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Frequency Re-Use In Mobile Computing Using the Openwns in Sectored Clusters and Non-Sectored Clusters

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Abstract *–This work develops a system using a simulation platform (openWNS) for performance evaluation and comparison of the frequency re-use in both sectored cluster and non-sectored cluster in cellular networks. The Signal to Noise ratio in a sectored cluster is compared to a non-sectored cluster.The number of handoffs that occurs when a communication is on, was also tested in the simulation environment in both sectored cluster and non-sectored cluster. In any radio network, the number of simultaneous calls that may occur is governed largely by the available frequency spectrum and the number of channels that can be supported by the available bandwidth.*

Keywords: *Frequency re-use, sectored cluster, non-sectored cluster*

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I. Introduction

Frequency reuse is the practice of splitting an area into smaller regions that do not overlap so as for each to utilize the full range of frequencies without interference [1, 2]. Frequency reuse which is also known as frequency planning is a technique of reusing frequencies and channels within a communication system, apart from improving capacity and coverage, it also helps in improving spectral efficiency. It is also one of the fundamental concepts on which commercial wireless systems are based, that involves the partitioning of a Radio Frequency (RF) radiating area into cells. Each cell is designed to use radio frequencies within its boundaries, while the same frequencies can be reused in other cells not far away without interference, in another cluster. Such cells are called 'co-channel' cells. In the cellular concept, the frequencies allocated to the service are re-used in a regular pattern of areas, called cells covered by a base station. To ensure that the mutual interference between users remain below a harmful level adjacent cells, it makes use of different frequencies. In a cellular system, each mobile station (MS) is connected with its base station (BS) via a radio link. The BS is responsible for sending the calls to and from the MS, which lie in the coverage area of the BS.A large number of users are reusing same frequencies repeatedly, which causes the increase of the probability of co-channel interferences. The lower reuse factor for larger cell or higher reuse factor for smaller cell have complex hand-over and high co-channel interference[3].

Hossein et al., (2012) proposed in their paper that the queuing of handoff calls could be used to minimize the forced call terminations due to unavailability of channels in the cell[4]. Sayawu et al., (2015) carried out a study which shows that, for cell sites with very low traffic intensity per channel ratio, and approximately equal rates for originating and handoff calls, there is the need to queue both originating and handoff calls which fits the conditions for Nano and Pico cells[5].Pathak et. al., (2014) worked on Channel Allocation in Wireless communication using Genetic Algorithm, he stated that frequency reuse is a process of selecting and allocating channels for all of the BSs within a cellular network. The research applied the genetic algorithms to channel assignment problems and the major limitation of the work is high interference[6].

The bandwidth available for a cellular system is always limited. With the increase in multimedia applications and ever increasing demand of wireless devices supporting higher data rate flow, cellular systems, in general, always face scarcity of channels. The increase in the demand for frequency bandwidth causedby the increase in the number of users created a need for frequency re-use in mobile computing.In wireless telephony, a cell is the geographical area covered by a cellular telephone transmitter. The cell shape is generally chosen to be hexagonal, as it avoids the overlap that occurs in case of circular shape, a cell may be surrounded by a large number of adjacent cells. The repeating regular pattern of cells is called cluster. As the number of users in the system increases, the channel capacity consequently decreases. So therefore, by using the methods such as cell splitting or cell sectoring, the capacity is increased. Both cell sectoring and non-cell sectoring techniques have their limitations. This work compares the effect of frequency reuse in a sectored and non-sectored cells using openWNS.

II. Simulation Environment

The simulation platform used in this work is the Open Wireless Networks Simulator (OpenWNS) which is available at www.openwns.org[7]. It uses a plugin architecture to allow developers to extend the simulator to their specific needs. Each official plugin is managed by its own project in launchpad. The OpenWNS.sdk provides a framework to help developers work on multiple projects concurrently. The simulation platform offers close-to-emulation implementation of the respective protocol stack, including implementations of detailed interference modeling in reference scenarios, mobility models, traffic load generators, statistical evaluation methods and detailed channel models.

The OpenWNS provides ways to sort measurements in-line with the measurement context and it also compresses the data usage during runtime by statistical process.

III. System Design

The data flow diagram shown in figure 1 maps out the information of the system operation. It shows a channel allocation for handoff request in order to improve the efficiency of channel utilization and reduce both dropping and blocking probabilities.

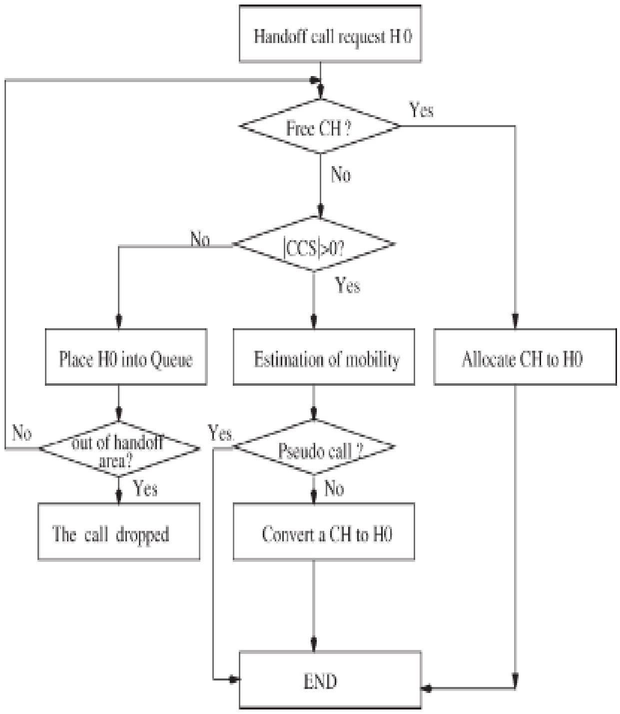


Figure 1: Flow diagram of the channel allocation

OpenWNS is an open source event-driven simulator, it is used to simulate sectored and non-sectored clusters in cellular networks, the performance evaluation of the sectored and non-sectored cluster are carried using the following parameters:

i. Relative signal strength.
ii. Frequency re-used
iii. Sigma
iv. Signal to Noise ratio
v. PLModel
vi. Rotation
vii. Cell radius
viii. Transmitter power
ix. Transmitter antenna power
x. Beam width

In this system, frequency re-use is achieved by assigning a subset of the total number of channels available to each base station, and controlling the power output of the transmitters. In this way, cellular networks increase capacity (number of channels available to users).Adjacent cells are not allowed to operate at the same frequency since this causes interference between the cells. To ensure the mutual interference between users remains below a harmful level, adjacent cells use different frequencies which is a set of C different frequencies {f1, …, fC} which are used for each cluster of C adjacent cells. Cluster patterns and the corresponding frequencies are re-used in a regular pattern over the entire service area.

Consider the cell diagram in Figures2 and Figure 3, let R be the distance from the cell centre to a vertex. It is denoted that the location of each cell by the pair (i, j) where, assuming cell A to be centred at the origin (0, 0), the location relative to cell A is obtained by moving i cells along the u axis, then turning 60 degrees counter clockwise and moving j cells along the v axis. For example, cell G is located at (0,1), cell S is located at (1,1), cell P is located at (-2,2) and cell M is located at (-1, -1). It is straightforward to show that the distance between cell centres of adjacent cells is 3R, and that the distance between the cell centre of a cell located at the point (i,j) and the cell centre of cell A (located at (0, 0) is given by $D = \sqrt{3}R \sqrt{i2 + j2 + ij}$[8]. The formula for D suggests a method for assigning frequency A to cells such that the cell separation between cells operating at frequency A is $D = \sqrt{3}R \sqrt{i2 + j2 + ij}$. Starting at the origin cell A, move i cells along any chain of hexagons, turn counter clockwise by 60 degrees, move j cells along the hexagon chain of this new heading and assign frequency A to the jth cell. Using this process to assign all frequencies results in hexagonal cell clusters, which are repeated at the distance D, as shown in Figure 2.

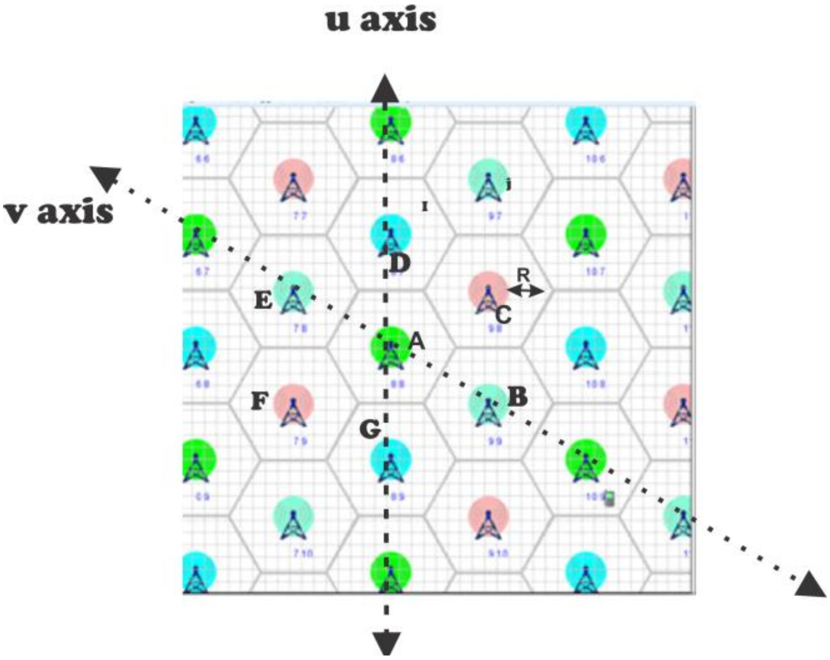


Figure 2: Non-sectored cluster.

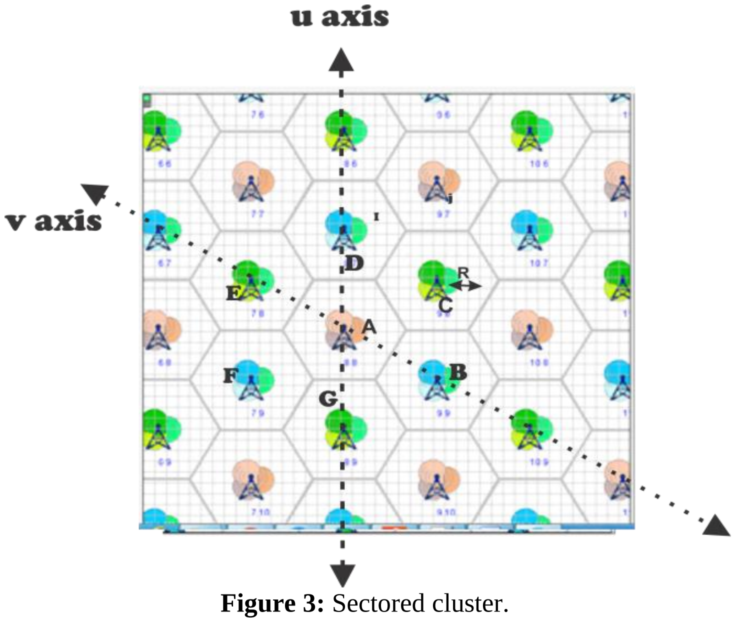


Figure 3: Sectored cluster.

In this work, the resource allocation rules which are
a) Inter-cell-interference randomization b)Inter-cell-interference cancellation and
c) Inter cell-interference co-ordination/avoidance (Naveed et. al., 2009) are designed so that they can avoid maximally inter-cell interference (ICI) when the loading factor is less than a threshold loading factor, while exceeding the threshold, ICI is averaged over the whole frequency resource.

With regard to signal strength, a cell can be divided into two areas, namely:
1. The normal area and
2. Handoff area.

Each cell is hexagonal and surrounded by six cells. It should be noted that the soft handoff area is mainly controlled by the handoff thresholds, such as T_{ADD} and T_{DROP}, broadcasted by the serving BS. Essentially, those areas are not always equivalent to the geometric areas identified by the physical distance at most time. The ratio A of the handoff area to the entire cell area is defined as
A = area of the handoff region / area of the cell.

Figure 4shows a visualization of the soft handoff area. The intersection area of two cells is considered the soft handoff area, in which all calls have two channels in their active sets. In the process of soft handoff, as defined in the U.S IS95A, there can be more than two BSs in the active set. When the strength of one of the pilots in the active set is less than T_{DROP}, the corresponding call will be considered to leave the handoff area for the normal area after waiting for a short period of duration.

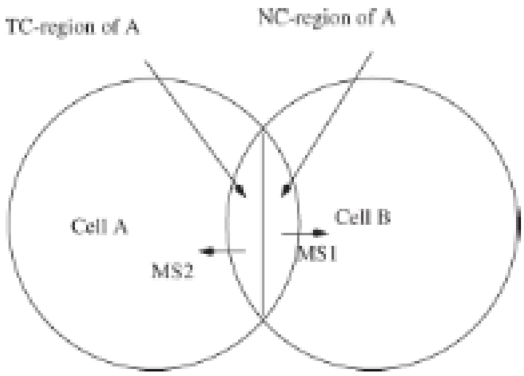


Figure 4: Cellular geometry of soft handoff.

IV. System Implementation

This section discusses the overall system implementation, simulation of a frequency re-use system inboth sectoring and non-sectoring clusters. The following parameters are used for the analysis:

Table 1: The parameters used for the simulation

.

Parameters	Value
PLModel	Urban Micro
Beam Width	70deg
Rotate	0 deg
Cell Radius	116m
Tx Power	43dBm
Fc	1.0GHz
hTx	10m
hRx	1.5m
Sigma	4Db
Vertical Tilt	6 deg
Re-use	1

V. Performance Metrics And Performance Evaluation

Average SNR: The Signal-to-Noise ratio is used to measure the signal strength which is relative to background noise in the system.
Number of call drops: This measures the number of call droppings that occurs on a Mobile Station within a specified distance, whereby a user will handover from one Base Station to the other without having to connect to an available Base Station when handover occurs.
Number of Handoffs: This measures the number of transferring of on-going calls or data session from a Base Station to another Base station either within a cluster (for a sectored cluster) or different clusters (for a non-sectored cluster).
Delta 1& Delta 2: These define the frequency used during the simulation.
Reading time: This is the time defined by the user which simulates the number of minutes a user will be on a call.
Outage Time (ms): This is the time measured by the system to simulate the result received.

VI. Results

Input Parameters	
Reuse: 1 ,Model: Rune	Pt(dBm): 34
fc(GHz): 0.8	Beam Width(deg): 70
Rotate(deg): 30	Cell Radius(m): 50
hT(m): 10	hM(m): 1
Sigma(dB): 4	Vertical Tilt(deg): 12
SNR(dB): 5	Band Width(MHz): 5
Noise Figure(dB): 7	Noise Power(dBm): -100.01
Pr0(dBm): -95.01	Time Slot(s): 20

Exp. Results								
SNR	No.Calldrops	No.Handoffs	Delta1	Delta2	Reading Time(ms)	Outage Time(ms)	% Outage	Alpha
5.0	0.0	0.0	3.0	3.0	20016.0	20016.0	100.0	0.1

Figure 5.0: Result of a sectored experiment.

Input Parameters	
Reuse: 1 ,Model: Rune	Pt(dBm): 34
fc(GHz): 0.8	Beam Width(deg): 70
Rotate(deg): 30	Cell Radius(m): 50
hT(m): 10	hM(m): 1
Sigma(dB): 4	Vertical Tilt(deg): 12
SNR(dB): 5	Band Width(MHz): 5
Noise Figure(dB): 7	Noise Power(dBm): -100.01
Pr0(dBm): -95.01	Time Slot(s): 20

Exp. Results								
SNR	No.Calldrops	No.Handoffs	Delta1	Delta2	Reading Time(ms)	Outage Time(ms)	% Outage	Alpha
5.0	6.0	6.0	3.0	3.0	20016.0	11232.0	56.12	0.1

Figure 6.0: Result of a non-sectored experiment

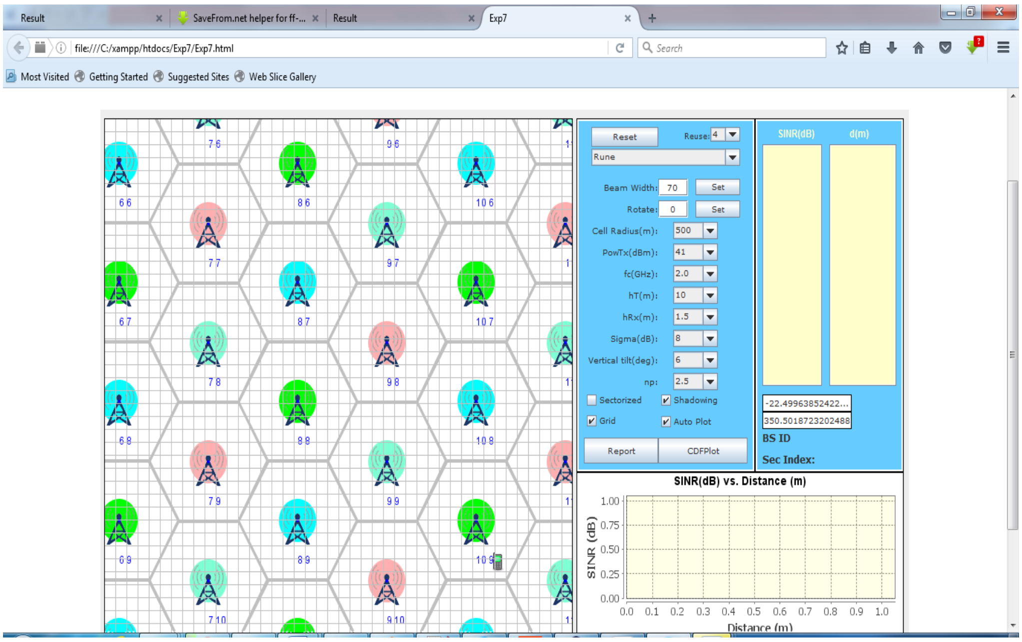


Figure 7.0: The simulated environment for a non-sectored set of cluster.

A user can choose the environment to be simulated either a rural area or an urban area. For every environment selected for experiment, the defined parameter is dependent on the environment which results to the graphical representation of the ratio of CDR to SINR as shown in Figure 9 and 12.

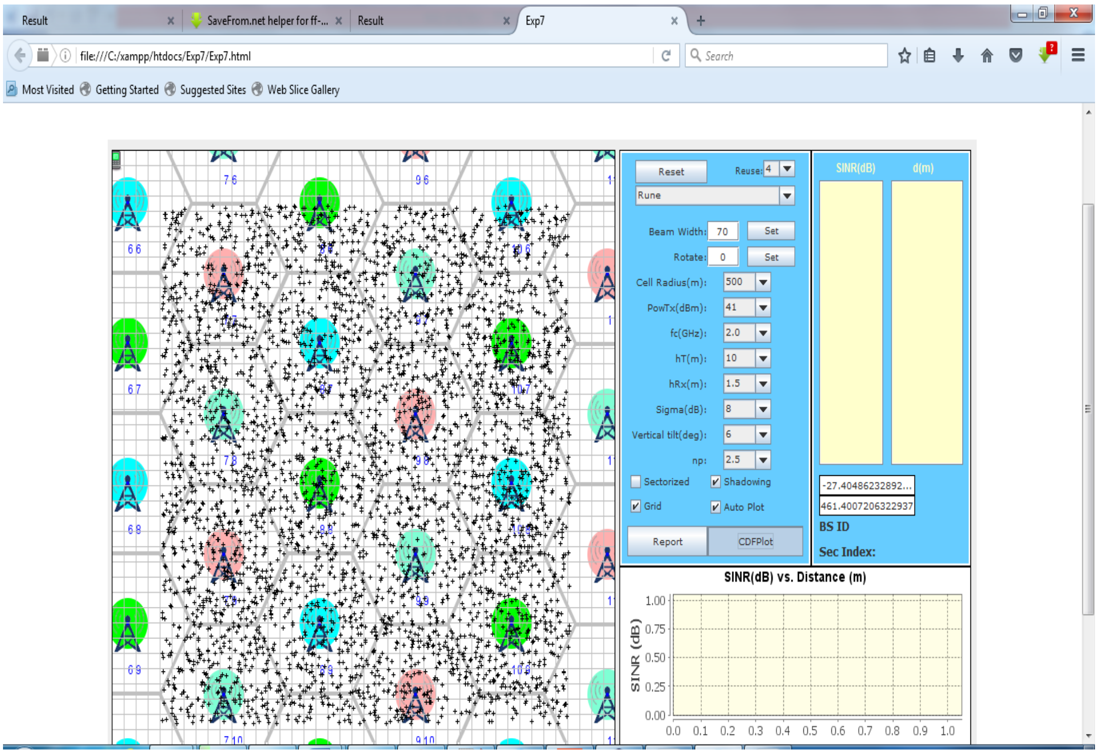


Figure 8: The selection of cells in a non-sectored cluster to plot a CDF graph.

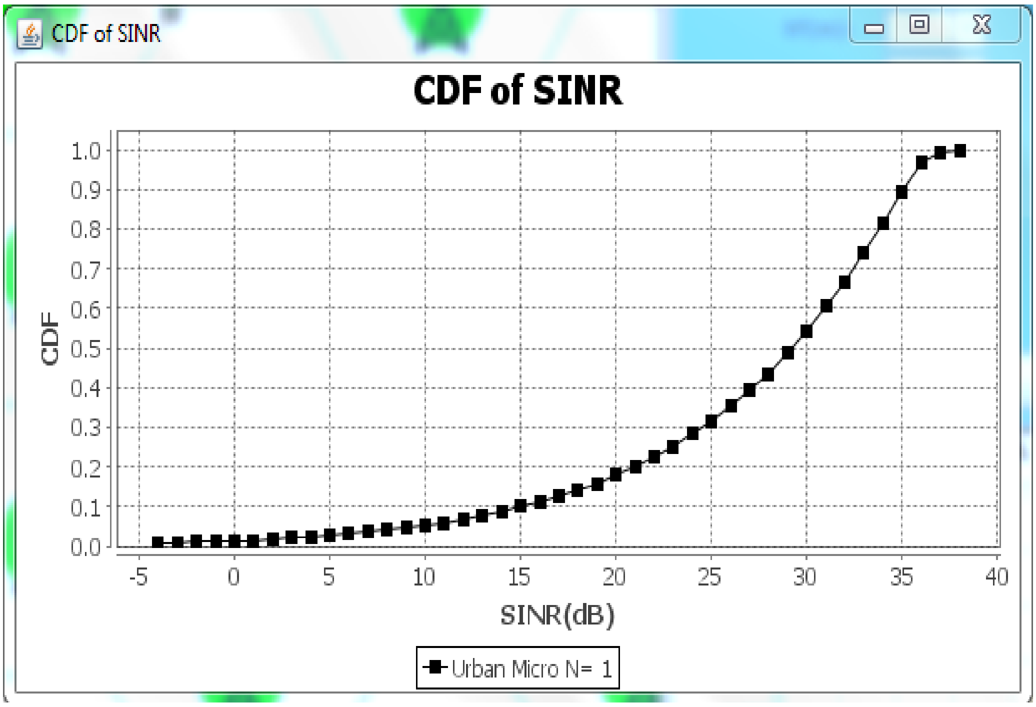


Figure 9: The result of selected non-sectored cluster in the simulated environment.

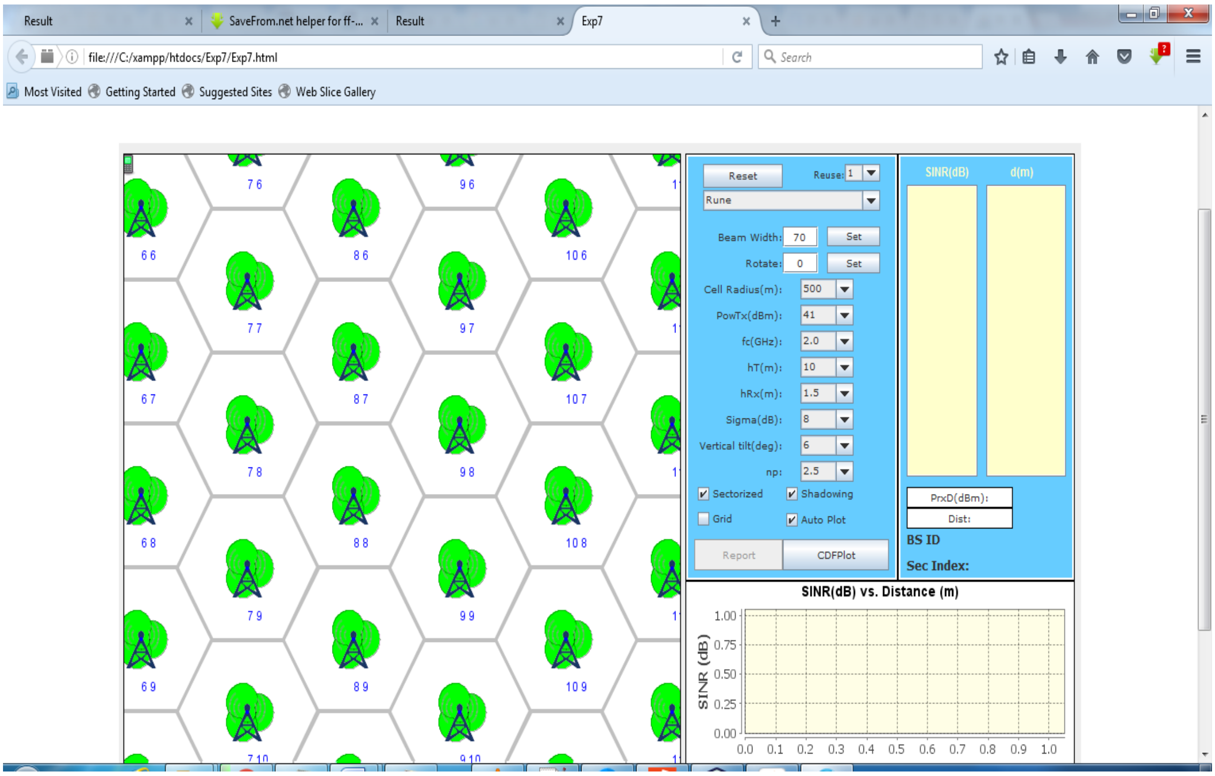


Figure 10: Sectored cluster in the simulated environment.

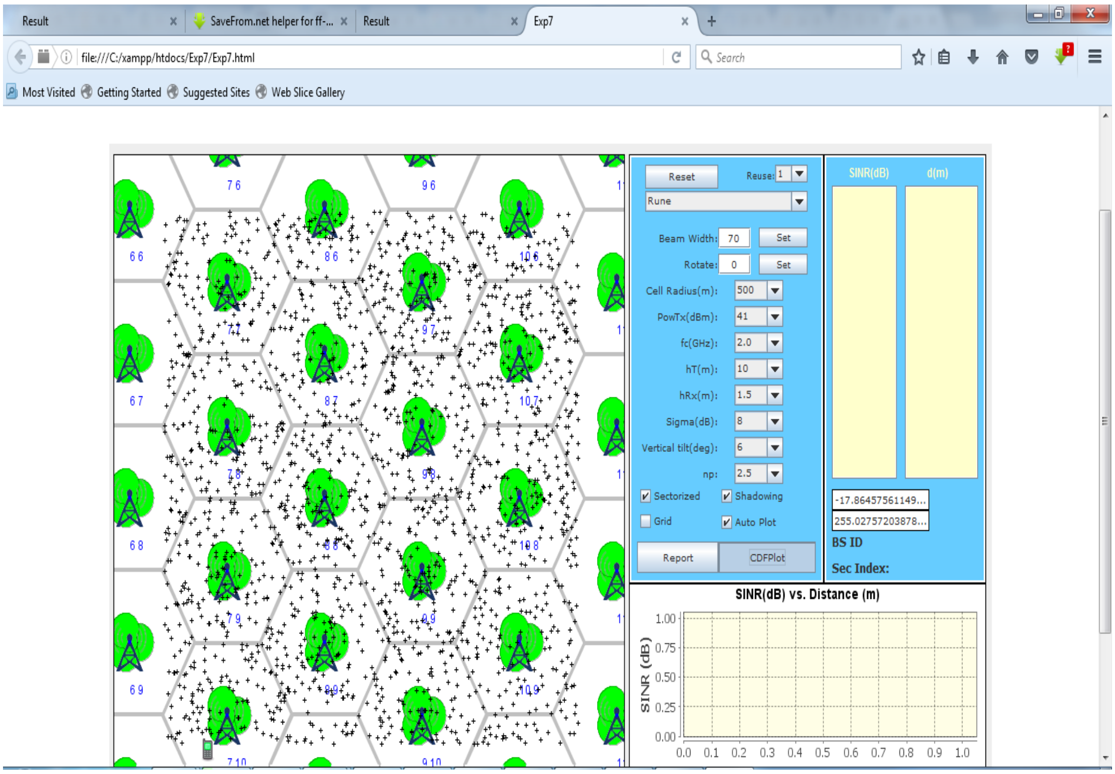
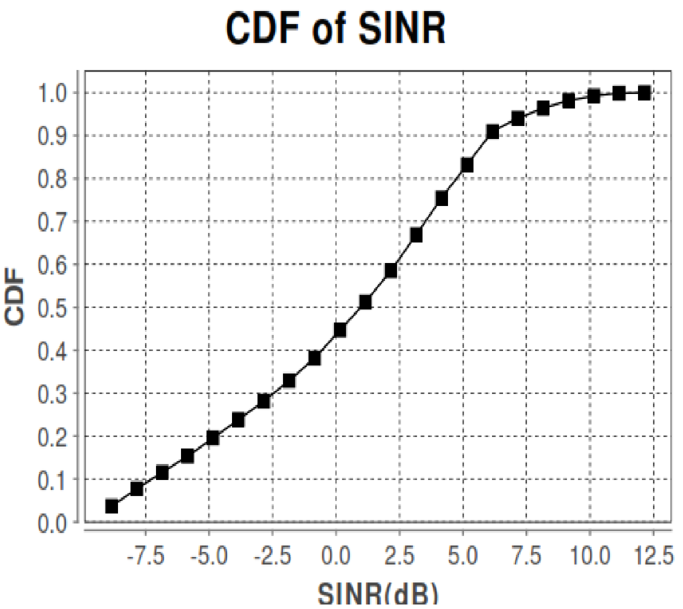


Figure 11: The selection of cells in a sectored cluster to plot a CDF graph.



PLModel	Urban Micro
Beam Width	70 deg
Rotate	0 deg
Cell Radius	116 m
Tx Power	43 dBm
fc	1.0 GHz
hTx	10 m
hRx	1.5 m
Sigma	4 dB
Vertical Tilt	6 deg
Sectoring	No
Shadowing	Yes
Reuse	1

Figure 12: The result of non-sectored cluster in the simulated environment.

VII. Discussion

In this work, the number of handoffs which occurs in a sectored cluster was to the minimal compared to the number of handoffs which occurs in a non-sectored cluster. From the graphical representation of the result from a sectored cluster and a non-sectored cluster which is a graph of CDF against SINR, it is noticed that in a non-sectored cell, the Signal to noise ratio which occurs in a non-sectored cluster is minimal compared to the one that occurs is a sectored cell during handoff.

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