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Technical Report

3rd Generation Partnership Project;
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A GLOBAL INITIATIVE

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Contents

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

VAMOS has been specified as a Rel-9 feature and was expected to theoretically double the voice capacity of GERAN per BTS transceiver. Capacity gains of VAMOS have however been seen from system level simulations to vary significantly depending on the frequency load of the network. In networks with relatively high frequency load the possible system capacity increase brought by VAMOS could thus result in degraded call quality.

Call quality in the network may rely upon factors which were not modelled/covered in the MUROS study, such as radio resource management and interference coordination/mitigation mechanisms. Hence it is desirable to explore standardization ways in these and/or other possible areas to optimize the call quality of VAMOS networks.

1 Scope

The present document contains the results from the 3GPP study item on VAMOS Enhancements. This includes study of the following aspects:

- Objectives of the study.
- Common assumptions for the evaluation of candidate techniques.
- Candidate techniques including those that utilize network synchronization, and further those that use inter-cell interference coordination/mitigation and inter-cell channel state sharing in and between BSS. A candidate technique shall support frequency hopping.
- Evaluations of candidate techniques based on the objectives.

VAMOS enhancements will also investigate a new logical interface between BSSs in A/Gb mode which applies to control plane only and can be utilised by VAMOS enhancement solutions, since no logical interface between BSSs in A/Gb mode exists in current specifications.

2 References

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

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

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TR 41.001: "GSM Release specifications".

[3] 3GPP TR 45.914: "Circuit Switched Voice Capacity Evolution for GERAN".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Editor's note: to be added

3.2 Symbols

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

Editor's note: to be added

3.3 Abbreviations

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

MUROS	Multi-User Reusing One Slot
VAMOS	Voice services over Adaptive Multi-user Channels on One Slot
RRM	Radio Resource Management

4 Objectives

4.1 Performance Objectives

4.1.1 Improved Call quality

The ENHVAMOS candidate techniques shall improve the call quality of both paired and non-paired mobiles in a VAMOS network.

4.2 Compatibility Objectives

4.2.1 Impacts to the Core Network

No implementation impacts shall be required for the core network. Any increase of signalling load on the A interface should be avoided.

4.2.2 Impacts to the BSS

No implementation impacts shall be required for the BTS and BSC hardware. Additional complexity in terms of processing power and memory should be kept to a minimum for the BSC.

4.2.3 Impacts to Mobile Stations

No implementation impacts shall be required for mobile stations.

4.2.4 Impacts to Network Planning

The study shall take into consideration the dependency of the gains of an ENHVAMOS candidate technique upon factors like frequency reuse, frequency hopping mode (i.e., baseband hopping or synthesized hopping) , and level of air interface synchronization etc.

5 Common Assumptions for Candidate Evaluation

5.1 General

The common working assumptions for the performance evaluation of ENHVAMOS candidate techniques shall be aligned with subclause 5 of the MUROS TR [3], except those explicitly listed in the following subclauses.

5.2 Air Interface Synchronization

For a candidate technique which requires network synchronization as a precondition, the system level performance should be evaluated in synchronous network mode. Otherwise the system level performance should be evaluated in both synchronous network mode and asynchronous network mode.

A candidate technique should indicate the level of synchronization it relies on, e.g. frame-based or multiframe-based, and possibly the dependency of the gains on the synchronization accuracy.

5.3 Definition of Model for External Interferers for Link Level Evaluations in Synchronous Network Mode

The link performance per each ENHVAMOS candidate technique shall be specified for the synchronous interferer scenarios defined in the MUROS TR [3] (i.e. MTS-1 and MTS-2), and in addition the following synchronous interferer scenarios:

a) for a new EVTS-1 (ENHVAMOS test) scenario with synchronous interferer.

Table 5-1: ENHVAMOS Test Scenario 1 (EVTS-1) with single synchronous interferer

Reference Test Scenario	Interfering Signal	Interferer relative power level	TSC	Interferer Delay range
1) EVTS-1	1) Co-channel 1	1) 0 dB	1) TBD	1) No delay

whereby Co-channel 1 is either GMSK or AQPSK modulated.

Interference performance shall be based on C/I for single external cochannel inteferer, where C is related to the total power of the received VAMOS signal (i.e. carrying two VAMOS subchannels) and I to the received power of the single external cochannel interferer.

b) for a new EVTS-2 (ENHVAMOS test) scenario with multiple synchronous interferers.

Table 5-2: ENHVAMOS Test Scenario 2 (EVTS-2) with multiple synchronous interferers

Reference Test Scenario	Interfering Signal	Interferer relative power level	TSC	Interferer Delay range
1) EVTS-2	1) Co-channel 1 2) Co-channel 2 3) Adjacent 1 4) AWGN	1) 0 dB 2) -10 dB 3) 3 dB 4) -17 dB	1) TBD 2) TBD 3) TBD 4) -	1) No delay 2) No delay 3) No delay 4) -

whereby Co-channel 1, Co-channel 2 and Adjacent 1 is either GMSK or AQPSK modulated. Only configurations, where all interferers are using the same modulation type, are considered.

Interference performance shall be based on C/I1 for multiple external cochannel inteferers, where C is related to the total power of the received VAMOS signal (i.e. carrying two VAMOS subchannels) and I1 to the received power of the dominant external cochannel interferer.

5.4 Definition of Model for External Interferers for Link Level Evaluations in Asynchronous Network Mode

The link performance per each ENHVAMOS candidate technique shall be specified for the asynchronous interferer scenarios defined in the MUROS TR [3] (i.e. MTS-3 and MTS-4).

5.5 Interference Measurement and Recording

5.5.1 Uplink Measurement

For the BTS the same measurement period as for the MS is assumed. RXQUAL and RXLEV are measured.

If a candidate technique utilizes interference measurements on the UL, then this shall be realistically modeled.

5.5.2 Number of Reported Cells

The definition of the number of reported cells is TBD.

The BA list shall be modeled if it is used to determine reported cells.

If the BA list is adapted by a candidate technique then this shall be modeled. The impact of such an adaptation on handover is expected to be seen in the speech quality.

Editor's note: Operator and MS vendor input might be needed on the important scenarios and the penetration of MS supporting EMR, and on whether EMR could be utilized during call setup.

5.5.3 Definition of Call Set-up Phase

The maximum call set-up phase is defined as 3 seconds.

5.5.4 BCCH Carrier Measurements

The BCCH carrier measurement shall be modeled by re-using the approach defined in subclause 6.5.1.2, 6.5.2 and 6.5.3 of 3GPP TR 45.926 for the MS in connected mode. Only CS services are assumed on the BCCH carrier.

The backoff used in simulations shall be declared.

5.6 Network Configurations

5.6.1 Information Sharing at RRM Level

Three levels of information sharing are defined:

a) Level 1, where no information sharing is applied.

b) Level 2, where information sharing is applied only within the BSSs.

c) Level 3, where information sharing is applied in and between the BSSs.

5.6.2 Simulation Scenarios

The reference case shall be based on MUROS-1, MUROS-2 and MUROS-3 defined in the MUROS TR [3].

If a candidate technique relies on network synchronization, it shall be evaluated against information sharing level 2 and level 3.

5.6.3 BSC Area and Inter-BSC Information Exchange

To model the BSC area one BSS-to-BSS border is defined. The number of cells next to the BSS-to-BSS border and the total number of simulated cells shall be declared.

To model the information exchange between BSCs, an inter-BSC connection should be defined. This is done in a vendor specific way, but the assumptions on the inter-BSC connection shall be declared. Such assumptions shall cover parameters e.g. delay, bandwidth and reliability.

It is expected that the ENHVAMOS study as an output will give recommendation on the above mentioned parameters.

5.6.4 Impact on TCH FER due to Handover

The impact on traffic channel FER due to handover should be taken into account for both downlink and uplink, in a vendor specific way.

5.7 Link-to-System Mapping

Re-use of the L2S mappings that were generated during the MUROS study (see section 5.7 of the MUROS TR [3]) is allowed.

In the case of network synchronization the following is taken into consideration:

a) If dynamic TSC planning methods are utilized then impact from carrier and interferer TSC cross correlation combinations on interference shall be modeled.

b) Otherwise an average impact (+/-) from TSC cross correlation shall be modeled.

Editor's note: The modeling can be done in a vendor specific manner. The verification procedure is TBD.

5.8 System Performance Evaluation Method

Two system performance evaluation methods are defined:

a) To evaluate the system performance of an ENHVAMOS candidate technique in terms of capacity gains, the system performance evaluation method defined in section 5.5 of the MUROS TR [3] is re-used.

b) To evaluate the system performance of an ENHVAMOS candidate technique in terms of call quality improvements,

b1) the system is first loaded with the usage of VAMOS but without the usage of the ENHVAMOS candidate technique until the minimum call quality performance is not any more ensured. This is treated as the reference case.

b2) the system is then loaded with the usage of both VAMOS and the ENHVAMOS candidate technique, and with the same amount of traffic as the above reference case.

b3) the system performance of the ENHVAMOS candidate technique in terms of call quality improvement is then calculated by the decrease of the median level in the CDF of average call FER.

The evaluation should be done in such a way that switching between non-VAMOS and VAMOS channel modes based on vendor specific channel mode adaptation thresholds shall be optimized for each channel mode adaptation type and in addition for each network configuration as specified in Table 5-8 and Table 5-9 of the MUROS TR [3].

Editor's note: the definition of system performance evaluation method is open for further discussion.

5.9 Signalling Aspects

For any candidate technique the evaluation should include the impacts to the signalling loads over any affected interface between network elements. Such impacts should be taken into account when comparing candidate techniques.

6 Candidate Solutions

6.1 Coordinated Channel Allocation for VAMOS

6.1.1 Concept Description

In a synchronized GSM network where timeslots are aligned, interferers to a given traffic channel are limited to those sharing the same timeslot number. So if the channel occupancy information in all interfering cells is known by the BSC, it will be possible for the BSC to enumerate all interferers. Further if additional information like transmission power of each interferer and relating pathloss can also be obtained or estimated, the BSC will be able to derive the C/I of that traffic channel. The estimated C/I reflects the quality of a traffic channel, so it is very useful to the RRM, especially the channel allocation algorithms.

When a traffic channel needs to be assigned as the result of call setup or handover, a “required C/I” is first determined based on factors like the mobile station’s capability (e.g. whether it supports DARP Phase I) and the chosen voice codec etc. The C/I of each idle traffic channel is then evaluated and a decision is made to choose a suitable traffic channel among those satisfying the ‘required C/I”.

It should be noted that the C/I estimation should take into consideration whether the corresponding idle traffic channel, once allocated, will be in VAMOS mode or non-VAMOS mode.

As the interferers to a given traffic channel may come from cells managed by different BSCs, for the above idea to work it is required for BSCs to exchange information, like TRX and timeslot configurations and channel occupancy etc, in neighbouring cells belonging to each other.

The C/I estimation applies to both downlink and uplink, and is for users both in VAMOS mode and non-VAMOS mode.

6.1.2 Frequency Hopping

Frame-based synchronization (i.e. the TDMA frame number, FN, of each cell may not be aligned) is assumed. As FN is an input parameter in hopping sequence generation, it is required for the BSC to know the FNOFFSET between any two cells having overlapping MAs.

With random frequency hopping (HSN$\neq$0), the interfering relationship between two hopping sequences “randomly” changes at TDMA frame level, whereas with cyclic frequency hopping (HSN=0), the interfering relationship is deterministic. To ease the interference estimation effort it is assumed here that cyclic frequency hopping is always used.

For example if the serving cell and the interfering cell share the same MA, and there is a traffic channel using MAIO1 in the serving cell and another traffic channel using MAIO2 in the interfering cell, and if the equation

$$(FNOFFSET + MAIO1)\%N = MAIO2$$

holds, then the interference type is CCI.

When evaluating the C/I of an idle traffic channel, the BSC traverses all possible MAs and MAIOs configured for the corresponding TRX and calculate the C/I for each (MA, MAIO) combination. This is also done for all other idle traffic channels and finally the most suitable (TRX, TSL, MA, MAIO) combination is identified in terms of C/I.

6.1.3 Estimation of Pathloss

The pathloss from one cell to another can be roughly estimated by reusing the neighbor cell measurement results which have been widely employed for handover and power control purposes in today’s BSCs. Figure 1 illustrates the downlink case, where the mobile station in dedicated mode reports the RXLEV of neighbor cell B to the base station, so the BSC can derive a pathloss sample from cell B to cell A by

$$PathlossDL\_BA = BsPwr\_B - RxLev\_B$$

where BsPwr_B is the transmission power of the BCCH TRX in cell B.

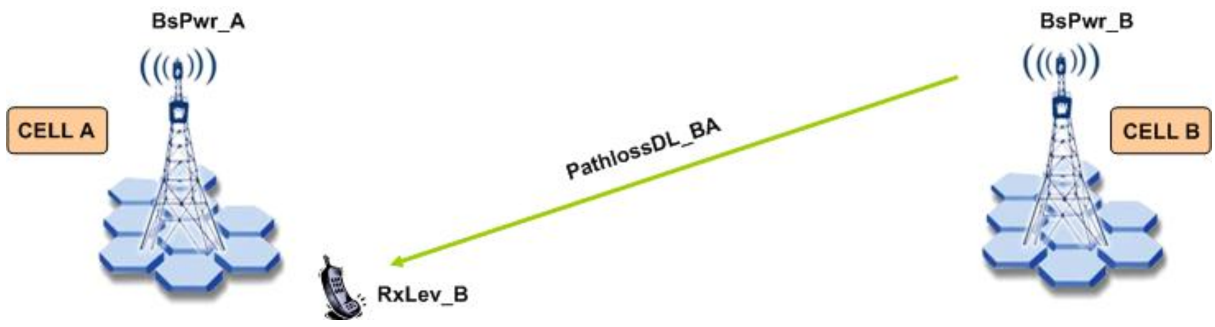

Figure 6-1 Pathloss estimation by means of neighbor cell measurements

The BSC maintains a pathloss database where for a given cell the pathloss from any interfering cell is stored and can be retrieved whenever needed.

The reported RXLEV for cell B may vary to some extent in different MR samples. The BSC may store a filtered (e.g. running average of) pathloss in the pathloss database.

It should be noted that the BA list in dedicated mode are normally configured for handover purpose, so chances are it does not cover any of the interfering cells. To allow sampling the RXLEV of interfering cells, the BSC should take these cells into consideration when generating the dedicated mode BA list.

With normal measurement reports the number of reported RXLEVs is 6, which may not be sufficiently large to include those of interfering cells of interest. But this is not believed to be a big problem, as the pathloss database stores long-term estimates of pathlosses between interfering cells, so it does not require having relevant RXLEV samples in every MR sample.

If there exists mobile stations that support EMR, more cells can be reported by such mobiles, thus it is easier for the BSC to build up the pathloss database.

6.1.4 Estimation of C/I

The “C/I” of an idle traffic channel here is the C/I of that channel assuming it has been assigned to a mobile station. The BSC knows exactly the initial power that will be assigned to that channel so there is a “C” even for an idle traffic channel. (Note that this is not the C/I as perceived by the mobile station)

The interference strength is obtained by subtracting the transmission power of the interferer and the estimated pathloss from the interfering cell to the serving cell. The “I” is then calculated by applying the relating attenuation factor to each interferer (assuming for instance GMSK CCI as the reference) before taking the sum.

When a VAMOS pair acts as an interference source, in downlink it can be modeled as one interferer with the modulation type set to AQPSK, and in uplink it can be viewed as comprising two separate GMSK modulated interferers.

6.1.5 Channel Allocation

The selection of a radio channel for TCH assignment is based on the CIR estimation for both downlink and uplink.6.1.6 Inter-BSC Information Exchange

As mentioned above, to allow accurate estimation of C/I, two BSCs managing mutually interfering cells need to exchange cell configuration and call information of the affected cells.

Cell configuration information should include e.g. the transmission power of all active timeslots, the MA configuration, and TRX and timeslot configuration etc.

The information for each ongoing call should include e.g. the MA, MAIO, speech codec, and the MS capability etc.

7 Link Level Studies

Editor's note: details to be added.

8 System Level Studies

Editor's note: details to be added.

Annex A: Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2011-08	3GPP GERAN #51	GP-111128			Initial version with skeleton, input to TSG GERAN#51		0.0.1
2011-08	3GPP GERAN #51	GP-111477			Version composed for the closing plenary of 3GPP GERAN#51. Inclusion of working assumptions agreed at TSG GERAN#51 during WG1 and WG2 sessions on ENHVAMOS.	0.0.1	0.1.0
2011-10	3GPP GERAN telco#1 on ENHVAMOS				Version composed for 3GPP GERAN telco#1 on ENHVAMOS (20th October 2011). Modifications based on comments received at the closing plenary of 3GPP GERAN#51.	0.1.0	0.1.1
2011-11	3GPP GERAN #52	GP-111593			Version composed for 3GPP GERAN#52. Modifications based on agreements reached at 3GPP GERAN telco#1 on ENHVAMOS.	0.1.1	0.1.2
2011-11	3GPP GERAN #52	GP-111906			Version composed for the closing plenary of 3GPP GERAN#52. Inclusion of working assumptions agreed at TSG GERAN#52 during WG1 and WG2 sessions on ENHVAMOS.	0.1.2	0.2.0
2012-01	3GPP GERAN telco#2 on ENHVAMOS				Version composed for 3GPP GERAN telco#2 on ENHVAMOS (9th January 2012). Incorporation of candidate technique proposed at 3GPP GERAN telco#1 on ENHVAMOS and 3GPP GERAN#52. Other modifications based on comments received at the closing plenary of 3GPP GERAN#52.	0.2.0	0.3.0
2012-02	3GPP GERAN #53	GP-120125			Version composed for 3GPP GERAN#53. Modifications based on agreements reached at 3GPP GERAN telco#2 on ENHVAMOS.	0.3.0	0.3.1
2012-02	3GPP GERAN #53	GP-120387			Version composed for 3GPP GERAN#53. Modifications based on comments received during the WG1 session on ENHVAMOS.	0.3.1	0.3.2
