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Wireless Powered Cognitive Radio Network to Reduce Path Handoff

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Abstract: *This work deals with an asynchronous channel access model performed by a primary ad hoc network underlaid with a cognitive secondary wireless-powered ad hoc network. Specifically, we consider that the primary transmitters are connected to the power grid whereas the cognitive secondary transmitters have radio frequency energy harvesting capabilities and their asynchronous channel access is established based on certain energy and interference-based criteria. The sporadic channel traffic is modeled by time-space Poisson point processes and we provide an analytical framework, based on stochastic geometry, for the performance of this asynchronous system.*

Keywords: Cognitive network, energy harvesting, Poisson process.

1. INTRODUCTION'

Previous technologies are independent types. There are different technologies like Wi-fi, WiMAX, Bluetooth, 2G, 3G… etc. The problem of previous network technologies in communication is possible only in its technologies of the communication device (Bluetooth to Bluetooth).

1. 1 *Infrastructure mode*

An Infrastructure mode network requires the use of an Access Point. The Access Point controls Wireless communication and offers several important advantages over an Ad-hoc network. For example, an Infrastructure based network supports increased levels of security, potentially faster data transmission speeds and integration with a wired network. To improve the infrastructure communication, researchers implemented the cellular concept and handoff schemes. A cellular network or mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell. The transfer of a cellular phone transmission from cell to another adjacent cell is called as a handoff. Handoffs occur when a cellular phone user passes out of the range that the cell can handle and into another cell range, and the signal is passed from one base station to the next.

1.2 Ad-hoc mode

An Ad-hoc network allows each device to communicate directly with each other. There is no central Access Point controlling device communication. Ad-hoc networks are only able to communicate with other Ad-hoc devices, they are not able to communicate with any Infrastructure devices or any other devices connected to a wired network. Besides, Ad-hoc mode security is less sophisticated compared to an Infrastructure mode network. An already available new technology is a heterogeneous network with a vertical handoff scheme. The previous scheme used in cellular communication is like a 2G-3G communication model. The researchers implemented the same technology for WiMAX and WLAN but the problem in the WiMAX communication area is larger than WLAN, the same technique hand off is not efficient like some other network (2G-3G). The main reason is whenever it's getting another network signal also there is no hand off from home station. If the node moves from home station to another station then the only node participated in the hand off. Cognitive radio technology proves the efficient spectrum usage. In the existing vertical hand off scheme, when the user is available in the home station then it can't participate in hand off, so communication (spectrum) problem will occur due to an increased number of users. To solve this problem, we are proposing an optimized proactive vertical hand off named as cognitive radio. In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity and can be conceived as applications of Mobile Ad-Hoc Networks. Cognitive radio (CR) will lead to a revolution in wireless communication with significant impacts on technology as well as regulation of spectrum usage to overcome existing barriers.

1.3 Problem Statement

In the base, the model author has considered only the Spectrum hand off in static mobility (within a region). By this model, we can achieve effective spectrum hand off but if node moment occurs between different regions, then efficient communication won't take place. The current system has well investigated the spectrum pricing issues in the spectrum market, where multiple primary users, whose goal is to maximize the monetary gains with their vacant spectrum, compete with each other to offer spectrum access to the CR users.

1.4 Objectives

The main objectives are:

1. To reduce path hand off problem.
2. Improve the throughput with regional movement.
3. To make continuous connectivity.

The following tasks are performed to achieve these objectives:

- Understood the basics of Cognitive radio.
- Studied the basics of path hand off.
- Developed the simulation of multiregional connectivity for CR.

2. COGNITIVE RADIO

2.1 Cognitive radio definitions:

There are likely to be a variety of different views of what exactly what a cognitive radio maybe. Accordingly, a definition of a cognitive radio may be of use in several instances. A cognitive radio may be defined as a radio that is aware of its environment and the internal state and with knowledge of these elements and any stored pre-defined objectives can make and implement decisions about its behavior.

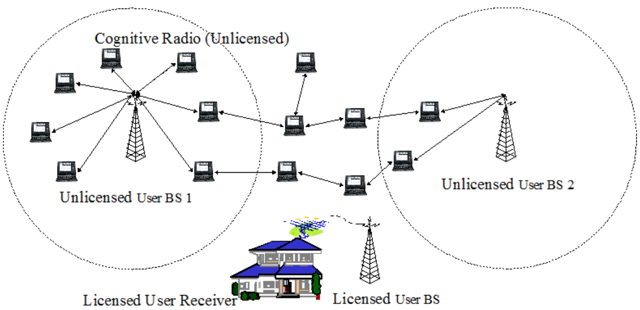

Fig 2.1: CR network in spectrum

2.2 Cognitive radio architecture

In addition to the level of processing required for cognitive radio, the RF sections will need to be particularly flexible. Not only they may need to swap frequency bands, possibly moving between portions of the radio communication spectrum that are widely different in frequency, but they may also need to change between transmission modes that could occupy different bandwidths. To achieve the required level of performance will need a very flexible front end.

Traditional front-end technology cannot handle these requirements because they are generally band limited, both for the form of modulation used and the frequency band in which they operate. Even so-called wideband receivers have limitations and generally operate by switching front ends as required.

Currently these requirements are beyond the limits of the technology available. Thus, the full vision for cognitive radio cannot yet be met.

The conversion to and from the digital format is handled by digital to analog converters (DACs) and analog to digital converters (ADCs). To achieve the performance required for cognitive radio, not only the DACs and ADCs have an enormous dynamic range, and are able to operate over a very wide range, extending up to many GHz, but in the case of the transmitter they must be able to handle significant levels of power.
Nevertheless, in the future the required DAC and ADC technology will undoubtedly become available, thereby making cognitive radio a reality.

2.3 Applications

CR can sense its environment and, without the intervention of the user, can adapt to the user's communication needs while conforming to FCC rules in the United States. In theory, the amount of spectrum is infinite; practically, for propagation and other reasons it is finite because of the desirability of certain spectrum portions.

The assigned spectrum is far from being fully utilized, and efficient spectrum use is a growing concern; CR offers a solution to this problem. A CR can intelligently detect whether any portion of the spectrum is in use, and can temporarily use it without interfering with the transmissions of other users. According to **Bruce Fette,** "Some of the radio's other cognitive abilities include determining its location, sensing spectrum use by neighboring devices, changing frequency, adjusting output power or even altering transmission parameters and characteristics. All of these capabilities, and others yet to be realized, will provide wireless spectrum users with the ability to adapt to real-time spectrum conditions, offering regulators, licenses and the general public flexible, efficient and comprehensive use of the spectrum".

3. NS 2 SIMULATION

3.1 Introduction

Network Simulator (Version 2), widely known as NS2, is simply an event-driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2.

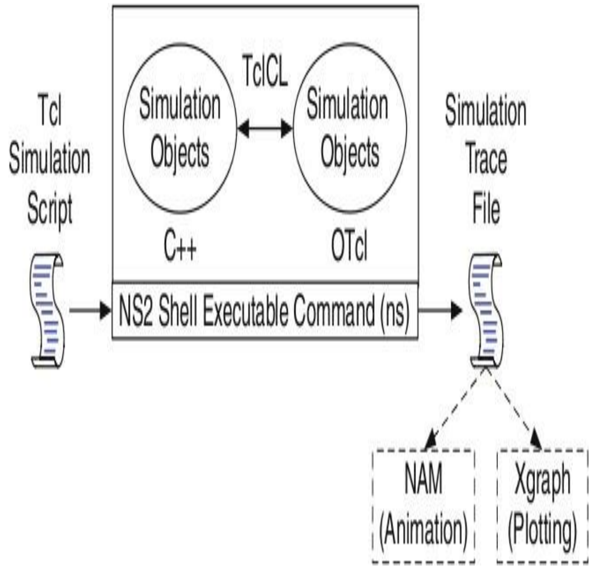

Fig3.1 Basic NS2 architecture

3.2 NS Features

3.2.1 NS is an object-oriented discrete event simulator maintains a list of events and executes one event after another.

2.A single thread of control: no locking or race conditions.

3. Back end is C++ event scheduler
    - Protocols mostly
    - Fats to run, more control
4. The front end is OTCL
    - Creating scenarios, extension to C++ protocols
    - Fast to write and change

3.4 MODEL OUTPUT

There are two types of outputs

- Nam window
- XGraph

NAM WINDOW

NS has a companion network animator called *Nam* hence, has been called the ns Nam project.

3.3 NS Programming structure

1) Create the event

scheduler 2)**Packets**

3) Create network topology

EVENT SCHEDULER

In this event scheduler while processing many data at a time it will be process one by one (FIFO concept), so there is no congestion while transferring the packets.

PACKETS

It is the collection of data, whether the header is called or not, all header files were present in the stack registers.

CREATING NETWORK TOPOLOGY (physical layer)

The Physical Layer is the first and lowest layer in the seven-layer OSI model of computer networking. The implementation of this layer is often termed PHY.

The Physical Layer consists of the basic hardware transmission technologies of a network. It is a fundamental layer underlying the logical data structures of the higher- level functions in a network.

Due to the plethora of available hardware technologies with widely varying characteristics, this is perhaps the most complex layer in the OSI architecture.

The Physical Layer defines the means of transmitting raw bits rather than logical data packets over a physical link connecting networking nodes.

The bit stream may be grouped into code words or symbols and converted to a physical that is transmitted over hardware.

3.5 SYSTEM MODELLING

System modeling refers to an act of representing an actual system simply. System modeling is extremely important in system design and development since it gives an idea of how the system would perform if implemented. Traditionally, there are two modeling approaches: an analytical approach and a simulation approach.

ANALYTICAL APPROACH:

The general concept of the analytical modeling approach is to first come up with a way to describe a system mathematically with the help of applied mathematical tools such as queuing and probability theories, and then apply numerical methods to gain insight from the developed mathematical model. When the system is simple and relatively small, analytical modeling would be preferable (over simulation). In this case, the model tends to be mathematically tractable. The numerical solutions to this model in effect require lightweight computational efforts.

If properly employed, analytical modeling can be cost- effective and can provide an abstract view of the components interacting with one another in the system. However, if many simplifying assumptions on the system are made during the modeling process, analytical models may not give an accurate representation of the real system.

XGRAPH

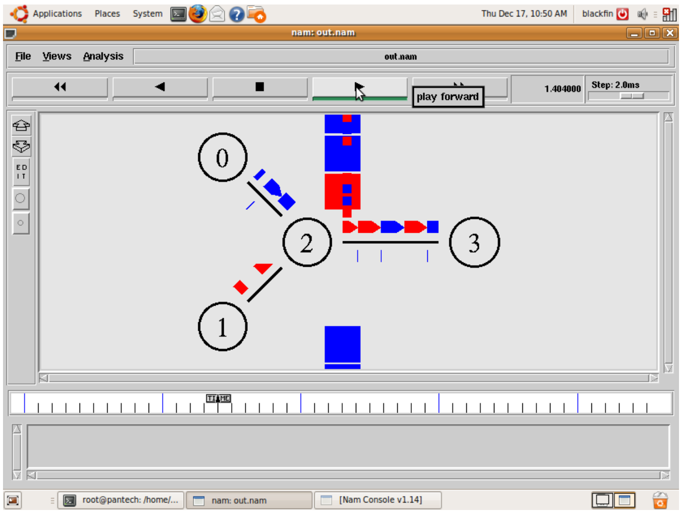

Fig 3.2 NAM window

SIMULATION APPROACH:

Simulation is a process of designing a model of a real system and conducting experiments with this model to understand the behavior of the system and/or evaluate One part of the NS-all in one package is 'Xgraph', a plotting program that can be used to create graphic representations of simulation results.

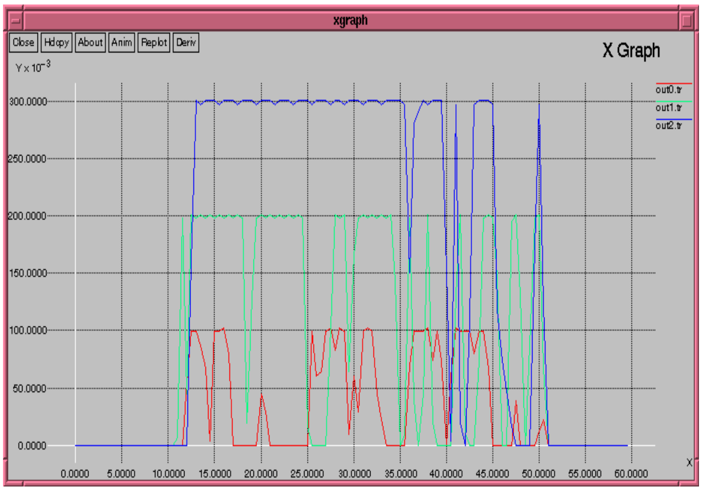

Fig 3.3 Xgraph

various strategies for the operation of the system. Simulation is widely-used in system modeling for applications ranging from engineering research, business analysis, manufacturing planning, and biological science experimentation, just to name a few. Compared to analytical modeling, simulation usually requires less abstraction in the model (i.e., fewer simplifying assumptions) since almost every possible detail of the specifications of the system can be put into the simulation model to describe the best actual system. When the system is rather large and complex, a straightforward mathematical formulation may not be feasible. In this case, the simulation approach is usually preferred for the analytical approach.

4. Project Description

In this chapter, we are going to discuss our project working process, before that we have to introduce the necessity of this project work. The next generation of cellular/wireless communications (3G or 4G) is expected to be purely IP-based and consists of access networks and a converged core network. The evolving 4G network will seamlessly integrate various types of wireless access networks including the following: Wireless personal area networks (WPANs), such as ultra-wideband and Bluetooth, that provide range-limited ad- hoc wireless service to users; Wireless local area networks (WLANs), such as 802.11x (Wi-Fi), that provide high-throughput connections for stationary/quasi-stationary wireless users without the costly infrastructure of 3G; Wireless metropolitan area networks (WANs), such as 802.16 (WiMAX); that provide wireless services requiring high-rate transmission and strict quality of service requirements in both indoor and outdoor environments; Wireless wide area networks (WWANs), such as Universal Mobile Telecommunications System (UMTS), that provide long-range cellular voice and limited-throughput data services to users with high mobility; and Regional/global area networks (e.g., radio and television broadcasting, satellite communications).

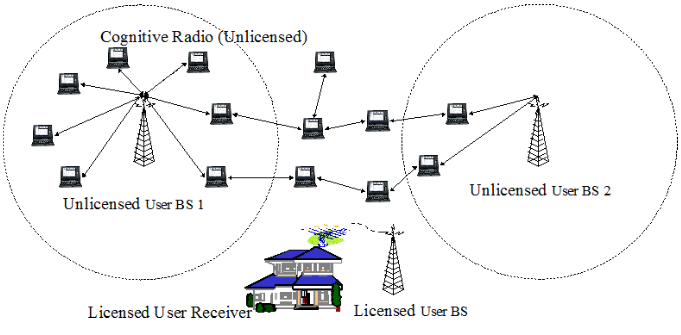

Fig4.1 wireless network connection

These heterogeneous wireless access networks typically differ in terms of signal strength, coverage, data rate, latency, and loss rate. Therefore, each of them is practically designed to support a different set of specific services and devices. However, these networks will coexist and use a common IP core to offer services ranging from low-data- rate non-real-time applications to high-speed real-time multimedia applications to end users since the networks have characteristics that complement each other.

4.1 Modules

To make our project work as efficient we divided our project work into small modules, such as given as bellow.

- Application selection
- Wireless network evolution
- Network

selection

APPLICATION

STATUS:

We focus on a cellular cognitive radio network as our framework. Also, we consider a new admission control as a way to improve the performance of our algorithm. We investigate the effect of letting users switch over base stations and show the resulting power-saving efficiency.

Also, we demonstrate how a simple admission control algorithm can improve system performance in terms of power consumption, SIR levels, and network capacity. The main point of this work is to introduce different tradeoffs that may be utilized to control network performance in various scenarios.

In real-time, users can select any type of application like video calling, voice calling, internet and e-transfer and so on… and in our project we are taking three items video, audio, e-trans.

WIRELESS EVOLUTION STANDARDS:

In the 1G to 2G transition, as well as a transition from analog to digital we saw a mono-service to multi-service transition. From 2G to 3G, as well as a mono-media to multimedia transition we are also seeing a transition from person-to-person to person-to-machine interactions, with users accessing the video, Internet/intranet and database feeds. The 3G to cognitive transition, supported by such technologies, will see a transition towards a predominance of automated and autonomously initiated machine-to-machine interactions. Such developments will, of course, be accompanied by the ongoing evolution of already anticipated 3G services, such as:

- send/receive e-mail
- Internet browsing (information)
- on-line transactions (e-business)
- location-dependent information
- company database access
- Large-file transfer.

NETWORK SELECTION:

In the current cellular systems, which are based on a star-topology, if the base stations are also considered to be mobile nodes the result becomes a 'network of mobile nodes' in which a base station acts as a gateway providing a bridge between two remote ad hoc networks or as a gateway to the fixed network. This architecture of hybrid star and ad-hoc networks has many benefits; for example, it allows self-reconfiguration and adaptability to highly variable mobile characteristics (e.g. channel conditions, traffic distribution variations and load-balancing) and it helps to minimize inaccuracies in estimating the location of mobiles. Together with the benefits there are also some new challenges, which mainly reside in the unpredictability of the network topology due to mobility of the nodes; this unpredictability, coupled with the local- broadcast capability, provides new challenges in designing a communication system on top of an ad-hoc wireless network. The following will be required: As already mentioned, in cognitive we will encounter a whole range of new MultiMate services, whose traffic models in isolation and in a mixed-mode need to be further examined. Likely, aggregate models will not be sufficient for the design and dynamic control of such networks. The effects of traffic scheduling, MAC and CAC (connection admission control) and mobility will be required to device the dimensioning tools needed to design cognitive networks. A suitable access network has to be selected once the hand off initiation algorithm indicates the need to handoff from the current access network to a target network. We formulate the network selection decision process as a MADM problem that deals with the evaluation of a set of alternative access networks using a multiple attribute wireless network selection function (WNSF) defined on a set of attributes. The WNSF is an objective or fitness function that measures the efficiency in utilizing radio resources and the improvement in the quality of service to mobile users gained by handing off to a particular network. It is defined for all alternative target access networks that cover the service area of a user. The network that provides the highest WNSF value is selected as the best network to handoff from the current access network according to the mobile terminal conditions, network conditions, service and application requirements, cost of service, and user preferences. Network selection in a heterogeneous all-IP wireless network environment depends on several factors.

4.3 Testing and debugging

Testing and debugging program is one of the most tedious parts of computer programming. The testing and debugging phase of a project can easily take more time than it took to write the application. Testing includes checking the code runs correctly under all circumstances, and it runs the same way it did before you made changes. TCL's error diagnostics make it easy to track down coding errors, the modular nature of TCL code make it easy to do unit testing of functions, and the TCL test package make it easy to write integrated regression test suites.

5. System testing

System implementation is a stage in the project where the theoretical designs turned into the working system. The performance of the reliability of the system was tested and it gained acceptance. The system was implemented successfully. Implementation is a process of converting a new system into operation. Proper implementation is essential to provide a reliable system to meet organization requirements. During the implementation stage a live demo was undertaken and made in front of end-users.
Implementation is a stage of the project when the system design is turned into a working system. The stage consists of the following steps.

- Testing the developed program with sample data.
- Detection and correction of internal error.
- Testing the system to meet the user requirement.
- Feeding the real-time data and retesting.
- Making a necessary change as described by the user.

5.1 *Black box testing:*

Black box testing is also called Behavioral testing and that focuses on the functional requirements of the software. Black box testing enables the software engineer to derive set of input conditions that will fully exercise all functional requirements for a program. Black box testing attempts to find errors in the following categories.

System Testing - Black box type testing that is based on an overall requirements specification and cover all combined parts of a system. The system testing to be done here is to check all the peripherals used in the project.

Performance Testing-Term often used interchangeably with 'stresses' and 'load' testing. Ideally 'performance' testing is defined in requirements documentation or QA or Test Plans.

Black box testing also called Behavioral testing focuses on the functional requirements of the software. Black box testing attempts to find errors in the following categories.

- Incorrect or missing functions
- Interface errors.
- Errors in data structures or external database access Behavior or performance errors.
- Initialization and termination errors.

5.2 *White box testing:*

White box testing sometimes called glass box testing is a test case design method that uses the control structure of the procedural design to derive test cases. Using white box testing methods, the software engineer can derive test cases that guarantee that all independent paths within a module have been exercised at least once. Exercise all logical decisions on their true and false sides. Execute all loops at their boundaries and within their operational bounds. Exercise internal data structure. We have tested out the project and path discovery module by following the screenshot, which worked perfectly.

5.3 *Application considered- Voice calls*

In this case, we are considering that both users are looking for voice communication. For voice communication, the main thing considered here is better connectivity through the network region, instead of looking cost of the service, bandwidth, etc. As per the parameter values of the different kinds of networks, net C is providing a better-connected network according to the distance function value. So, both the users are connected with net C in the process of voice communication. that is shown in Fig 5. 1

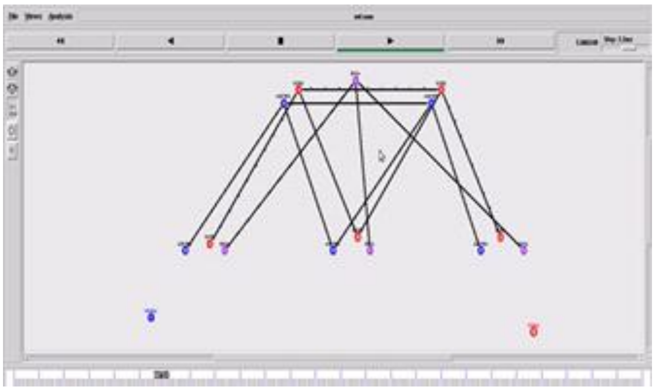

Fig5.1 Network selection for voice call application

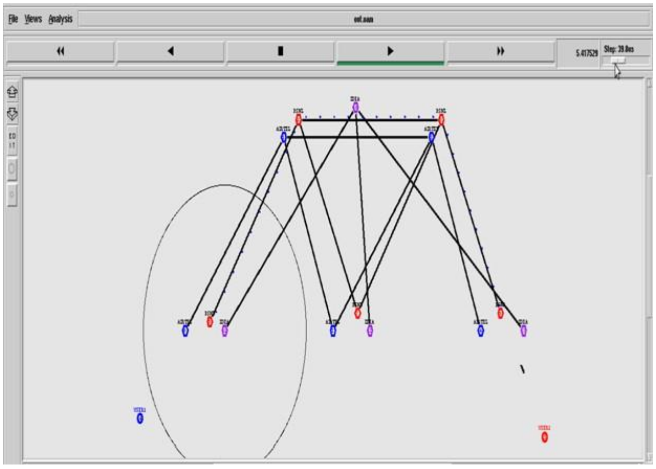

Fig5.2 data collection in the user

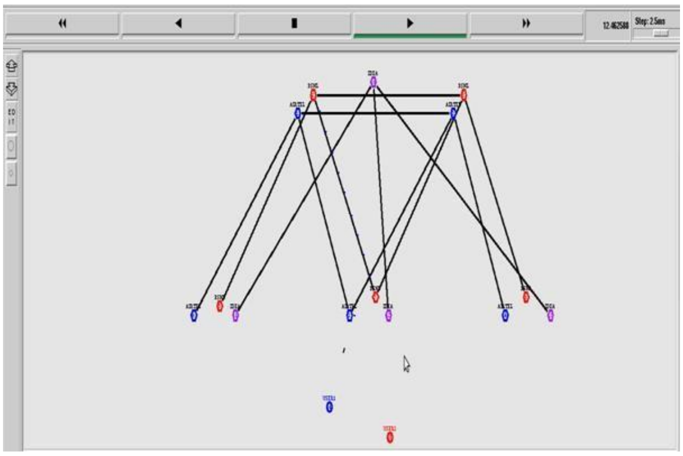

Fig5.3 Node is moved inside of another base station, so hand off has been done

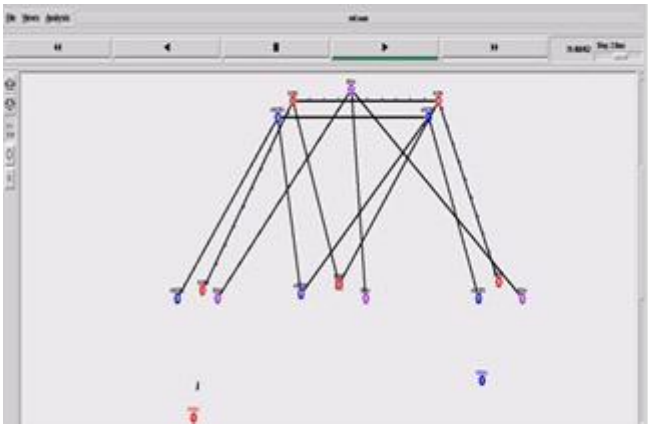

Fig5.4 User moved to another base station region, so here also hand off has been done.

6. 1Verification and validation

Verification refers to the set of activities that ensure that software correctly implements a specific function. Validation refers to a different set of activities that ensures that the software has been built is traceable to customer requirements. Verification and validation encompass a wide array of SQA activities that include formal technical reviews, quality and configuration audits, performance monitoring, simulation, feasibility study, documentation review, database review, algorithm analysis, development testing, qualification testing and installation testing.

6.2 *Test- case conclusion*

In our project, we have tested our program with the different type of testing, while testing we have solved so many errors and we verified our project output result. After error debugging, we got the perfect result as our main objective. Due to time duration we have not implemented in real-time and we have not tested in real-time, in the future we will implement it in real-time and we will test it.

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