3GPP TSG RAN WG1 **TSGR1#5(99)773**
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Source: TSG-R WG1

Title: Liaison statement to TSG-R WG2 as a reply to questions submitted to TSG-R WG1 on Tx diversity issues

Summary:

In RAN WG1 meeting #4 a liaison statement having several questions on Tx diversity issues was received from WG2. In this document more information about the use of Tx diversity on different downlink channels is provided. In addition, latest available information is used to answer the questions presented by WG2.

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1. INTRODUCTION

TSG-R1 send a liaison statement to TSG-R2 on transmit diversity issues [1]. The main issue was the signaling requirements and other issues related to the support of different transmit diversity modes. As a response WG2 sent back a liaison statement with several detailed questions [2].

2. TRANSMIT DIVERSITY MODE CONTROL

In order to answer the questions by TSG-R WG2 the Tx diversity mode control and associated signaling requirements as seen from WG1 perspective are first discussed in the subsequent chapters.

2.1 Tx diversity modes

Tx diversity modes can be classified into two categories:

- Open loop modes
- Closed loop modes

In open loop mode no feedback information from the UE to the Node B is transmitted in order to control how the signal is transmitted from the diversity antennas. This is in contrast to closed loop operation where UE sends feedback information to the Node B in order to optimize the transmission from the diversity antennas.

2.1.1 FDD mode

Two different open loop techniques are used:

1. Space Time Transmit Diversity (STTD)
2. Time Switched Transmit Diversity (TSTD)

STTD is used on all the other channels except SCH where TSTD is used.

For closed loop operation three different modes are specified. They can be characterized by parameters like number of feedback bits per slot, N_{FBI}, feedback command update rate, feedback bit rate, number of power bits per command, $N_{po,}$ and number of phase bits per command, N_{ph}. They are listed for the different closed loop modes in the Table 1. Note that in RAN WG1 meeting #5 a tentative decision was made to modify the FB mode 1 so that phase switching is done instead of amplitude switching. The changed parameter values reflecting the tentative decision are in square brackets in the Table 1.

Table 1. N_{FBI}, N_W, update rate, feedback bit rate and number of power and phase bits per signaling word for different FDD feedback modes.

FB mode	N_{FBI}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
1	1	1	1600 Hz	1600 bps	1[0]	0[1]
2	1	2	800 Hz	1600 bps	0	2
3	1	4	400 Hz	1600 bps	1	3

In WG1 meeting #5 the application of open and closed loop Tx diversity modes on different downlink physical channels for FDD mode in release –99 were agreed as shown in the Table 2.

Table 2. Application of Tx diversity modes on downlink physical channels in FDD.

Channel	**Open loop mode**	**Closed loop mode**	**Note**
PCCPCH	X	N/A	STTD applied only to data symbols
SCH	X	N/A	TSTD used
SCCPCH	X	N/A	
DPCH	X	X	
PDSCH (associated with DPCH)	X	X	
AICH	X	N/A	Only if closed loop Tx diversity is used in the cell and/or open loop mode is used on PCCPCH

N/A = Not applied
X = Can be applied

2.1.2 TDD mode

In TDD, open loop solution is based on switching the transmitted signal between the antennas in a similar fashion as in FDD closed loop mode 1. Naturally, no feedback is needed as the channel is the same in both Tx directions. This solution has been approved to be used on DPCH only.

Other Tx diversity techniques, like schemes based on Tx AA, and use of Tx diversity in general for other physical channels are FFS.

2.2 Tx diversity mode control and related signaling requirements

From layer 1 point of view the most important piece of information is to know what Tx diversity method (if any) is used, at any given time instant, on different downlink physical channels that the UE needs to receive. Of secondary importance is the possible support (e.g. measurement reports) UE may give to Node B in order to give guidance for mode selection.

In the following subchapters all the downlink physical channels are considered separately. Note that the description is for FDD only. In addition, the possible support by UE for the Node B on the mode control is described.

2.2.1 PCCPCH

Only open loop can be used on PCCPCH. In initial synchronization the UE must assume that Tx diversity is used on PCCPCH. Information about the use of open loop mode on the PCCPCH is transmitted on BCCH. Therefore, 1 bit of information from each frame of BCCH must be reserved indicating the presence/absence of Tx diversity transmission on PCCPCH.

2.2.2 SCCPCH

Only open loop can be used on SCCPCH. The UE must somehow get the information if it is applied or not. One obvious way of doing this is to broadcast the information (1 bit) on BCCH channel. Whether this needs to be done in each frame should be further considered. Moreover, if any other way of providing the indication of presence/absence of STTD encoding on SCCPCH to the UE could be considered.

2.2.3 SCH

Open loop Tx diversity based on TSTD technique is potentially used on SCH. It is not mandatory for the UE to know if TSTD is applied on SCH.

2.2.4 AICH

Open loop STTD encoding can be used on AICH. Unless explicitly somehow told the UE must assume that the AICH is STTD encoded. This will result in small performance degradation in case the assumption is incorrect. As in case of PCCPCH, the use of Tx diversity on AICH could be broadcasted on BCCH. If the information needs to be in every BCCH frame should be further considered. Also possible other methods to tell the UE about the use of Tx diversity on AICH could be studied.

2.2.5 DPCH

All of the Tx diversity methods, except open loop TSTD used on SCH, can be used on DPCH. As DPCH is a channel that will be established as part of call set up procedure the needed Tx diversity related information can be told to the UEs individually without a need to use e.g. BCCH broadcasting. There are, however, some limitations how the modes can be applied:

1. In SHO no closed loop modes can be used[1]

2. As closed loop modes require feedback channel they can be used on downlink DPCH only after the uplink connection has been established

3. SSDT power control and open loop mode diversity transmission can be used in parallel. So far no decision has been made if also closed loop modes can be utilized simultaneously with SSDT power control.

In addition we have identified several questions related to the use of Tx diversity on DPCH:

1. If open loop can be used how does the Node B start the transmission on a DPCH ?

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[1] There is a proposal that this should be possible. It has not been accepted yet.

- By default start in non-diversity mode and tell UE that diversity transmission will be used from frame X onwards (either open or closed loop) or
- By default start in open loop mode (UE must assume open loop Tx diversity or the use of it in the cell must be told to the UE by some means) or
- As part of call set up process tell UE using higher layer message if open loop diversity Tx will be used from the very beginning on DPCH

2. When ever the Tx mode is changed does to UE know the exact timing of it (i.e. starting from frame X the mode Y will be used ?) ?

3. Related to SHO

   - If closed loop mode is used prior SHO how the mode change is managed for the serving Node B transmission (e.g., starting from frame X open loop/no diversity Tx will be used instead of closed loop) ?
   - Should the use of Tx diversity in neighboring cells be told to UE as part of neighboring cell information ?

This is not an exhaustive list of questions. Note that the purpose of these questions is to help WG2 in specifying the needed control of the use of Tx diversity on DPCH. Therefore, no formal answer from WG2 to WG1 on these questions is required (but can be provided if so desired).

2.2.6 PDSCH when associated with DPCH

When PDSCH is associated with DPCH application of Tx diversity modes and related mode control is done as for DPCH alone with the exception that PDSCH is not used in SHO.

2.2.7 PDSCH when associated with PSCCCH

Not part of release –99.

2.2.8 PSCCCH

Not part of release –99.

2.2.9 UE support for mode control by Node B

On DPCH all other Tx diversity modes except open loop based on TSTD can be used. What mode will be used and when is controlled by Node B. Important criteria for the mode control are the radio channel conditions. This is because depending on the radio channel different modes will provide the best performance.

Regarding the downlink performance there are two important factors which should be considered when doing mode control:

- Maximum doppler frequency (i.e. speed of the UE)
- Number of multipath components

Basically UE could measure both of these and report back to Node B. As it happens both of these can be measured by Node B as well. Therefore, there is no need to signal this information from UE to Node B.

2.3 Summary of mode control and signaling

For common channels the most straightforward way of informing the UE about the use of Tx diversity on them is to broadcast the information on BCCH. How many bits per BCCH frame is needed depends on how much flexibility will be given to operators in use of Tx diversity. Two extreme cases are:

- Most limited flexibility
  - ★ One bit in every BCCH frame is used to indicate if Tx diversity is being used on PCCPCH, SCCPCH and AICH
- Maximum flexibility
  - ★ Use of Tx diversity on different broadcast channels can be controlled independently. Obvious way of informing UE about this is to transmit 3 bits of information in each BCCH frame.

In addition it could be useful to indicate if there is a default Tx diversity mode used on the dedicated channels. We could further define a default Tx diversity mode separately for the case of non-SHO and SHO. This kind of information could be broadcasted on BCCH or could be defined in call set-up. The benefit of it could be reduced signaling e.g. in SHO but the drawback is the increased overhead of BCCH or additional signaling in call set-up. Note that even if no default modes exist the use of Tx diversity on dedicated channels can be told to UE in call set-up phase.

UE support for mode control by Node B is not needed from WG1 perspective.

3. ANSWERS TO SPECIFIC QUESTIONS BY WG2

Based on the information presented in chapter 2 our answers to the questions in [2] are as follows:

QA1: Is there different measurement information required by each of the modes ? What measurement parameters would have to be passed to the network ?

Answer to QA1:

Based on further consideration no support from UE to Node B is needed for mode control purposes. Thus no measurement information is required and no parameters need to be passed.

QA2: If there is different information required for the different modes does it mean that all the information required by each of the modes has to be supplied by the UE for the case when the network makes the selection of mode ?

Answer to QA2:

See answer to QA1. Question has become obsolete as no support from UE to Node B is needed.

QA3: We have been evaluating the requirement on RACH payload size at call set-up. Is it necessary for the UE to supply the measurement information in the initial call set-up request message ? If so what is the quantity of information which would have to be transmitted ?

Answer to QA3:

See previous answers. Question has become obsolete as no support from UE to Node B is needed.

QB1: From the liaison we gather that the only information which has to be transmitted on the BCCH is what modes are supported in the cell. Is this correct ? If not how much and what information has to be transmitted, is it the same for the different transmit diversity modes ?

Answer to QB1:

See chapter 2.3.

QB2: How frequently does the information transmitted on the BCCH have to be updated ?

Information about the use of Tx diversity on PCCPCH must be broadcasted in every BCCH frame. In case of separate signaling on BCCH for SCCPCH and AICH the information has to be acquired before decoding those channels. Similarly, for dedicated channels if any information is available from BCCH, the information about the use of Tx diversity must be acquired before these channels are established. Note that the information itself on BCCH will change only if operator decides to change it for any reason.

REFERENCES

[1] TSG-R1. Liaison statement to TSG RAN WG2 on transmit diversity issues. TSG-R WG1 document, TSGR1#3(99)270, 22-26th, March, 1999, Nynäshamn, Sweden, 1 pp.

[2] TSG-R2. Liaison from RAN WG2 to RAN WG1 in response to questions raised on transmit diversity issues. TSG-R WG2 document, TSGR2#3(99)334, 13-16th, April, 1999, Yokohama, Japan, 1 pp.