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Agenda item	**:**
Source	**: NEC and Fujitsu**
Title	**: UE complexity analysis for the support of SSDT**
Document for	**: discussion**

Summary

UE complexity is analyzed for the support of SSDT. We raise 4 distinct features required to UE for SSDT operation, i.e. (1) pilot power measurement for primary cell selection, (2) assignment of path to RAKE finger, (3) uplink TPC command detection and (4) FBI feedback. The analysis indicates that the most impact on UE complexity for the support of SSDT is thought to be a frequent pilot measurement for primary cell detection which relates to the feature (1). Although it is possible to reuse the pilot measurement circuit already implemented for the active cell detection, the additional processing of 11% in case of per-frame site selection will be required in SIR estimation processing unit implemented for DPCH reception provided that SIR is estimated in a half slot time measurement basis

1. Introduction

Adhoc-11 in TSG-RAN-WG1#3 meeting reaches the agreement on which Site Selection Diversity TPC (SSDT) as well as Tx antenna diversity should be mandatory in UE subject to acceptable complexity increase. This document analyzes UE complexity in the application of SSDT by viewing a couple of additional functions required for the support of SSDT operation.

2. Functions required to UE for the support of SSDT operation

The functions required to UE for the support of SSDT are explained in the following.

(1) Pilot power measurement for primary cell selection

For the support of SSDT, UE has to periodically sense pilot power of common control channel in order to determine primary cell. Since the common pilots measurement is subject to only for the active cells' common control channel, the path information already obtained for BCCH (or DPCH) reception of the active cells can be reused. Furthermore, the function of common pilot power measurement is implemented for detecting active set regardless of the SSDT support.

During SSDT operation, the measurement cycle of the common pilots is identical to site selection cycle, i.e. 1/2 frame or 1 frame in the current specification. On the other hand, the cycle of pilot level measurement for the active set detection is possible to be several frames. So our concern is how much extent of the impact such a frequent pilot measurement gives on UE for the support of SSDT. This concern is especially lying on the processing activity increase.

We investigated the relationship between observation period of a common pilot and capacity in Appendix A. According to the assumption of sensing PCCPCH with –10dB a maximum power of 384kbps (data rate) DPCH, the result indicated that less than 3% capacity degradation will take place when the power measurement period is over 1 slot time. This capacity degradation would be tolerable by taking into account the 30% capacity gain of SSDT compared to the conventional TPC. Provided that SIR estimation of DPCH is carried out in a half slot time measurement basis, the additional processing amount relevant to the SIR estimation processing is given as follows.

$$\frac{0.625[ms]*0.9*1[slot]}{0.625[ms]*1/2*16[slot]}=0.11 \tag{1}$$

in which we assume per-frame site selection. The factor of 0.9 in the above calculation denote PCCPCH activity ratio defined in S1.11. As seen in (1), the processing increase of 11% on the SIR estimation processing will take place by the introduction of SSDT.

(2) Assignment of path to RAKE finger

In conventional implementation of UE, assignment of path to RAKE finger will be based on a power order low in which the maximum “N” paths are chosen and assigned to "N" RAKE fingers for demodulation. In this path assignment scenario, however, we should note that at least 1 RAKE finger must be assigned to every active BTS for DPCCH demodulation even though all paths of a BTS are not chosen as the maximum “N” paths.

The same rule is applied to UE supporting SSDT, but since DPDCH transmission is omitted in non primary BTS, UE must discard the omitted DPDCH paths in the RAKE finger assignment. Although UE knows which cell is primary, the cells cannot prevent their decision from being wrong primary / non-primary state because the primary ID reception is inherently non error free. As a result, UE sometimes encounters multiple / different / no cells transmission of DPDCH in spite of during SSDT mode. In order for UE to avoid demodulating inefficient DHO branches, UE should choose efficient paths by itself.

There are two ways of DPDCH detection, i.e. a way of using TFCI and a way of blind detection. Both methods will be also used for the signal detection in DTX control, and thus it is possible to share the methods between SSDT and DTX operations. However, the rate detection in DTX operation would take place in a frame cycle basis, thus long detection delay cannot be avoided. In addition, the TFCI method is limited to the case of per frame site selection.

Alternatively, we can use a blind detection by sensing power of DPDCH signal. According to Appendix B, our estimation of the required number of symbols to detect the DPDCH signal shows that 1 slot DPDCH measurement is enough for the channel bit rate of 64kbps (used for voice traffic). Since SIR of DPCH would be continuously measured for making uplink TPC bit, some results obtained in making

TPC bit can be reused in the DPDCH detection. If it is the case, processing activity for the DPDCH detection is considered to be a slight.

(3) Uplink TPC command detection

Uplink TPC command should be detected based on SIR for the DL signal of primary cell. Alternatively, the use of SIR calculated from all DPDCH signals in active set is possible.

(4) Primary ID feedback

Primary ID code word should be transmitted via uplink FBI.

3. Conclusion

From the analysis done so far, the most impact on UE complexity for the support of SSDT is thought to be a frequent pilot measurement for primary cell detection. Although it is possible to reuse the pilot measurement circuit already implemented for the active cell detection, the frequent pilot measurement makes the processing activity increase. The analysis shows that if SIR estimation of DPCH is carried out in a half slot time measurement basis, the additional processing amount relevant to the SIR estimation processing is 11% for per-frame site selection.

Appendix A The relationship between pilot measurement period and capacity

For reliable primary cell selection, pilot measurement in long period should be carried out in order to reduce the influence of interference and noise. The longer the measurement period, the higher the accuracy of signal power detection. However, the pilot measurement for the cell selection requires additional processing of UE. In this appendix, the relationship between measurement period and capacity is investigated by system simulation.

When $r_{j,I}$ and $r_{j,Q}$ are assumed to be in-phase and quadrature components of received signal, the reception power of desired signal, S can be computed from the following equation.

$$S = \frac{1}{2n}\sum_{j=1}^{n}\left\{\left(r_{j,I}\hat{r}_{j,I}\right)^2 + \left(r_{j,Q}\hat{r}_{j,Q}\right)^2\right\} \qquad \text{(a)}$$

where $\hat{r}_{j,I}$ and $\hat{r}_{j,Q}$ denote the detected signals with respect to $r_{j,I}$ and $r_{j,Q}$. In the above equation, n and j denote the number of collected symbols and symbol index.

The simulation assumes DPCH for 384kbps data transmission and the pilot measurement for PCCPCH (channel bit rate of 32kbps, SF=256, 9 symbols/slot). Transmission power of PCCPCH is set to

–10dB from a maximum DPCH power. In PCCPCH power measurement, we introduce a random power offset due to noise and interference. The random offset which depends on SIR of the received PCCPCH signal is produced so that the statistics of the offset vale equals to that to be practically obtained by the power measurement given as Eq.(a). The variance of the offset increases as SIR of the received signal decreases. 2 antenna branch diversity reception at UE are assumed, but as for the random offset computation, we assumed 1 path and 1 branch diversity reception in order to prepare for the worst.

Fig.A-1 shows the interference probability versus the number of given UEs for 3 sectored Vehicular deployment model. UE speed is assumed to be 4km/h. The number of collected symbols from PCCPCH signal, n is assumed to be 3 and 9, each of which corresponds to 1/3 slot and 1 slot time lengths, respectively. We also investigated conventional TPC and SSDT in primary cell detection error free.

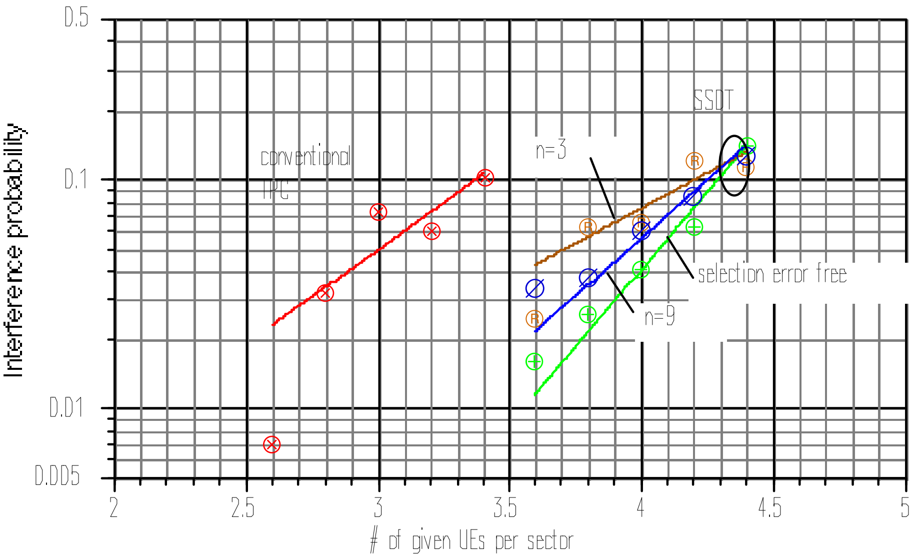

Fig.A-1 Interference probability versus the number of given UEs in a sector.

From Fig.A-1, SSDT capacity degradation for n=9 is less than 3% compared with SSDT in primary cell detection error free (we focus on 5% interference capacity). Although PCCPCH power is set to –10 dB from a maximum DPCH power, SIR of primary cell's PCCPCH was achieved of 20dB in average. This is due to high processing gain and fixed transmission power of PCCPCH signal. In practical system, SIR of active cells' PCCPCH will be actually kept high because the coverage for PCCPCH signal must be wider than that for DPCH.

Appendix B Estimation of minimum signal integration period for DPDCH detection

The DPDCH signal transmission is detected if the following condition is satisfied.

$$S_{DPDCH}>S_{th} \quad (b)$$

where S_{DPDCH} and S_{th} denote reception power of DPDCH signal calculated by Equation (a) and DPDCH detection threshold. Fig. B-1 shows detection error probability of switched-off DPDCH signal versus S_{th}. In Fig. B-1, channel bit rate of 64kbps (48kbps for DPDCH and 16kbps for DPCCH, for voice traffic), and in order to prepare for the worst, 1 branch & 1 path diversity reception are assumed. The number of collected symbols to estimate signal power, n is set to 15 (1 slot), 30 (2 slot) and 45 (3 slot).

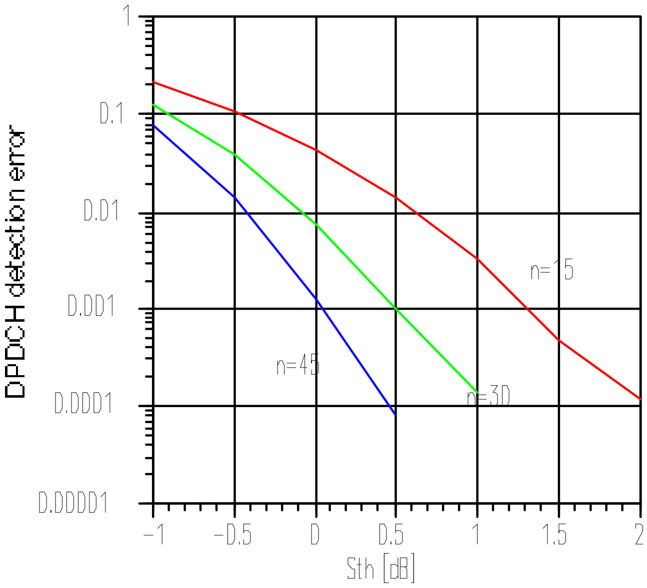

Fig.B-1 Detection error probabilities of switched-off DPDCH signal

From Fig. B-1, detection error probability of switched-off DPDCH signal is 0.01% if S_{th} is set to 2.0 dB for n=15, 1.0 dB for n=30 and 0.5 dB for n=45, respectively. The detection error probability of 0.01% is thought to be small enough compared to the site selection error probability of 1.3% (in case of 8bit CW) encountered at BS due to FBI reception error. On the other hand, detection error probabilities of switched-on DPDCH signal are shown in Fig.B-2 assuming S_{th}=2.0 dB for n=15, S_{th}=1.0 dB for n=30 and S_{th}=0.5 dB for n=45, each of which keeps the switched-off DPDCH signal detection error of 0.01%.

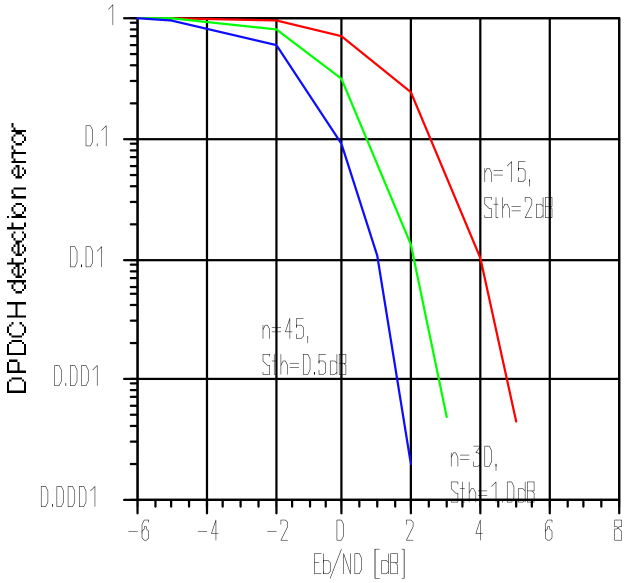

Fig.B-2 Detection error probabilities for switched-on DPDCH signal

According to the reference [1], the required downlink Eb/No for voice is 6.7~8.9 dB (depending on deployment model). From Fig.B-2, detection error probability of the switched-on DPDCH signal is less than 0.01% in the Eb/No region of greater than 6.0dB regardless of n and S_{th} setting. In addition, as low Eb/N0 signal would less contribute to add energy in maximum ratio combining, the detection error for such a signal would not so much impact on the reception performance of UE.

As a conclusion, collecting 15 symbols is enough to detect DPDCH signal in case of the channel bit rate of 64kbps. This symbol collection size corresponds to 1 slot time measurement.

Reference

[1] “Japan’s proposals for candidate radio transmission technology on IMT-2000: W-CDMA,” ARIB, Sept. 1998.