The Study & Implementation of Handover Procedure in LTE-based Femtocell Network

Shaik Asif, C.Pavan Kumar, Siva Krishna, Jamanjyothi Sreekanth and Anish Chandra

CERTIFICATE

This is to certify that the project entitled "**The Study of Handover Procedure in LTE-based Femtocell Network**", being submitted by **Shaik Asif Ahammeed**, Roll no. CS10B034, **C.Pavan Kumar**, Roll No. CS10b009, **Siva Krishna**, Roll No. CS10B028, **Jamanjyothi Sreekanth,** Roll No. CS10B015, **Anish Chandra**, Roll No. CS10B022 to the Indian Institute of Technology, Hyderabad, is a bonafide record of work carried out by them under my supervision.

Bheemarjuna Reddy Tamma
Assistant Professor
Dept. of CSE
IIT Hyderabad

Abstract

Femtocells are a promising technology to improve network performance with the short range, low-power, and cost-beneficial small base stations. With the advent of femtocells in cellular networks, the inter-cell handover process has become more complex, frequent and time-sensitive. We implemented Handover procedure in a femtocell network. The 3GPP LTE based handover is analyzed in three scenarios: hand-in, hand-out and inter-FAP. We used ns-3.16 for implementation. For this we implemented Femto-Gateway, Mobility for building mobility model, X2 interface between two Femto-Cells in NS3.

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Contents

Chapter 1

Introduction

Nowadays, handover has turned out to be an obligatory functionality on all mobile wireless systems. Continuous connection during user mobility among cells is allowed due to handover procedure, but on the other hand, the handover also brings a significant increase of Medium Access Control (MAC) overhead and also increases the delay of packet delivery to the destination user.

The implementation of the new emerging network technology i.e., femtocell at home and residential area is expected to cover the "blank spot" and to boost the utilization of wireless capacity which is not covered by conventional macrocell base station. However, the availability of hundreds femto access points (FAPs) in a particular area most likely increase the technological challenges in handover procedure. Another challenge is the mitigation of unnecessary handover since it can trigger the very frequent handovers even before one already initiated handover procedure is completed.

1.1 OVERVIEW OF LTE-BASED HANDOVER IN FEMTOCELL

In this section we shall describe the LTE-based handover in a femtocell network.

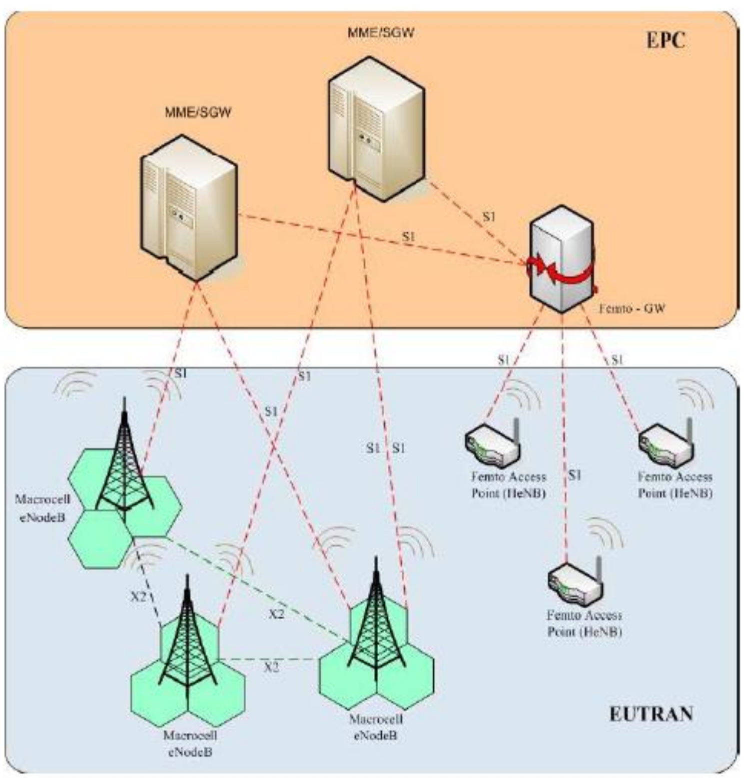


Fig. Deployment of HeNB in EUTRAN Architecture

(The Study of Handover Procedure in LTE-based Femtocell Network Ardian Ulvan*, Robert Bestak* and Melvi Ulvan)

1.1.1 eNodeB Macrocell Handover

The 3GPP LTE for the fourth generation (4G) mobile system specifies the handover procedure and mechanism that support various users' mobility. A handover process, in general, is divided into four parts

1. UE measures downlink signal strength
2. Processing the measurement results and
3. Sends the measurement report to the serving eNodeB.
4. The serving eNodeB then makes the handover decisions based on the received measurement reports.

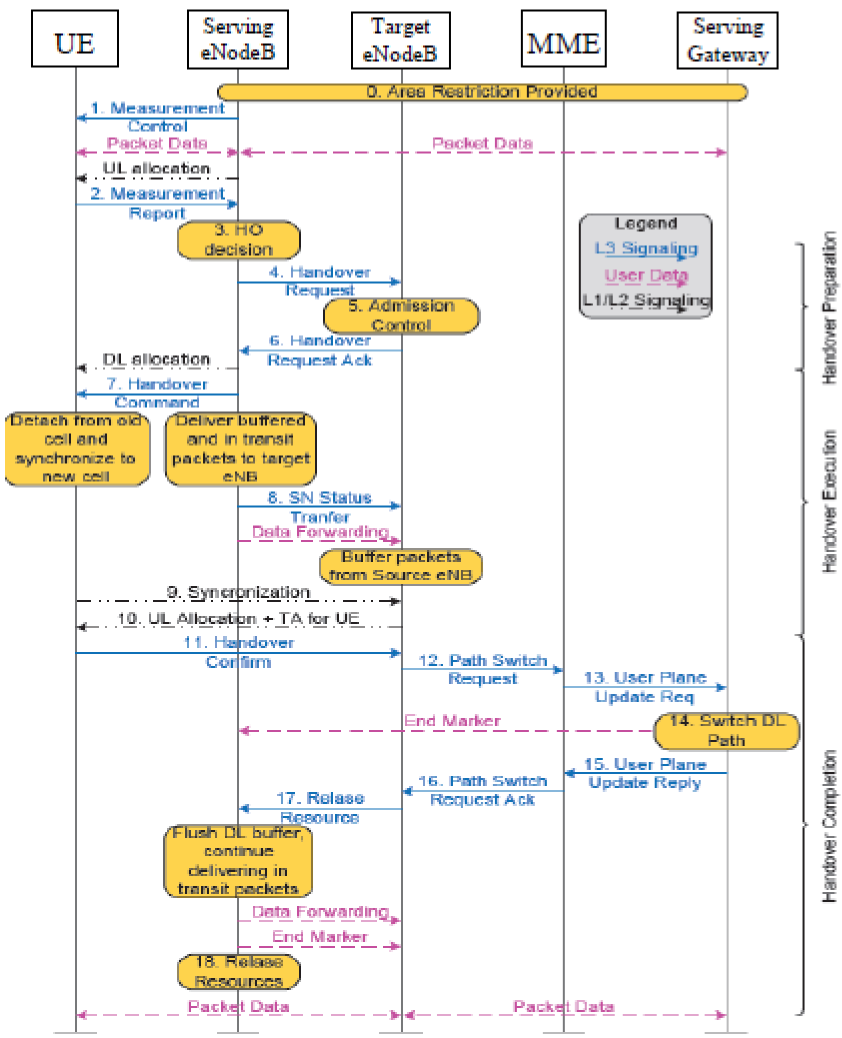


Fig. Message sequence diagram of handover procedure in 3GPP-LTE

(The Study of Handover Procedure in LTE-based Femtocell Network Ardian Ulvan*, Robert Bestak* and Melvi Ulvan)

1.1.2 Handover Scenario in Femtocell

Due to limited frequency allocation for femtocells, it most likely that the soft handover will not be implemented

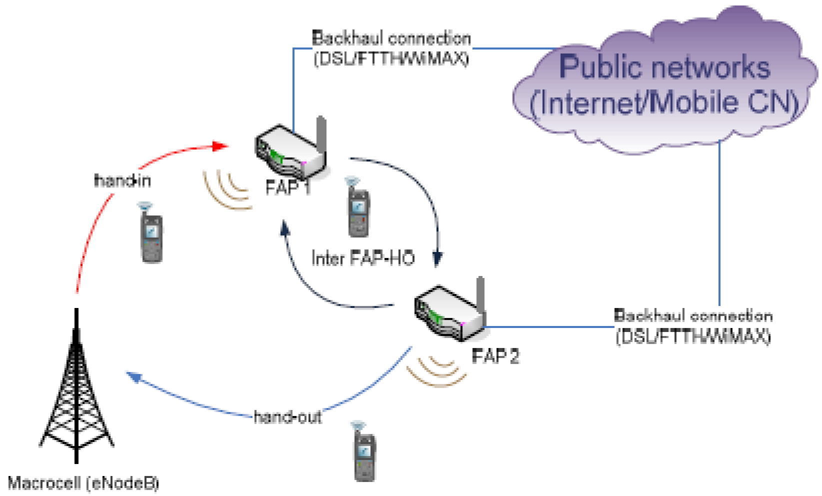


Fig. Handover Scenario in FemtoCell Network

(The Study of Handover Procedure in LTE-based Femtocell Network Ardian Ulvan*, Robert Bestak* and Melvi Ulvan)

There are three possible handover scenarios in femtocell, they are:

- Hand-in: The handover scenario where an UE switch out from macrocell eNodeB to FAP.
- Hand-out: The handover that is performed from FAP to macrocell eNodeB.
- Inter-FAP handover: The handover from one FAP to another FAP.

1.2 HANDOVER DECISION POLICY

The common metrics for handover decision mechanism include Carrier to Interference-and-Noise Ratio (CINR), Receive Signal Strength Indicator (RSSI) and Quality of Service (QoS).However, along with these metrics we have to control frequent handovers in femtocells. For this we have to introduce Mobility prediction for the UEs'.

We have to take care of Load balancing. In the load balancing point of view, when a large number of active UEs are located in a given cell, available resources may be insufficient to meet the QoS for the real time service, but it may offer the good performance for the best effort service. Particularly, in the FAP case where the available user is limited, if the available resource is too short for UE to handover to CSG cell, then it needs to handover to another accessible FAP or eNodeB macrocell.

1.3 NETWORK SCENARIO

We implemented the FemtoCell handover in ns3. For this we created a network scenario consisting of few UEs of which some are connected to Femto Access Point and some connected to Macro eNodeB. The UEs will be moving randomly. The movement of the UEs can be confined to a certain region or can be made unconfined based on user. We then made Handovers between the FAPs and the Macro eNodeBs based on the algorithm. We also created a new node for FemtoCell gateway, which is not available in the present version of ns3. However, we did not include the gateway in our implemenataion.

The Network Scenario consists of a building with rooms with n*x*y rooms, where n is the number of floors, x is number of rooms in x-direction, y is the number of rooms in y-direction. Each room consists of a FemtoCell and some number of users (can be set) connected to it, and there will be Macro Cells outside the building at some positions. The Users are allowed to move in some direction: within the room, outside the room (can be set by the user).

Chapter 2

Mobility for UE's in ns3

For implementing the Handovers we had to create a network scenario as mentioned above. For this we used Building Mobility Model. In ns3 there is no mobility of nodes implemented for the Building mobility model. So, we had to create the mobility for the users in the network scenario.

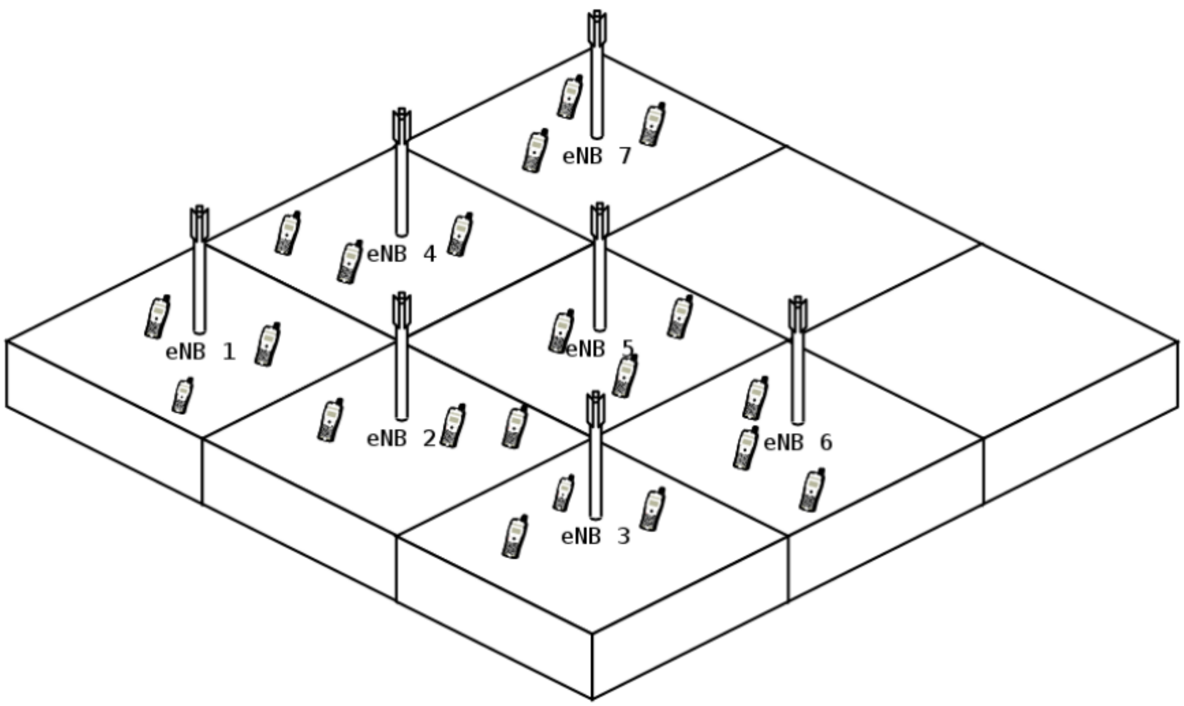


Fig. Network Scenario showing the FemtoCells
(http://www.nsnam.org/docs/release/3.14/models/html/lte-profiling.html)

2.1 IMPLEMENTATAION

For introducing the mobility for users in the building mobility model (with or without confinement to a region) we just change the position of the user every milli second in the mentioned direction. The position should not cross the boundaries of the room if there is any confinement on the motion of the User. For this we introduced new element velocity to the mobility model.

Chapter 3

Handover parameters

Next, we compute the metrics for taking Handover decisions. The parameters that are computed are

- Number of users per Macro eNodeB or Home eNodeB
- RSRP (Referenced Signal Received Power)
- SINR (Signal to Interference-and-Noise Ratio)
- Velocity of the User

These can be later used in Handover decisions for efficient handovers. At present we used only SINR values.

For this we had to change the following files:

- radio-envirornment-helper.cc
- radio-envirornment-helper.h
- Lte-spectrum-phy.h
- Lena-dual-stripe.cc

Chapter 4

X2 Interface between the FemtoCells

The X2 interface is used to interconnect eNodeBs and HeNodeBs(Femto cells). The main purpose of this interface is to minimize packet loss due to user mobility. As the terminal moves across the access network, unsent or unacknowledged packets stored in the old eNodeB(or HeNodeB) queues can be forwarded or tunnelled to the new eNodeB(or HeNodeB) using X2 interface.

X2 has two planes: Control Plane and User Plane. User plane is based in GPT-U (GPRS Protocol Tunnel), UDP and IP. Control Plane use SCTP and IP. It supports the exchange of signaling info between eNodeBs. It also supports forwarding of PDUs to tunnel endpoints. X2 is a point to point interface and even if two eNBs may not be connected physically it works in that way.

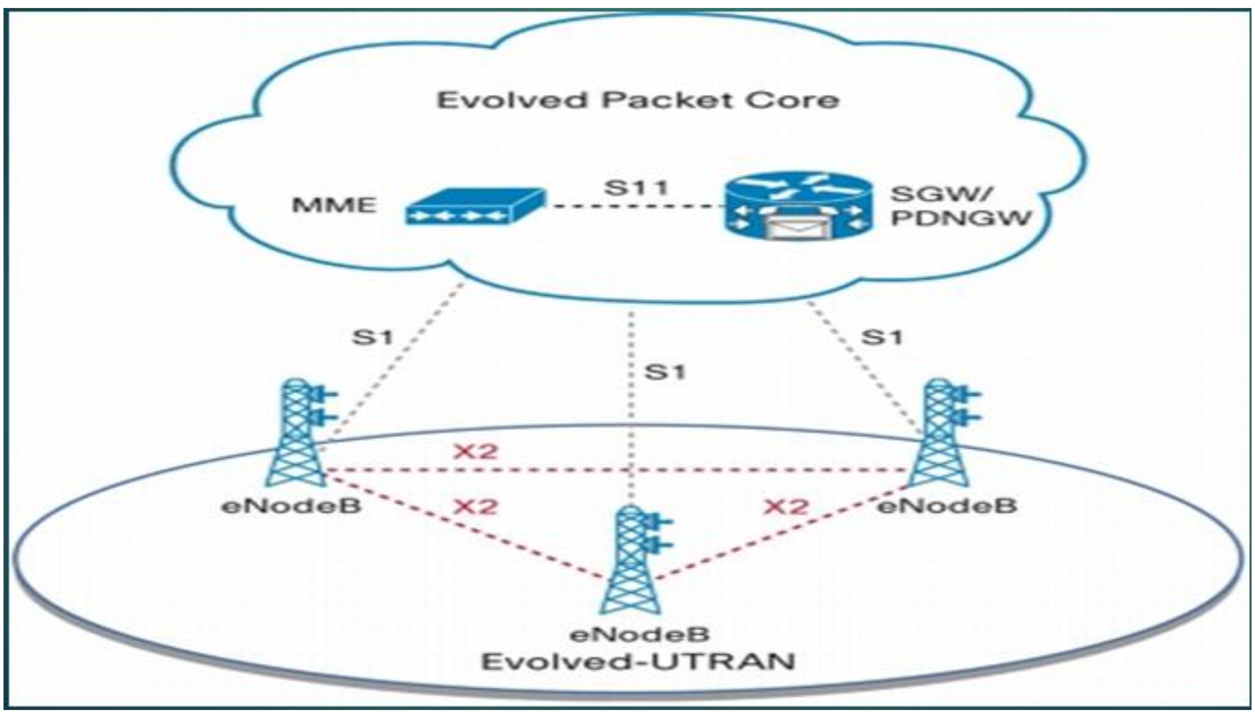


Fig. Typical diagram showing interfaces between different nodes of LTE Architecture

The present ns3 version does not have any X2 interface between Femtocells deployed but it has the X2 interface between the Macro eNodeBs. So, we introduced X2 interface between the Femtocells. Which we later used for handovers.

Chapter 5

FemtoCell Gateway

The E-UTRAN architecture may deploy a Home eNB Gateway (HeNB GW) to allow the S1 interface between the HeNB and the EPC to support a large number of HeNBs in a scalable manner. The HeNB GW serves as a concentrator for the C-Plane, specifically the S1-MME interface. The HeNB GW appears to the MME as an eNB. The HeNB GW appears to the HeNB as an MME.

The main function that HeNB GW hosts is Relaying UE-associated S1 application part messages between the MME serving the UE and the HeNB serving the UE, except the UE CONTEXT RELEASE REQUEST message received from the HeNB with an explicit GW Context Release Indication. Another function of Henb GW is making handover decision.

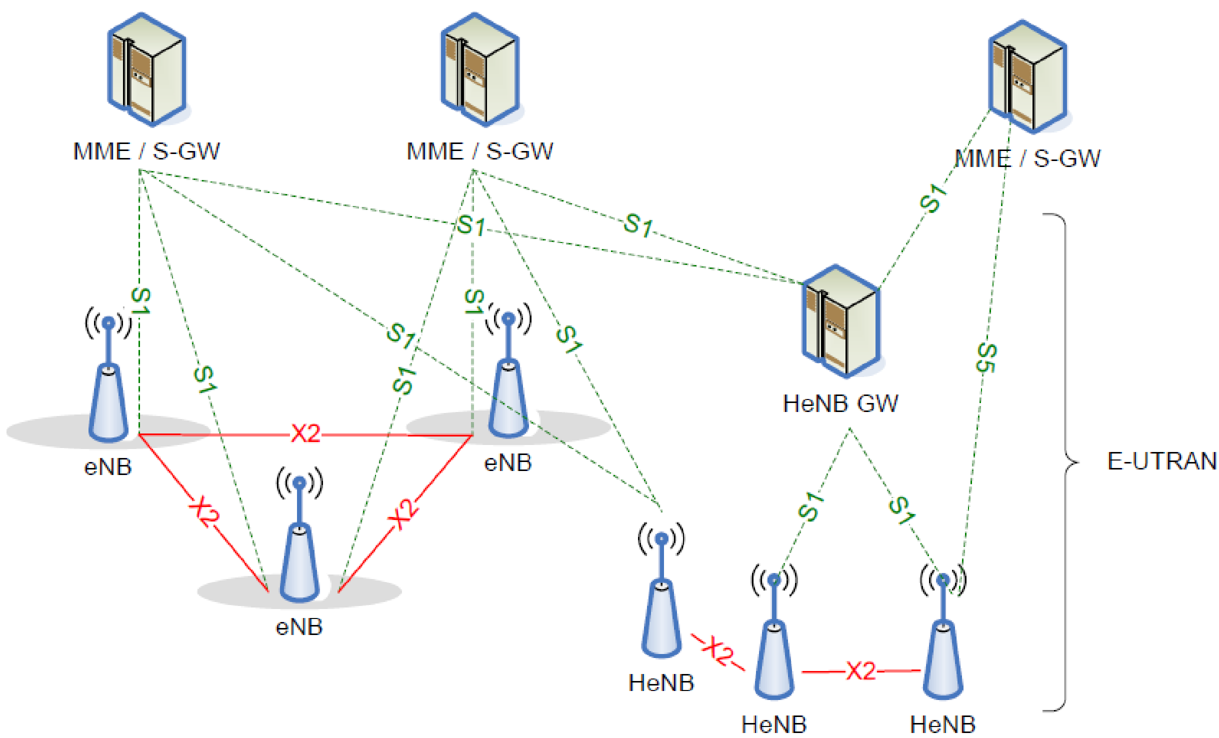


Fig. Overall E-UTRAN Architecture with deployed HeNB GW.

The present ns3 version does not have the FemtoCell gateway deployed. So, we implemented the HeNB gateway in ns3. We implemented this gateway in two parts. First part is data plane and the next part is for control plane. We did not integrate these two parts.

5.1 CONTROL PLANE

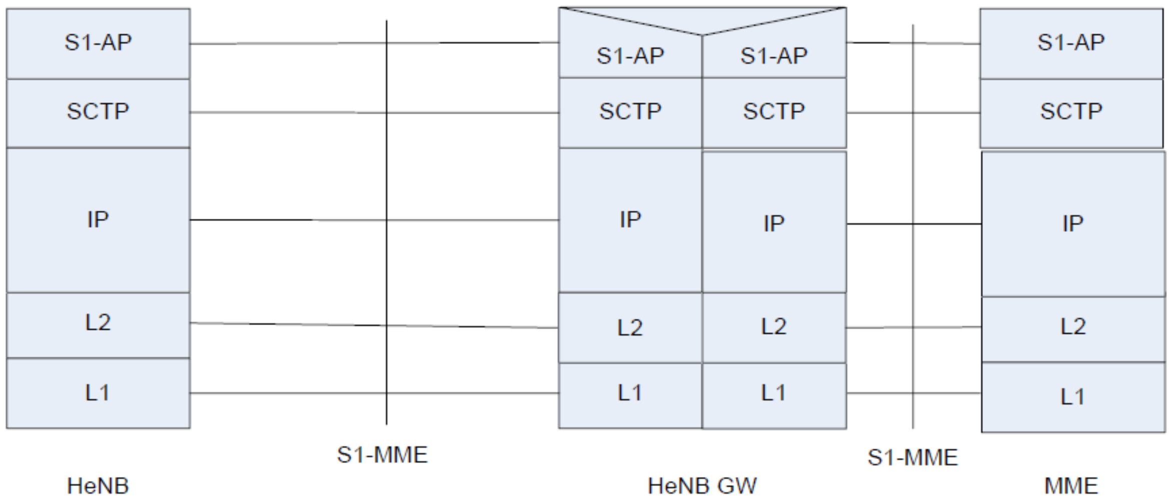


Fig. Control plane for S1-U interface for HeNB with HeNB GW

(3GPP TS 36.300 V11.3.0 (2012-09))

For the implementation of Control plane side of FemtoCell Gateway we have the code for MME in developer's code. For the implementation we did the following

- Created a new model for HeNB Gateway which relays all the control messages from HeNBs to MME and MME to HeNBs.
- Created a S1 link between HeNB Gateway and MME to pass the messages between the HeNB gateway and MME.
- Created a S1 link between HeNB and HeNB Gateway to pass the messages between the HeNB and HeNB gateway.
- Add this created model to epc-helper class
- Change the code of MME and ENB such that they send the messages to HeNB Gateway which in turn relays the messages

The HeNB Gateway collects all the information regarding the UEs and HeNBs connected to it. We did not take handover decisions in the HeNB gateway.

5.2 USER PLANE

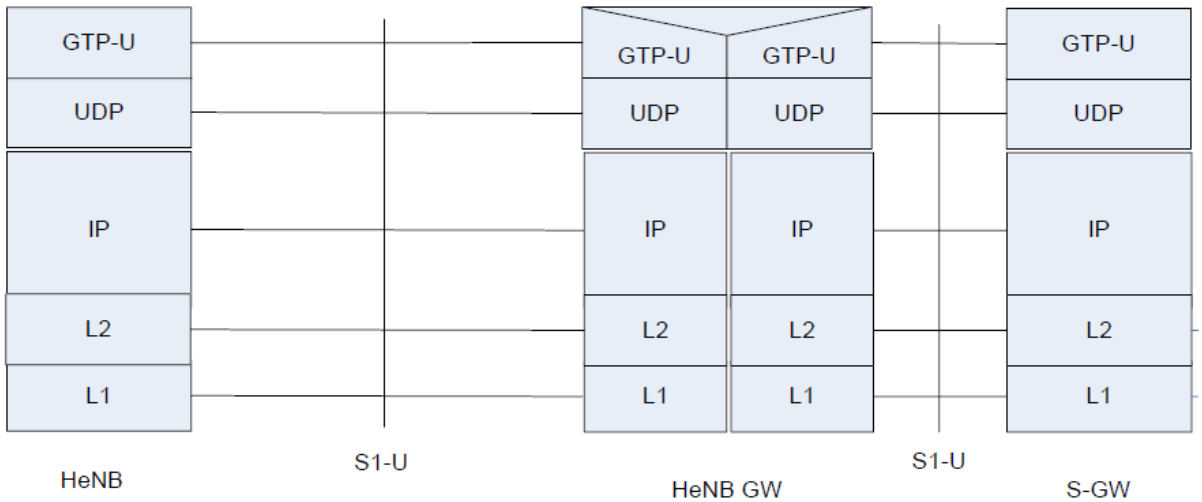
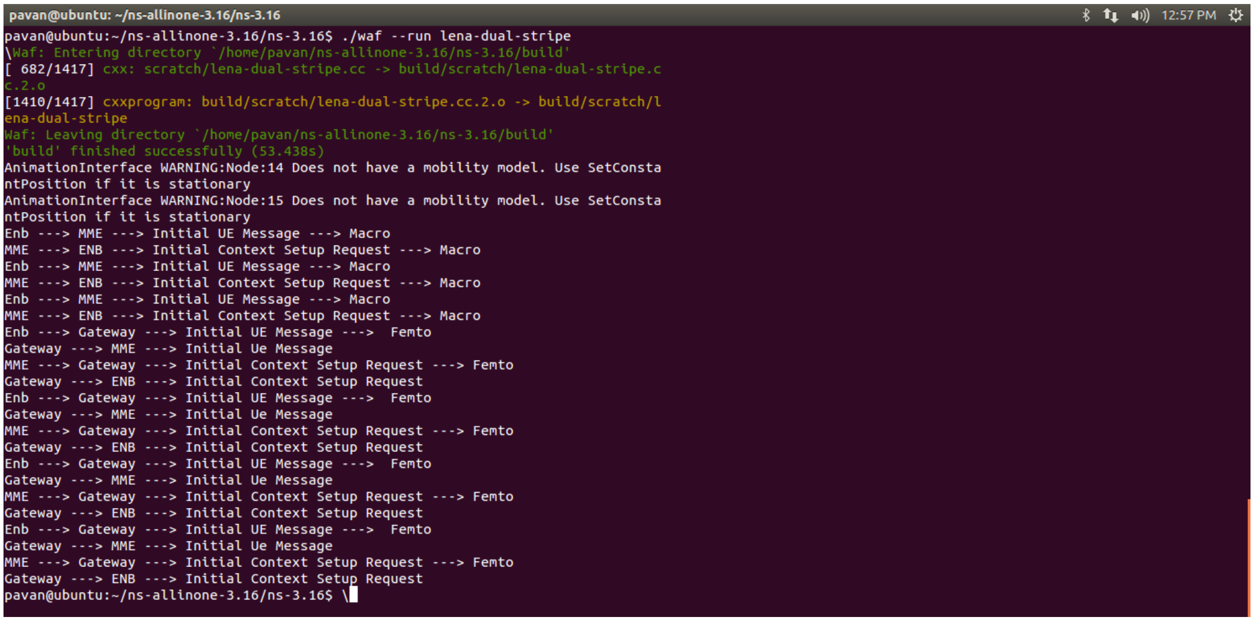


Fig. Data plane for S1-U interface for HeNB with HeNB GW
(3GPP TS 36.300 V11.3.0 (2012-09))

For implementation of data plane side of HeNB GW we have Serving Gateway already implemented in ns3. For this, we did the following

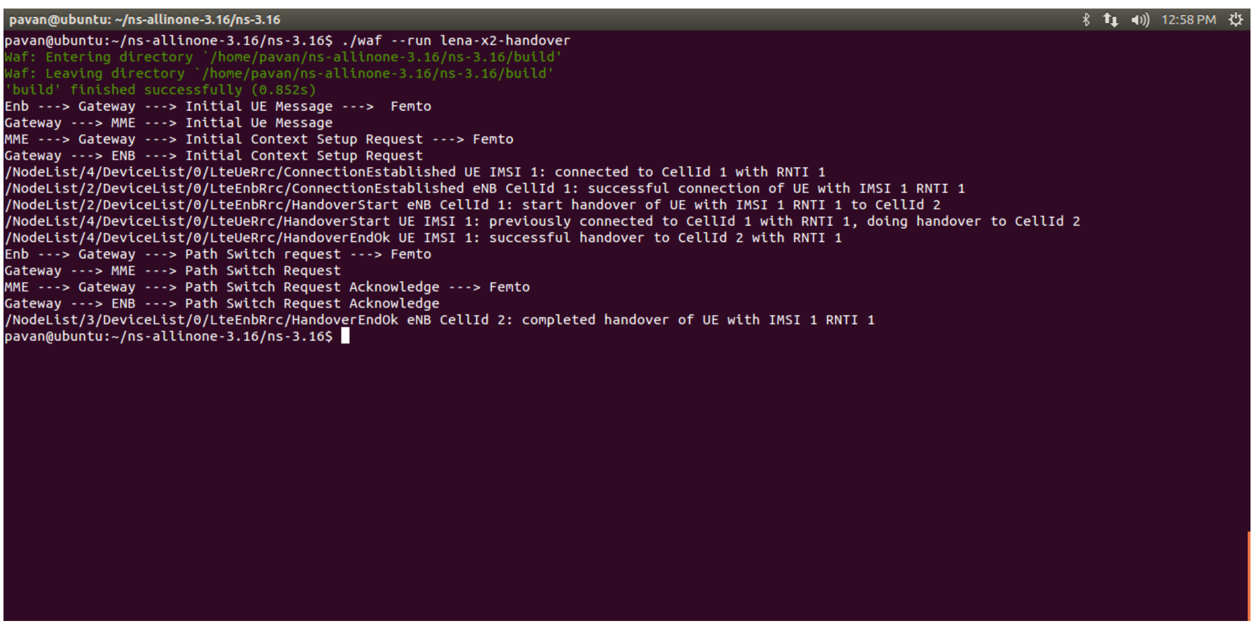
- Introduced a new Boolean type indicating whether it is a Femto or a Macro
- Create a new node for Femto Gateway with two layers as shown in above figure.
- Whenever the S-GW wants to send any data to a Femto it first sends it to the HeNB GW which inturn sends to the HeNB
- Similarly it also relays the data flow between HeNB and S-GW

We considered the case of single HeNB GW. We did not integrate these two parts. So, we did not use the gateway for further handovers. But still it would be a great contribution to ns3. The MME in the developer's code is not yet completed. Only single MME is present. Even all the functions of MME are implemented at present. We relayed whatever functions that are present. So, it limited our work till here.



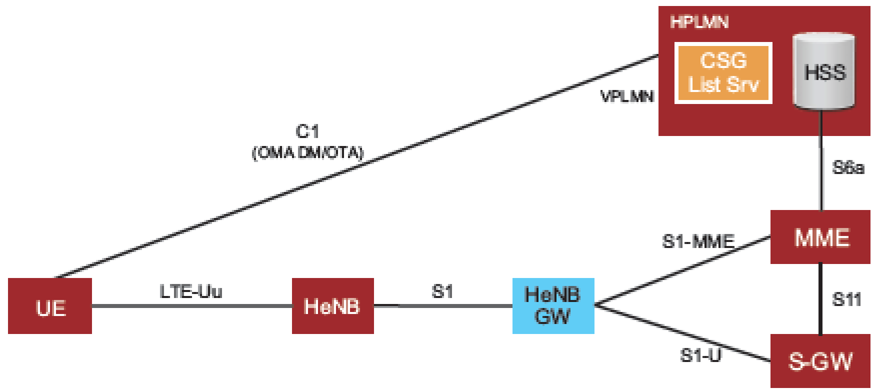
```
pavan@ubuntu: ~/ns-allinone-3.16/ns-3.16
pavan@ubuntu:~/ns-allinone-3.16/ns-3.16$ ./waf --run lena-dual-stripe
\Waf: Entering directory `/home/pavan/ns-allinone-3.16/ns-3.16/build'
[ 682/1417] cxx: scratch/lena-dual-stripe.cc -> build/scratch/lena-dual-stripe.c
c.2.o
[1410/1417] cxxprogram: build/scratch/lena-dual-stripe.cc.2.o -> build/scratch/l
ena-dual-stripe
Waf: Leaving directory `/home/pavan/ns-allinone-3.16/ns-3.16/build'
'build' finished successfully (53.438s)
AnimationInterface WARNING:Node:14 Does not have a mobility model. Use SetConsta
ntPosition if it is stationary
AnimationInterface WARNING:Node:15 Does not have a mobility model. Use SetConsta
ntPosition if it is stationary
Enb ---> MME ---> Initial UE Message ---> Macro
MME ---> ENB ---> Initial Context Setup Request ---> Macro
Enb ---> MME ---> Initial UE Message ---> Macro
MME ---> ENB ---> Initial Context Setup Request ---> Macro
Enb ---> MME ---> Initial UE Message ---> Macro
MME ---> ENB ---> Initial Context Setup Request ---> Macro
Enb ---> Gateway ---> Initial UE Message --->  Femto
Gateway ---> MME ---> Initial Ue Message
MME ---> Gateway ---> Initial Context Setup Request ---> Femto
Gateway ---> ENB ---> Initial Context Setup Request
Enb ---> Gateway ---> Initial UE Message --->  Femto
Gateway ---> MME ---> Initial Ue Message
MME ---> Gateway ---> Initial Context Setup Request ---> Femto
Gateway ---> ENB ---> Initial Context Setup Request
Enb ---> Gateway ---> Initial UE Message --->  Femto
Gateway ---> MME ---> Initial Ue Message
MME ---> Gateway ---> Initial Context Setup Request ---> Femto
Gateway ---> ENB ---> Initial Context Setup Request
Enb ---> Gateway ---> Initial UE Message --->  Femto
Gateway ---> MME ---> Initial Ue Message
MME ---> Gateway ---> Initial Context Setup Request ---> Femto
Gateway ---> ENB ---> Initial Context Setup Request
pavan@ubuntu:~/ns-allinone-3.16/ns-3.16$ \
```

Screenshot showing flows for Femtos and Macros



```
pavan@ubuntu: ~/ns-allinone-3.16/ns-3.16
pavan@ubuntu:~/ns-allinone-3.16/ns-3.16$ ./waf --run lena-x2-handover
Waf: Entering directory `/home/pavan/ns-allinone-3.16/ns-3.16/build'
Waf: Leaving directory `/home/pavan/ns-allinone-3.16/ns-3.16/build'
'build' finished successfully (0.852s)
Enb ---> Gateway ---> Initial UE Message --->  Femto
Gateway ---> MME ---> Initial Ue Message
MME ---> Gateway ---> Initial Context Setup Request ---> Femto
Gateway ---> ENB ---> Initial Context Setup Request
/NodeList/4/DeviceList/0/LteUeRrc/ConnectionEstablished UE IMSI 1: connected to CellId 1 with RNTI 1
/NodeList/2/DeviceList/0/LteEnbRrc/ConnectionEstablished eNB CellId 1: successful connection of UE with IMSI 1 RNTI 1
/NodeList/2/DeviceList/0/LteEnbRrc/HandoverStart eNB CellId 1: start handover of UE with IMSI 1 RNTI 1 to CellId 2
/NodeList/4/DeviceList/0/LteUeRrc/HandoverStart UE IMSI 1: previously connected to CellId 1 with RNTI 1, doing handover to CellId 2
/NodeList/4/DeviceList/0/LteUeRrc/HandoverEndOk UE IMSI 1: successful handover to CellId 2 with RNTI 1
Enb ---> Gateway ---> Path Switch request ---> Femto
Gateway ---> MME ---> Path Switch Request
MME ---> Gateway ---> Path Switch Request Acknowledge ---> Femto
Gateway ---> ENB ---> Path Switch Request Acknowledge
/NodeList/3/DeviceList/0/LteEnbRrc/HandoverEndOk eNB CellId 2: completed handover of UE with IMSI 1 RNTI 1
pavan@ubuntu:~/ns-allinone-3.16/ns-3.16$
```

Screenshot showing flows for Femtos and Macros (During Handover)



Home eNodeB Gateway Architecture

(http://www.polarisnetworks.net/henb-gw.html)

Chapter 6

Handover

Currently we got four parameters to make handover decision. But we implemented only using SINR values.

6.1 IMPLEMENTED APPROACH

Currently we took the handover decisions based on only SINR values. Following rules

- If the SINR is less than -6dbm handover to Macro.
- If the SINR is less than -3dbm handover to another Femto.

6.2 PROPOSED ALGORITHM:

In the present LTE model handover decision is taken by the strongest cell hand over. The strongest cell HO decision policy results in a HO execution whenever the RSRP of an accessible cell exceeds over the RSRP of the serving cell plus a policy-defined HHM, for a policy-defined time period namely the Time To Trigger (TTT).

$$\arg\max_{c\in \boldsymbol{L_u}} RSRP^{TTT}_{c\to u,(dB)} := \left\{c \,|\, RSRP^{TTT}_{c\to u,(dB)} > RSRP^{TTT}_{s\to u,(dB)} + HHM_{c,(dB)}\right\}$$

Our algorithm is based on energy efficient hand over decision algorithm and lte hand over based on mobility prediction. Energy efficient decision is based on the transmit power of UE after handover should be less than that of before.

P(u,s) > P(u,c)

P(u,s) is transmit power of UE connected to cell s, P(u,c) is transmit power of UE connected to candidate cell c , s € C(Total cells in the given frequency band).

Mean SINR is given as follows

$$\overline{\gamma}^{T}_{s\to u} = \frac{\overline{P}^{T}_{s\to u}\cdot \overline{h}^{T}_{s\to u}}{\sum_{c\in \boldsymbol{C_n}-\{s\}} \overline{P}^{T}_{c}\cdot \overline{h}^{T}_{c\to u} + \sum_{u'\in \boldsymbol{U_n}-\{u\}} \overline{P}^{T}_{u'}\cdot \overline{h}^{T}_{u'\to u} + \left(\overline{\sigma}^{T}_{u}\right)^{2}}$$

$$\overline{P}^{T}_{u\to c} = \frac{\overline{\gamma}^{u}_{target}\cdot\left(\sum_{c'\in \boldsymbol{C_n}-\{c\}} \overline{P}^{T}_{c'}\cdot \overline{h}^{T}_{c'\to c} + \sum_{u'\in \boldsymbol{U_n}-\{u\}} \overline{P}^{T}_{u'}\cdot \overline{h}^{T}_{u'\to c} + \left(\overline{\sigma}^{T}_{c}\right)^{2}\right)}{\overline{h}^{T}_{u\to c}}$$

where P(u->c) denotes the power transmission of cell c to user u, *h*(u->c) denotes the channel gain from cell c to user u. and $\overline{\sigma}_u^{\,2}$ the noise power at user u.

Under the assumption of a symmetric channel gain, the following estimation can be made:

$$\overline{h}_{u\to c}^{T} \cong \overline{h}_{c\to u}^{T} = \frac{RSRP_{c\to u}^{T}}{P_{c,RS}^{T}}$$

And Received Interference Power (RIP) is given as follows:

$$\overline{I}_{c}^{T} = \left(\sum_{c'\in \boldsymbol{C_n}-\{c\}} \overline{P}_{c'}^{T} \cdot \overline{h}_{c'\to c}^{T} + \sum_{u'\in \boldsymbol{U_n}} \overline{P}_{u'}^{T} \cdot \overline{h}_{u'\to c}^{T} + \left(\overline{\sigma}_{c}^{T}\right)^{2}\right)$$

Therefore finally

P(u,s) > P(u,c) =>

$$\frac{\overline{\gamma}_{target}^{u} \cdot P_{s,RS}^{T} \cdot \overline{I}_{s}^{T}}{RSRP_{s\to u}^{T}} > \frac{\overline{\gamma}_{target}^{u} \cdot P_{c,RS}^{T} \cdot \left(\overline{I}_{c}^{T} - \overline{P}_{u}^{T} \cdot \overline{h}_{u\to c}^{T}\right)}{RSRP_{c\to u}^{T}} \Rightarrow$$

$$RSRP_{c\to u}^{T} > RSRP_{s\to u}^{T} \cdot \frac{P_{c,RS}^{T} \cdot \left(\overline{I}_{c}^{T} - \overline{P}_{u}^{T} \cdot \overline{h}_{u\to c}^{T}\right)}{P_{s,RS}^{T} \cdot \overline{I}_{s}^{T}}$$

Which can be written in the form

$$\arg\max_{c\in \boldsymbol{L_u}} RSRP_{c\to u,(dB)}^{TTT} \coloneqq \left\{c \middle| \, RSRP_{c\to u,(dB)}^{TTT} > RSRP_{s\to u,(dB)}^{TTT} + HHM_{c,(dB)} + HHM_{c,(dB)}^{UTPR}\right\}$$

HHM is the normal hysteresis parameter for avoiding unnecessary hand overs and HHM(utpr) is the parameter for energy efficient hand overs;

PROPOSED ALGORITHM

1. IF RSSIBS < RSSIFAP
2. Perform HAND-IN
3. ELSE
4. No HAND-IN
5. EXAMINE V # V is the speed of UE
6. IF V > 10 Km/h
7. NO HAND-IN
8. ELSE IF V> 5 Km/h

$$\arg\max_{c \in \boldsymbol{L_u}} RSRP_{c\to u,(dB)}^{TTT} \coloneqq \left\{c \mid RSRP_{c\to u,(dB)}^{TTT} > RSRP_{s\to u,(dB)}^{TTT} + HHM_{c,(dB)} + HHM_{c,(dB)}^{UTPR}\right\}$$

$$HHM_{c,(dB)}^{UTPR} = \begin{cases} 10\log\frac{P_{c,RS}^{TTT}\cdot\left(\bar{I}_c^{TTT} - \bar{P}_u^{TTT}\cdot\bar{h}_{u\to c}^{TTT}\right)}{P_{s,RS}^{TTT}\cdot\bar{I}_s^{TTT}} & c, s \in \boldsymbol{C_n} \\ 10\log\frac{P_{c,RS}^{TTT}\cdot\bar{I}_c^{TTT}}{P_{s,RS}^{TTT}\cdot\bar{I}_s^{TTT}} & otherwise \end{cases}$$

9. IF Traffic = Real-Time
10. PERFORM PROACTIVE HO
11. ELSE IF Traffic = Non Real-Time
12. PERFORM REACTIVE HO
13. ELSE IF Traffic =Real-Time
14. PERFORM PROACTIVE HO
15. IF Traffic = Non Real-Time
16. PERFORM REACTIVE HO
17. ELSE
18. PERFORM HO based on RSRP values rule declared above.
19. RETURN

Advantages & Disadvantages

• Mobility Prediction(velocity value) helps to avoid unnecessary handover between femto cell and macro cell.

• Femto cell is preferred over macro cell

• This algorithm reduces the average transmit power in the UE and as well as LTE cells.

• Substantial interference mitigation achieved in the LTE downlink in terms of RSSI and in the LTE uplink in terms of Received Interference Power at the LTE cells

• Only disadvantage with this algorithm is increased hand over signaling time.

6.3 MESSAGES INDICATING THE HANDOVER:

For knowing whether the handover is taking place we introduced trace functions. They are:

- NotifyHandoverStartEnb:

  Indicates start of handover at eNodeB displaying it's CELLID, RNTI, IMSI of the user, CELLID of target eNodeB.

  Trace path: "/NodeList/*/DeviceList/*/LteEnbRrc/HandoverStart",

- NotifyHandoverStartUe

  Indicates start of handover at UE displaying its IMSI, previously connected CELLID and currently connected CELLID.

  Trace path: "/NodeList/*/DeviceList/*/LteUeRrc/HandoverStart"

- NotifyConnectionEstablishedUe

  Indicates connection of a UE to eNodeB displaying its IMSI and CELLID of the eNodeB.

  Trace path: "/NodeList/*/DeviceList/*/LteUeRrc/ConnectionEstablished"

- NotifyConnectionEstablishedEnb

  Indicates connection of a eNodeb to UE displaying its CELLID and IMSI of the eNodeB.

  Trace path: "/NodeList/*/DeviceList/*/LteEnbRrc/ConnectionEstablished"

- NotifyHandoverEndOkUe

  Indicates the success of Handover of a UE

Trace path: "/NodeList/*/DeviceList/*/LteUeRrc/HandoverEndOk"

- NotifyHandoverEndOkEnb
  Indicates the success of Handover to a eNodeB

  Trace path: "/NodeList/*/DeviceList/*/LteEnbRrc/HandoverEndOk"

Chapter 7

Conclusions and Future Work

We have implemented Handover in ns3. For this we created mobility for users in Mobility model, X2-interface between the Femtocells, computed parameters for taking an efficient handover in femtocell network. We also created a Femtocell gateway for User Plane and Data Plane separately. Future work for this project would be to integrate both the planes to get a single Femtocell Gateway and take Handover decisions in FemtoCell Gateway. Further, we can also implement the proposed approach.

<u>FILES MODIFIED:</u>

Mobiltiy model

1. building-mobility-model.cc
2. building-mobility-model.h
3. lena-dual-stripe.cc

Handover parameters

1. radio-envirornment-helper.cc
2. radio-envirornment-helper.h
3. lte-spectrum-phy.h
4. lena-dual-stripe.cc

X2-Interface

1. lena-dual-stripe.cc
2. test.cc

Femto Gateway

Control Plane

1. FemtoGW.cc
2. FemtoGW.h
3. epc-enb-application.cc
4. epc-enb-application.h
5. epc-mme.cc
6. epc-mme.h
7. epc-s1ap-sap.h
8. epc-s1ap-sap.cc
9. epc-helper.cc
10. epc-helper.h
11. node.h

Data Plane

1. epc-helper.cc
2. epc-helper.h

REFERENCES:

[1]. The Study of Handover Procedure in LTE-based Femtocell Network Ardian Ulvan*, Robert Bestak* and Melvi Ulvan* * Czech Technical University in Prague, Czech Republic [ardian.ulvan, robert.bestak, ulvanmel]@fel.cvut.cz

[2]. http://www.youtube.com/watch?v=H0hNrLh6mUw

[3]. A green handover protocol in two-tier OFDMA macrocell–femtocell networks Yuh-Shyan Chen∗ , Cheng-You Wu

[4]. Handover Scenario and Procedure in LTE-based Femtocell Networks, Ardian Ulvan, Robert Bestak, Melvi Ulvan