Mobility Management for LTE-based Small Cell Networks

Dr. Saba Al-Rubaye

Ryerson University, Canada

saba@ryerson.ca

Outline

WIRELESS WORLD
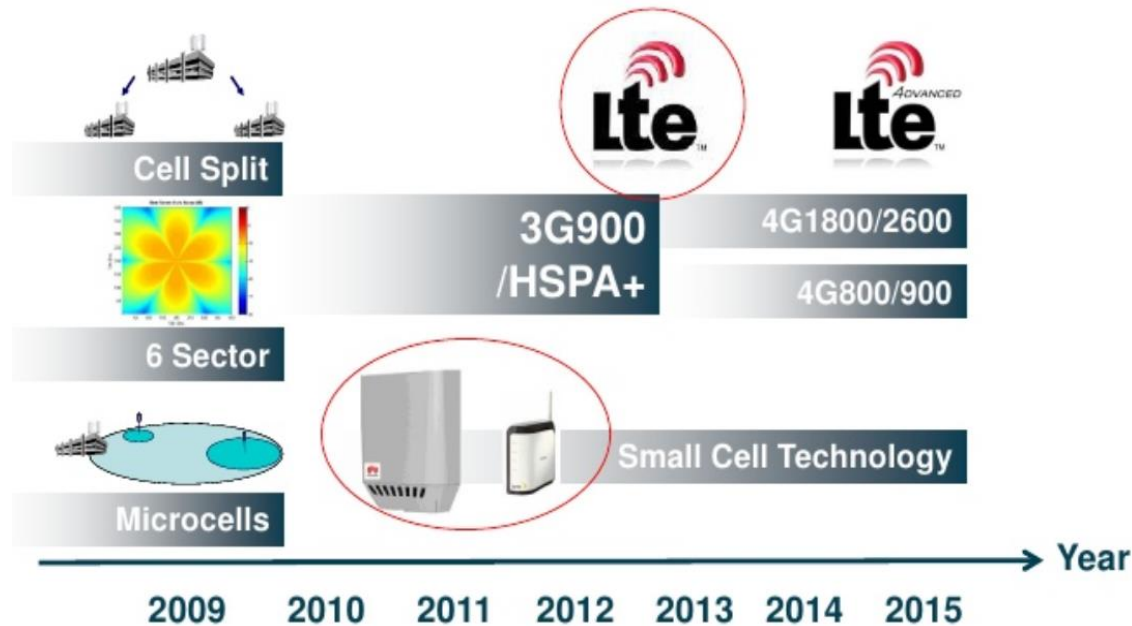**RESEARCH FORUM®**

More traffic with large screen devices

2000
0.02x traffic

2010
1x traffic

2020
~ 500x traffic

- According to Cisco: the future networks should support explosive mobile data traffic which is growth by:
- More Large screen devices
- More Multimedia applications
- More connected users & devices

Radio Network Evolution

- Wide range of available bands and combinations
- Efficiently support low-mobility traffic, mobile video, internet applications
- Low power, and environmentally friendly
- Interwork efficiently with other radio technologies
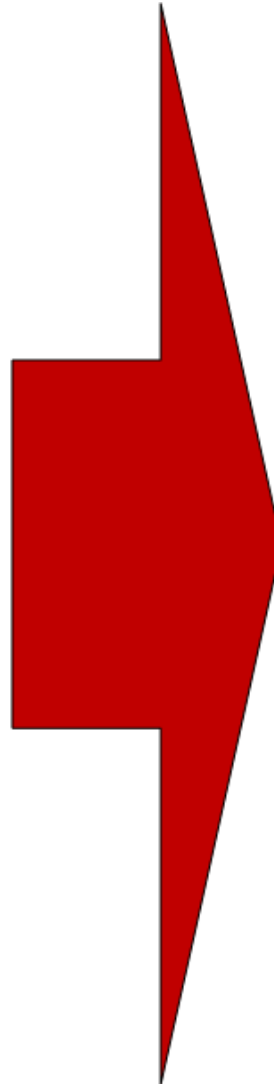- Converged multi-access networks and terminals

The Challenge in the Broadband Era

Growing number and varieties of connection

New relation between sender and recipient
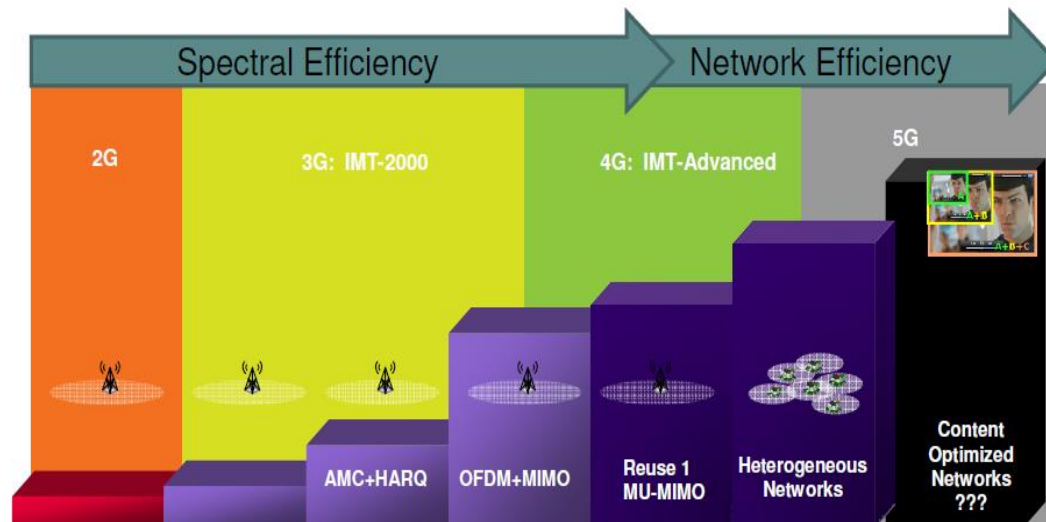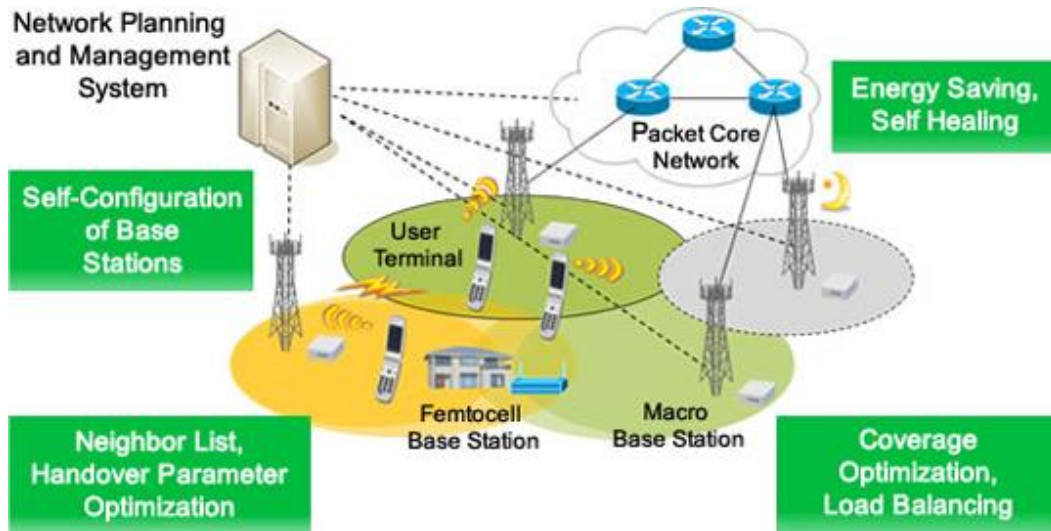
Infrastructure for ubiquitous society

How to manage capacity increase and pattern change in traffic at low cost

How to serve user better services and Trust system

Low and friendly environment
To realize low energy activities

How to obtain hug amount of data with high QoS

Management Network

- on 4G networks achieved system capacity limits(frequency reuse, multi-user scheduling)
- Wireless industry Shifting from Spectral efficiency to network efficiency
- Improve network efficiency in two ways:

1. Continue to Improve efficiency of access network using small cell

2. 5G: Optimized and management Network by improve the efficiency of transmitted information

LTE-Small Cell Architecture

LTE-Small Cell Architecture enables various opportunity of accesses in the next generation cellular broadband systems.
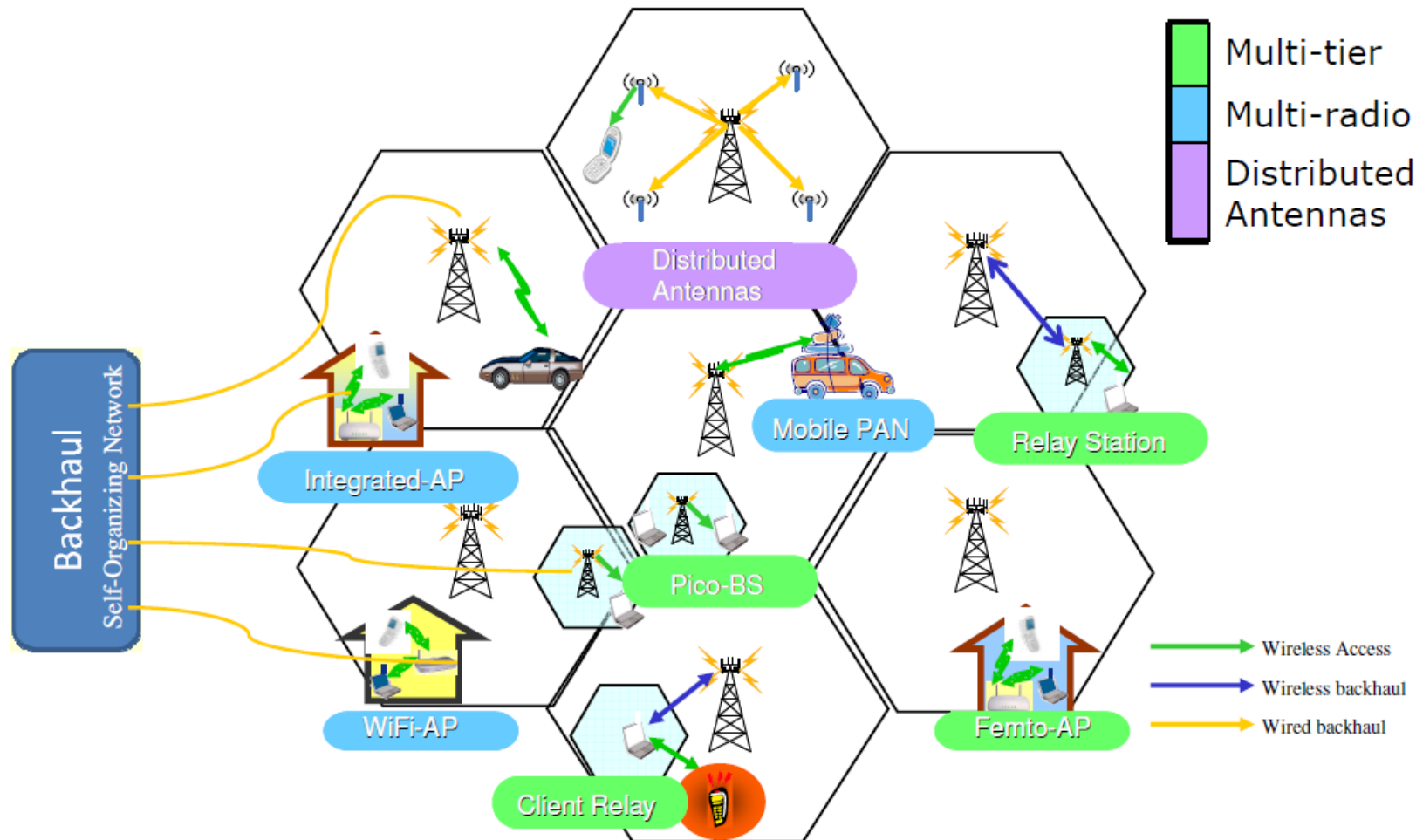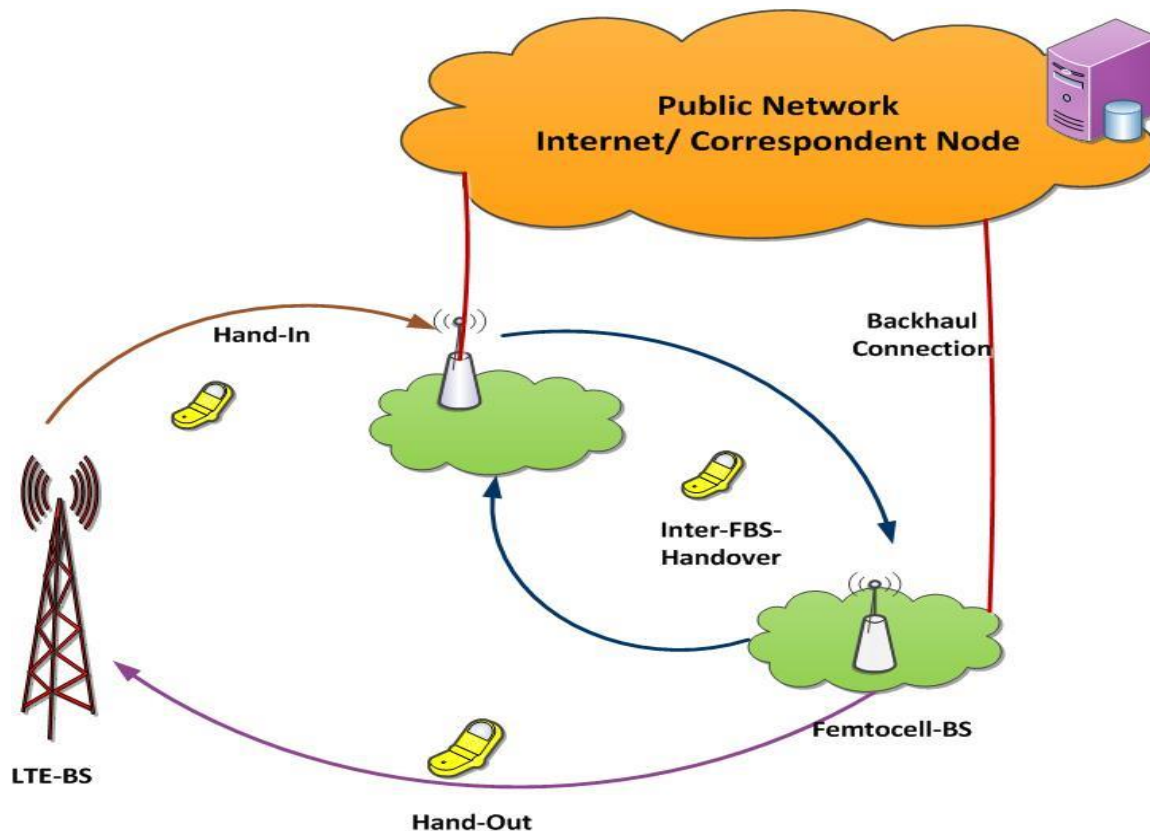

A network that consists of a mix of macro cells and low-power nodes, e.g. Pico, Femto, Relay Node

Mobility Mechanism

The deployment of small cell BS increase the numbers of unnecessary handovers for mobile users moving between different domains which lead to reduce the resource availability.
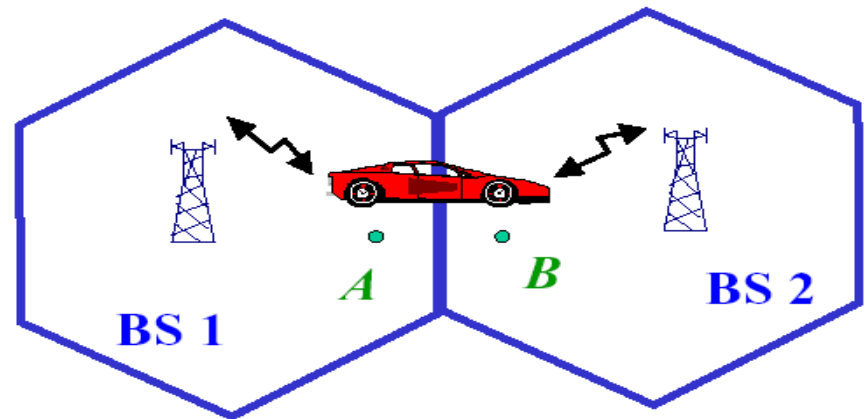
Basic of Mobility Management

- Handover (Europe) = Handoff (North America)

- Handover is the process that occurs when a mobile is "handed over" from one access point to another

The HO procedure is:

- Cell discovery
- Measurement
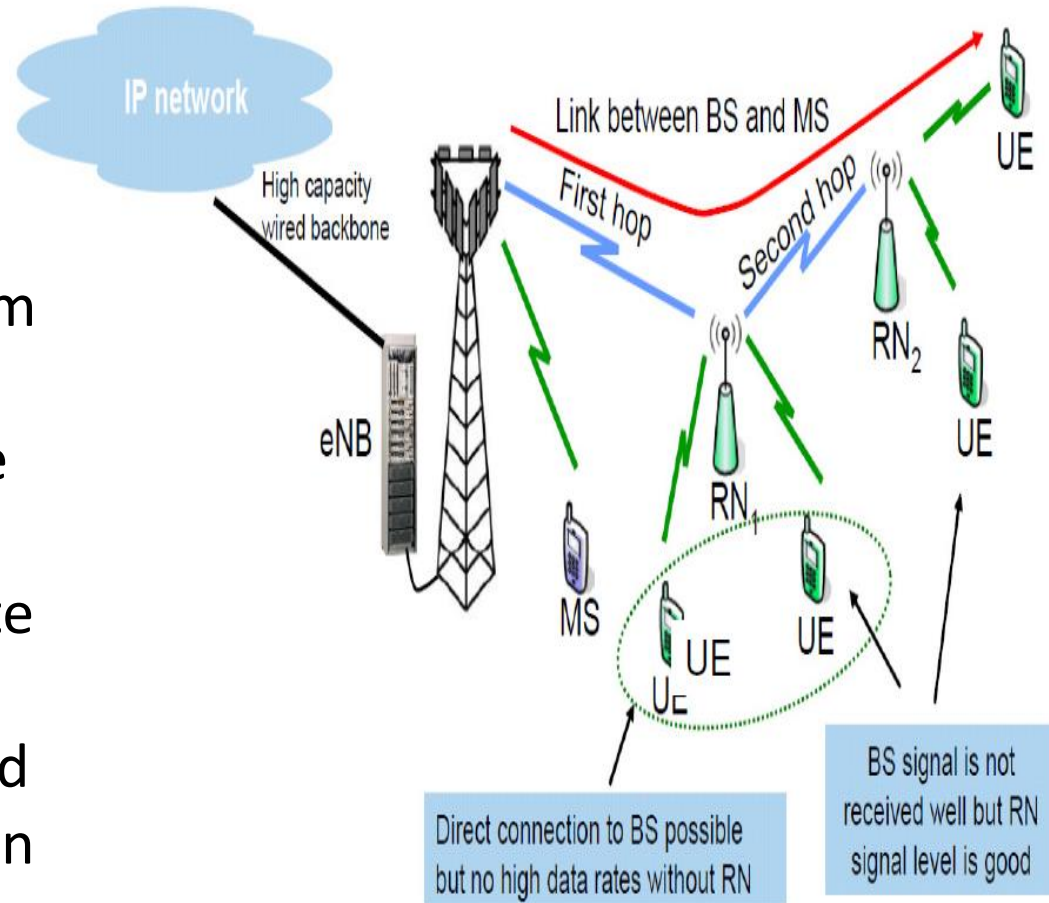- Handover Decision
- Handover Execution

How Handover Happens?

UE investigate and collect the information about the neighborhood Cells and BS.

During the scanning phase the UE seeing to connect to the target BS with suitable number of HO.

Cell Selection

- The UE will measure the downlink signal strength after cell selection
- The source cell based on measurement reports from the UE determines the target cell and queries the target cell if it has enough resources to accommodate the UE.
- The handover decision and re-connections process can be initialized if all other conditions for HO are met

IP network

High capacity wired backbone

eNB

Link between BS and MS

First hop

Second hop

RN₂

RN₁

MS

UE

UE

UE

UE

UE

Direct connection to BS possible but no high data rates without RN

BS signal is not received well but RN signal level is good

Cell selection is critically important in a relay network

Requirements

- To achieve Seamless HO (Vertical-Diff. techs)
  - Identify issues related to handover between LTE and small cell
  - Requirements for handover: small delay, low packet loss ☺
- Network Layer : Mobile IP with extensions (IPv6)
- Link Layer: Handover Algorithm
- Achieve high spectrum utilization
- Low power ☺
- Provide a QoS-based mobility management across LTE-Small cell networks
- HO should performed quickly
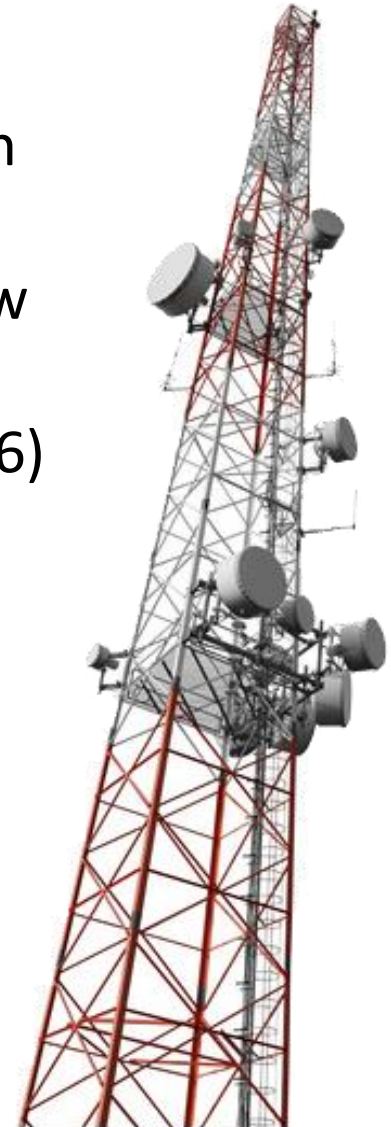
# Handover Failure

Reasons for failed handover:

- Signal received is too low
- High mobile speeds
- High traffic level
- Un-availability of channels

What happens if there are insufficient resources in the new BS?

Existing calls cannot be handed over ⇒ New calls will be blocked

Radio Link Failure

If the UE looses contact with source cell it will select a new cell and send a RRC Recovery Request Message
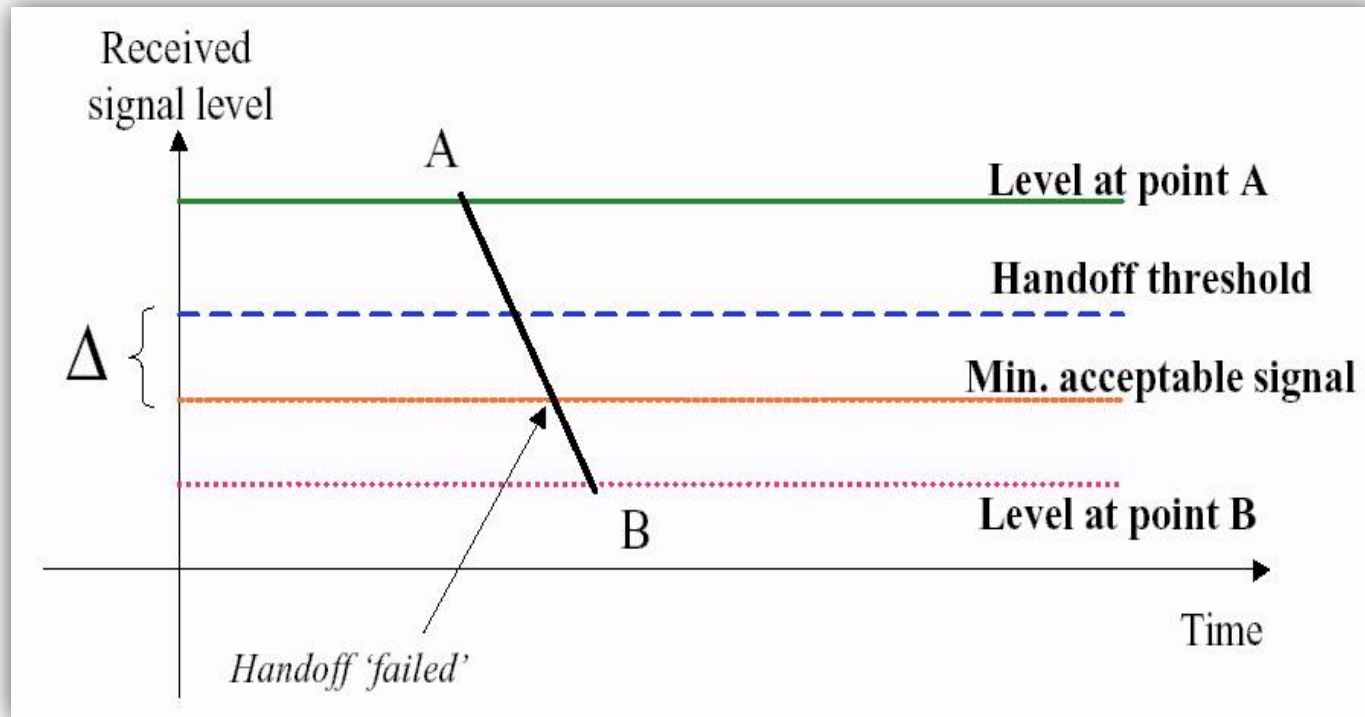
If the Mobile Switching Center was unable to perform the handover before the signal level dropped below the minimum usable level, and so the call was lost.

Unnecessary Handover Crises

Prioritize small cell access according to the RSS and mobile speed
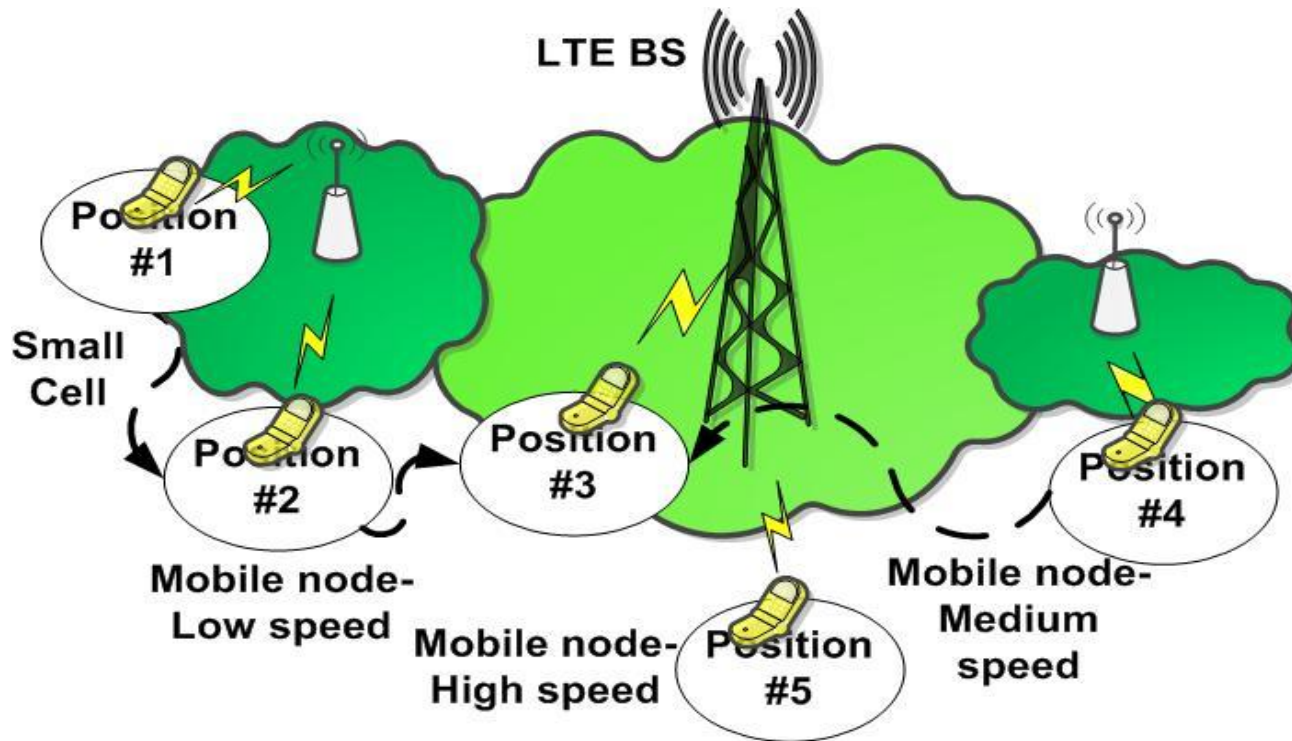
Proposed Solution
➢Novel Call Admission Control (CAC) is proposed to the IP layer to allocate mobile users according to their speeds.
➢Mobile users with low and medium speeds are approved admission to small cell domains while higher speed users are assigned to LTE macrocell BSs.

Probability of Handover

Handover occurred in LTE and Small Cell networks can be calculated as follows:
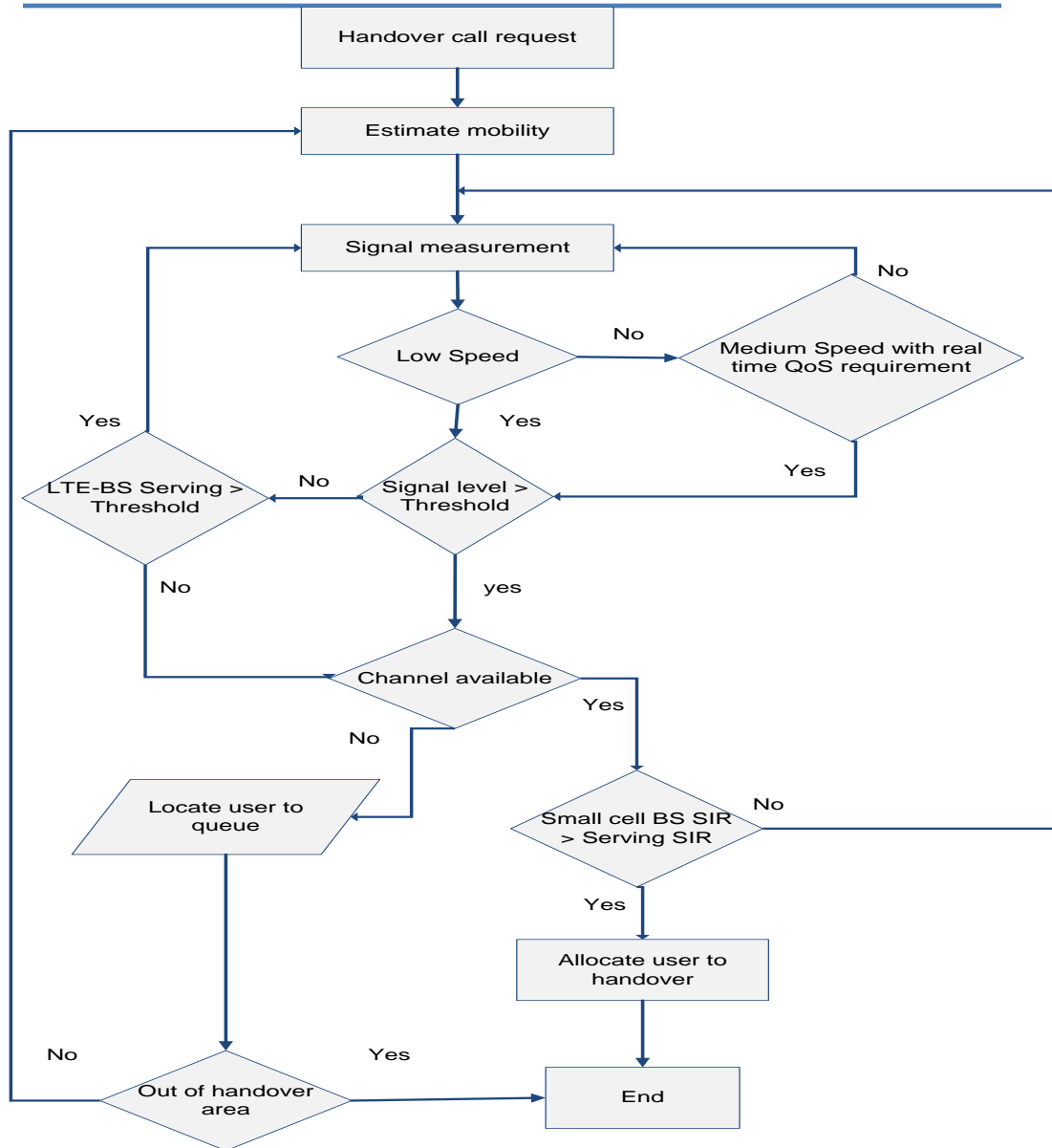
Total number of handovers that occurred at specific state

$$\text{Probability}_{HO} = \sum_{\forall_S} N_{HO} * \pi . N_{calls} (S)$$

Number of services residing at a certain domain

Probability of being in a state

Novel CAC Mechanism

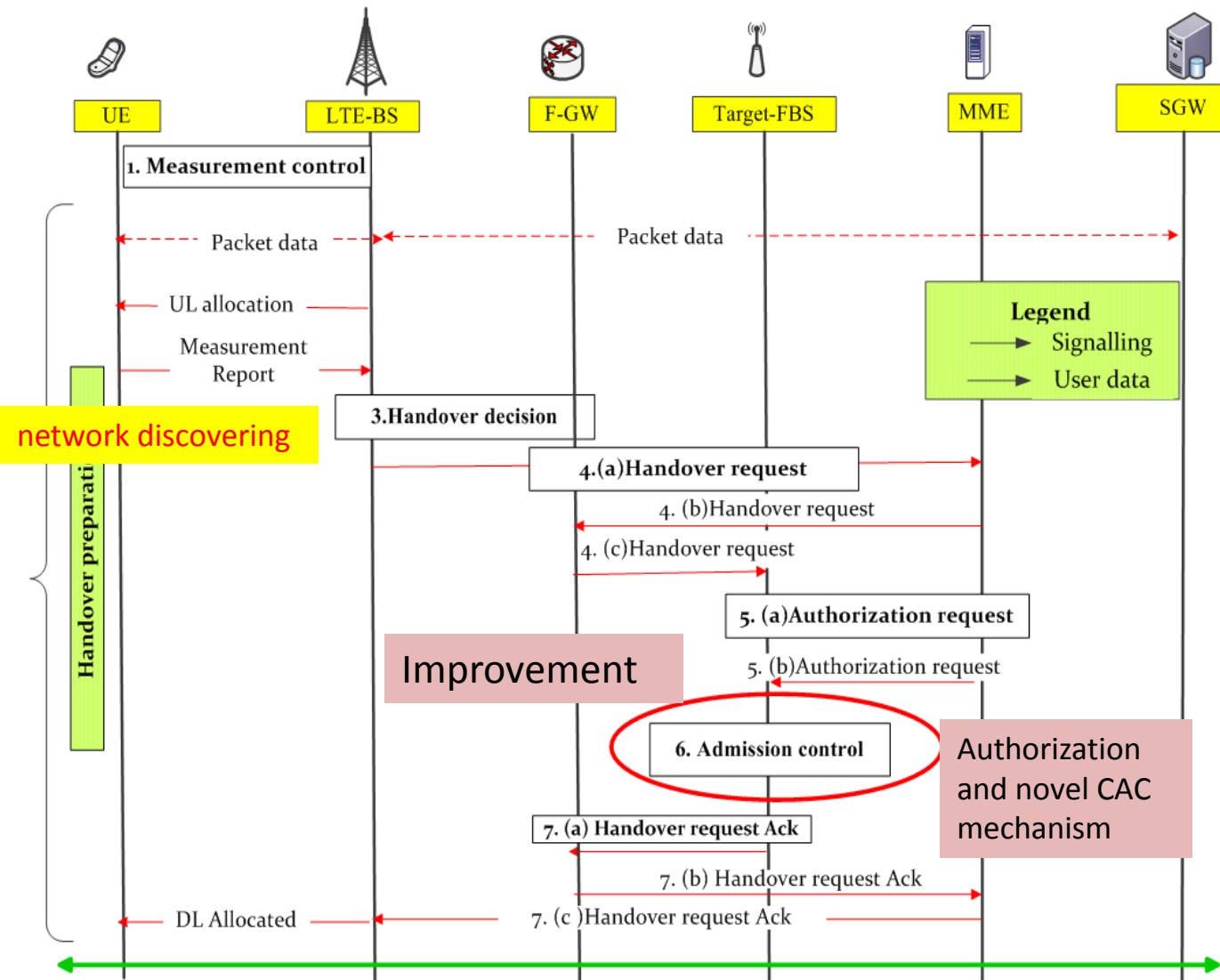- CAC is proposed to monitor the necessary measured parameters on the cell and control the admission of incoming connections

- Whenever the Small BS receives a handover request from the access service network from the UE, the Small BS makes a decision to allow the handover to take place OR NOT

- The handover threshold may be adjusted according to the QoS requirement, and the velocity of the user

Signal Flow for Handover Preparation

- The UE performs continuous measurements on neighboring cells and send measurement reports
- Once the measurement report is sent the serving LTE which can take a handover decision
- Start the handover preparation phase When the terminal successfully receives the handover command no more communication is required in the source cell

Handover from Macrocell to Small Cell

System Implementation

Call arrival is predicted using Markov chain model in order to analyze the system performance

Node model for Small cell BS where CAC integrated

Code to decided to connect to arrival UE or not


```
Algorithm 5.1. C++ code for calculating mobile speed in OPNET
1    dra_propdel_mt  (OP_SIM_CONTEXT_ARG_OPT_COMMA  Packet  *
2    pkptr)
3    {
4    double    start_prop_delay, end_prop_delay;
     double    start_prop_distance, end_prop_distance;
     double     start_prop_VELOCITY, start_prop_velocity;
     * Compute the propagation delay separating the        **/
     / * radio transmitter from the radio receiver.**/
         FIN_MT (dra_propdel (pkptr));
     /* Get the start distance between transmitter and receiver. */
         start_prop_distance          =          op_td_get_dbl          (pkptr,
     OPC_TDA_RA_START_DIST);
     /* Get the end distance between transmitter and receiver. */
         end_prop_distance = op_td_get_dbl (pkptr, OPC_TDA_RA_END_DIST);
     /* Compute mobile speed to start of reception. */
         start_prop_velocity = start_prop_distance / start_prop_delay;
     /* Compute mobile speed to end of reception. */
         end_prop_velocity = end_prop_distance / end_prop_delay;
     /* Place both mobile speeds in packet transmission data attributes. */
         op_td_set_dbl           (pkptr,            OPC_TDA_RA_START_PROPDEL,
     start_prop_velocity);
         op_td_set_dbl           (pkptr,            OPC_TDA_RA_END_PROPDEL,
     end_prop_velocity);
         FOUT
     }
```
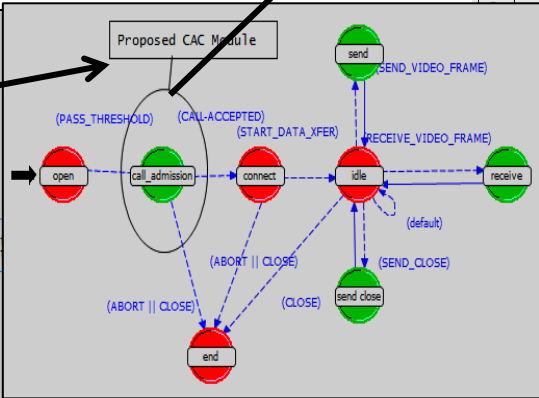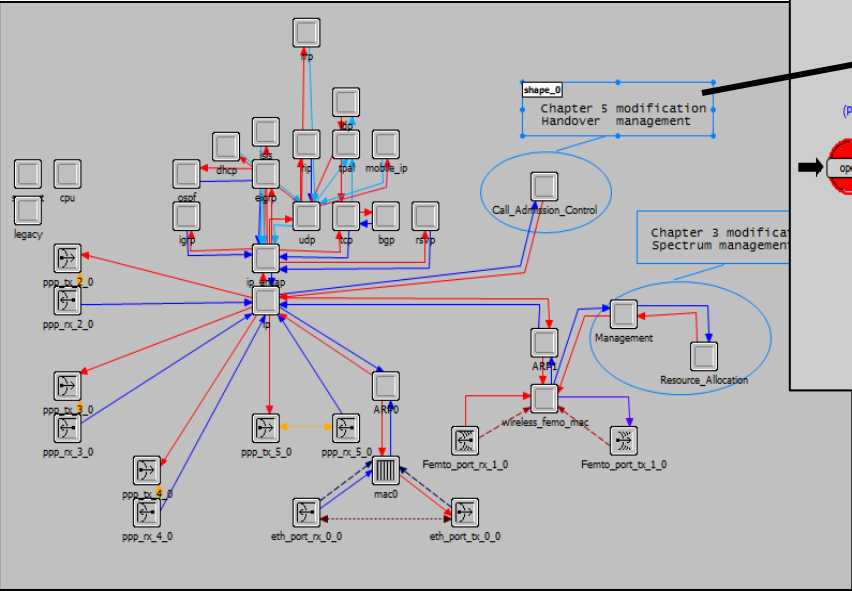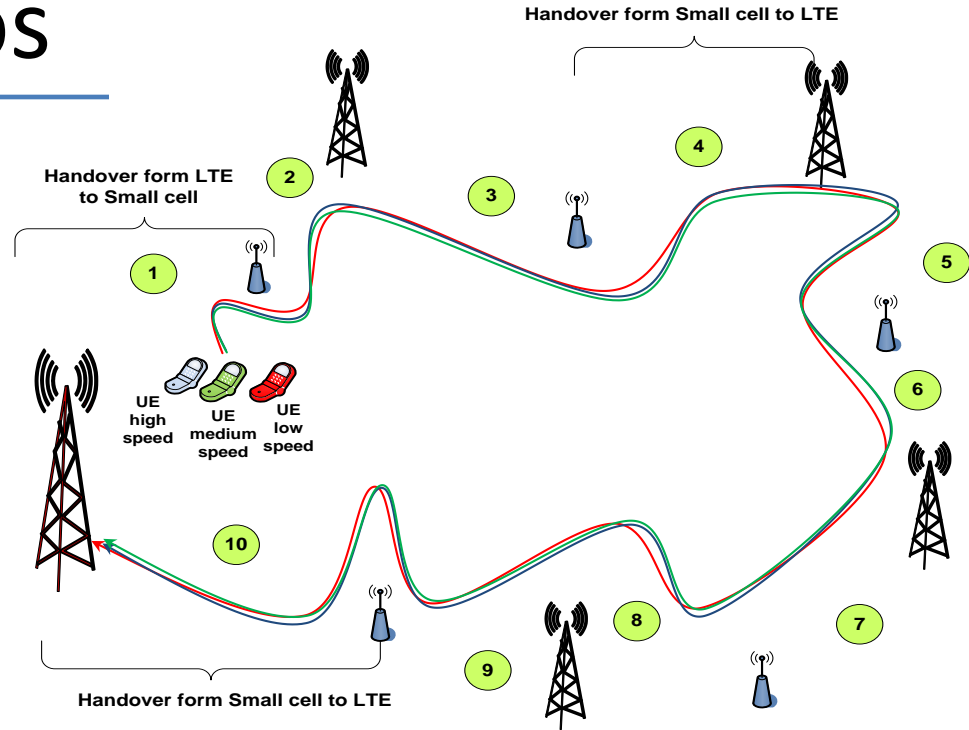
➢A new modification has been developed to allow calculating the ground speed of mobile users and attach it to the packets attributes to enable the functioning of the proposed CAC.

Simulation Scenarios

The aim of these five case studies is to evaluate the different approaches and technologies that can be used to reduce the numbers of handovers for mobile phones travelling between LTE and small cell transmission domains.


Handover form Small cell to LTE

Handover form LTE to Small cell

UE high speed
UE medium speed
UE low speed

Handover form Small cell to LTE

Transition States for Mobiles

	Scenario(1)	Scenario(2)	Scenario(3)	Scenario(4)	Scenario(5)
	1 2	1 2	1 2	1 2	1 2
		3 4	3 4	3 4	3 4
			5 6	5 6	5 6
				7 8	7 8
					9 10

LTE Macrocell BS   Small cell BS

Parameters Value		Parameters Value	
LTE transmit power		40dBm	
Small cell BS transmit power		20dBm	
Number of LTE		5	
Number of Small Cell		5	
Number of UE		3	
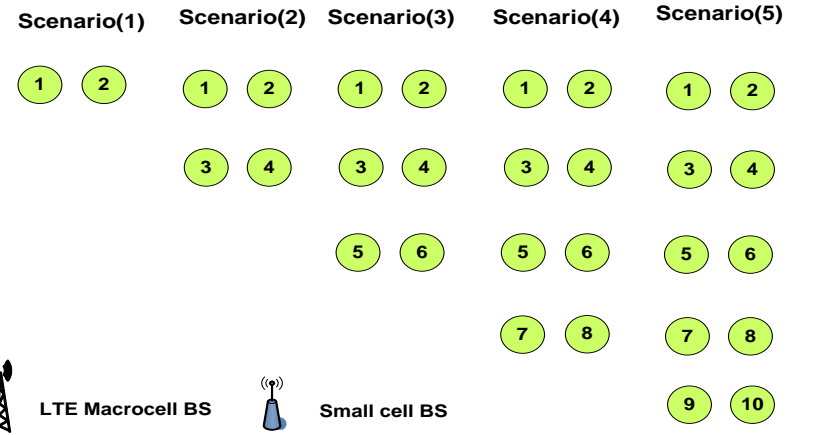
Results

the simulation results show clearly that the effectiveness of the proposed CAC algorithm for handover management increases the system performance significantly. The comparison with the traditional scheme shows that the algorithm proposed have a better performance in the rate of less unnecessary handovers
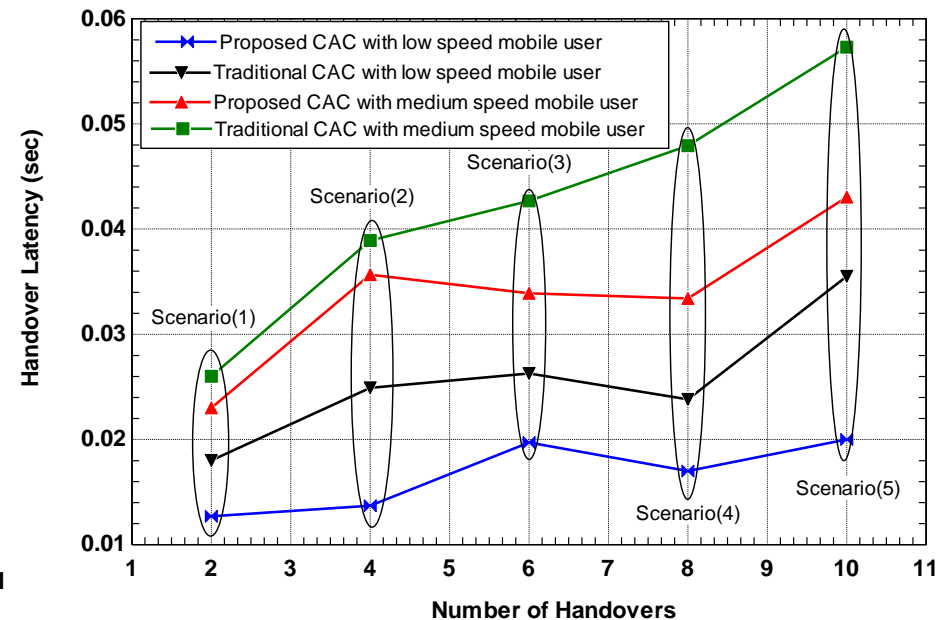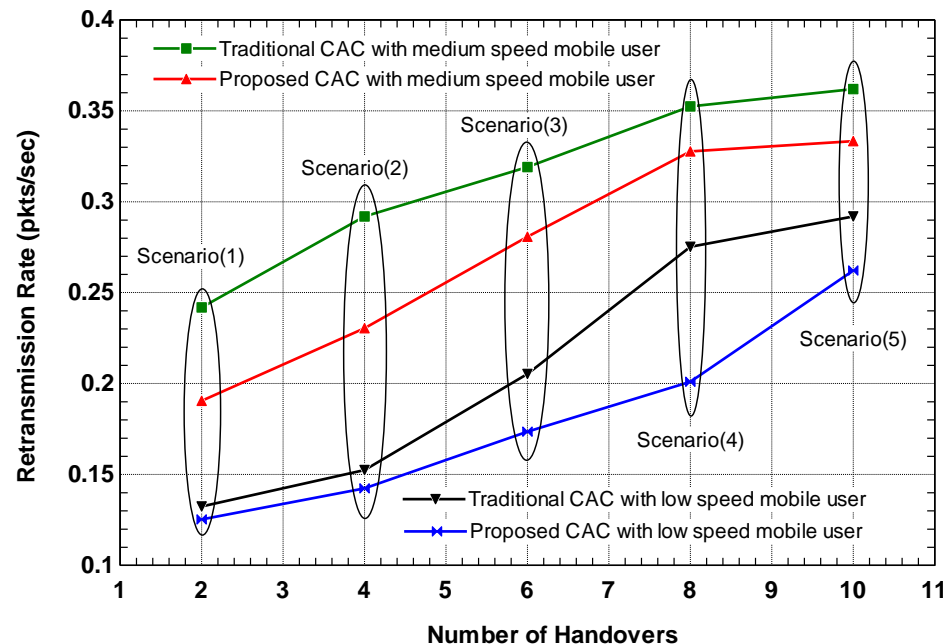
Results show major improvements in the system performance for the LTE network compared to the traditional handover schemes.

Summary

- The LTE standard have good support for seamless mobility from the fact that the handover triggering will be faster in LTE compared to existing networks

- Seamless handover execution is important in order to minimize the risk of radio link failure

- New CAC algorithms are help to improve management system to achieve spectrum efficiency and increased the network capacity ☺

- Novel mobility mechanism is incresaed the network perforamnce by reducing the numbers of unnecessary handovers by 40%

Thank you for your attention

saba@ryerson.ca