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Agenda Item: **5 AH 14**
Source: **Golden Bridge Technology**
Title: **Firm Handover for CPCH**
Document for: **Discussion and Approval**

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1. Problem statement

The UEs at the cell edge that opt to communicate through CPCH with 2 or more candidate cells (with Ec/I0 within Δ dB of the controlling cell) will potentially adversely impact the capacity of the candidate cell since the transmitted Packet will be independently Rayleigh faded towards the candidate cells. This problem exists for both RACH and CPCH schemes. This problem is more pronounced for indoor and pedestrian environments. Note that with RACH and OLPC, this effect degrades the capacity significantly. The same is true for CPCH with CLPC. As a slowly faded packet at high data rate could potentially degrade capacity unless its data rate is decreased. This contribution outlines another solution to this problem, which is employment of Firm Handover.

The use of the word firm distinguishes the process from soft which implies some kind of selection diversity or combining diversity of the continuous or bursty in the infrastructure. In this method, we propose an UE-based-macro-diversity-selection of the preambles in the firm-firmer Handover State. The bursty packets are only sent through one cell. However, as long as there are 2 or more cells in the candidate set, the UE stays in the firm-firmer handover state which implies possible transmission through any of the cells in the set. When the UE exits that state, it communicates through once cell only.

2. Background

Here is a summary of consensus building on Firm handover so far:

1. The ping-pong method is favored over the common preamble method.

2. It has been recognized that the use of Firm Handover does not introduce any new hardware in the Base Node.
3. How is the transmission on FACH (L23 ACK for CPCH messages) handled? Should there be transmission from two cells? Should the UE be required to receive two FACHs simultaneously?
In order to reduce complexity, the UE should only 1 FACH rather than two. One way to achieve this is to have the infrastructure send the UE-directed messages over the original cell only.

4. What are the signaling requirements for the UE as it enters and exits the Firm handover region?

As the UE moves into the Firm Hanover region, the UE should signal in that to UTRAN so that it assigns to the UE the CPCH set corresponding to the new cell. While the UE is in the Firm Handover state, the L23 ACKs and downlink packets should be transmitted through the FACHs corresponding to both cells, however, the UE should only be required to monitor one cell [the old cell]. **Note that there will only be one context at the SRNC for the UE at all times.**

Once the UE moves out of the Firm Hanover region, it will signal that to UTRAN again [another signaling message is required] so that it removes the UE from the "firm handover region" category.

3. Discussion

The UEs on the cell edge (same Base Node or various Base Nodes) which could constitute up to 30% of the overall mobiles could experience long delays, cause cell capacity degradation (uncontrolled faded transmission to the adjacent cell) and throughput decline in RACH and CPCH if they employ a simple hard handover method. We propose a new handover technique for bursty traffic, which is UE-based-Firm-handover. We call it Firm Handover since uplink macro-selection-diversity is employed in a DTX manner and the data is transmitted via one base station only. Also, the selection is made in the UE rather than the infrastructure during the preamble transmission. The message part is only sent to one cell.

The UEs are continuously measuring the RSSI from the neighbor list. When an RSSI of BS in the neighbor list is Δ dB below the received RSSI from the current base, then it will be in the active set. When the UE has a packet to transmit via CPCH, it will alternate preamble transmissions between the two base nodes in the active set and wait for the AICH from the Base Nodes. After the receipt of the AICH, the UE will transmit the Collision Detection code and start transmission if it receives the right CD code from the Base Node. This solution applies to the Firm handover between two cells belonging to different Base Nodes. We call this solution the Ping-Pong method.

3.1 What are the gains?

The shadow fading margin that has been selected due to handover gains can be maintained without incurring long packet delays for the cell-edge-mobiles. Negative impact on CPCH throughput is contained. Negative impact on cell capacity is contained.

3.2 CPCH with a Ping-Ponging Preamble

Normally, the Mobile Station before going into the transmitting mode, it searches the Base Stations in its immediate neighborhood, and chooses to transmit to the strongest received Base Station. This is a UE transmission decision and it is based on the received RSSI from the neighbor list. Most of the time, the UE transmission is being received by appreciable power from a single Base Station only. In that case, UE needs only to communicate to that Base Station.

An estimate of the power, at which a Base Station receives a UE, can be estimated by the amount of power the Remote Station receives the Base Station. This is normally called an Open Loop Power Estimate. It allows a UE to determine the power its being received at different Base Stations by the amount of power the UE receives those Base Stations. Given that the Uplink and Downlink frequencies are different, this is not a very accurate estimate. However, it can be used to determine if one or more Base Stations are worthy (candidates) for communication. This can serve especially well when the UE is located at the outskirts of a cell. In that case, its transmission could be received strongly from more than a single Base Station. A more important measure is the power by which the UE is being received by the Base Stations. This is because, when operating the Common Packet Channel, most of the information transmission is on the uplink. The proposed Firm Handover in this contribution allows the UE to most of the time, select the best receiving Base Station. This will provide considerable capacity advantage to UEs operating at the outskirts of a cell. By being connected to the Base Station they are being received the strongest, the overall system capacity is maximized.

When the UE chooses a particular Base Station to communicate with, and establishes communication with it, then, the Remote Station is linked to that Base Station. One way the UE can choose which Base Station it should link to, is to transmit a UE-Preamble to more than one Base Station, and then choose either the one that acknowledges the reception, or to the one that has being received the strongest if more that one Base Station acknowledges the reception at about the same time.

Normally, there is different UE-Preambles for each Base Station. Also, given that the Base Stations are not synchronized, transmissions to different Base Stations might need to occur at different times. Therefore, the Remote Station will need to transmit alternatively to a number of Base Stations and also expect their acknowledgements at different times. Clearly, the UE will transmit to a single Base Station and always the same UE-Preamble if the UE deems that it is in the receiving range of a single Base Station.

Let's assume that the UE is in the receiving range of two Base Stations. As seen from Fig. 1, the UE transmits sequentially two different preambles to two Base Stations. These are UE-Preamble0 and 1. The powers of the preambles are again increased in time. The preamble for the first Base Station (Base Station 0) is transmitted at powers $P_{0,0}$, $P_{1,0}$, $P_{2,0}$….. The preamble for the second Base Station (Base Station 1) is transmitted at powers $P_{0,1}$, $P_{1,1}$, $P_{2,1}$….. . In this case, only Base Station 0 acknowledges the reception of UE-Preamble0. The UE then undergoes through the Collision Detection/Collision Resolution CD/CR process, the transmission of the UE-CLPC-Preamble, and the transmission of the data information. Ways to enable preamble transmissions to more than two Base Stations can be easily derived from the above procedure. It is understood from Fig. 1, that the reception of the last UE-Preamble0 at Base Station 0 was received stronger than the last UE-Preamble1 at Base Station1. Therefore, the Base Station that possessed the better Uplink Channel was chosen. A UE could also have the choice of responding to the first Base Station that acknowledges a preamble reception. This could be for the case when the information transmission delay needs to be minimized.

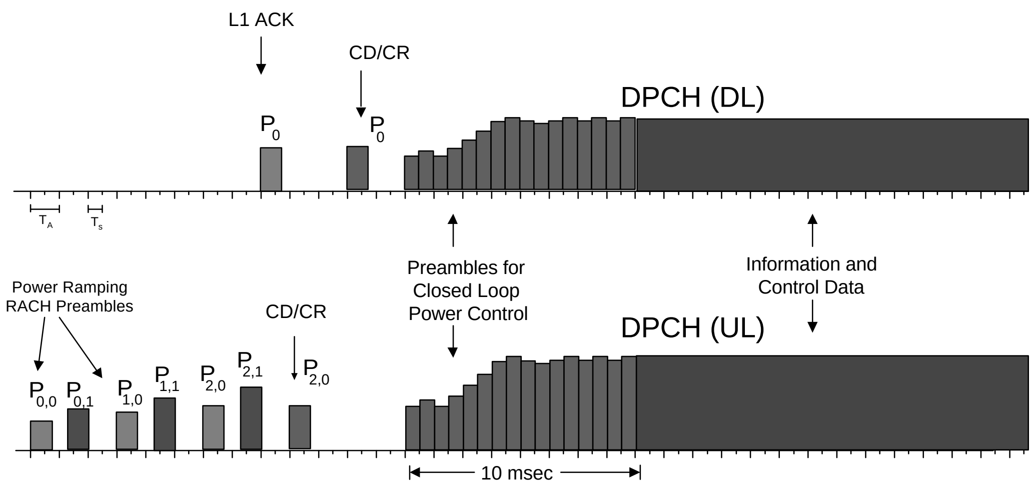

FIG 1. Common Packet Channel (CPCH) Timing Diagram with its Associated Downlink Dedicated Physical Channel.

In Fig. 2, both Base Station 0 and Base Station 1 acknowledged their corresponding UE-Preamble reception. However, the UE underwent the CD/CR process for Base Station 0 without waiting for the reception of the Base Station 1 acknowledgement. The remaining process is the same as before with the UE being in link with base Station 0.

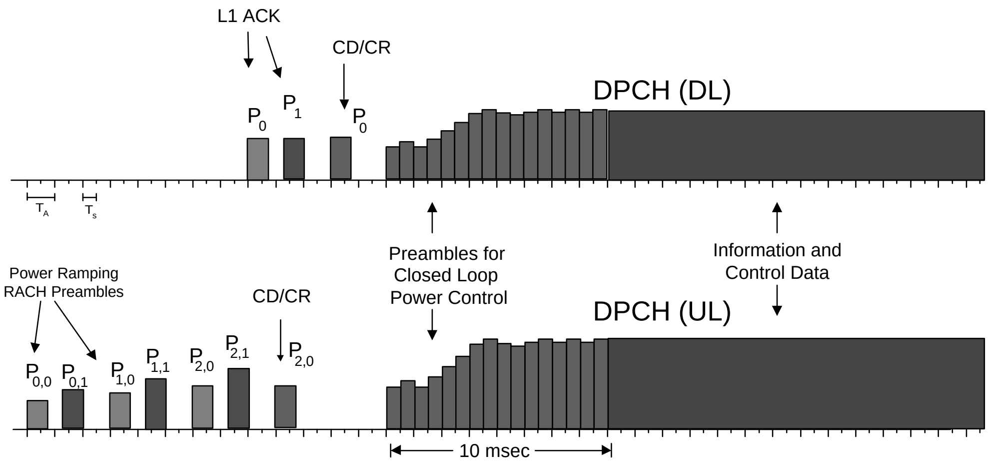

FIG 2. Common Packet Channel (CPCH) Timing Diagram with its Associated Downlink Dedicated Physical Channel.

In Fig. 3, the UE awaits for the possible reception of both acknowledgements before deciding which Base Station to transmit the CD/CR preamble signal. This allows the UE to select the Base Station that is being received the strongest. This does not necessarily guarantee that the Base Station selected is the one with the better Uplink channel. Statistically, however, the one being received strongest by the UE, is the most likely one to have the better Uplink channel.

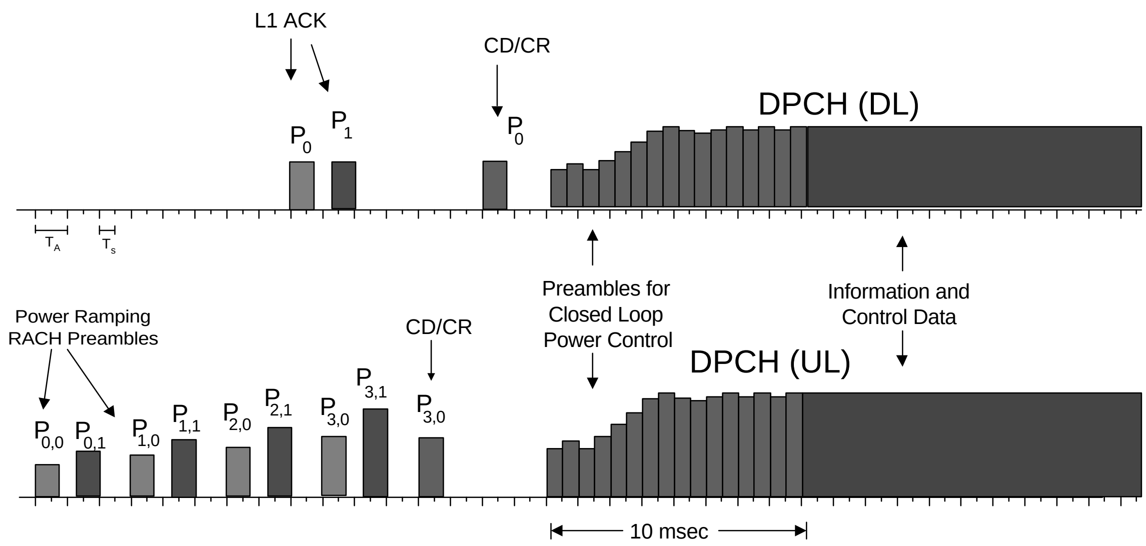

FIG 3. Common Packet Channel (CPCH) Timing Diagram with its Associated Downlink Dedicated Physical Channel.

4. Proposed text

Add to the end of section 6.2 (CPCH physical layer procedures) of S25.214

6.2.2 Physical layer procedures associated with Firm Handover over CPCH