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Introduction

UMTS power control for directed FACH messages (messages addressed to a single UE) is based on imperfect OLPC methods. UTRAN may broadcast the directed FACH at a power level sufficient for UEs at the cell edge. Alternatively, UTRAN may lower the FACH power based on the accuracy of pathloss information for the UE recipient of the FACH message.

GBT has performed simulation and analysis documenting the benefits and improved capacity of CLPC for FACH as compared to perfect downlink OLPC. Perfect DL OLPC requires a precise measure of the pathloss from UTRAN to destination UE at beginning of each OLPC message transmitted by the Node B. The measurement and signaling resources required for perfect DL OLPC are excessive and are not implemented in the specifications. This paper describes practical techniques for improved OLPC for FACH.

The set of measurements defined in 25331 (and referenced in 25133), provide means for the UTRAN to order UE measurement of Primary CPICH pathloss (based on measure of Received Signal Code Power (RSCP)). UTRAN may order periodic or event-triggered measurement reports. In both cases the reported pathloss includes significant errors due to measurment inaccuracy and reporting delay. These errors require UTRAN to transmit at DL OLPC levels significantly higher than needed if accurate pathloss measurements were available when needed. This paper describes various techniques to provide improved pathloss measures with which to implement improved OLPC for FACH. The benefits in terms of increased DL capacity for these OLPC improvements is also listed.

Discussion

1. FACH OLPC Error in UTRAN

The intra-frequency measurments defined in 25.331 permit the UTRAN to command periodic measurements of CPICH RSCP in the UE. In section 8.1.2 of 25133, the UE measurement performance requirements for CPICH RSCP are defined:

A. CPICH RSCP measurement is for DL open loop power control, UL open loop power control, handover evaluation, path loss evaluation.

B. Intra frequency measurement accuracy: The measurement period for the Cell-DCH state is [150] ms and Cell-FACH is [600 ms.]

C. The absolute accuracy requirement: CPICH RSCP: one code power after de-spreading Normal condition: (+- 6 dB), Extreme Condition: (+-9 dB)

D. In section 5.1.1 of 25133, the measurement reporting delay for CPCH RSCP is defined to be 800 msec for periodic or for event triggered measurements.

With these performance requirements in mind the UTRAN will need to augment the OLPC level based on RSCP measurement to compensate for a) measurement inaccuracy, and b) decorrelation due to measurement reporting delay.

Rayleigh fading measurements for UMTS bandwidth indicate the standard deviation of the fade depth to be 5.0 dB (9% probability that fade depth is in the range of 7-17 dB, 20% probability between 2-7 dB, 20% probability between 0-2 dB) [2] and velocity dependant Rayleigh fading rates ranging from several Hz (pedestrian) to 100 HZ (highway speed vehicle). Considering the 800 msec measurement reporting delay, any reported CPICH RSCP measurement will be fully decorrelated before the UTRAN even receives the measurement report. Even periodic measurement of CPICH RSCP will not permit the UTRAN to set the OLPC level withon?? the fading range. The periodic measurement reports will permit the UTRAN to assess the DL fade depths, but due to the reporting delay, will not the proper OLPC level for FACH transmission.

An event triggered measurement scheme will be able to track the upper and lower limits of the fading range for the serving cell CPICH RSCP. As defined in 25.331, measurement events 1E and 1F can be used to bound the fading range and report changes as average pathloss increases or decreases. This is shown in Figure 1, below.

2. Improved FACH OLPC level measurement

Various approaches are considered to more accurately assess the OLPC level needed for directed FACH messages. Each approach includes three functional elements:

- Buffering of directed FACH message to permit time for improved OLPC measurement
- Technique to signal destination UE of need for improved OLPC measurement
- Technique for coordinated measurement (UE and Node B) of required OLPC level.

The RNC or the Node B may buffer the directed FACH message while a cooperative measurement of required OLPC level is signaled and performed. If the Node B buffers the message, the OLPC level can more accurately be set since the delay from measurement to message transmission will not include Iub and Iur delays. However, buffering at Node B could potentially interfere with other RNC scheduling functions. Buffering at RNC will require additional delays for message transmission, but will assist in coordinated scheduling of FACH and Paging messages.

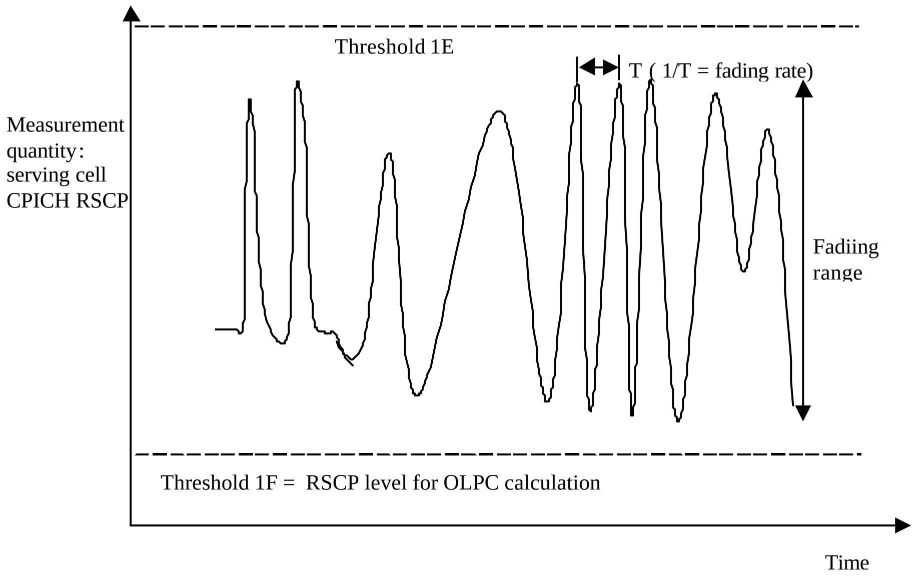

Figure 1: Primary CPICH RSCP fading range measurment

The destination UE must be signalled to provide a cooperative OLPC measurement. Obviously, a new directed FACH message may explicitly signal the destination UE indicating the need to perform coordinated OLPC measurement. Another alternative is to use a reserved AICH channel to signal to one UE of a set of UEs which may monitor this reserved AICH. The AICH would be sent from the Node B using one of 32 signatures and sent in one of 15 access slots. This provides the capability to signal up to 15 x 32 = 480 UEs with a single reserved AICH. When a UE executes the RRC Connection Setup procedure, the RRC Connection Setup message would include new information providing the channel details for the reserved AICH and the signature/slot address for this UE.

There are several techniques available to provide a coordinated OLPC measurement. The OLPC measurement may be implemented by using the DCH power control preamble in

UL and DL for a fixed time period (DCH PCP technique). An alternate technique involves the use of a reserved RACH signature to be used with fixed power steps in the uplink. At the appointed time, the UE would begin a sequence of RACH transmissions, starting at a known power level and increasing power by a fixed step size. When the Node B detected the uplink RACH, the slot number would indicate to the UTRAN the transmit power level used by the UE. After receiving the RACH, the Node B would transmit an AICH_nak to the UE indicating the end of the OLPC measurememt. This RACH technique (RACH UL step technique) actually measures the pathloss of the uplink, and thus would be a solution only for TDD. A third technique would involve using 2 signatures in the RACH uplink (AICH DL step). The UE would use a normal RACH ramp up with signature1 until the NODE B detected the RACH and responded with an AICH_ack at broadcast power level. Then the Node B continues to transmit AICH_acks (in every third or fourth slot), but steps down the power of the AICH_ack at each transmission. When the UE receives each AICH_ack it responds by sending a RACH with signature 2 with a smaller RACH power step. When the UE does not receive an AICH_ack in the expected slot, the UE then sends a RACH with signature1, again with the smaller power step increase. The procedure ends when the Node B broadcasts an AICH_nak to the UE.

Table 1, below, summarizes the possible combination of the above three elements to list potential methods for improved OLPC for FACH.

TABLE 1. Alternate Methods for Improved OLPC for FACH

Method	Buffer location	Signal technique	OLPC measure
1	RNC	FACH message	DCH PCP
2	Node B	FACH message	DCH PCP
3	RNC	AICH code	DCH PCP
4	Node B	AICH code	DCH PCP
5	RNC	FACH message	RACH UL step
6	Node B	FACH message	RACH UL step
7	RNC	AICH code	RACH UL step
8	Node B	AICH code	RACH UL step
9	RNC	FACH message	AICH DL step
10	Node B	FACH message	AICH DL step
11	RNC	AICH code	AICH DL step
12	Node B	AICH code	AICH DL step

3. Recommended Method for Improved FACH OLPC level measurement

To summarize the impact of the above options on current architectures:

- Method 1 requires minimal changes to architecture uses the fasted measurement technique and is compatible with both FDD and TDD.
- Methods 5 is for TDD only and uses no DCH resources in Node B.
- Method 8 is for TDD only and requires changes only in Node B.
- Method 12 is for TDD and FDD and requires changes only in Node B.

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Benefits of Improved OLPC for FACH

By using any of the above listed methods, the Node B is able to determine the appropriate power level for an OLPC FACH directed message. The measurement must be timely (i.e. must occur just prior to the OLPC FACH message) since the actual pathloss may be changing rapidly in a fast fading environment.

The simulation results show a gain of 3.5 dB in indoor 4.5 dB in vehicular environment by providing a improved OLPC on FACH [3-simulation document by GBT]. These gain values do not include the impact of measurement inaccuracy. Assuming an inaccuracy of 1.5 dB, the overall downlink capacity with provision of the improved OLPC on FACH will be 5-6 dB.

Conclusion

The capacity gain that is achieved by introducing improved OLPC on FACH directed messages is significant in the downlink direction. The disadvantages include a slight increase in message delivery delay and an increase in complexity for coordinated UE/Node B OLPC measurement. The level of gain is sensitive to the operating environment and is expected to range from 5-6 dB . All of the proposed signaling techniques and measurement techniques are new uses for already existing elements of the UMTS specification and are thus low risk from an implementation and testing perspective. This contribution is presented for discussion and information to R1.

[1] 3G TS 25.133 V3.2.0 (2000-06)

[2] S. GhassemZadeh, etal, “On the statistics of multipath fading usingDS-CDMA Signal at 2GHz, in Microcellular and Indoor environment” ICC ‘94

[3] R1-00-1235, “Optimizedand imperfect OLPC-FACH versus CLPC-FACH simulations”