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A Pre-Fetch Based Fast Handover Scheme for Femtocell Networks

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Abstract- **Mobility is the most important feature of a wireless cellular communication system. Usually, continuous service is achieved by supporting handover from one base station to another. The legacy handover procedure is designed for handover between macrocell base stations which are part of Mobile core network (MCN). The femtocell base stations connect to the MCN through public internet which introduces additional latency while it makes use of existing legacy handover procedure. Thus, we propose a new Pre-fetch based fast handover scheme for cellular networks with femtocells to increase the efficiency of handovers. This scheme requires only a little change in the existing architecture to achieve simplified, fast and more efficient handover.**

Index Terms- **MCN, SGW, MME, (e)NB, H(e)NB, UE, LTE.**

I. INTRODUCTION:

Handover is the process by which a mobile phone switches between different cellsites during a phone call, continuing with seamless audio in both directions. When a User Equipment (UE) starts a call with the macrocell base station ((e)NB) and moves close to the femtocell base station (H(e)NB) while still active on the call, the call quality can degrade as it approaches the femtocell. Upon detecting the strong signal of the femtocell, the mobile device will report to its macrocell base station that the signal it is experiencing has decreased and that another cell with a stronger signal is nearby. And now handover takes place. The aim of the handover procedure is to be fast enough to maintain its transparency to the running applications [1].

The macrocell base stations are part of Mobile Core Network (MCN), in traditional handover procedure it is assumed that the latency is minimum between the (e)NB and the other entities of MCN [2]. But this assumption becomes invalid with the introduction of femtocells.

Femtocell is a low-power wireless base station for cellular access indoor in areas with limited or no cellular provider. The access point operates in a licensed spectrum and is designed to route mobile phone traffic through a home or corporate IP network. A femtocell is connected to a broadband and provides complete voice and data service to standard mobile devices such as cell phones, or PDAs that are registered and within a limited range. A high speed data connection is provided by the femtocell to subscribers within a small range [3].

A femtocell and a macrocell differs with their respective backhauls. A femtocell is connected to the MCN through the public internet, and the macrocell is connected to the MCN with its dedicated lines. it takes less than 100 ms for a handover between macrocells [4], it could take well over 200 ms to transmit a single message over the public internet. Because of the small size of femtocells, the frequency of handovers will also increase. When an UE is moving too fast it may find it hard to keep connected with fast passing femtocells in its path. Thus, a fast handover procedure is required for the mobile UE's to take advantage of the fast passing femtocells.

The handover issue on femtocell networks has been less studied by the research community. Ideas such as proactive and reactive triggering handover procedures by predicting mobility of users [5], reducing the scanning time to identify associable femtocells by caching recently visited cell information [6], reducing unnecessary handovers by modifying the architecture and signal flow [7][8], have started appearing in the literature. There are also been some work focusing on increasing handover efficiency in other networks such as WMAN [9] and WiMAX [10].

In order to overcome the shortcomings of the Legacy Handover procedure due to the introduction of femtocells in the network, we propose a new Prefetch-based Fast Handover scheme and the MCN architecture needs a little change. The handover procedures that take place before and after actual handoff of the UE is decoupled to two processes and higher layer data is prefetched to nearby femtocells. And thus the latency is reduced substantially.

II. THE ARCHITECTURE OF LTE NETWORK:

The already existing 3G and LTE (Long term evolution) network architectures are designed for handover between macrocells. Figure 1 shows the LTE network architecture. The emerging femtocell network architecture is a new addition to those existing components. The relevant components of LTE network are Serving Gateway (SGW), Mobile Management Entity (MME) and Mobile core network (MCN). The routing and forwarding functions taking place between the base stations are supported by the Serving Gateway (SGW). For controlling the signals, the femtocell and macrocell base stations are connected to the MCN and the Packet Data Network (PDN) through the SGW. The key control node for LTE access network is the Mobility Management Entity (MME) and it provides the control plane function for mobility between LTE and other access networks. Interface scalability and support to a large number of H(e)NBs is provided by a H(e)NB Gateway (H(e)NB-GW).

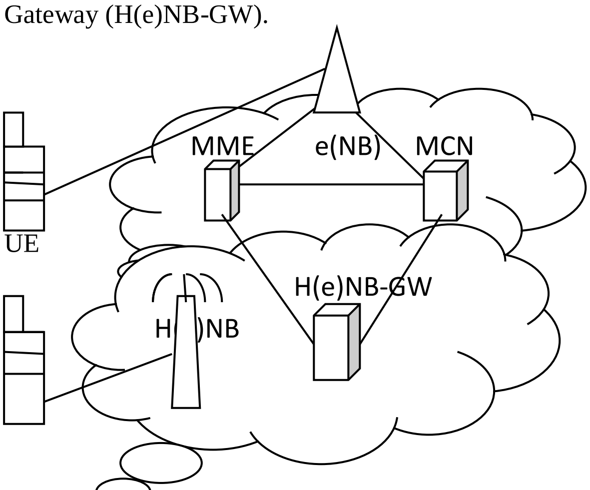

Figure 1: LTE network architecture

a) The Legacy handover Procedure:

Signal strengths of all the available channels are measured by the User Equipment periodically and the measurement report message is sent to its associated femtocell or macrocell base station. When it is noticed from the measurement report message that the signal strength received by the User Equipment is high from an macrocell or femtocell base station which it is not currently associated with, a positive handover decision is made. Now a handover process is triggered

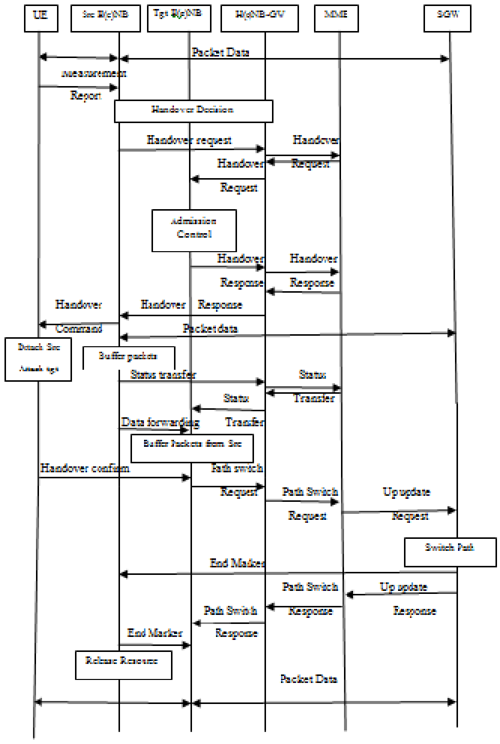

Figure 2: Legacy handover procedure

Figure 2 shows the legacy handover procedure used in LTE networks and the same is extended for a femto-femto handover.

- Src H(e)NB is the femtocell the UE is currently associated with and Tgt H(e)NB is the femtocell that the UE is to be handed-over to.
- A Handover Request message is sent to the Tgt H(e)NB via the MME from the Src H(e)NB when it takes a positive handover decision.
- Admission Control is performed by the Tgt H(e)NB for the UE, and responds with a positive Handover Response message to the Src H(e)NB.
- After receiving the positive Handover Response, the Handover Command is issued to the UE by Src H(e)NB, which then detaches from the associated femtocell and tries to handoff to the new femtocell.
- Meanwhile, the application layer data is buffered by the Src H(e)NB it continues to receive from the SGW.
- After that the Src H(e)NB sends a status transfer message to the Tgt H(e)NB through the MME and starts transferring the buffered data to it.
- After receiving the Status Transfer message, the Tgt H(e)NB begins to buffer the data being forwarded by the Src H(e)NB and accepts the Handover

Confirm message from the UE, thus association with it is allowed.

- Then the buffered data is transmitted to the UE from the Tgt H(e)NB. The data is now sent to the Tgt H(e)NB from the SGW through the Src H(e)NB, and thus the public internet is traversed twice.
- A Path Switch Request is sent to the SGW from Tgt H(e)NB, which then switches the data path and responds with a Path Switch Response message.
- The SGW then sends an End Marker data packet to the Src H(e)NB and then switches the data path so that it now streams the data directly to the Tgt H(e)NB. The Src H(e)NB forwards the End Marker packet when it is done forwarding all the data it has been receiving and buffering from the SGW.
- The Tgt H(e)NB, after receiving the End Marker packet, begins to transmit data from the SGW directly to the UE. This marks the end of the legacy handover process.

b) Disadvantages of legacy handover procedure:

- The data rate received by UE is very low, since the signal from Src H(e)NB is weak.
- When the UE receives data from Tgt H(e)NB, initially the data is routed through Src H(e)NB and thus the public internet is traversed twice,

Due to the above disadvantages, the legacy handover procedure becomes inefficient

III. PRE-FETCH BASED FAST HANDOVER:

In the Pre-fetch based fast handover procedure the handover decision completely depends on the speed of the UE, where the legacy handover process is independent of the UE speed. The new procedure needs a little change in the existing architecture.

In this Pre-fetch based fast handover the actual handoff process is separated from the processes taking place before and after it unlike the legacy handover process. We define two different regions for a UE, associable region and proximity region. When the signal from a femtocell base station is stronger than that of other base stations (including macrocell), the region of that femtocell is associable region of the UE. This associable region along with its surrounding region is defined as the proximity region of the UE.

Thus, the UE can be in proximity region of one or more base stations and it can be in associable region of only one of the base station. The higher layer data is streamed to each one of the base station when the UE is in the proximity region, but only its associated base station transmits the data to it. The other base stations are ready to be associated with the UE since they already have fetched the data. The actual handoff takes place after the Pre-fetch process. The base stations need to be added to the proximity region when UE comes in and released when the UE moves out of that region. This is defined as proximity add or release process.

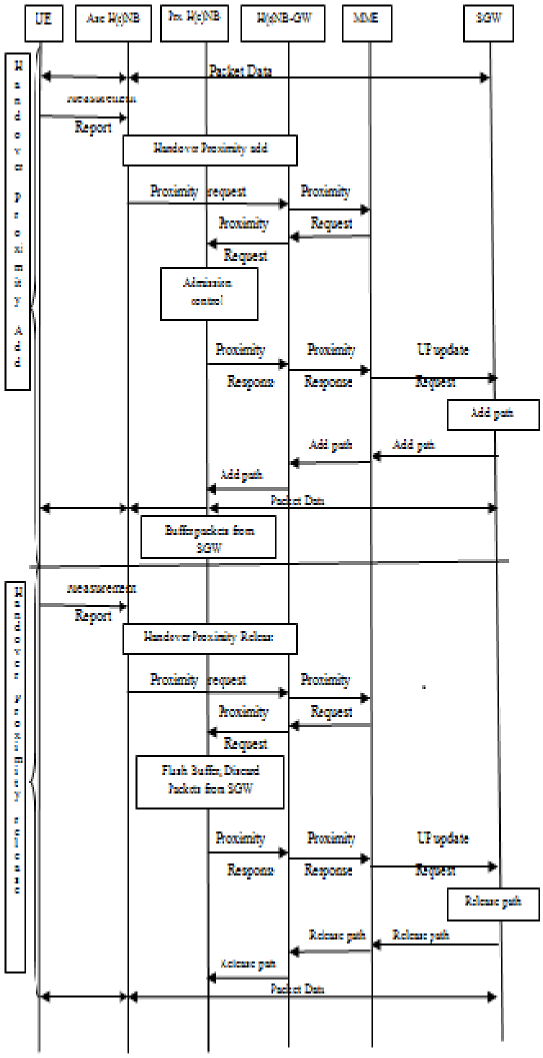

Figure 3: Proximity add/release process

Figure 3 shows the proximity add or release process. As shown in the figure the associated femtocell base station (H(e)NB) along with the H(e)NB-GW makes a decision whether to add the new base station (Prx H(e)NB) to the proximity of

UE. This is called as handover proximity add function. The MME tracks the femtocells in proximity of UE, and a Path Update Request is sent to the SGW. The SGW sends the information about the new data stream to be initiated along with the Add Path control message. Now a copy of data that is being sent to the associated H(e)NB is streamed to the Prx H(e)NB simultaneously. The new H(e)NB buffers this data and gets ready to be associated with the UE in future. In proximity release process the Prx H(e)NB flushes the buffered data and SGW stops streaming data to it.

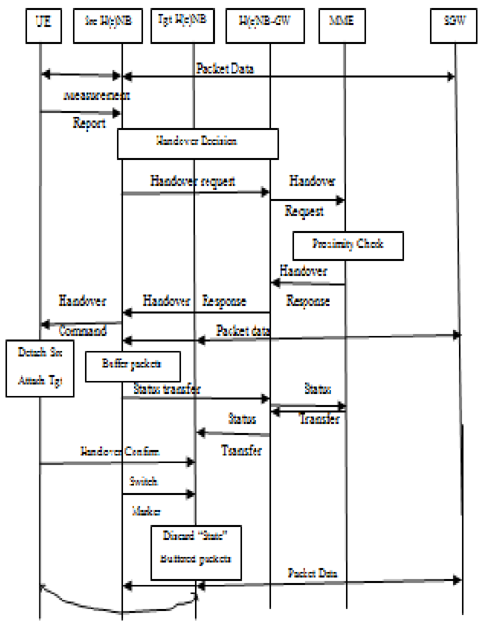

Figure 4: The actual handoff process

Figure 4 shows the actual handoff process. The process here takes place very quickly since some of the processes are already done. The handover taking place is similar to legacy handover. The handover decision function is followed by the handover request message from the Src H(e)NB. Then a Proximity check is done by the MME to verify whether the Tgt H(e)NB is gone through the proximity add process. Then the Handover response and Handover command are sent to the Src H(e)NB and UE accordingly. Now the Tgt H(e)NB needs a marker to know the point from which it has to transmit the data to the UE, since it has already buffered the higher layer data. Upon receiving the Switch Marker and status transfer from SGW the Tgt H(e)NB starts transmitting the data to the UE. And thus handover has taken place.

IV. SIMULATION RESULTS:

We have simulated the scheme using Network Simulator to evaluate the benefits of Pre-fetch based fast handover scheme. Number of nodes is set to 6. The process of both swift mode and normal mode is initiated. Based on the average speed of the user mobility, the handover between base stations takes place and the graphs are plotted accordingly.

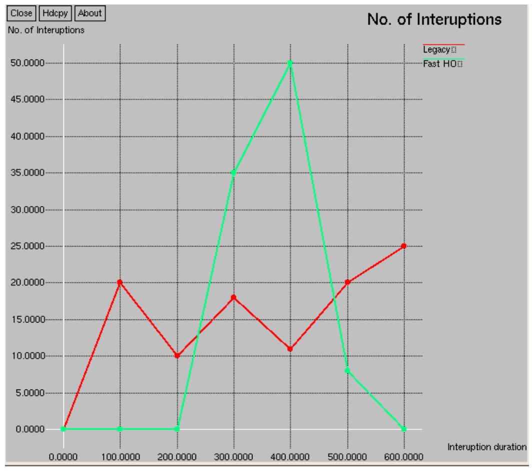

Figure 5: Interruption time distribution

The above graph of Interruption time distribution is plotted between number of interruptions and interruption duration. From the graph it is clear that the interruption rate for Pre-fetch based fast handover scheme is less compared to legacy handover.

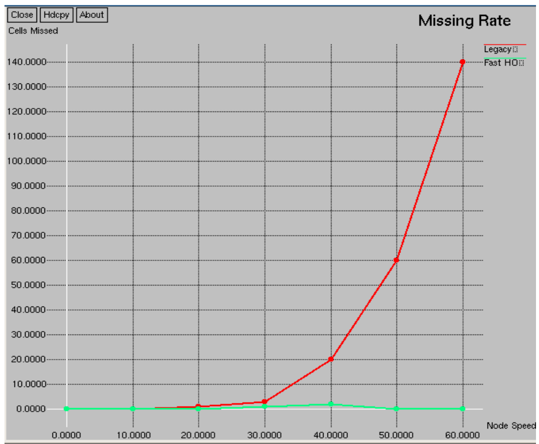

Figure 6: Number of cells missed by the UE

The above graph of Number of cells missed by the UE is plotted between node speed and cells missed based on the average speed of the user node. From the graph it is clear that the data served to the user in legacy handover is decreased and the cells are not skipped in Pre-fetch based fast handover.

V. CONCLUSION :

Thus we proposed a new Pre-fetch based fast handover scheme to overcome the disadvantages of legacy handover when femtocells are introduced, with little modifications in the existing architecture. Simulations are demonstrated for reduction in number of data interruption and number of cells missed. The fast moving UE's takes maximum advantage and more efficient handover from the deployed Pre-fetch based fast handover scheme.

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