TSG-RAN Working Group1 meeting #2
Yokohama 22-25, February 1999

TSGR1#2(99)083

Agenda Item:

Source: Texas Instruments

Title: Possibility to use STTD on PCCPCH

Document for:

STTD encoding for PCCPCH

Texas Instruments
February 17th, 1999

1.0 Introduction

We propose that STTD encoding can be done on the data symbols of the PCCPCH in addition to the SCCPCH. The STTD encoded data on PCCPCH uses the same pilot symbol pattern on the diversity antenna, as that required for feedback mode transmit diversity on DPCH channels. Thus, the PCCPCH pilot symbol power does not have to be increased by 3 dB (as is being done currently) for feedback mode transmit antenna diversity to work on DPCH channels.

Further, we show that a simple blind detection algorithm, using the pilot symbol pattern of the diversity antenna, can be used to determine the presence/absence of the diversity antenna. The time required by the algorithm to make this decision is between 30-250 msec.

In case an L3 message indicating transmit antenna diversity is sent on the Perch channel, it could be received by STTD decoding the Perch channel (PCCPCH) by *apriori* assuming that the diversity antenna is present. Alternatively, a combined decision about the presence/absence of the diversity antenna can be made using the blind detection and the L3 message.

During soft handoff, either of the above two schemes can be used to determine whether transmit antenna diversity is used on the neighboring/soft handoff base station. Alternatively, this information can be provided to the mobile along with the long code group/other information for the neighboring base stations.

In either case, the mobile will be able to determine the presence/absence of transmit antenna diversity on PCCPCH. Hence STTD encoding can be done on the PCCPCH (Perch channel).

2.0 Proposed STTD encoding for ETSI/ARIB PCCPCH/Perch channel

Table 1 compares the different nomenclature for the broadcast channels as used in ARIB and ETSI and our proposed STTD encoding for the different channels.

ARIB nomenclature	ETSI nomenclature	STTD encoding
1st search code	Primary SCH	No
2nd search code	Secondary SCH	No
Data symbols of Perch channel (N_{data}= 5 symbols)	Data symbols of PCCPCH (N_{data} = 5 symbols)	Yes
Forward link common physical channel (N_{data} = 36 symbols)	SCCPCH (N_{data} = 36 symbols)	Yes

Table 1: ARIB and ETSI nomenclature for the broadcast channels.

We propose to STTD encode the N_{data} symbols on the PCCPCH as shown in figure 1. The diversity antenna pilot symbol pattern for the Perch channel (PCCPCH) is given in table 2 and is the same as that proposed for feedback transmit antenna diversity schemes [2]

Figure(1): STTD encoding of the data symbols of the PCCPCH is shown.

Symbol rate	Diversity antenna pilot pattern for Perch channel			
Symbol #	0	1	2	3
Slot # 1	11	11	00	00
2	11	11	00	10
3	11	01	00	10
4	11	10	00	10
5	11	10	00	00
6	11	10	00	00
7	11	01	00	11
8	11	10	00	10
9	11	11	00	11
10	11	01	00	10
11	11	11	00	01
12	11	01	00	10
13	11	00	00	10
14	11	10	00	11
15	11	01	00	11
16	11	00	00	11

Table 2: Pilot symbol pattern for the diversity antenna when STTD encoding is used for the N_{data} symbols of the Perch channel (PCCPCH). Notice that the pilot symbol pattern is the same as the feedback systems implying that the Perch channel pilot symbol power *is not required to be increased by 3 dB.*

3.0 Transmit diversity antenna determination

One of the crucial issues in employing STTD for PCCPCH is, how is the mobile going to determine whether the base station is employing antenna diversity on the PCCPCH?

3.1 Blind detection of transmit diversity

The pilot symbol pattern of the diversity antenna (table 2) can be used to do a *blind detection* of the diversity antenna. A number of different algorithms could be used to do this. We consider a simple algorithm based upon sequential detection [3] to determine whether the diversity antenna is present, or not. The mobile *coherently* adds the received pilot symbol data corresponding to the two antennas, over K time slots. The parameter K is the same as the WMSA parameter for channel estimation (6 slots for Doppler < 80 Hz. and 4 slots for Doppler > 80 Hz.). The mobile then takes the ratio of output of the main antenna to the diversity antenna (denoted as λ), to compare it *two* thresholds, η_1, η_2 ($\eta_1 >= \eta_2$) and uses the following algorithm

$\lambda >= \eta_1$ => Diversity antenna absent

$\lambda <= \eta_2$ => Diversity antenna present

$\eta_2 < \lambda < \eta_1$ => receive data for K more time slots. Coherently combine the K slots and non-coherently accumulate it with the previous data, and compare to the threshold again.

As mentioned above, when $\eta_2 < \lambda < \eta_1$, coherently combined data from K more time slots is *non-coherently* accumulated with the previous data and again compared to the thresholds. As is common in sequential detection, the thresholds η_1 and η_2 are made to converge to each other in time, to a single threshold η. Let us now define the probability of miss to be

P_m *= probability (mobile wrongly says diversity antenna **absen**t when diversity antenna is indeed **presen**t).*

And the probability of false detection,

P_f *= probability (mobile wrongly says diversity antenna **present** when diversity antenna is indeed **absent**).*

We now do the simulations to determine the P_f, P_m and the time to detect whether the diversity antenna is present or absent. Simulation parameters are given in table 3 and simulation results in figures 1-4.

	5 Hz	20 Hz	200 Hz
Channel model	Indoor to outdoor pedestrian	Indoor to outdoor pedestrian	Vehicular
Number of time slots for coherent averaging (K)	6	6	4
Threshold η_1	13 dB	13 dB	10 dB
Threshold η_2	3 dB	3 dB	2 dB
Threshold η	8 dB	8 dB	6 dB
Change of η_1 to η	Linear, over 48 frames.	Linear, over 48 frames.	Linear, over 24 frames.
Change of η_2 to η	Linear, over 48 frames.	Linear, over 48 frames.	Linear, over 24 frames.
Simulation scenario	19 cell model	19 cell model	19 cell model
Log normal fading standard deviation	10 dB	10 dB	10 dB
Path loss parameter	5.0	5.0	3.8
Traffic channels	64 KSPS	64 KSPS	64 KSPS
Spreading gain	64	64	64
Coding rate	1/3, K = 9	1/3, K = 9	1/3, K = 9
Total spreading gain (G)	192	192	192
Number of traffic channels (C)	40	40	40
Ratio C/G	21 %	21 %	21 %
PCCPCH spreading gain	256	256	256
Power of PCCPCH/Power of traffic channel	0 dB	0 dB	0 dB
99 percentile of time to detect presence of diversity antenna (figure 2)	***250 msec.***	***145 msec.***	***30 msec.***
99 percentile of P_m (figure 3)	1.7 e-3	1.2 e-4	No error occurred.
99 percentile of time to detect absence of diversity antenna (figure 4)	***170 msec.***	***140 msec.***	***55 msec.***
99 percentile of P_f (figure 5)	6.5 e-3	3.6 e-3	6.1 e-4

Table 3: Simulation results for the blind detection of the diversity antenna are shown. We can see that the presence of the diversity antenna can be detected in 30-250 msec., and its absence in about 55-170 msec.

Title:
acq_time_two_ant_det.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 2: Simulation results giving the cumulative probability for the time taken to detect presence of the diversity antenna We can see that the 99 percentile of the time to detect the diversity antenna is between 30-250 msec.

Title:
p_m_cum_all_dopp.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 3: Simulation results giving the cumulative probability distribution of P_m, the probability of not detecting the diversity antenna (when present). No error occurred for the 200 Hz. case. We can see that the 99 percentile of P_m is less than 1.7 e-3 for a Doppler of 5 Hz.

Title:
acq_time_one_ant_det.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 4: Simulation results giving the cumulative probability for the time taken to detect the absence of the diversity antenna We can see that the 99 percentile of the time to detect the absence of the diversity antenna is between 55-170 msec.

Title:
p_f_cum_all_dopp.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 5: Simulation results giving the cumulative probability distribution of P_f, the probability of wrongly detecting the diversity antenna We can see that the 99 percentile of P_f is less than 6.5 e-3 for a Doppler of 5 Hz.

We can thus conclude that the mobile should be able to reliably detect (blindly) the presence/absence of the diversity antenna between 30-250 msec. The P_m, the probability of not detecting the diversity antenna (when diversity antenna present), is less than 1.7e-3 for the worst case of 5 Hz fading. Similarly P_f, the

probability of falsely detecting the diversity antenna (when diversity antenna absent), is less than 6.5e-3 for the worst case of 5 Hz fading.

3.2 Transmit diversity detection by demodulating the Perch channel (PCCPCH)

We now try to analyze an alternative scheme to determine the presence/absence of the diversity antenna, in case the transmit diversity information is being transmitted as an L3 message on the Perch channel. The question would be, how should the mobile demodulate the Perch channel (PCCPCH) when it does not know whether transmit antenna diversity is being used on PCCPCH or not? However, notice that the only impact of wrongly assuming that PCCPCH is STTD encoded, is the increased number of rake fingers in the maximal ratio combiner (MRC). Hence, the mobile can start demodulating the PCCPCH assuming that it is STTD encoded. ***In case it really is STTD encoded, the mobile will confirm it by successfully receiving the L3 message***. The STTD encoding gives a diversity gain of 3.0 dB for 5 Hz. indoor-to-outdoor pedestrian channel and 0.6 dB for the 200 Hz (table 4 of [4]) vehicular channel, over a no-diversity (ND) transmission for DPCH channels. Similar gains are expected for the STTD encoding of the PCCPCH channel. On the other hand, if the PCCPCH is not STTD encoded its STTD decoding will lead to a degradation due to extra interference from additional fingers. Figures 6, 7 illustrate the degradation for a 5 Hz. indoor-to-outdoor pedestrian and 200 Hz. vehicular channel respectively, including WMSA channel estimation. The degradation is 0.2-0.4 dB for the 5 Hz. case and 0.6-0.7 dB for the 200 Hz case. ***Thus the mobile should be able to demodulate the L3 message (with a degradation of 0.2-0.7 dB over a normal single antenna reception) to know that no transmit diversity is used by the base station***.

Title:
False_div_det_degrad_5hz_cest_npc_16.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 6: Comparison of normal and STTD decoding of single antenna transmission, for a Doppler of 5 Hz. and indoor-to-outdoor pedestrian channel, including WMSA channel estimation.

Title:
False_div_det_degrad_200hz_cest_npc_16.eps
Creator:
MATLAB, The Mathworks, Inc.
Preview:
This EPS picture was not saved
with a preview included in it.
Comment:
This EPS picture will print to a
PostScript printer, but not to
other types of printers.

Figure 7: Comparison of normal and STTD decoding of single antenna transmission, for a Doppler of 200 Hz. and vehicular channel, including WMSA channel estimation.

3.3 Transmit diversity detection by combining blind detection and demodulation of the Perch channel (PCCPCH)

Alternatively, a mobile can combine the blind detection scheme (section 3.2.1) and the PCCPCH demodulation to receive the L3 message (section 3.2), to make an improved decision of whether transmit diversity antenna is present/absent. One way the mobile can combine this, is by first doing the blind detection, and then use this decision to demodulate the PCCPCH for the L3 message. If the L3 message decision about the diversity antenna present/absent is the same as the blind detection decision, then the mobile knows for sure whether the diversity antenna is present/absent. In case the two decisions are not the same, the mobile can repeat the above algorithm.

3.3 Transmit diversity determination of neighboring/soft handoff base stations

During soft handoff, the mobile can use the same schemes given in section 3.2.1, 3.2.2 or their combination to determine whether transmit diversity is being used by the neighboring/soft handoff base stations. Alternatively, this information can be provided to the mobile by the current base station along with the long code group/other information, about the neighboring base stations.

4.0 Conclusions

A summary of the issues involved in STTD encoding the PCCPCH is given.

	STTD encoding for PCCPCH
Path diversity for data symbols of PCCPCH	***Yes***
Diversity antenna notification (during power on)	• ***Blind detection on PCCPCH can be done*** • ***If L3 message transmitted, it can be received by demodulating PCCPCH assuming that it is STTD encoded.*** • ***A combination of the above schemes can be done***
Diversity antenna notification (during soft handoff)	• ***Blind detection on PCCPCH of soft handoff base station can be done***

	- ***If L3 message transmitted, it can be received by demodulating PCCPCH of the soft handoff base station assuming that it is STTD encoded.*** - ***Transmit diversity information of neighboring base station can be provided along with long code group information by the current base station.*** - ***A combination of the above schemes can be done.***
Perch channel pilot symbol power to be increased by 3 dB (when feedback mode used on dedicated physical channels)	***No***

Table 4

Thus we can conclude that the mobile can determine whether STTD is being used on the PCCPCH or not. Hence STTD encoding can be done on the PCCPCH.

Further, the advantages of STTD encoding the data symbols of the PCCPCH are;

(1) Extra path diversity to the N_{data} symbols of the Perch channel (PCCPCH), thus improving its BER significantly.

(2) The same perch channel pilot symbol pattern can be used for feedback mode on dedicated physical channels as STTD encoding of data symbols for Perch channel. Hence, the Perch channel pilot symbol power is not required to be increased by 3 dB when feedback diversity is used for dedicated physical channels. This gives a slight increase (~0.2 dB) in forward link capacity for feedback mode diversity.

References

[1] ETSI L1 Expert Group. UTRA FDD: Transport channels and physical channels. UMTS XX.03 v.1.3.0 Tdoc SMG2 106/99.

[2] Association of Radio Industries and Businesses (ARIB). Volume 3: Specifications of Air-Interface for 3G Mobile Systems, v1.0, 14th January, 1999.

[3] A. Wald, *Sequential Analysis*, Wiley, New York, 1947.

[4] Texas Instruments, “Additional results on space time block coded transmit antenna diversity for WCDMA”, Tdoc 25/99, ETSI SMG2 UMTS-L1, 18-20 January 1999, Espoo, Finland.