Project Number: 248267
Project acronym: BuNGee
Project title: Beyond Next Generation Mobile Networks

BuNGee Deliverable: D5.4

Standardisation Report

Due date of deliverable: M30
Actual submission date: 09/07/2012

Start date of project: January 1, 2010	**Duration**: 30 months
Lead Participant: ART, Mariana Goldhamer **Contributors:** See page 3 **Release number:** 1.0 **Keywords:** BuNGee, high capacity mobile network, 1Gb/s, 1Gb/s/km2 , in-band backhauling, self-backhauling, below roof-top, Hub BS, Access BS, Multi-beam antenna, MIMO	
Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)	
Dissemination Level: Public	

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Executive Summary

This Report summarises the contribution of the BuNGee project to standardisation in ETSI BRAN and IEEE 802.16n and justifies the lack of contributions to ETSI TM4 and 3GPP.

BuNGee had an overwhelming contribution to ETSI standardisation, as the entire ETSI TR 101 534 was drafted based solely on the contributions submitted by the BuNGee partners and reflecting the BuNGee research results. In addition, a substantial contribution has been made to the ETSI draft TR 101 589.

BuNGee standardisation in ETSI confirms the conclusions of the "Report of the Future Networks", 7th FP7 Concertation Plenary Meeting, Brussels, 10 February 2011, showing that even STREP projects can bring a substantial contribution to the ETSI standardisation.

In WiMAX Forum, BuNGee members contributed to definitions of WiMAX technology Road Map, introducing some of the concepts and features developed in BuNGee.

BuNGee has also contributed to IEEE 802.16n, however the proposals were not accepted for inclusion in the IEEE 802.16n standard.

Contributors

Participant #	Participant short name	Name of the Contributor	E-mail
2	ART	Mariana Goldhamer	mariana.goldhamer@ieee.org
4	CASMA	Patrick Hemphill	patrick.hemphill@cobham.com
1	ALV	Oleg Marinchenco	oleg.marinchenco@alvarion.com
5	UoY	Alister Burr	agb1@ohm.york.ac.uk

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List of Acronyms

Abbreviation / acronym	Description
3GPP	3rd Generation Partnership Project
ABS	Access BS
ART	Above Roof Top
BRAN	Broadband Radio Access Networks
BS	Base Station
BuNGee	Beyond Next Generation Mobile Broadband
ETSI	European Telecommunications Standards Institute
HBS	Hub Base Station
LE	License Exempt (frequency band)
MIMO	Multiple Input Multiple Output
MS	Mobile Station
RAN	Radio Access Network
RRM	Radio Resource Management
RS	Relay Station
SON	Self Organizing Network
TM4	Transmission and Multiplexing 4
TC	Technical Committee
UE	User Equipment
UL	Uplink

1 Introduction

Based on the Description of Work, our project has committed to ETSI standardisation and in addition to IEEE 802.16, WiMax Forum and/or LTE-Advanced standardisation.

The main BuNGee target for standardization activities was considered ETSI, as the most appropriate standardization body for the "looking forward" projects. The initial ETSI standardisation had three targets:

- Architecture standardisation (BRAN);
- Protocol standardisation (BRAN);
- Multi-beam antenna standardisation (TM4).

We started the ETSI BRAN standardisation in Sept. 2010 (M9) and continued during the entire project life, until June 2012. During this period of time we have finalized an entire ETSI standard on BuNGee architecture (TR 101 534) and we have achieved an approved draft covering BuNGee protocols (TR 101 589). This Report provides detailed information on the standardisation process of BuNGee results.

Regarding the ETSI TM4 standardisation envisaged by the initial plans, after the in-depth technical analysis of the existing EN 302 326-3, it appeared that the BuNGee multi-beam antenna is already supported by this standard, such that no additional standardisation was needed.

We have contributed to IEEE 802.16 with one contribution.

In WiMAX Forum (WMF), BuNGee submitted the contributions for WiMAX technology Road Map, introducing the BuNGee-essential technical topics as described in Section 4.

In LTE, we did not find appropriate Work Items for Rel.10 and Rel.11. The detailed explanation is provided in Section 5.

In this Report we provide detailed information on those ETSI BRAN and WiMAX documents which are not visible to non-members by inserting their text into Annexes. Such documents are the support presentations for the opening of new Work Items in ETSI BRAN and the WiMAX contribution outline. We note that the published TR 101 534 is freely downloadable, as indicated in Section 2.

2 ETSI BRAN Standardisation

Our main ETSI standardisation efforts were focused on BRAN activities. We have opened two Work Items. Their content and drafting activities are described below.

2.1 TR 101 354

2.1.1 New Work Item adoption

At the BRAN meeting #64 from Oct. 2010, Alvarion submitted the documents:

- BRAN(10)0062r1, New Work Item proposal for "Very high capacity density BWA networks: System architecture, economic model, technical requirements", see Annex 1 for its Summary. The supporting companies were: Alvarion, Thales, Polska Telefonia Cyfrowa, Siklu, CTTC. The Rapporteur of the work Item, based on Alvarion proposal, was Mariana Goldhamer.
- Supporting presentation BRAN(10)0075r1 , which is included in Annex 5.

The main elements of the BuNGee architecture can be recognized in both the work Item description and the supporting presentation, as reflected in D1.2. These are:

- Two tier deployment, the first tier (backhauling network) using a very high capacity hub, while the second tier (access network) providing broadband access to the mobile terminals;
- Using both in-band and out-of-band backhauling in the first tier; the out-of-band backhauling may use the license-exempt spectrum, including the 60GHz band;
- Collaborative technologies at Base station:
  - Support for collaborative (network) MIMO techniques, through BS-BS and MS-MS direct communication;
  - Radio resource "sharing" between ABSs;
  - Joint backhaul – access design.

In addition, it was emphasized the energy and cost efficiency of this architecture.

In its plenary meeting from 8 Oct. 2010, TC (Technical Committee) BRAN has adopted the New Work Item. No objection was raised in ETSI, such that the NWI was adopted in ETSI after one month.

2.1.2 The first contribution to TR 101 354

In the December 2010 BRAN meeting, the first contribution (BRAN(10)0086r2) was submitted by Mariana Goldhamer, in the name of the ETSI members active in BuNGee: Alvarion, Thales, Polska Telefonia Cyfrowa, Siklu, CTTC.

This first contribution included the following technical elements:

- Architecture for 1 Gbit/s/km^2 network, including the following features:
  1. Multiple access links aggregation;
  2. Backhauling link aggregation;
  3. Network MIMO (for Downlink and Uplink);
  4. Direct BS-BS or MS-MS communication.

The proposed system architecture was relevant to BuNGee D1.2:

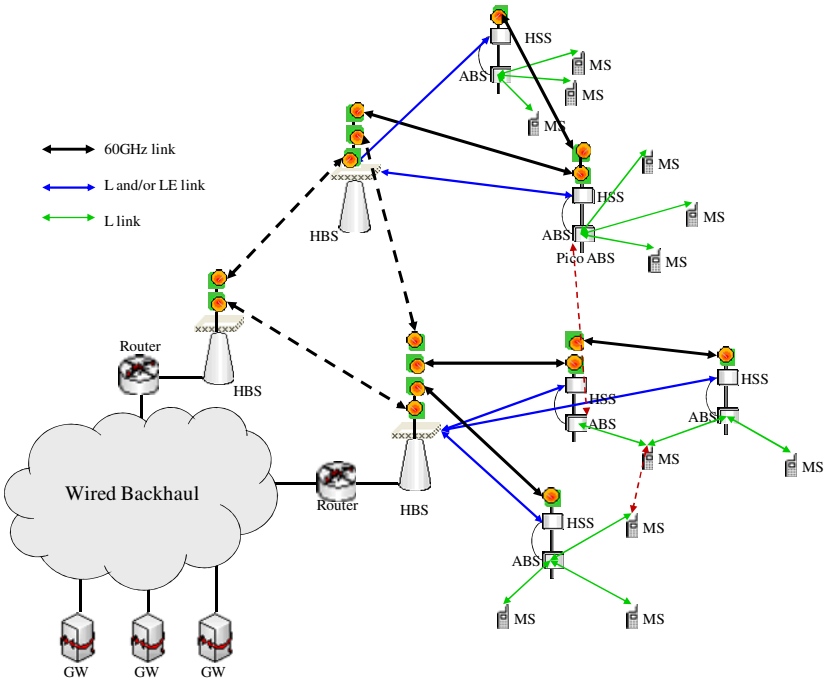


Figure 2-1: Basic architecture

At the top level of the architecture, Hub Base Stations (HBSs) are directly connected to the wired backhaul. If in some cases a wired link could not be provided, this link may be replaced by a LE wireless high capacity link.

The text included a detailed description of the system architecture and provided a figure of the network architecture and its description.

A special section was dedicated to the user and business requirements, as identified in BuNGee D1.1 and D1.2 and pertinent to user and business needs.

Another section was dedicated to the in-band backhauling wireless network.

- The identified technical and business requirements pertinent to the in-band backhauling wireless network were used.
- In continuation, the Economic Requirements were addressed, while taking into account the spectrum license fees, site related costs, network equipment costs.

The contribution was presented and discussed in ETSI BRAN HiperMAN. It was approved as the first draft of TR 101 534 with some editorial changes made at the meeting.

No objection was raised in ETSI, such that the NWI was adopted in ETSI after one month.

2.1.3 The second contribution to TR 101 534

The second contribution was prepared by Mariana Goldhamer and was discussed, modified and approved by BuNGee. The contribution was submitted to the BRAN#68 meeting, taking place in Sept. 2011, as BRAN(11)0046, authored by THALES, Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC.

This contribution includes the following elements:

- The improved system architecture figure, relevant to D3.1;
- Characteristics of the multi-beam antenna;
- Extensive text on multi-beam assisted MIMO, relevant to D1.2, and including:
  - An overview;

  - Up-link and down-link multi-beam assisted MIMO operation in licensed bands;
  - Network MIMO operation in uplink and downlink;
  - Hybrid MIMO operation in uplink and downlink.
- Extensive text on Radio Resource management, relevant to D3.1 and including:
  - Dynamic frequency allocation;
  - Self-organizing frequency allocation;
  - Cognitive band frequency allocation;
  - RRM for joint access and self-backhaul networks;
  - Joint access and self-backhauling.

The contribution was presented and discussed in ETSI BRAN HiperMAN and was accepted as the second draft of TR 101 534.

2.1.4 The third contribution to TR 101 534

The third contribution was prepared by Mariana Goldhamer and was discussed, modified and approved by BuNGee. The contribution was submitted to the BRAN#69 meeting, taking place in Dec. 2011, as BRAN(11)0061, authored by Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC.

It included the following new elements:

- The system network figure and the corresponding description were replaced, such to give a neutral view of the actual networking interfaces;
- Detailed deployment approaches were introduced, using the materials from D3.1 and D1.2 for the square and cross topologies;
- The figure with antenna characteristics was replaced by Cobham, to respond to specific ETSI requests;
- The CTTC capacity simulation results for the entire system were added, taking into account the joint access and backhaul design, as presented in D3.1;
- The section of direct inter-BS communication, as presented in D1.2, was added;
- The capacity and spectrum calculations, as presented in D1.2, were added.

The contribution was presented and discussed in ETSI BRAN HiperMAN and was accepted as the third draft of TR 101 534.

2.1.5 The fourth contribution to TR 101 534

The forth contribution was prepared by Mariana Goldhamer and was discussed and approved by BuNGee. The contribution was submitted to the BRAN#70 meeting, taking place in Feb.2012, as BRAN(12)000013, Consolidated text for TR 101 534 was authored by Thales, Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC.

The contribution provided the text, relevant for D1.3 (continuation of BuNGee D1.2 deliverable), the section named “Time resource allocation” and addressed the spectrum sharing between the backhaul and access tiers. In addition, the conclusion section was finalized. Because the meeting targeted the approval of the standard, the contribution provided the appropriate editorial changes.

2.1.6 TR 101 354 approval for publication

The contribution BRAN(12)000013 was approved for publication, as the final draft of TR 101 534, by the HiperMAN Working Group and afterwards by the BRAN Plenary.

It followed the interactions with the BRAN ETSI Officer and the editHelp staff, asking a small number of clarifications. The answers were prepared by the ETSI Rapporteur (Mariana Goldhamer) in collaboration with CTTC.

Finally, the Rapporteur announced that the standard had been published on March 26, 2012.

The standard can be downloaded here.

2.2 TR 101 389

2.2.1 New Work Item adoption

At the BRAN meeting #70 from Feb. 2012, the ETSI members, active in BuNGee, submitted the documents:

- BRAN(12)000011r1, New Work Item proposal for "Very high capacity density BWA networks: Protocols", see Annex 3 for its Summary. The supporting companies were: Alvarion, Thales, Polska Telefonia Cyfrowa, Siklu, CTTC. The Rapporteur of the Work Item, based on Alvarion proposal, was Mariana Goldhamer.
- Supporting presentation BRAN(12)000014r1 is included in Annex 6.

The main elements of the BuNGee architecture may be recognized in both the Work Item description and the supporting presentation, as reflected in D3.2. These are:

- RRM Functional Decomposition;
- Autonomous Distributed Cognitive Radio Frequency Assignment;
- Autonomous Distributed Dynamic Frequency Assignment;
- Learning and docition;
- Joint power and frequency control.

In the plenary meeting from 8 Oct. 2010, BRAN Technical Committee (TC) adopted the New Work Item unanimously.

2.2.2 The first contribution to TR 101 389

In the June 2012 BRAN meeting #71, the contribution BRAN(12)000057 was submitted by Mariana Goldhamer, in the name of the ETSI members active in BuNGee: Alvarion, Thales, Polska Telefonia Cyfrowa, Siklu, CTTC.

This first contribution included the following technical elements:

1. Architecture for the underlying system;
2. Radio resource management;
3. RRM functional decomposition in system architecture;
4. Dynamic centralized frequency assignment;
5. Spectrum sensing based dynamic frequency assignment;
6. Learning based cognitive frequency assignment.

The following table shows the mapping between the ETSI contribution and the relevant sections of D3.1 and D3.2:

Table 2-1: D3.1 and D3.2 mapping

BRAN contribution content	BuNGee D3.1 relevance	BuNGee D3.2 relevance
5.1 Architecture for the underlying system	Introduction	
5.2 Radio Resource Management		2. Radio Resource Management
5.3 RRM Functional Decomposition in system architecture		2.1 RRM Functional Decomposition in BuNGee architecture
6.1 Dynamic Centralized Frequency		2.2.1 Dynamic Centralized Frequency

Assignment		Assignment
6.2.1 Spectrum Sensing based Dynamic Frequency Assignment		2.2.2.1 Spectrum Sensing based Dynamic Frequency Assignment
6.2.2 Learning based Cognitive Dynamic Frequency Assignment		2.2.2.2 Learning based Cognitive Dynamic Frequency Assignment 2.2.2.3 Control Primitives for Cognitive Dynamic Frequency Assignment
6.3 Cognitive and Docitive RRM		2.3 Cognitive and Docitive RRM

2.3 ETSI TM4 standardisation

Initially it was considered that the novel multi-beam antenna will require dedicated standardisation work in ETSI TM4. However it was assessed that the existing EN 302 326-3 already includes the necessary parameters allowing the type-approval of the multi-beam antenna.

The mapping of the multi-beam antenna parameters, as specified for the BuNGee project, with EN 302 326-3 is shown in the following section.

Table 2-2: Multi-beam antenna parameters mapping to EN 302 326-3

Parameter	**Value Specified**		**Relevant section in EN 302 326-3**
Frequency	3.4 – 3.6 GHz		Table 1, 4.4.3.1
Gain	18.5 dBi min target for any of the 6 beams		4.5.4
Polarisation	Dual slant 45˚		N.A.
Cross Polar/Axial ratio	15 dB min		Table 18
Azimuth HPBW	C15˚ for each of the 6 beams		Producer declaration
Elevation HPBW	C9˚		Producer declaration
Radiation pattern envelope	12dB sidelobes min for each of the 6 beams		Table 17
Electrical tilt	2˚ downtilt		4.2.2
Front to back	N/S, 30 dB target		Table 17

VSWR (maximum)	N/S, 2:1 target		N.A.
DC grounding	**Y** **N**		**N.A.**
Isolation	N/S, 15 dB min target		N.A.

In continuation, some basic explanations regarding this antenna are given:

- Each individual azimuthal beam is produced by a beam-forming network connected to the antenna array.
- The beams are spaced at intervals of 22.5˚ apart; each of the 6 inputs to the beam-forming network provides a unique combination of amplitude and phase inputs to the antenna array, producing the 6 beams.
- Gain and sidelobe levels are a function of pointing angle and will vary across the 90˚ sector of the whole antenna.

2.3.1 Radiation Patterns of the Complete Array

The overlaid plots below show the performance of a 90˚ assembly for one polarisation; the gain shown includes losses in the beam-forming network and phase-matched cables. From the graph the handover at the 3dB points can be seen, giving the total beam coverage of 90˚ in azimuth.

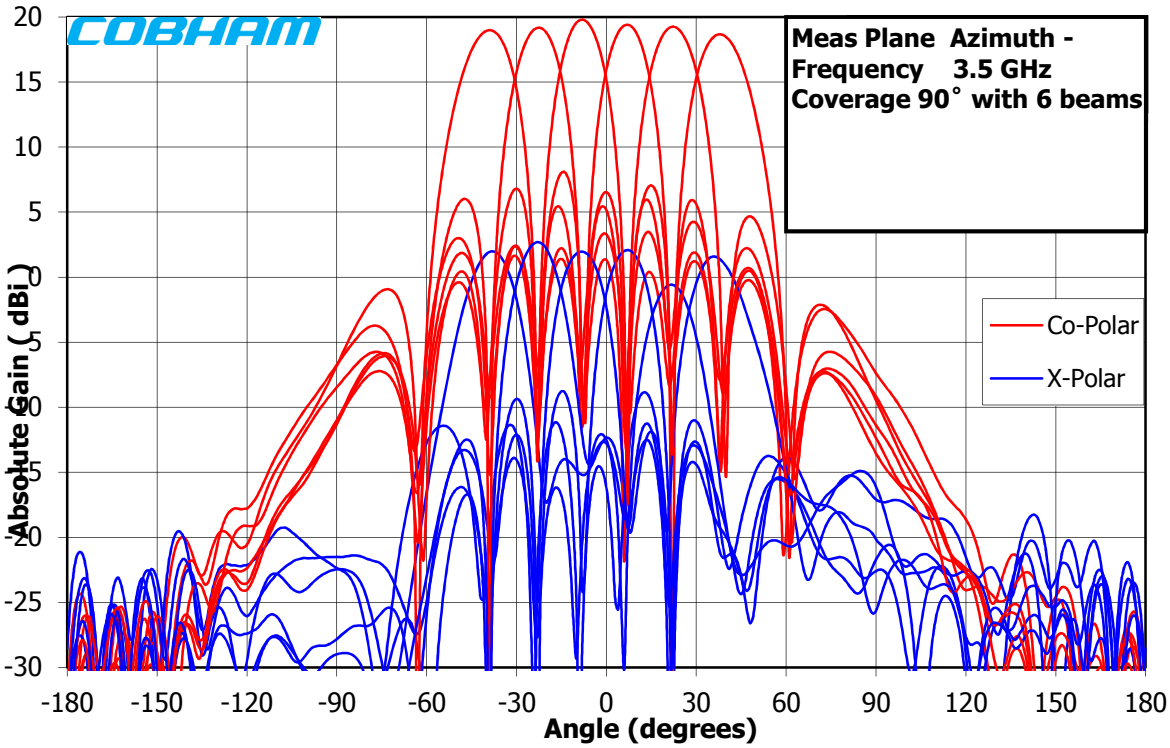


Figure 2-2: Graph showing overlaid beams from -37.5˚ to + 37.5˚ over a 90˚ spread

2.3.2 The Beam-forming Assembly

The beam-forming network is laid out to a standard passive Butler matrix design. Two are used with each antenna, one for each polarisation, connected to the antenna input ports with phase matched cables. Each

beam-former is able to feed the 8 antenna inputs to create the six, high gain, narrow azimuth beam patterns across a 90˚ arc in azimuth; the 15˚ wide beam centres occurring at +/- 37.5˚, +/- 22.5˚ and +/- 7.5˚. The "handover" between beams occurs at the Half Power points thus providing continuity of coverage across the 90˚ arc of each antenna.

3 IEEE standardisation

At the IEEE 802.16 meeting from January 2011, the contribution IEEE C802.16n-10/0068r1, "Proposal for 802.16n architecture with path and frequency resilience" was submitted by Alvarion and Thales.

This contribution proposed a new resilient architecture based on the subscriber-to-subscriber direct communication developed in D2.1 section 5.4. In addition, the solutions were proposed using the frequency allocation agility, as developed for multi-beam frequency allocation in D1.2 section 8 and D1.3 section 3.

The meeting discussed the solutions presented by us and Samsung + ETRI. Finally, the Samsung solution, based on the multi-hop relay connectivity, was preferred.

4 WiMAX Forum (WMF) standardization

In the WiMAX Forum (WMF), Alvarion, on behalf of BuNGee, submitted the contribution [13] for WiMAX technology Road Map, introducing the BuNGee-essential technical topics – such as:

- License Exempt Operations (introducing operations of WiMAX network at license exempt frequency channels);
- Notion of deployment models with fixed beams antennas, such as BuNGee-specific multi-beam antenna providing aggressive frequency reuse (for high-capacity Fixed/ Backhauling Broadband Wireless Access Networks using multi-beam antennas);
- Establishing new activity related to Heterogeneous RAN Network deployments (HetNets);
- Proposing enhancements for In-band backhauling / Wireless Relays concepts;
- Formalizing Self-Organizing Networks concepts and features (as developed in BuNGee).

The contribution outline is presented in the Annex 7.

This contribution and the supporting presentation were presented in the WMF Technical Coordination Committee (TCC) and in the Technical Working Group (TWG).

Finally, WMF adapted Heterogeneous Networks (HetNets) as the Work Item for future WiMAX Releases.

5 LTE advanced standardisation

There were a number of issues that influenced the decision regarding the submission of BuNGee contributions to 3GPP standardisation, due to the content and the timing of 3GPP work, such as:

1. CoMP Study Item for Release 10: BuNGee has different channel models and a different deployment topology relative to those considered in 3GPP, based on TR 36. 814.
2. Direct communication: the relevant RAN study items will be approved for Release 12, starting in Q4-2012, after the end of the BuNGee project.
3. Use of BuNGee multi-beam antenna: LTE-Advanced supports max. 8 beams, instead of 12 provided by this antenna.
4. Small cell deployment: a topic to be addressed by 3GPP in Release 12; the Study Item will be finalized in the RAN meeting taking place in September 2012.

6 Conclusions

BuNGee had an overwhelming contribution to ETSI standardisation, as the entire ETSI TR 101 534 was drafted based solely on the contributions submitted by the BuNGee partners. In addition, a substantial contribution was made to ETSI draft TR 101 589.

The BuNGee standardisation in ETSI confirms the conclusions of the Future Networks: Report of the Future Networks 7th FP7 Concertation Plenary Meeting, Brussels, 10 February 2011, showing that even STREP projects can bring a substantial contribution to standardisation.

We have found, based on a serious technical assessment, that there was no need for the TM4 standardisation, as the multi-beam antenna developed in BuNGee is already covered by ETSI type-compliance standards.

BuNGee also contributed to IEEE 802.16n, however the proposals were not accepted for inclusion in the IEEE 802.16n standard.

BuNGee members contributed in the WiMAX Forum to the WiMAX technology Road Map, introducing a number of BuNGee-essential technical topics, one of which, Heterogeneous Networks (HetNet) concept, was adapted as the Work Item for future WiMAX standardization releases.

7 References

[1] D1.2 BuNGee Baseline Architecture
[2] D3.1 BuNGee Baseline RRM & Joint Access/Self-Backhaul Design
[3] BuNGee D3.2 BuNGee RRM protocol suite
[4] ETSI BRAN(10)0086r2, “Alvarion, CTTC, Polska Telefonia Cyfrowa, Siklu, Thales: Initial text for 1Gig architecture”
[5] ETSI BRAN(11)0046, “THALES, Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC, Contribution to TR 101 534”
[6] ETSI BRAN(11)0061, “Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC, Further text for TR 101 534”
[7] ETSI BRAN(12)000013, Consolidated text for TR 101 534, authored by Thales, Polska Telefonia Cyfrowa; ALVARION S.R.L.; Siklu Communication Ltd.; CTTC.
[8] ETSI TR 101 534 V1.1.1 (2012-03) Broadband Radio Access Networks (BRAN);Very high capacity density BWA networks; System architecture, economic model and derivation of technical requirements
[9] ETSI EN 302 326-3 V1.3.1 Fixed Radio Systems; Multipoint Equipment and Antennas; Part 3: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive for Multipoint Radio Antenna
[10] IEEE C802.16n-10/0068r1, “Proposal for 802.16n architecture with path and frequency resilience”
[11] 3GPP TR 36.814, “3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Further advancements for E-UTRA physical layer aspects (Release 9)
[12] Future Networks: Report of the Future Networks 7th FP7 Concertation Plenary Meeting, Brussels, 10 February 2011.
[13] WiMAX Forum, RMP-TCC-11-00000r000, WiMAX Technology Road Map proposal, Alvarion, Bangkok, Sept. 2011.

Annex 1: Work Item on Architecture

Below is reproduced the Work Item content as appears in the ETSI database.

2012-06-17 **Work Programme** Version 2.3.2

Simple Search | Advanced Search | Pre-Defined Reports | Help

Details of 'DTR/BRAN-0040008' Work Item

Work Item Reference	ETSI Doc. Number	STF	Technical Body in Charge	Download Standard
DTR/BRAN-0040008	TR 101 534		BRAN	
Current Status (Click to View Full Schedule)	**Latest Version**	**Cover Date**	**Standstill**	**Creation Date**
Publication (2012-03-26)	1.1.1	2012-03-26		2010-10-06
Rapporteur	**Technical Officer**		**Harmonized Standard**	
Mariana Goldhamer	Martin Arndt		No	

Title	Broadband Radio Access Networks (BRAN); Very high capacity density BWA networks; System architecture, economic model and derivation of technical requirements 1 Gig architecture
Scope and Field of Application	To address the architecture, the economic model and the requirements for a BWA system, proving 1Gb/s/km2, using 40MHz of licensed spectrum and including self-backhauling in both licensed and un-licensed bands, network MIMO, cognitive-radio based self-organization, etc.
Supporting Organizations	THALES, Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC

Annex 2: Cover of the published TR 101 534 standard

Below is reproduced the cover page of the ETSI standard TR 101 534.

ETSI TR 101 534 V1.1.1 (2012-03)

**Broadband Radio Access Networks (BRAN);
Very high capacity density BWA networks;
System architecture, economic model and
derivation of technical requirements**

Annex 3: Work Item on Protocols

Below is reproduced the Work Item content as appears in the ETSI database.

Details of 'DTR/BRAN-0040009' Work Item

Work Item Reference	ETSI Doc. Number	STF	Technical Body in Charge	Standard Not Ready For Download
DTR/BRAN-0040009	TR 101 589		BRAN	
Current Status (Click to View Full Schedule)	**Latest Version**	**Cover Date**	**Standstill**	**Creation Date**
Early draft (2012-06-07)	0.1.0			2012-02-09
Rapporteur	**Technical Officer**		**Harmonized Standard**	
Mariana Goldhamer	Martin Arndt		No	

Title	Broadband Radio Access Networks (BRAN); Very high capacity density BWA networks; Protocols 1Gig protocols
Scope and Field of Application	To describe the specific protocols for a system, providing 1Gb/s/km2, including self-backhauling in both licensed and license-exempt bands, cognitive-radio based self-organization, etc.
Supporting Organizations	THALES, Polska Telefonia Cyfrowa, ALVARION S.R.L., Siklu Communication Ltd., CTTC

Annex 4: Cover of the ETSI draft TR 101 589

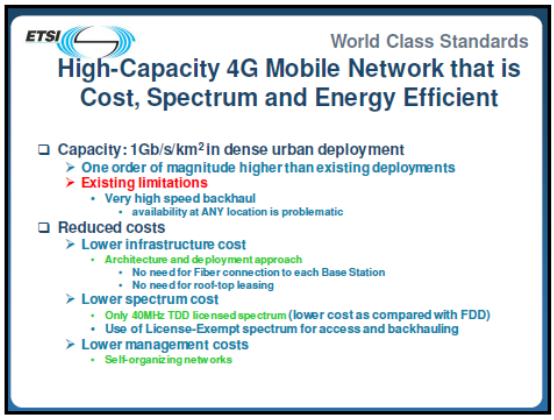
Below is reproduced the cover page of the ETSI draft standard TR 101 589.

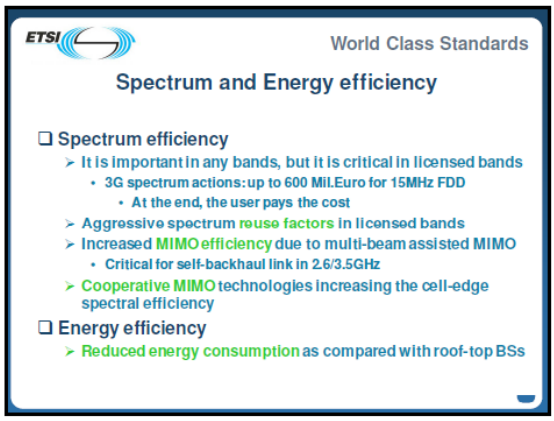
ETSI TR 101 589 V0.1.0 (2012-06)

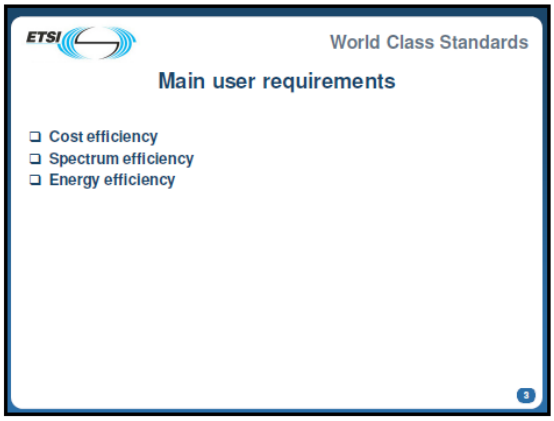
**Broadband Radio Access Networks (BRAN);
Very high capacity density BWA networks;
Protocols**

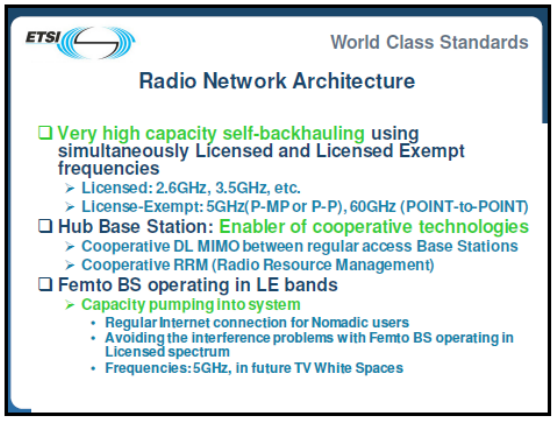
Annex 5: Supporting Presentation for the First WI Adoption

Below is reproduced the content of the supporting presentation for the first WI adoption in Oct. 2010 BRAN meeting.









ETSI World Class Standards

Radio Network Architecture - cont

- Pico BSs
  - For improved coverage in radio holes
- Mobile Station
  - Enabler of cooperative MIMO, by inter-MS communication
  - High DL and UL throughputenabled by multiple simultaneous connections to Access BS and Femto BS
- Direct communication
  - BS-BS, MS-MS
  - Enabler of network MIMO
  - Enabler of a number of vertical applications

7

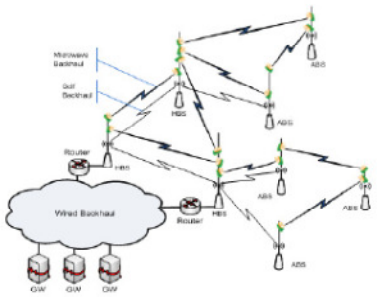
ETSI World Class Standards

Cognitive Radio and Network Technologies for Reduced Management

- Basis for a self-organizing network based on Cognitive Radio
- Examples of cognitive elements
  - Operation per network element (modulation& coding, SINR, MIMO matrix, etc.
  - Capacity and QoS (requested and achieved)
  - Channel availability, including potential operation channels in LE bands
  - Performance of interference avoidance algorithms for each network element
- Radio Resource Management
  - Algorithms and protocols
    - Maximization of the system capacity
    - Joint access and backhaul network optimization
      - Beneficial when the same spectrum is used for both
    - Interference control protocols, at medium access and network levels
    - Radio resource assignment, including frequency channels

ETSI World Class Standards

Radio Network Architecture - example



8

ETSI World Class Standards

Innovative Usage of Licensed, Unlicensed and Unused Radio Spectrum

- Market limitation: 40MHz licensed spectrum
- For comparison: IMT-Advanced spectrum request in ITU-R Report M.2078

TABLE 26

Ranges of predicted spectrum requirements (MHz)

a) Lower user density market development

	1 network (see Note 3)	2 networks (see Note 1)	3 networks (see Note 1)	4 networks (see Note 1)	5 networks (see Note 1)
RATG 1 (see Note 2)	800	880	840	1 120	1 000
RATG 2	480	560	720	800	1 000
RATG 1 + RATG 2	1 280	1 440	1 560	1 920	2 000

ETSI World Class Standards

Co-operative Technologies at Base Station

- MIMO operation
  - HBS – Hub for Control and Data traffic – essential architecture enabler of cooperation between ABSs
  - ABS: virtual MIMO network
    - Synchronization of DL MIMO operation
    - MIMO operation
- Radio resource "sharing" between ABSs
  - One ABS can release radio resource in licensed spectrum
    - Traffic characteristics
    - LE operation possible
- Joint backhaul – access design
- In-band Control Channel, connecting the HBS and ABSs

ETSI World Class Standards

Economic model

- Comparison of HSDPA+, over roof-top and Bungee, below roof-top
  - As calculated in BuNGee deliverable D1.1 per one km2
- BuNGee experience: most important influencing factors for reducing costs

System	CAPEX	OPEX /month
HSDPA+, optical fibre backhauling	2.989,500 €	63,507 €
HSDPA+, microwave backhauling	2.777,500 €	89,687 €
BuNGee	1.557,000 €	21, 240 €

WG HM Executive Summary

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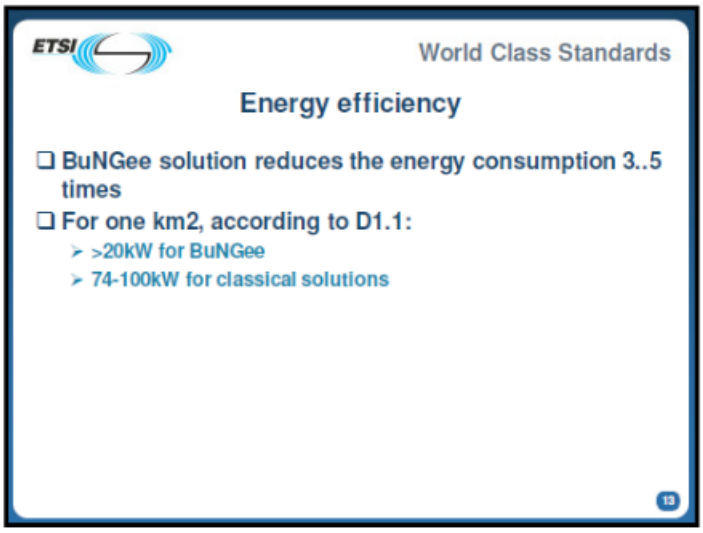
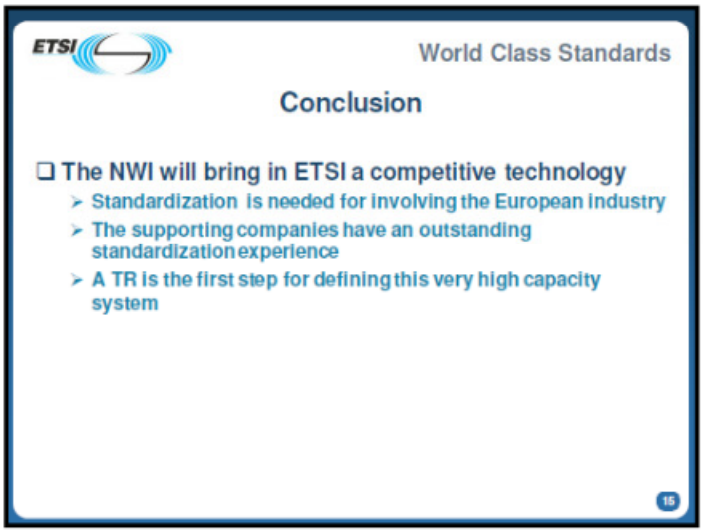
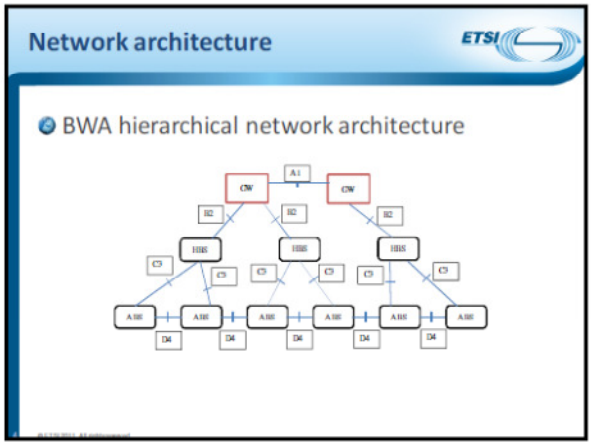
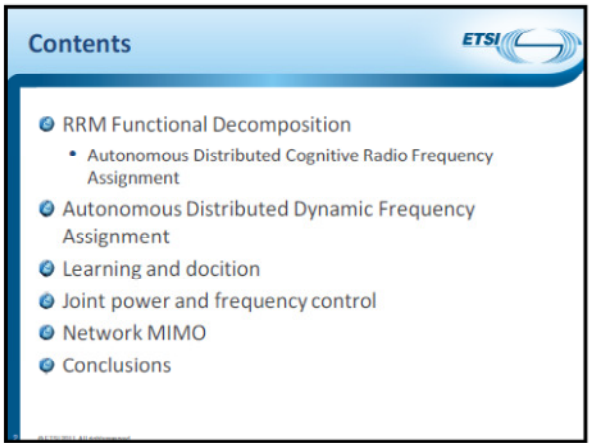

ETSI
World Class Standards
Energy efficiency
BuNGee solution reduces the energy consumption 3..5 times
For one km2, according to D1.1:
>20kW for BuNGee
74-100kW for classical solutions
13

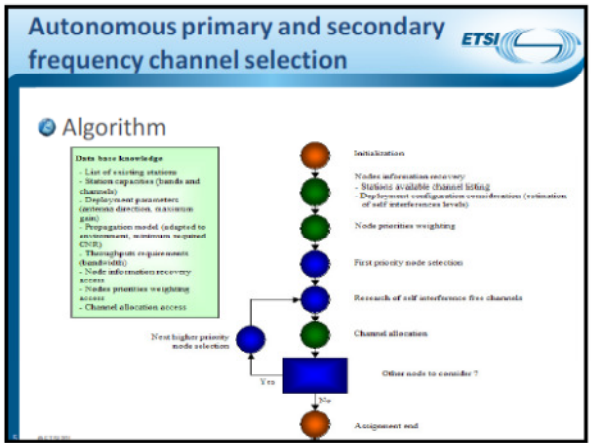

ETSI
World Class Standards
Technical requirements
To be detailed during the TR development
The main elements will be provided by BuNGee experience
Supporting WI companies
14

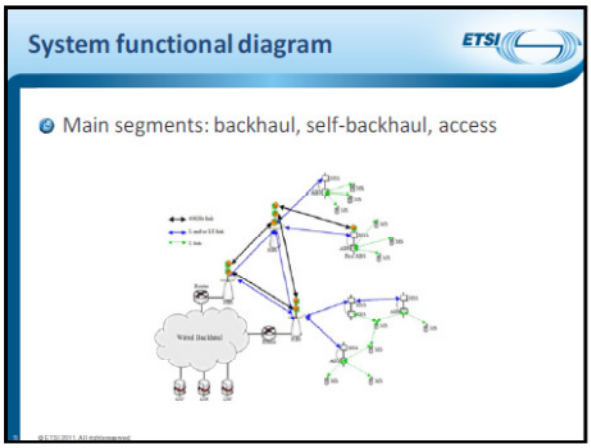

ETSI
World Class Standards
Conclusion
The NWI will bring in ETSI a competitive technology
Standardization is needed for involving the European industry
The supporting companies have an outstanding standardization experience
A TR is the first step for defining this very high capacity system
15

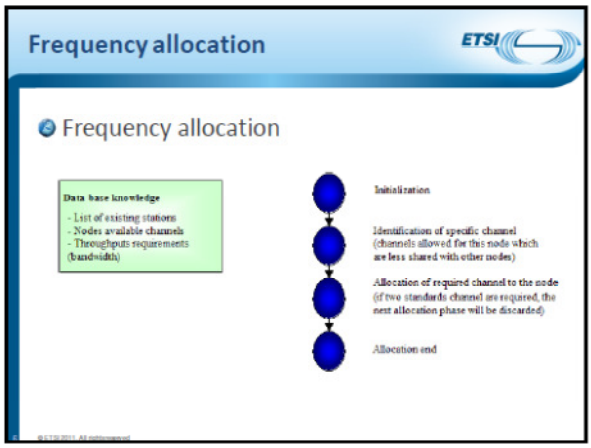
Annex 6: Supporting Presentation for the Protocols WI Adoption



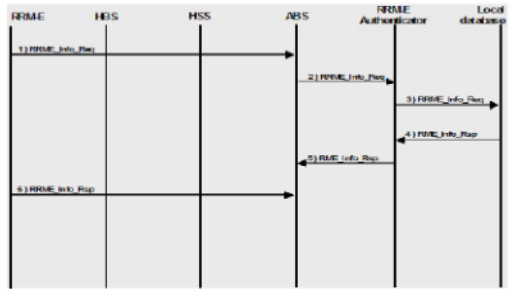






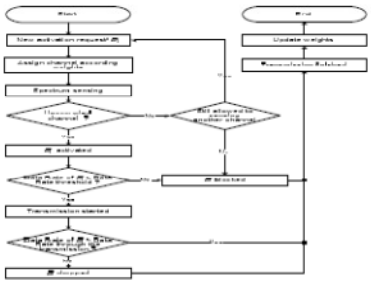


Information flow for ABS insertion



Autonomous Distributed Dynamic Frequency Assignment

- Learning based



Examples of protocol primitives

Message name	RRME_Info_Req	
Message purpose	Query RRM-related information from a node	
Trigger for the msg. generation	Triggered by the centralized RRM-E	
Source	Centralized RRM-E	
Destination	ABS	
List of Information Elements		
IE Name	M/O	Description
RRME_Id	M	The centralized RRME identifier to be recognised by ABSs
ABS Id	M	The identity of the station, which information is requested.
InformationKey	M	Bitmap indicating what information is requested

Message name	RRME_Info_Rsp	
Message purpose	Delivers RRM related information (such as deployment and capacity information) to the centralized RRME	
Trigger for the msg. generation	Triggered by an information request message (RRME_Info_Req)	
Source	ABS	
Destination	Centralized RRM-E	
List of Information Elements		
IE Name	M/O	Description
Status_Table	M	Contains ABSs deployment specificities (GPS location, antenna type and aiming direction), and RF capacities (available channels, output power, interferences levels if known)
Failure Indication	O	Failure indication providing the code of the corresponding error cause.

Primitives example

Message name	Transmission_REQ	
Message purpose	Indicates that new transmission is needed	
Trigger for the msg. generation	When either a downlink or a uplink transmission needs to be initiated	
Source	RRM entity in HBS,ABS, or MS	
Destination	RRM entity in targeted MS, ABS or HBS	
List Of Information Elements		
IE Name	M/O	Description
Transmitter_ID	M	Identifier of the entity sending the message
Receiver_ID	M	Identifier of the entity receiving the message
Subchannel_ID	O	Identifier of the selected subchannels for transmission. Only required for non-cognitive MS devices.
Weight Info	O	Used in Transmission_REQ sent from ABS to HBS to exchange learning information (weights of subchannels) between ABS and HBS. Includes Weight-vector values of the available subchannels.
Subchannel Info	O	Subchannels list used to notify ABS of the available subchannels. Included in Transmission_REQ message sent from HBS to ABS (HSS) and contains IDs of the available subchannels

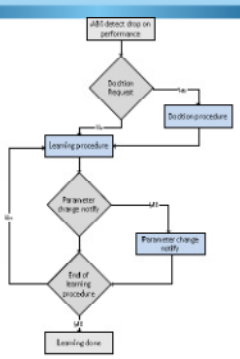
Message name	Transmission_ACK	
Message purpose	Acknowledges the Transmission_REQ and completes the service initiation process	
Trigger for the msg. generation	Transmission_REQ has been recieved	
Source	RRM entity in HBS,ABS, or MS	
Destination	RRM entity in MS, ABS or HBS	
List of Information Elements		
IE Name	M/O	Description
Transmitter_ID	M	Identifier of the entity sending the message
Receiver_ID	M	Identifier of the entity receiving the message
Subchannel_ID	M	Identifier of the selected subchannels for transmission.

Examples of protocol primitives - cont

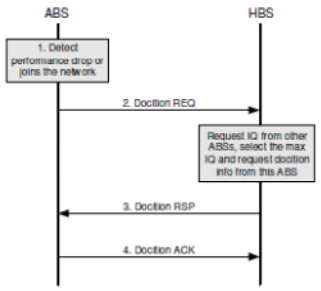
Message name	RRM_Insertion_Req	
Message purpose	Request for a new station insertion in the access network	
Trigger for the msg. generation	Triggered by the new node/ station activation	
Source	ABS	
Destination	Centralized RRM-E	
List of Information Elements		
IE Name	M/O	Description
ABS Id	M	The identifier of the ABS node
Deployment Topology Info	M	The information blob including parameters related to the station deployment (such as e.g. station location, antenna pattern direction and tilt, etc.)
ABS Authentication Extension	M	Authentication extension providing the capabilities for message source authentication and possibly providing other security means (such as message integrity protection and non-repudiation).

Message name	RRM_insertion_Ack	
Message purpose	Respond for the new station insertion request, providing the result of operation and the station operational parameters.	
Trigger for the msg. generation	Triggered by RRM_Insertion_Req message reception and request authentication transaction completion	
Source	Centralized RRM-E	
Destination	ABS	
List of Information Elements		
IE Name	M/O	Description
ABS Id	M	The identifier of the ABS node
RRME_Id	M	The centralized RRME identifier to be recognised by ABSs
Result Indication	M	Provides the result of the "Insertion" operation (success, failure).
RRM Config	O	Radio configuration parameters to be used by the station. It includes the list of the selected frequency channels available for local assignment.
Failure Indication	O	Failure indication providing the code of the corresponding error cause.

Flow diagram of learning and docition procedures



Docition procedure



Examples of primitives

Message name	Param_notify
Message purpose	Notifies the new sub-channel used by the ABS
Trigger for the msg. generation	When RRM entity of an ABS decides to change the sub-channel used for transmission.
Source	RRM entity in ABS
Destination	MS
List of information Elements	
IE Name	M/ O — Description
Sub_ch_Id	M — Identifier to indicate the new sub-channel in use

Message name	Param_ACK
Message purpose	Acknowledges the reception of the new parameters.
Trigger for the msg. generation	The reception of a Param_notify message.
Source	MS
Destination	RRM entity on the ABS
List of information Elements	
IE Name	M/ O — Description
	No IEs is required.

Examples of primitives

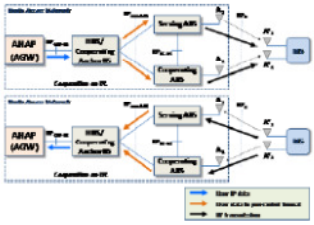
Message name	Docition_REQ
Message purpose	Indicates the HBS that ABS requires docition.
Trigger for the msg. generation	When an ABS starts up or detects a drop on performance and requires docition.
Source	RRM entity in ABS
Destination	RRM entity in Hub BS
List of information Elements	
IE Name	M/ O — Description
IQ Id	M — Indicates the type of IQ value required

Message name	Docition_INF_REQ
Message purpose	Once an HBS has collected IQ values from several ABSs and selected the ABS with max IQ value, an HBS requests the best ABS to send docitive info.
Trigger for the msg. generation	After evaluating the IQ values of the ABSs received in the IQ_RPRT messages.
Source	RRM entity in Hub BS
Destination	RRM entity in ABS
List of information Elements	
IE Name	M/ O — Description
Doc_Id	O — Indicates the type of docitive info required.

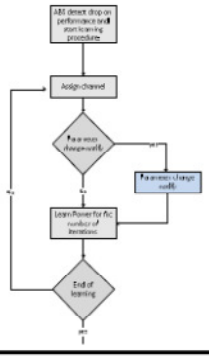
Message name	IQ_RPRT
Message purpose	An ABS reports its IQ value to the HBS
Trigger for the msg. generation	Triggered by receiving IQ_REQ message from HBS.
Source	RRM entity in ABS
Destination	RRM entity in Hub BS
List of information Elements	
IE Name	M/ O — Description
IQ	M — IQ value of the ABS
Failure indication	O — Failure indication providing the code of the corresponding error cause.

Network MIMO – Option 1

- HBS transmits/receives data to/from two ABSs

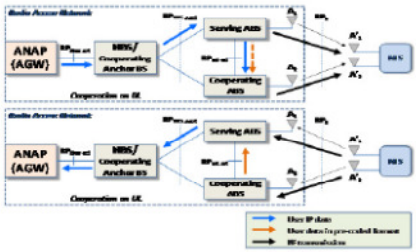


Joint power and frequency control



Network MIMO-Option 2

- HBS transmits/receives data to/from one ABS



N-MIMO Primitive examples

Message name	Cooperation trigger report	
Message purpose	Provides the cooperation event notification – either cooperation start, modify or terminate.	
Trigger for the msg. generation	RRM entity of an ABS detects conditions for cooperation state change	
Source	RRM entity in ABS	
Destination	Remote RRM entity (e.g. HBS RRM)	
List of Information Elements		
IE Name	M/ O	Description
MS ID	M	Technology-specific MS or UE identity
ABS ID	M	The identity of the MS' Serving ABS station.
Event Indicator	M	Indicates the cooperation event triggering the transaction – either: • Start cooperation, • Modify cooperation, or • Terminate cooperation.
Potential C-BS List	O	The list of potential Cooperating BSs as per MS scanning report available in ABS. Must be included in Cooperation Trigger Rprt message with Event Indicator set to either start or modify.
Next period Scheduling info	O	Serving ABS scheduling info for the MS in the next period. Used by HBS and potential cooperating BSs to perform MS' transmission strength estimation on UL.

N-MIMO Primitive examples - cont

Message name	Channel estimation acknowledge	
Message purpose	Provides the cooperation event notification – either cooperation start, modify or terminate.	
Trigger for the msg. generation	RRM entity of an ABS detects conditions for cooperation state change	
Source	RRM entity in ABS	
Destination	Remote RRM entity (e.g. HBS RRM)	
List of Information Elements		
IE Name	M/ O	Description
MS ID	M	Technology-specific MS or UE identity.
Source RRM ID	M	Identity of the RRM entity sending the response and channel estimation information.
Result Code	M	Result code of the requested operation: • Successful; • Failure.
Failure Indication	O	Error code for the requested operation. Mandatory, if Result Code = Failure.
Channel Estimation Info	O	Information blob including ABS-MS radio channel estimation parameters. One of the "child" TLVs must be present. Must be present if the Result Code of the operation = "Successful".
➢ RSSI	O	The estimated signal RSSI
➢ CINR	O	The estimated signal CINR

N-MIMO Primitive examples - cont

Message name	Cooperation trigger ACK	
Message purpose	Provides the cooperation event notification – either cooperation start, modify or terminate.	
Trigger for the msg. generation	RRM entity of an ABS detects conditions for cooperation state change	
Source	RRM entity in ABS	
Destination	Remote RRM entity (e.g. HBS RRM)	
List of Information Elements		
IE Name	M/ O	Description
MS ID	M	Technology-specific MS or UE identity
ABS ID	M	The identity of the MS' Serving ABS station.
Event Indicator	M	Indicates the cooperation event triggering the transaction – either: • Start cooperation, • Modify cooperation, or • Terminate cooperation.
Potential C-BS List	O	The list of potential Cooperating BSs as per MS scanning report available in ABS. Must be included in Cooperation Trigger Rprt message with Event Indicator set to either start or modify.
Next period Scheduling info	O	Serving ABS scheduling info for the MS in the next period. Used by HBS and potential cooperating BSs to perform MS' transmission strength estimation on UL.

Conclusions

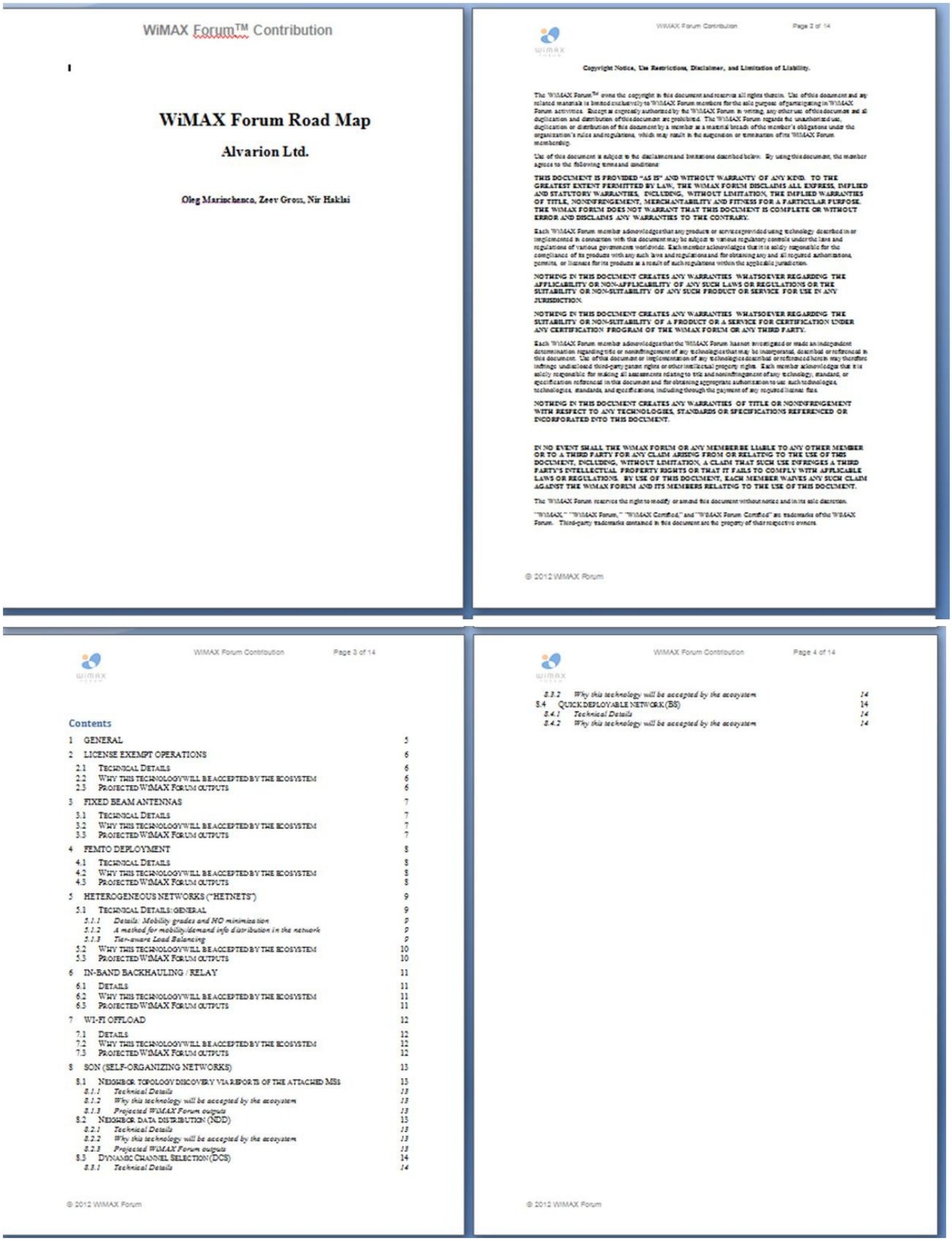
- This presentation contains novel protocols, targeting the operation of the system described in draft TR 101 534
  - It is proposed a NWI targeting the inclusion of such protocols in a Technical Report
  - The work is supported by 5 ETSI companies

N-MIMO Primitive examples - cont

Message name	Channel estimation request	
Message purpose	Provides the cooperation event notification – either cooperation start, modify or terminate.	
Trigger for the msg. generation	RRM entity of an ABS detects conditions for cooperation state change	
Source	RRM entity in ABS	
Destination	Remote RRM entity (e.g. HBS RRM)	
List of Information Elements		
IE Name	M/ O	Description
MS ID	M	Technology-specific MS or UE identity
ABS ID	M	The identity of the MS' Serving ABS station.
Event Indicator	M	Indicates the cooperation event triggering the transaction – either: • Start cooperation, • Modify cooperation, or • Terminate cooperation.
Potential C-BS List	O	The list of potential Cooperating BSs as per MS scanning report available in ABS. Must be included in Cooperation Trigger Rprt message with Event Indicator set to either start or modify.
Next period Scheduling info	O	Serving ABS scheduling info for the MS in the next period. Used by HBS and potential cooperating BSs to perform MS' transmission strength estimation on UL.

Annex 7: Contribution to WiMAX Forum

This contribution proposed introduction of BuNGee-essential technical topics as a part of WiMAX technology Road Map.



WiMAX Forum™ Contribution

WiMAX Forum Road Map

Alvarion Ltd.

Oleg Marinchenco, Zeev Gross, Nir Haklai

WiMAX Forum Contribution Page 2 of 14

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1 General

This contribution was submitted in response to call for contributions RMP-TCC-11-00000000 by the TCC. It is suggesting several possible items for WiMAX technology Road Map for 2011-2012.

2 License exempt operations

The proposal is standardize operations of WiMAX network at license exempt frequency channels. It can be 802.16h or WiMAX Forum may initiate development of a new standard.

2.1 Technical Details

This technology should include special arrangements for interference mitigation.

2.2 Why this technology will be accepted by the ecosystem

Extends existing market which currently is for licensed bands only.

2.3 Projected WiMAX Forum outputs

Stage 1 (Recommendations) liaison to IEEE and/or specifications.

3 Fixed beam antennas

3.1 Technical Details

Create multiple narrow beams to improve the frequency reuse; enables new deployment schemes.

3.2 Why this technology will be accepted by the ecosystem

This technology will provide for more aggressive frequency reuse. May need new types of ICIC.

3.3 Projected WiMAX Forum outputs

In case when some standardization is needed, Stage 1 (Recommendations) liaison to IEEE or specifications. Otherwise a White Paper.

4 Femto deployment

4.1 Technical Details

Mass deployment of low power low cost in-door BSs, typically deployed by users, both 16e and 16m.

4.2 Why this technology will be accepted by the ecosystem

Capacity increase with higher frequency reuse; deployment cost reduction; mitigation of the out-door to in-door penetration problem.

4.3 Projected WiMAX Forum outputs

Some standardization will be needed for 16e air interface and for the legacy network and possibly additional standardization for 16m air interface and the network.
Stage 1 - 3 specifications, cooperation with IEEE.

5 Heterogeneous Networks ("HetNets")

5.1 Technical Details: general

For example, it can be an overlay to a regular out-door macro deployment, with mass of Micro / Pico BSs. Out-door deployment by the operator which is different from Femto which is normally deployed in-door and by a customer

5.1.1 Details: Mobility grades and HO rate optimization

The feature's purpose is to provide an MS velocity estimation to adjust the HO rate to the density of the Base Stations in the area.

The BS may use various types of velocity estimators using both MAC (e.g. past HO or sojourn time) and PHY (e.g. RSSI/CINR change rate) estimation methods. In addition to the local estimation the system may need to have a centralized module providing an over all look of a wider area and a more accurate diagnostic.

The BSs shall constantly monitor the deployment's users, choosing the appropriate estimator for each user, determine user's velocity level and advertise that info to the relevant entities.

When deploying a hierarchical cell structure (HCS) type of deployment users are typically assigned to tiers according to their mobility characteristics, for example, highly mobile users are typically assigned to macro-BSs whereas stationary users are assigned to Pico-BSs. Thus, the decision where to assign which user is based on the mobility-level of the user.

The suggested mobility estimation mechanism provides an accurate estimation of the user's mobility-level.

5.1.2 A method for mobility/demand info distribution in the network

The mechanism distributes multi-tier related info to the NW elements for the purpose of optimization and high NW utilization, the mechanism includes the following main functionalities:

- A mechanism that constructs and keeps the list of entities (to which the data is distributed) updated (for example, list may be constructed according to entity location or the direction the MS is heading)
- Once the distribution list is ready, an advertising decision mechanism is in-charge of triggering an advertisement (data may be distributed in a pull or push manner)
- Actual data distribution is via R6/8

In order to maximize multi-tier's deployments capacity and minimize service disruption it is essential that the tier assignment mechanism shall have a wide-overall picture of the whole deployment. Hence, a well calibrated multi tier deployment needs to have a method to enable distribution of data that is relevant for tier assignment.

5.1.3 Tier-aware Load Balancing

The mechanism shall be in-charge of collecting and distributing all data that is relevant for LB, taking into consideration users and different tiers characteristics (data collection requires tailor-made messages and distribution protocol). The collected data will be used for assessing the need for resource directing and MS shifting (considering multi-tier aspects). Part of it is that the nodes are informed to which tier every BS belongs

Load balancing is needed for system performance optimization. When the deployment includes different types of BSs and different tiers, the issue of resource sharing, HO metrics, timing and protocols becomes a complex issue. Therefore, there's a need to define a LB scheme that takes into consideration HO metrics due to different frequency reuse scheme, different sizes cells (i.e. DL EIRP), cell barring for hierarchical setup, etc.

5.2 Why this technology will be accepted by the ecosystem

Capacity increase based on more aggressive frequency reuse.

5.3 Projected WiMAX Forum outputs

Some standardization will be needed for air interface and possibly for the network

6 In-band backhauling / Relay

6.1 Details

WiMAX network with backhaul which is based also on WiMAX technology and operates at the same frequency channel. Can be used in heterogeneous deployments e.g. backhaul P2P links above rooftops and Pico BSs below rooftops. Can be based on subset of 16j, possibly with some modifications

6.2 Why this technology will be accepted by the ecosystem

Deployment cost reduction

6.3 Projected WiMAX Forum outputs

Some standardization will be needed for 16e air interface and for the network and possibly additional standardization for 16m air interface.
Stage 1 - 3 specifications, cooperation with IEEE.

7 Wi-Fi Offload

7.1 Details

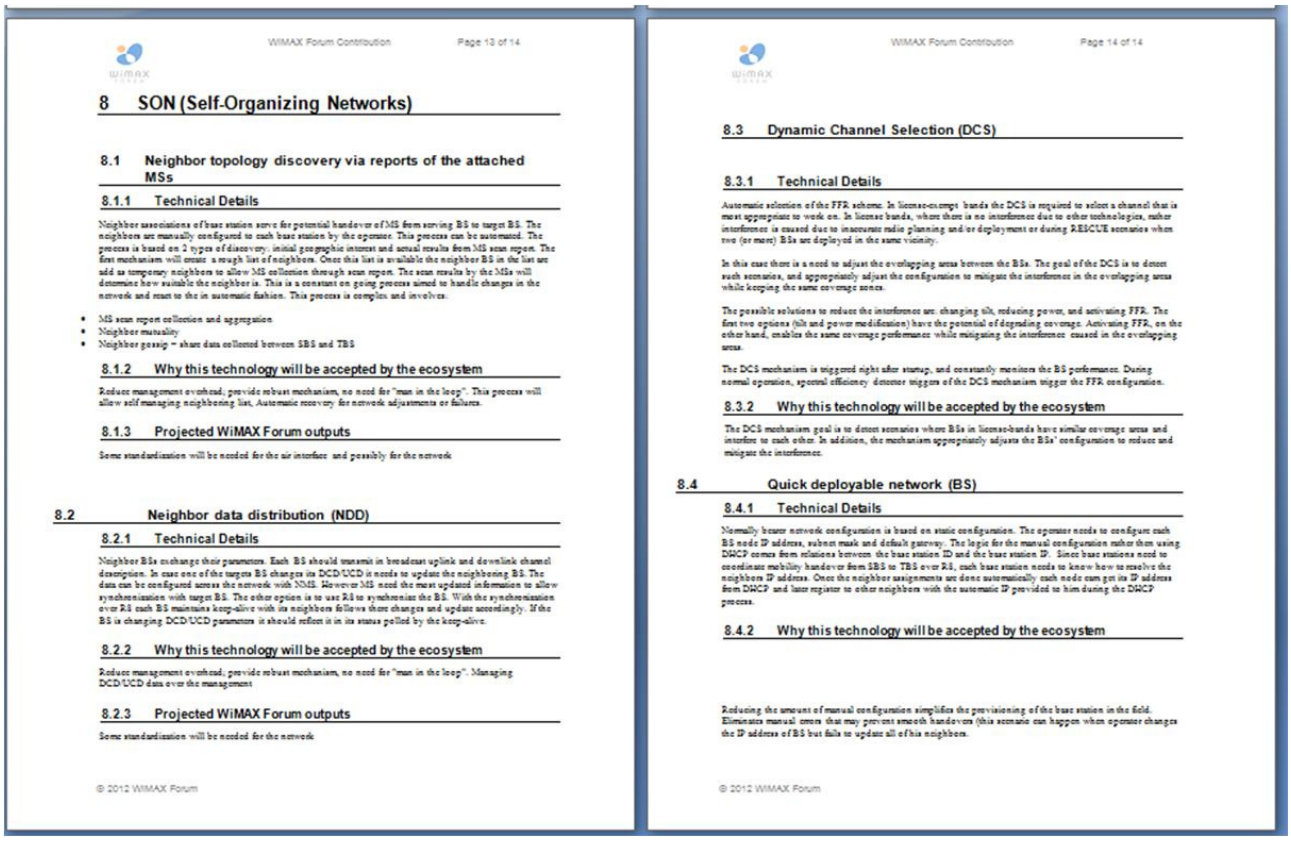
For dual mode WiMAX/Wi-Fi terminals Offload data traffic from cellular frequency band to in-door or out-door Wi-Fi APs

7.2 Why this technology will be accepted by the ecosystem

Data offload from the cellular network, in-door and out-door.
Deployment cost reduction, fighting capacity crunch problem, in case of in-door deployment mitigation of the wall penetration problem.

7.3 Projected WiMAX Forum outputs

Some standardization may be needed for the air interface and for the network to provide for seamless switching / HO between the cellular network and the Wi-Fi network in case of Idle state, HO.
Stage 1 - 3 specifications, cooperation with IEEE.



8 SON (Self-Organizing Networks)

8.1 Neighbor topology discovery via reports of the attached MSs

8.1.1 Technical Details

Neighbor associations of base station serve for potential handover of MS from serving BS to target BS. The neighbors are manually configured to each base station by the operator. This process can be automated. The process is based on 2 types of discovery, initial geographic interest and actual results from MS scan report. The first mechanism will create a rough list of neighbors. Once this list is available the neighbor BS in the list are add as temporary neighbors to allow MS collection through scan report. The scan results by the MSs will determine how suitable the neighbor is. This is a constant on going process aimed to handle changes in the network and react to the in automatic fashion. This process is complex and involves:

- MS scan report collection and aggregation
- Neighbor mutuality
- Neighbor gossip – share data collected between SBS and TBS

8.1.2 Why this technology will be accepted by the ecosystem

Reduce management overhead, provide robust mechanism, no need for "man in the loop". This process will allow self managing neighboring list, Automatic recovery for network adjustments or failures.

8.1.3 Projected WiMAX Forum outputs

Some standardization will be needed for the air interface and possibly for the network

8.2 Neighbor data distribution (NDD)

8.2.1 Technical Details

Neighbor BSs exchange their parameters. Each BS should transmit in broadcast uplink and downlink channel description. In case one of the targets BS changes its DCD/UCD it needs to update the neighboring BS. The data can be configured across the network with NMS. However MS need the most updated information to allow synchronization with target BS. The other option is to use R4 to synchronize the BS. With the synchronization over R4 each BS maintains keep-alive with its neighbors follows there changes and update accordingly. If the BS is changing DCD/UCD parameters it should reflect it in its status polled by the keep-alive.

8.2.2 Why this technology will be accepted by the ecosystem

Reduce management overhead, provide robust mechanism, no need for "man in the loop". Managing DCD/UCD data over the management

8.2.3 Projected WiMAX Forum outputs

Some standardization will be needed for the network

8.3 Dynamic Channel Selection (DCS)

8.3.1 Technical Details

Automatic selection of the FFR scheme. In license-exempt bands the DCS is required to select a channel that is most appropriate to work on. In license bands, where there is no interference due to other technologies, rather interference is caused due to inaccurate radio planning and/or deployment or during RESCUE scenarios when two (or more) BSs are deployed in the same vicinity.

In this case there is a need to adjust the overlapping areas between the BSs. The goal of the DCS is to detect such scenarios, and appropriately adjust the configuration to mitigate the interference in the overlapping areas while keeping the same coverage zones.

The possible solutions to reduce the interference are: changing tilt, reducing power, and activating FFR. The first two options (tilt and power modification) have the potential of degrading coverage. Activating FFR, on the other hand, enables the same coverage performance while mitigating the interference caused in the overlapping areas.

The DCS mechanism is triggered right after startup, and constantly monitors the BS performance. During normal operation, spectral efficiency detector triggers of the DCS mechanism trigger the FFR configuration.

8.3.2 Why this technology will be accepted by the ecosystem

The DCS mechanism goal is to detect scenarios where BSs in license-bands have similar coverage areas and interfere to each other. In addition, the mechanism appropriately adjusts the BSs' configuration to reduce and mitigate the interference.

8.4 Quick deployable network (BS)

8.4.1 Technical Details

Normally busser network configuration is based on static configuration. The operator needs to configure each BS node IP address, subnet mask and default gateway. The logic for the manual configuration rather than using DHCP comes from relations between the base station ID and the base station IP. Since base stations need to coordinate mobility handover from SBS to TBS over R8, each base station needs to know how to resolve the neighbors IP address. Once the neighbor assignments are done automatically each node can get its IP address from DHCP and later register to other neighbors with the automatic IP provided to him during the DHCP process.

8.4.2 Why this technology will be accepted by the ecosystem

Reducing the amount of manual configuration simplifies the provisioning of the base station in the field. Eliminates manual errors that may prevent smooth handovers (this scenario can happen when operator changes the IP address of BS but fails to update all of his neighbors.

8 Release History

This page is used to follow the deliverable production.

Release number	Date	Comments	Dissemination of this release
1.0.0	04.07.2011	Reviewed document	Public
1.1.0	08.07.2011	Mistaken in 2.2.2 fixed	Public