LTE X2 Handover

Software Recommended: NetSim Standard v11.0, Microsoft Visual Studio 2015/2017

Project Download Link:

https://github.com/NetSim-TETCOS/LTE_X2_HANDOVER_v11.0/archive/master.zip

Handover

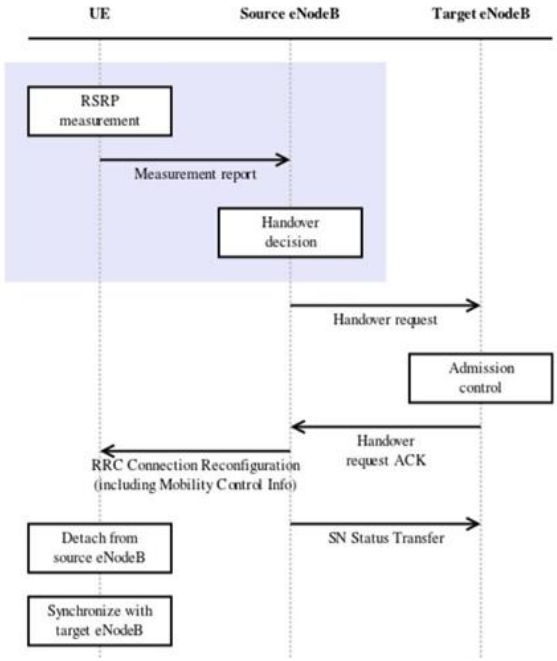
Handover is an important function that maintains seamless connectivity when transitioning from one base station to another.

- Due to mobility UEs can move from one place to another.
- Then UE sends the MEASUREMENT REPORT to the S-eNB.
- The S-eNB issues a HANDOVER REQUEST message to the T-eNB.
- The T-eNB checks for resource availability and, if available, reserves the resources and sends back the HANDOVER REQUEST ACKNOWLEDGE message.

LTE X2 Handover

In event-triggered handover procedures, each UE evaluates the Event condition every time a new averaged measurement sample is available .The evaluated condition is the entering condition of Event whether the RSRP/SNR measured from a neighbouring cell becomes an offset better than the RSRP/SNR measured from the serving cell . The offset is represented as hysteresis.

The UE generates a measurement report and transmit it as an RRC message to the serving cell. This report typically contains measurement results of at least the serving cell, but is extendable with measurement results of neighboring cells. Series of steps occurs to carry out handover process which can be seen in the diagram below and also in our table in Result Section.



Code Changes done to obtain SNR logs in NetSim:

1. In the LTE Project of NetSim source codes modifications are done to perform LTE X2 Handover.

2. Open the Source codes in Visual Studio using the NetSim.sln file present in the code folder.

3. In file LTE Phy.c the following changes(highlighted in red) were made:

```
#include "main.h"
#include "LTE.h"
#define devid(id) fn_NetSim_GetDeviceIdByConfigId(id)
NETSIM_ID fn_NetSim_LTE_FindNearesteNB(NETSIM_ID nDeviceId);
FILE* fp;
char snrlog[100];
int fn_NetSim_LTE_CalculateReceivedPower()
{
NETSIM_ID i;
//fp = fopen("LTE_UE_SNR.txt", "w+");
for(i=0;i<NETWORK->nDeviceCount;i++)
{
..........................................................


if(ber<TARGET_BER)
break;
else
{
info->DLInfo[j].nCQIIndex--;
info->ULInfo[j].nCQIIndex--;
}
}
sprintf(snrlog, "LTE_UE_SNR_%d.csv", devid(info->nUEId));
fp = fopen(snrlog, "w+");
int arr[512],k=0,c;
if (fp)
{
for (c = 0; c < NETWORK->nDeviceCount; c++)
{
if (NETWORK->ppstruDeviceList[c]->nDeviceType == eNB)
{
arr[k] = NETWORK->ppstruDeviceList[c]->nDeviceId;
k++;
}
}
fprintf(fp, "UE_ID,Time");
for (c = 0; c < k; c++)
{
fprintf(fp, ",SNR_ENB_ID_%d",arr[c]);
}
```

```
fclose(fp);
}
}
info=(LTE_ASSOCIATEUE_INFO*)LIST_NEXT(info);
}
}
}
return 1;
}
```

4. Now in NAS.c change the initial function as following

```
#define MEASUREMENT_REPORT_SIZE  184/8.0
#define HO_REQUEST_SIZE  288/8.0
#define HO_CONFIRM_SIZE  112/8.0
#define HANDOVER_DIFF       3 //db
#define devid(id) fn_NetSim_GetDeviceIdByConfigId(id)
int fn_NetSim_LTE_InitHandover(NETSIM_ID  ueId,NETSIM_ID nENBId)
{
//Prepare the measurement report
NetSim_PACKET*  packet;
LTE_MAC_PACKET*  macPacket;
LTE_PHY_PACKET*  phyPacket;
LTE_MEASUREMENT_REPORT*  report=NULL;
NETSIM_ID i;
FILE* fp = NULL;
char snrlog[100];

sprintf(snrlog,  "LTE_UE_SNR_%d.csv",  fn_NetSim_GetDeviceIdByConfigId(ueId));
fp = fopen(snrlog,  "a+");
fprintf(fp,  "\n%d,%lf",  fn_NetSim_GetDeviceIdByConfigId(ueId),  pstruEventDetails-
>dEventTime);

for(i=0;i<NETWORK->nDeviceCount;i++)
{
//fprintf(fp, "\n%d,%lf",  devid(info->nUEId),  pstruEventDetails->dEventTime);
if(DEVICE_TYPE(i+1)  == eNB)
{
unsigned int j;
LTE_MEASUREMENT_REPORT*  temp=MEASUREMENT_REPORT_ALLOC();
LTE_ASSOCIATEUE_INFO*  info = UEINFO_ALLOC();
LTE_ENB_PHY*  enbPhy=(LTE_ENB_PHY*)DEVICE_PHYVAR(i+1,1);
info->nUEId=ueId;
info->nUEInterface=1;
temp->nENBId=i+1;
temp->nUEId=ueId;
temp->carrier_count = enbPhy->ca_count;

for(j=0;j<enbPhy->ca_count;j++)
{

fn_NetSim_LTE_CalculateRxPower(i+1,1,info,j);
fn_NetSim_LTE_CalculateSNR(i+1,1,info,j);
```

```
fn_NetSim_LTE_GetCQIIndex(i+1,1,info,j);
fn_NetSim_LTE_GetMCS_TBS_Index(info,j);
while(info->DLInfo[j].nCQIIndex>1 && info->ULInfo[j].nCQIIndex>1)
{
double ber;
fn_NetSim_LTE_GetMCS_TBS_Index(info,j);
ber = fn_NetSim_LTE_CalculateBER(0,info->DLInfo[j].MCSIndex,info->DLInfo[j].dSNR);
if(ber<TARGET_BER)
break;
else
{
info->DLInfo[j].nCQIIndex--;
info->ULInfo[j].nCQIIndex--;
}
}

temp->nCQIIndex_DL[j]=info->DLInfo[j].nCQIIndex;
temp->dSNR_DL[j]=info->DLInfo[j].dSNR;


//dETime = pstruEventDetails->dEventTime;

if (fp)
{
if (j == 0)
{

fprintf(fp,  ",%lf",  info->DLInfo[j].dSNR);
}

}


}
LIST_FREE((void**)&info,info);
LIST_ADD_LAST((void**)&report,temp);
}

}
fclose(fp);
if(report)
{
packet=fn_NetSim_LTE_CreateCtrlPacket(pstruEventDetails->dEventTime,
LTEPacket_MeasurementReport,
nENBId,
ueId,
nENBId,
MEASUREMENT_REPORT_SIZE);
macPacket=calloc(1,sizeof* macPacket);
macPacket->logicalChannel=LogicalChannel_CCCH;
macPacket->MessageType=LTEPacket_MeasurementReport;
macPacket->MessageVar=report;
macPacket->transportChannel=TransportChannel_RACH;
phyPacket=PACKET_PHYPROTOCOLDATA(packet);
phyPacket->physicalChannel=PhysicalChannel_PRACH;
```

```
packet->pstruMacData->Packet_MACProtocol=macPacket;
packet->pstruPhyData->Packet_PhyData=phyPacket;

//Add physical out event
pstruEventDetails->nDeviceId=ueId;
pstruEventDetails->nDeviceType=UE;
pstruEventDetails->nInterfaceId=1;
pstruEventDetails->nProtocolId=MAC_PROTOCOL_LTE;
pstruEventDetails->dPacketSize=MEASUREMENT_REPORT_SIZE;
pstruEventDetails->nApplicationId=0;
pstruEventDetails->nEventType=PHYSICAL_OUT_EVENT;
pstruEventDetails->nPacketId=0;
pstruEventDetails->nSegmentId=0;
pstruEventDetails->nSubEventType=0;
pstruEventDetails->pPacket=packet;
pstruEventDetails->szOtherDetails=NULL;
fnpAddEvent(pstruEventDetails);
}
return 0;
}
```

5. Right click on the LTE project in the solution explorer and select rebuild. Upon successful build copy the libLTE.dll file from the DLL folder present inside the Code Directory. Rename the already existing libLTE.dll file in <NetSim_Install_Directory>/bin and paste the copied libLTE.dll file over there.

Steps to be done in NetSim scenario to Create LTE X2 Handover

Configuration

Grid Length: 5000m

Distance between ENB: 5Km

Distance between UE: 5Km

Properties UE-ENB Link: Default

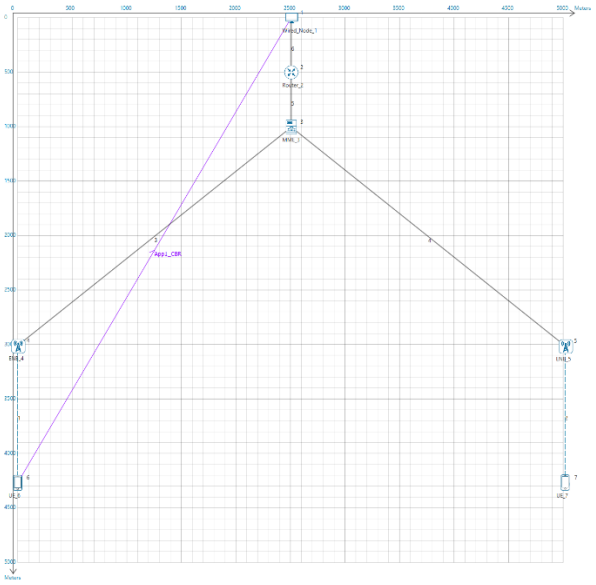
Simulation Time = 100 Sec

Mobility model = File based mobility for UE6, No Mobility for UE 7

A sample **Configuration.netsim** file is provided in the Config_File folder, with all the above settings which can be directly loaded in NetSim

Place the **mobility.txt** file present in the code folder in <NetSim_Install_Directory>/bin Directory.

Network Scenario:



1. Simulate the scenario in Netsim and you will get two .csv files in bin folder of Netsim corresponding to each UE's involved in the simulaiton. Open any .csv file of the UE for which File Based Mobility was configured. You will observe the columns containing SNR measured by each ENB with respect to that particular UE.

LTE_UE_SNR_6.csv	12/6/2017 1:01 PM	Microsoft Excel C...	2 KB
LTE_UE_SNR_7.csv	12/6/2017 1:01 PM	Microsoft Excel C...	1 KB

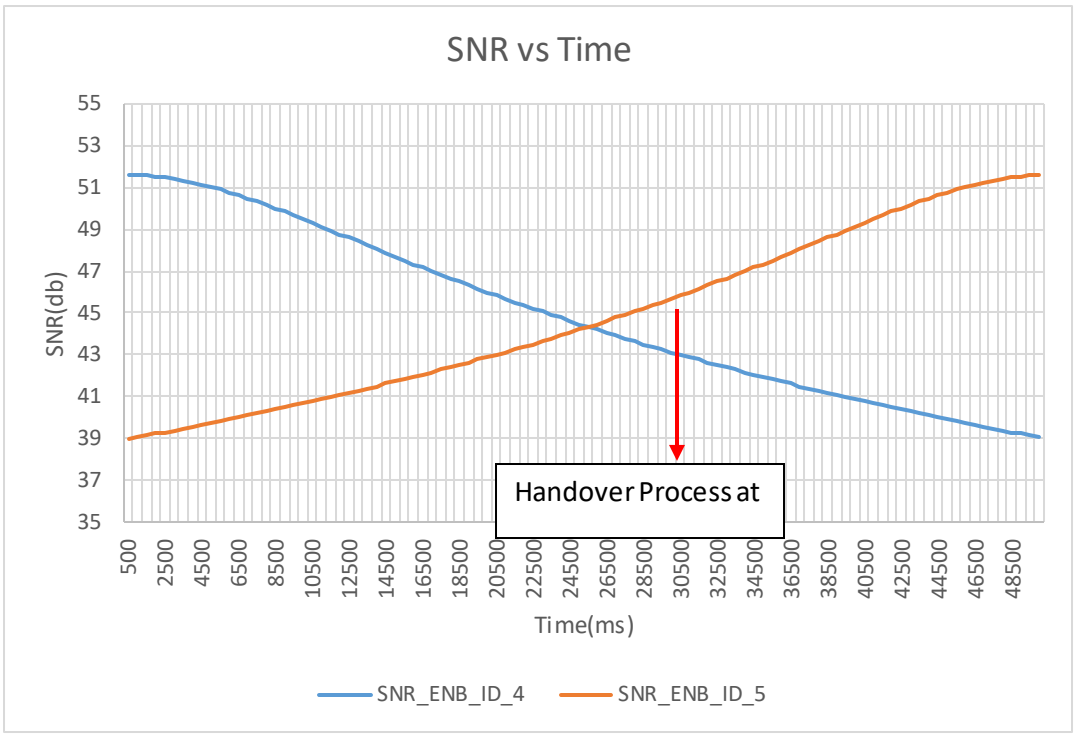
2. With the help of Excel tools create a graph between SNR measured by each ENB with respect to time period. Properly set the gaps on x-axis and y-axis so you will get a clear graph.

UE_ID	Time	SNR_ENB_	SNR_ENB_ID_5
6	500000	51.60512	38.96413
6	1000000	51.59759	39.04661
6	1500000	51.57506	39.12985
6	2000000	51.53778	39.21383

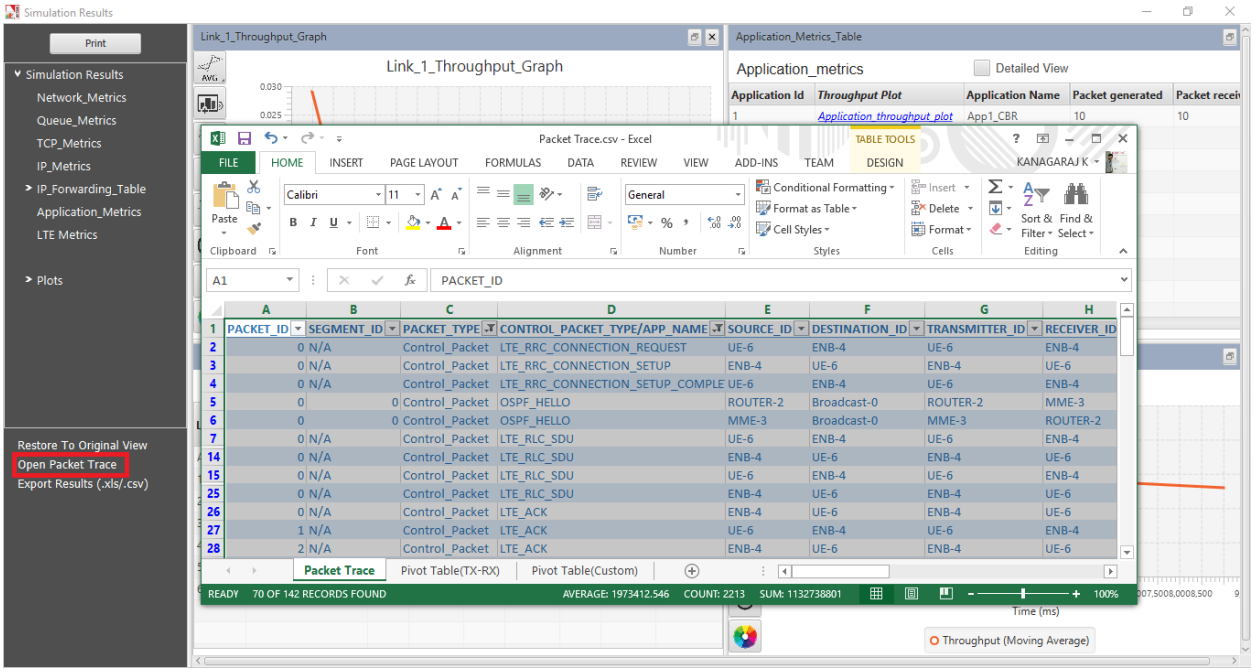
3. Handover occurs when SNR difference between two ENBs is equal to 3 db. So for this scenario find in the graph the time value when SNR_ENB_5-SNR_ENB_4 measured is equal to 3 db.
4. This is the time value at which handover occurs.

Result

Handover occurs when difference between SNR measured by two ENB is equal to 3 db. In below chart Handover occurs when Difference value is equal to 3 on y axis which is between 30.5 sec and 31 sec.



The packet trace file can be accessed from the results window to understand the various packets involved in the handover process.



As UE moves from one position to another it sends measurement report to each ENB in range. As it moves SNR received by each ENB keeps on changing based on distance between ENB and UE. If the difference between SNR received by new ENB to that of old ENB to which it is connected gets greater than 3 decibel than at that point handover occurs.

Related Article links:

How to Implement Time to Trigger (TTT) used in LTE Handover Modelling?

How to vary the Handover Margin in LTE?