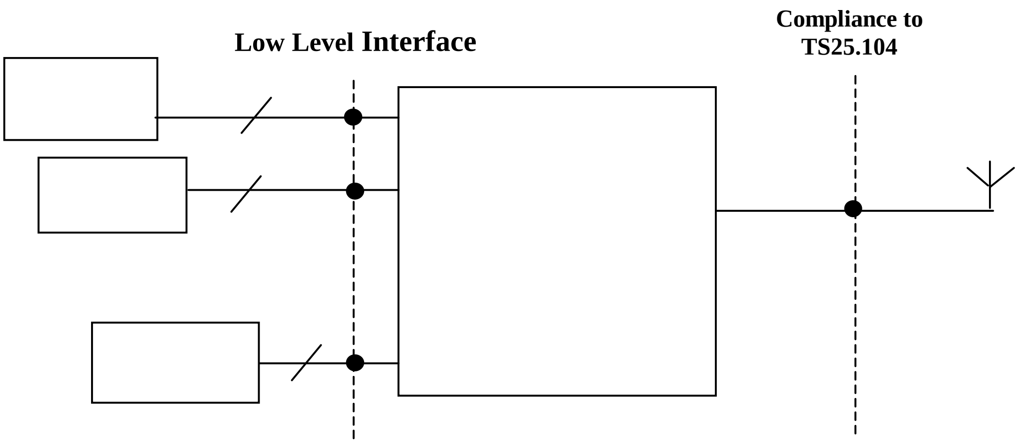
The simulation work carried out has supported the belief that WDS would bring system enhancements for all concerned in terms of improved quality of service in multi-operator and multi-carrier environments.

2.2 LLI concept

Existing 2G WDS systems were accepted for network integration under operators direct responsibility as existing specs did not fully address the requirement.
The driver in this case is to standardise a specification for the concept of a wide band distribution system for 3G. This will enable the option to be made available to the OEM's and the Network operators to include a WDS as part of their equipment/network planning if they choose to do so.

Preliminary specifications are available from a number of OEM's for connection of a WDS type system to a linear LLI.

Although there is no standard specification for this at present this can be worked on and agreed by all interested parties through 3GPP to ensure that a LLI meets the expectations of the OEM's for Node B interface and operators for system performance.



Location of LLI with respect to Node B

The specification would be created to cope with a range of values in order to service required expectations and enable a generic interface point.

The benefits realised from inclusion of a WDS would bring system enhancements which could be utilised if required.

2.3 Communications Interface

In order to identify the requirements and impact of a comms interface between WDS and other network elements R3-0119333 [Ref. 2] and R5-010481 [Ref. 3] were input to RAN 3 and SA5 respectively.
No objections to the proposal have been raised by either working group.

SA WG5 (Telecom Management) – Accepted as a new work task by SA5 plenary

RAN WG3 (O & M) – No concerns raised from RAN 3 meeting or reflector

Liason Statement R4-011044 (WDS impact on O&M) is presented at this meeting for approval in order to formally approach both groups.

2.4 TDD Applicability

Analysis of the TS 25.105 UTRA (BS) TDD specification has not highlighted any parameters that suggest that the WDS as a static, transparent fixed gain device would not comply in a TDD environment.

WDS shall be designed to operate in any full UTRA FDD paired or TDD bands according to regional requirements.

2.5 WDS RF Performance

The node B will satisfy the dynamic performance of the system as detailed by TS 25.104, whereas the WDS will act as a wide band, linear, transparent, and time-invariant device that offers constant gain between the base stations and the antenna connector. Its dynamic range is assumed to be at least an order of magnitude larger than that of base stations as discussed in R4-010668 (RAN WG #17). This will allow multiple base stations to operate on the same WDS.

The detail below demonstrates the key performance requirements at the LLI and of the WDS in order that the system is compliant to TS25.104 at the antenna.

The final parameters would be defined and specified as part of a WDS work item.

2.5.1 Transmitter Characteristics

These parameters are a first proposal and need to be confirmed by further simulation and investigation.

Key performance requirements

DL Parameters	TS25.104	Suggested LLI	WDS	Comments
Total Power Dynamic Range	>18 dB	>18 dB	> 30 dB	WDS technology is transparent to power control
Occupied bandwidth	< 5 MHz	< 5MHz	N/A	Driven by modulation process
Output RF spectrum / out of band Emissions				
Spectrum emission mask	See mask	See mask & para.2.5	See mask in TS25.104	WDS contributes only in ACLR
ACLR	45dB (5MHz) 50dB (10MHz)	48dB (5MHz) 55dB (10MHz)	48dB (5MHz) 52dB (10MHz)	Refer to Tech. Annex to R4-10668 [Ref. 6]
Spurious emissions in any applicable scenarios	As stipulated	< -60dBc	Same as in 25.104	Substantially driven by RF filtering on WDS
Tx Inter-modulation	As specified	The contribution of the LLI and the WDS need to be defined	The contribution of the LLI and the WDS need to be defined	
Tx Modulation	EVM < 12.5% PCDE < 33dB	The contribution of the LLI and the WDS need to be defined and calculated with RSS	The contribution of the LLI and the WDS need to be defined and calculated with RSS	Linearity of WDS ensures compliance

Output power dynamics

WDS is a linear and time-invariant device, that offers constant gain between the LLI and the antenna connector.

Therefore it shall allow a transparent transmission of any dynamic power adjustment from FDD or TDD base stations, including Transmit ON/OFF Time mask for TDD base stations.

Output RF spectrum emissions

WDS can operate on a multi-operator situation. Each channel bandwidth shall remain compliant with minimum requirements for spectrum emissions for a base station of equivalent power. This shall apply to out of band emissions, ACLR, and spurious emissions. Co-existence and co-location issues with other services shall also be considered.

Transmit inter-modulation

WDS shall comply with the requirement.

Transmit modulation

WDS, due to its intrinsic linear behaviour, shall allow transmit modulation to remain compliant to minimum requirements for Frequency Error, Error Vector Magnitude and Peak Code Domain Error.

2.5.2 Receiver characteristics

WDS shall offer key RF receive performance parameters as stipulated for base stations of equivalent power class, with specific reference to Reference Sensitivity Level, Blocking, Inter-modulation and Spurious Emissions. Other parameters such as ACS and Dynamic Range depend on IF and signal processing and are not relevant to WDS.

These parameters are a first proposal and need to be confirmed by further simulation and investigation.

	Key performance requirements			
UL Parameters	**TS25.104**	**Suggested LLI**	**WDS**	**Comments**
Reference Sensitivity	-121 dBm @ 12.2 kbps	Case specific	-121dBm @ 12.2 kbps – shall match all cases	WDS RF gain can be flexibly adapted
Dynamic Range	As stipulated	As stipulated in 25.104	N/A	Depends on IF & signal processing performance of Node B
ACS	>63dB @ 5MHz	>63dB @ 5MHz	N/A	Depends on IF & signal processing performance of Node B
Blocking	In band > -40dBm Out of band > -15dBm	In band – case specific Out of band N/A	In band > -40dBm – shall match all cases Out of band > -15dBm	In band driven by WDS UL linearity Out of band driven by RF filtering
Inter-modulation	> -48dBm	The contribution of the LLI and the WDS need to be defined	The contribution of the LLI and the WDS need to be defined	Driven by WDS UL linearity
Spurious Emissions	As stipulated	The contribution of the LLI and the WDS need to be defined	The contribution of the LLI and the WDS need to be defined	Driven by industrial design not WDS

3 Simulation Results

The scope of the simulation work is to demonstrate the WDS capability to improve UTRA performance, and the fact that its insertion in the UTRA specifications causes a significant advantage with respect to the current standards without affecting QoS.
The simulations were limited to two operators as this allowed the concept to be adequately demonstrated whilst enabling maximum number of simulation runs.

The following are the key findings from Wide band Distribution Subsystem (WDS) - Performance Simulation Study [Ref. 4]

3.1 Definition of Measurement Parameters

- **Blocked call**: a call originated by or terminated to a user within the coverage area that can't be initiated for any reason (essentially, for link budget constraints or for lack of available codes);
- **Dropped call**: a call that is interrupted for any reason before reaching completion;
- **Unsatisfied user**: a user is unsatisfied when the power control algorithm requires an increase in transmitted power that can't be allowed; the simulator distinguishes unsatisfied user in UL and DL;
- **Soft Hand-over**: a user is in condition of Soft Hand-Over (SHO) when it is simultaneously communicating with more than one base station;
- **Noise rise**: the perceived increase of noise power due to interference.

3.2 Shared Sites – Traffic Loading Comparisons

- The presence of two operators with equal offered traffic density and cellular layout does not cause a significant loss of quality nor of capacity with respect to the single operator case.
- The presence of WDS, which allows site sharing among operators, is not detrimental when the systems are scarcely loaded, while it tends to yield benefits when the offered traffic increases (2.2.2)

Table 1.

2 OPERATORS, MACROCELLS, RADIUS 500 METRES

BIT RATE 12.2 KB/S, EB/NO TARGET 4DB (UL) / 7DB (DL) , VELOCITY 3KM/H

Parameter	Un-shared Sites		Shared sites	
Offered traffic (Erl/cell)	5	12	5	12
Blocking probability (%)	0.29	1.76	0.93	1.31
Dropping probability (UL) (%)	0	0.10	0	0.16
Dropping probability (DL) (%)	0.34	0.39	0	0
Unsatisfied Users (UL) (%)	0.67	0.39	0.65	0.34
Unsatisfied Users (DL) (%)	0.07	0.14	0.007	0.04
Users in SHO (%)	36.07	33.22	38.24	34.28
Users per cell	12.43	30.65	12.74	31.27
Noise rise (dB)	3.44	10.32	4.44	9.03

3.3 Shared Sites – Unequal Traffic Loading

- The presence of WDS shows clearer benefits in the likely scenario when the traffic densities of the two operators differ. (2.4.).

Table 2. 2 OPERATORS, MACROCELLS, RADIUS 500 METRES,

OFFERED TRAFFIC (ERL/CELL) 7.5 (OPERATOR 1) AND 5 (OPERATOR 2))

Parameter	Un-shared Sites		Shared sites	
Operator	1	2	1	2
Offered traffic (Erl/cell)	18	12	18	12
Blocking probability (%)	4.11	1.05	5.01	1.78
Dropping probability (UL) (%)	0.11	0	0.06	0.04
Dropping probability (DL) (%)	1.40	0.57	0.94	0
Unsatisfied Users (UL) (%)	0.40	0.34	0.27	0.30
Unsatisfied Users (DL) (%)	1.34	0.15	0.9	0.01
Users in SHO (%)	25.61	36.43	27.58	36.40
Users per cell	38.29	29.21	38.80	29.55
Noise rise (dB)	15.49	9.93	15.00	9.16

3.4 WDS Resiliance to Performance Degradation

- The site sharing solution made possible by adoption of WDS, is more resilient to system degradation characteristics such as adjacent carrier interference. This is evident even when the ACS and ACLR values are substantially reduced (e.g. due to hardware failures or malfunction) (2.5)

Table 3. 2 OPERATORS, MACROCELLS, RADIUS 2000 METRES

BIT RATE 12.2 KB/S EB/NO TARGET 11.9 (UL) / 10 (DL)) , VELOCITY 3KM/H

Parameter	**Un-Shared Sites**		**Shared sites**	
	Standard	Degraded	Standard	Degraded
ACS	45 dB (UL) / 33 dB (DL)	35 dB (UL) / 23 dB (DL)	45 dB (UL) / 33 dB (DL)	35 dB (UL) / 23 dB (DL)
ACLR	33 dB (UL) / 45 dB (DL)	23 dB (UL) / 35 dB (DL)	33 dB (UL) / 45 dB (DL)	23 dB (UL) / 35 dB (DL)
Offered traffic (Erl/cell)	5	5	5	5
Blocking probability (%)	0.05	0.05	0.43	0
Dropping probability (UL) (%)	5.48	7.42	5.51	6.14
Dropping probability (DL) (%)	0.24	0.76	0	0
Unsatisfied Users (UL) (%)	7.80	10.20	7.81	8.84
Unsatisfied Users (DL) (%)	0.10	0.31	$8*10^{-4}$	$4*10^{-4}$
Users in SHO (%)	33.57	34.66	34.86	35.97
Users per cell	11.45	11.27	11.70	11.73
Noise rise (dB)	11.18	12.15	11.56	11.40
Internal noise rise (dB)	9.89	10.62	10.30	10.13
External noise rise (dB)	5.77	6.40	6.04	6.09
Other operator noise rise (dB)	0.69	2.31	0.08	0.35

3.5 Microcells – Capacity and Quality Benefits

- Deployment of microcells, which is made possible by the introduction of WDS, allows an increase in system capacity. A traffic density which would lead to system congestion may be served by means of an appropriate reduction of cell radius (2.3)

Parameter	Shared sites 2 operators **microcells**, radius 250 m Ordered Traffic 12 Erl / Cell , Target Eb/No 11.9 (UL) / 10 (DL))	Shared sites 2 operators **macrocells**, radius 500 m Ordered Traffic 12 Erl / Cell , Target Eb/No 11.9 (UL) / 10 (DL))
Blocking probability (%)	3.29	51.75
Dropping probability (UL) (%)	0	12.17
Dropping probability (DL) (%)	0	2.20
Unsatisfied Users (UL) (%)	0.23	4.17
Unsatisfied Users (DL) (%)	0.001	1.61
Users in SHO (%)	37.63	33.57
Users per cell	7.92	12.82
Noise rise (dB)	13.77	30.02

From comparison of the values obtained for microcells with those for macrocells we observe that the performance shows a drastic improvement. As well as the obvious QoS improvements the key observation is the increase in potential user density.

The number of users per cell is slightly less than 8 for the microcell, which corresponds to 32 users in an area corresponding to one macrocell of 500 m radius. This figure is more than double that of the corresponding macrocell (almost 13 users).

3.6 Microcells – Ability to Reduce DL Power

- The maximum DL power can be reduced to as low as 20 dBm while offering satisfactory quality, provided that the cell radius is adequately reduced to compensate for the decreased coverage.(2.3.3)

Table 4. 2 OPERATORS - MICROCELLS, RADIUS 100 METRES ,

DL POWER 20DBM BIT RATE 12.2 KB/S,

EB/NO TARGET 11.9 (UL) / 10 (DL)) , VELOCITY 3KM/H

Parameter	Shared sites
Blocking probability (%)	7.54
Dropping probability (UL) (%)	0
Dropping probability (DL) (%)	0
Unsatisfied Users (UL) (%)	0.53
Unsatisfied Users (DL) (%)	0.006
Users in SHO (%)	38.98
Users per cell	7.79
Noise rise (dB)	24.61

The above values show that the system can satisfactorily work with a high traffic density and only 20 dBm of maximum DL transmit power. This can be achieved by means of a small cell radius.

3.7 Site Sharing – Higher Data Rates

- The advantages of site sharing appear more clearly when user bit rates higher than the basic 12.2 Kb/s are considered.(2.6)

Table 5. 2 OPERATORS, MACROCELLS, RADIUS 500 METRES,

DATA RATE 144 KB/S

Parameter	Non-shared sites	Shared sites
Offered traffic (Erl/cell)	4	4
Blocking probability (%)	11.60	10.63
Dropping probability (UL) (%)	0.07	0.07
Dropping probability (DL) (%)	0.87	0
Unsatisfied Users (UL) (%)	0.5	0.59
Unsatisfied Users (DL) (%)	0.41	0.05
Users in SHO (%)	37.25	37.41
Users per cell	8.58	8.89
Noise rise (dB)	19.46	17.45

3.8 Mixed layouts (Microcells and Macrocells)

- The analysis of mixed layout systems (composed of both macrocells and microcells) confirms that microcells can carry a traffic density significantly higher than macrocells in spite of the higher interference they receive from neighbouring macrocells.(2.7)

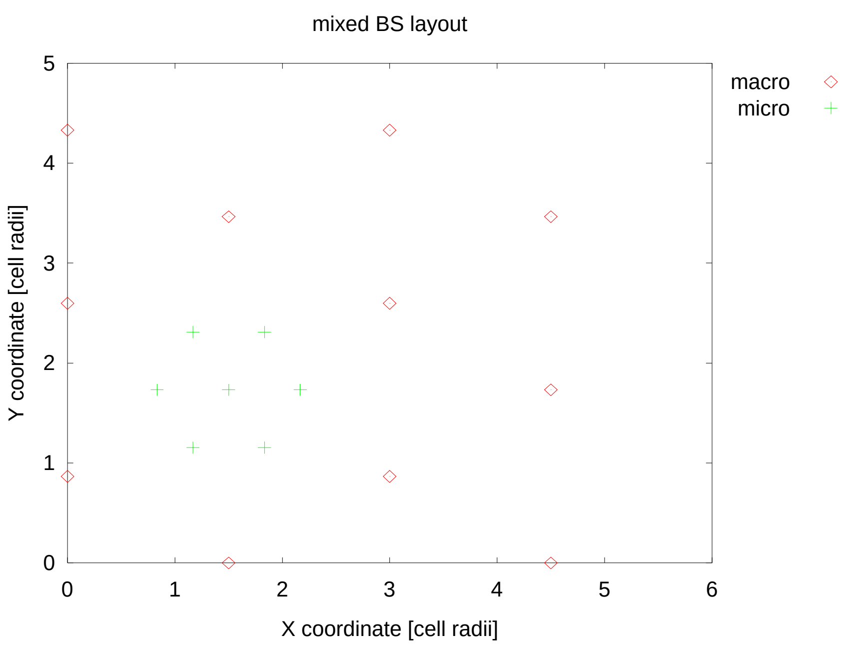


Table 6. 2 OPERATORS, MACROCELLS + MICROCELLS

BIT RATE 12.2 KB/S EB/NO TARGET 11.9 (UL) / 10 (DL), VELOCITY 3KM/H

Parameter	Value			
Offered traffic (Erl/macrocell)	5		12	
Blocking probability (%)	5.67		47.87	
Dropping probability (UL) (%)	0		9.60	
Dropping probability (DL) (%)	0		1.26	
Cell type	macro	micro	macro	micro
Unsatisfied Users (UL) (%)	0.31	0.03	4.30	0.007
Unsatisfied Users (DL) (%)	0.02	0	1.09	0
Users in SHO (%)	36.11	42.60	34.13	42.07
Users per cell	11.63	2.41	13.61	4.23
Noise rise (dB)	15.93	14.42	30.11	27.51
Internal noise rise (dB)	14.54	8.26	28.89	21.06
External noise rise (dB)	10.21	12.89	23.34	26.06
Other operator noise rise (dB)	0.41	0.33	2.52	1.64

When the traffic increases the blocking probability grows from about 5% up to almost 50%. This is actually in line with the results found for the system with macrocells only.

The increment in blocking probability is obviously due to the macrocells, which is confirmed by the number of users per cell. The macrocells exhibit a saturation and the number of users per cell increases only marginally when the offered traffic grows from 5 to 12 Erl/macrocell, while the number of users actually carried by microcells increases by about 75%.

The congestion status of macrocells is confirmed by the total noise rise, which is practically equal to the 30 dB threshold. The split of noise rise in its three contributions confirms that the presence of the second operator does not give a significant contribution to the overall noise rise. Furthermore, we observe that for both traffic values the internal noise rise is higher than the external one by about 4 or 5 dB in macrocells, while for microcells the opposite occurs. This results confirms that the interference generated by macrocells on microcells is more serious than the one in the opposite way.

3.9 Increased Terminal Velocity

- The presence of WDS, which allows to share sites among operators, shows clear benefits when the terminal velocity increases, i.e. when vehicular users instead of pedestrians are taken into account when voice traffic is considered (3.2)

Table 7. 2 OPERATORS, MICROCELLS, RADIUS 250 METRES

User Velocity 50Km/h

Offered Traffic 3 Erl/cell Data Rate 12.2kbs

Parameter	Non-shared sites	Shared sites
Offered traffic (Erl/cell)	3	3
Blocking probability (%)	9.66	7.85
Dropping probability (UL) (%)	0.02	0.02
Dropping probability (DL) (%)	1.09	1.07
Unsatisfied Users (UL) (%)	0.57	0.52
Unsatisfied Users (DL) (%)	1.96	1.78
Users in SHO (%)	25.59	26.21
Users per cell	6.32	6.48
Noise rise (dB)	16.97	15.52
Internal noise rise (dB)	12.40	11.53
External noise rise (dB)	13.86	12.57
Other operator noise rise (dB)	2.93	0.86

3.10 Indoor Environments

Analysis of indoor systems with shared operators showed the ability to carry one 2Mb/s user for each operator, even in the presence of a traffic ‘floor’ due to voice users.
When the traffic increases it was found that more voice calls were blocked, whilst the performance of the 2Mb/s data user remained optimal.

3.11 Simulation Summary

The simulation results demonstrate that a WDS, enabling the advantage of site sharing among operators, does not negatively impact on the radio network performance.
In many cases system performance was seen to improve when compared with non-shared sites.

4 Service Aspects

No deterioration of LCS due to inclusion of WDS is envisaged as discussed hereinafter.[Ref 5]

Cell ID Method

The only impact is that the cells have the potential to become smaller using WDS thereby giving greater accuracy compared to a larger cell.

OTDOA-IPDL Method

As measurements are made by the UE who then reports them to the PCF in the serving RNC, any delays between the remote RF head and the serving Node B which may be introduced by the WDS are not part of the LCS calculation.

The PCF must be aware of the geographical layout of the UTRAN transmitters.

Network Assisted GPS Method

No impact

5 Questions from Previous RAN 4 Meetings

A summary of the open questions from previous RAN 4 meetings are listed below along with the section of this report which addresses the concern.

1. It is not possible to add a WDS to Node B and not degrade performance. Ref. Para 2.1
2. Concept of a low level interface is not clear Ref. Para. 2.2
3. How will a WDS impact O&M Ref. Para. 2.3

6 Proposal

This document presents simulation results which indicate the system performance improvements that can be gained from a WDS and addresses previous concerns raised.

An overview of the key RF performance requirements has been shown, indicating the WDS system feasibility. A final detailed study and specification of the parameters should be carried out at the work item stage.

RAN4 should discuss and agree to move to a Work Item.

7 References

[1] TSG R4-010935 WDS Study Item Status

[2] R3-011933 Impact and assessment for study item on WDS into O&M aspects of Node B

[3] S5-010481 Impact assessment for study item on WDS into O&M aspects

[4] Wide band Distribution Subsystem (WDS) - Performance simulation results Ref. R TEK 002/01 v. 5

[5] TS 25.305 v3.2.0 (Stage 2 Functional Specification of Location Services in UTRAN)

[6] TSG RAN 4 R4– 010668 Technical justification and overall advantages for UTRA WDS – Technical Annex