7 Signal Sapphire

Wireless Quality Assurance (WQA)

Ayodeji O. Olumuyiwa

Bachelor's Thesis

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Valitse kohde.

SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS Abstract**

Field of Study Technology, Communication and Transport			
Degree Programme Degree Programme in Information Technology			
Author(s) Ayodeji Olumuyiwa			
Title of Thesis 7 Signal Sapphire Wireless Quality Assurance (WQA)			
Date	10 May 2014	Pages/Appendices	44
Supervisor(s) Mr. Pertti Kainulainen, Laboratory Engineer			
Client Organisation/Partners			

Abstract

The 7 Signal Sapphire Monitoring System provides the platform for comprehensive WLAN analysis that measures, monitors and manages network performance in an organisation or a certain environment. It is capable of monitoring all kinds of on-going activities within the network such as video streaming, voice over IP (VoIP) and data speed quality.

The objective of this project was to carry out measurements of real connection quality for all the clients on the wireless network including their device-specific medical applications, web apps, video or VoIP. The test was carried out to be able to identify, analyse and troubleshoot common WLAN problems.

The method that was used in monitoring the performance and network quality is based on the Wireless Quality Assurance (WQA). Devices deployed were Sapphire Eye for monitoring WLANs, a test server Sonar, an interactive test monitoring station and management tool Sapphire Carat and a reporting application Sapphire Loupe.

As a result of this project, it can be concluded that the WQA gives in-depth knowledge of different wireless network behaviour and their characteristics as well as a complete realization of WLAN usability, deployment, behaviour and monitoring both from the end user's perspective and the administrator's perspective.

Keywords

Wireless LAN, 7 Signal Sapphire System, Eye, Sonar, Carat, Loupe

Koulutusohjelma Informaatioteknologia
Tekija Ayodeji Olumuyiwa
Otsikko 7 signal Sapphire WLAN monitorointi järjestelmä

Päivämäärä	10 Toukokuu 2014	Sivumäärä	44

Ohjaaja Mr. Pertti Kainulainen, laboratorioinsinööri
Asiakas/organisaatio

Tiivistelmä

7 Signal Sapphire – monitorointijärjestelmä tarjoaa alustan perusteelliselle WLAN-analyysille, joka mittaa, monitoroi ja hallitsee verkon esiintymistä organisaatioissa tai tietyssä ympäristössä. Se pystyy valvomaan kaikenlaisia meneillään olevia verkon toimintoja, kuten videostreamingiä, voice over IP (VoIP) ja tiedonnopeuden laatua.

Opinnäytyön tarkoituksena on toteuttaa todellisen yhteyden laadunmittaukset kaikille langattoman verkon asiakkaille, sisältäen myös heidän käyttämänsä laitekohtaiset lääketieteelliset sovellukset, web- sovellukset, videot ja VoIP. Testin tarkoituksena on pystyä tunnistamaan, analysoimaan ja ratkaisemaan yleisiä WLAN- verkon ongelmia.

Projektissa käytettävä esiintymisen monitorointi ja verkon laadun menetelmän perusteena on Wireless Quality Assurance (WQA). Käytettäviä laitteita ovat Sapphire Eye WLAN-yhteyksien monitorointiin, testipalvelin Sonar, interaktiivinen monitorointiasema ja hallintatyökalu Sapphire Carat sekä raportointisovellus Sapphire Loupe.

WQA antaa syvällisen tietämyksen erilaisisten langattomien verkkojen käyttäytymisestä ja niiden ominaisuuksista sekä laajan ymmärryksen WLAN:in käytettävyydestä, käyttöönotosta, käyttäytymsestä ja monitoroinnista niin käyttäjän kuin ylläpitäjänkin näkökulmasta.

Avainsanoja
Wireless LAN, 7 Signal Sapphire System, Eye, Sonar, Carat, Loupe

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APPENDICES

Acknowledgements

My profound gratitude goes to the Almighty God for giving me the privilege to complete this project.

Special thanks to administration of Savonia University of Applied Sciences, Kuopio Finland for the opportunity bestowed on me to study in their reputable institution and the members of staff of the department of Information Technology.

I wish to express my special appreciation to the course coordinator of my department, Mr. Arto Toppinen, for his patient guidance and support throughout my study time at Savonia and also my project supervisor, Mr. Pertti Kainulainen, for his relentless support and guidance throughout the course of my project.

I am highly indebted to my mother Mrs. F.I. Olumuyiwa (JP), my brother Babajide Olumuyiwa and every member of the family for their undying love, prayers, inspirations and encouragements towards me throughout my study.

Many thanks to my friends; Paul Adeola, Olufemi Ekundayo, Olusola Adekoya and to those who I have not been able to mention their names here, I really appreciate your friendship and support towards me.

Finally, I wish to sincerely appreciate everybody who has supported me in any way during the course of my study.

1 INTRODUCTION

In recent times, the evolution of the Internet has made activities and things easier, making things get done faster than ever before. Nowadays, it is rare day-to-day activities are done without the use of the internet and without it some businesses or organizations cannot survive.

Talking about the Internet now, it is impossible to do without the technology behind it which makes it work and also allow users from different locations to access the same information on the server at the same time. This technology includes the routing and networking protocol aspect of it, which is briefly explained in this part as this project is dependent on it.

The Local Area Network (LAN) is a computer network which allows multiple users to interconnect to the same network using a coaxial cable. This kind of connection is limited to a restricted area in the network environment due to the cable connectivity. But, because of the restrictions and not being able to access the same network from a farther location, researchers were able to discover networks could be connected wirelessly which brought about the Wireless Local Area Network (WLAN).

Wireless Local Area Network (WLAN) is a wireless connection to the network between multiple computers through a radio signal or even infrared instead of the convectional cabling system like the LAN connection. This WLAN is widely used in different establishments as it has been able to satisfy our network connectivity needs beyond our limitations. With continuous research, the advent WLAN has made it possible for researchers to be able to come up with 7 Signal Sapphire Wireless Quality Assurance (WQA) which this project is focused on.

2 TYPES OF WIRELESS CONNECTIONS

There are different types of wireless connections that enable people to connect or communicate with different servers to access applications or information. The type of wireless connection we deploy depends on the motive and distance. Mainly, there are four known and widely used wireless connections.

2.1 Wireless Local Area Network (WLAN)

WLAN allows users in local area, such as campuses or libraries to form a network or gain access to the internet. A temporary network can also be formed by a small number of users without the need of the access point; provided they do not need access to the network resources. (Computer Networking Notes, 2010).

2.2 Wireless Personal Area Network (WPAN)

Basically, the two main technologies behind wireless personal area network are Infra-Red (IR) and Bluetooth (IEEE 802.15). These allow the connectivity of personal devices within an area of about 30 feet. However, IR requires a direct line of site and the range is less. (Computer Networking Notes, 2010).

2.3 Wireless Metropolitan Area Network (WMAN)

Wireless metropolitan area network allows the connection of multiple networks in a metropolitan area such as different buildings in a city, which can be an alternative or a backup to laying copper or fiber cabling. (Computer Networking Notes, 2010).

2.4 Wireless Wide Area Network (WWAN)

Wireless wide area networks are types of networks that can be maintained over large areas, such as cities or countries, via multiple satellite systems or antenna sites looks after by an ISP. These types of systems are referred to as 2G (2^{nd} Generation) systems. (Computer Networking Notes, 2010).

2.5 Comparison of Wireless Network Types

Table 1 shows the comparisons between all the available wireless network types.

TABLE 1. Network Comparison (Computer Networking Notes, 2010).

Type	Coverage	Performance	Standards	Applications
Wireless PAN	Within reach of a person	Moderate	Wireless PAN Within reach of a person Moderate Bluetooth, IEEE 802.15, and IrDa Cable replacement for peripherals	Cable replacement for peripherals
Wireless LAN	Within a building or campus	High	IEEE 802.11, Wi-Fi, and HiperLAN	Mobile extension of wired networks
Wireless MAN	Within a city	High	Proprietary, IEEE 802.16, and WIMAX	Fixed wireless between homes and businesses and the Internet
Wireless WAN	Worldwide	Low	CDPD and Cellular 2G, 2.5G, and 3G	Mobile access to the Internet from outdoor areas

2.6 Wireless Local Area Network (WLAN) Standards 802.11 Wi-Fi

This is a group of specifications for wireless local area networks (WLANs) that was developed by a team in the Institute of Electrical and Electronics Engineers (IEEE). (University of Glasgow IT Services, 2014). The family currently has six over-the-air modulation techniques that use the same layer 2 protocols and the popular and prolific ones are the ones defined by the a, b and g amendments to the original standard; security was initially included and then later enhanced through the 802.11i amendments while other standards of the family like c-f, h-j and n are service enhancements and extensions, or corrections to the previous specifications. (IEEE.org, 2014).

Wi-Fi—A wireless Ethernet network, Wi-Fi uses a wireless access point to connect mobile devices, such as laptops or handheld devices, to a local area network (LAN). These wireless access points or “hotspots” are commonly used in homes, coffee shops, airports and other public places to share an Internet connection. (HP Wireless Networking Glossary, 2011).

2.6.1 802.11

The original version of the standard specifies two raw data rates of 1 and 2 megabits per second (Mbit/s) transmitted via infrared (IR) signals or in the Industrial Scientific Medical (ISM) frequency band of 2.4 GHz. It uses Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) as the media access similar to Ethernet protocol. (IEEE.org).

2.6.2 802.11b

The IEEE amendment to the original standard has the maximum raw data rate of 11 Mbit/s and uses the same Ethernet based signaling protocol. But due to the CSMA/CA protocol overheads, the maximum 802.11bt throughput an application can achieve is approximately 5.9 Mbit/s over TCP and 7.1 Mbit/s over UDP. It also operates in the unprotected 2.4 GHz frequency band with an 83.5MHz wide channel. (IEEE.org).

2.6.3 802.11a

The IEE amendment to the original standard uses the same core protocol as the original standard, it operates in 5GHz frequency band and uses 52-subscriber OFDM (Orthogonal Frequency Division Multiplexing) with a maximum raw data rate of 54 Mbit/s which gives an approximate throughput of about 24 Mbit/s. This is not directly interoperable with 802.11b. It has a frequency band of 2.4 GHz which is commonly used by many users and appliances, so changing to 5 GHz band gives 802.11a the advantage of less interference. (IEEE.org).

2.6.4 802.11g

The third modulation standard also uses 2.4 GHz band with 83.5MHz just as 802.11b wide channel which operates at a maximum raw data rate of 54 Mbit/s or about

24.7Mbit/s throughput like 802.11a allowing it to be fully backwards compatible with 802.11b and uses the same frequencies.

2.6.5 802.11n

In the quest for greater transmission speed, a high throughput standard 802.11n was launched and became the fourth IEE802.11 variant. This approximately quadruples WLAN throughput performance compared to IEEE 802.11a/g networks. Using a wider channel bandwidth with OFDM give significant edge in maximum performance. It has a maximum raw data rate of 300 Mbit/s at a channel width of 40 MHz and still capable of delivering up to 600 Mbit/s. (Intel Networking Devices and Standards).

3 SIGNAL SAPPHIRE WIRELESS QUALITY ASSURANCE

Due to the necessity of the wireless technologies in the day-to-day activities around the world and in many business organisations, the need to monitor the quality, track and keep log of the wireless signal for different purposes arise. It is very important to take note of the performance level, the strength and quality of the wireless networks being used and also to study how they work in order to be effective for their main objectives.

In this thesis, 7 Signal sapphire will be used to monitor all these aforementioned parameters as its purpose is mainly to monitor network efficiency and it will be used to scan and monitor all available networks in the Savonia UAS Technopolis Campus.
7 Signal Sapphire is a new and modern way to continuously and automatically monitor and measure the health and quality of wireless networks. The effectiveness of the 7 Signal sapphire has become a demanding part of companies and businesses for the performance and service quality of their wireless networks. It uses Sapphire Eye to monitor performance and quality in WLAN cells and to also monitor the surrounding radio frequency environment. The performance of the managed network is tested on a test server Sonar while the interactive tests, monitoring stations, and parameters for automatic measurement are managed with a centralized management tool Sapphire Carat and measurement results are taken from a reporting application Sapphire Loupe. The 7 Signal monitoring station, Sapphire Eye, constantly monitors the selected WLAN channels via passive listening, which does not interfere with the network performance or quality. During the network measurement results analysis, the monitoring solution can detect network performance and quality-of-service (QoS). It can also give a practical statistic on the predicted user experience of the network performance which enables the network expansion in advance before any loss of performance or limited connectivity issues. (7signal Sapphire Carat User Guide Release 3.1, 2012).

In the course of the active tests, the Sapphire Eye connects to the test server which is Sonar via the wireless network and works like the regular wireless service which may include wireless VoIP calls, browser downloads or file transfer connections to another production server. The active test can monitor the network even when there are no active users, locate problem areas in the network topology to allow easy troubleshooting. (7signal Sapphire Carat User Guide Release 3.1, 2012).

3.1 System Overview

The 7 Signal Sapphire Quality Monitoring System consists of the Sapphire Eye Monitoring Station, a Sonar test server, Sapphire Carat management software and the Sapphire Loupe for viewing and reporting of results. (7signal Sapphire Carat User Guide Release 3.1, 2012). Figure 1 shows 7 Signal system overview.

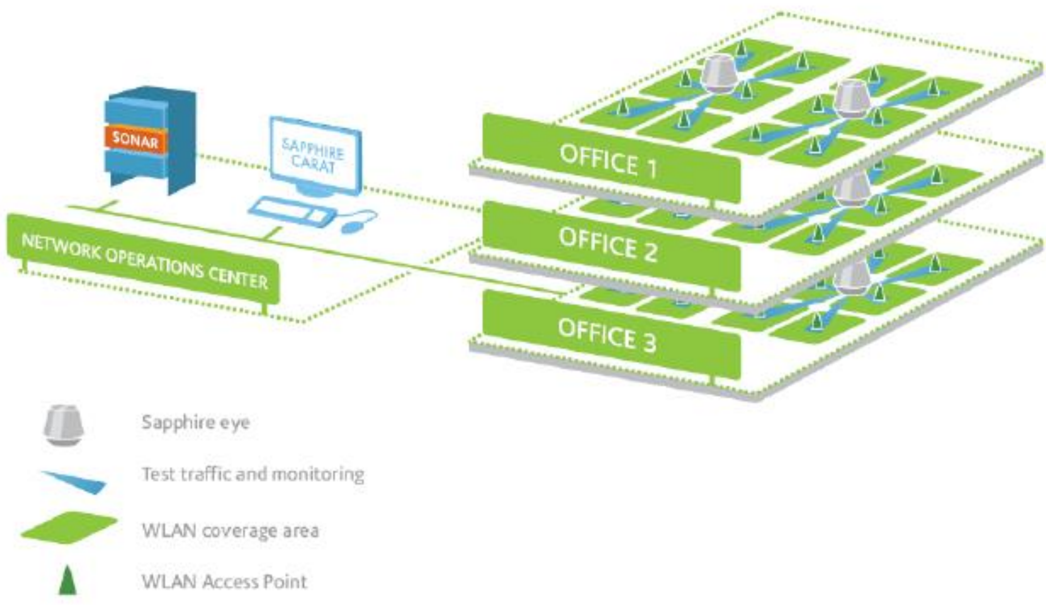

FIGURE 1. 7 Signal System Overview. (7signal Sapphire Carat User Guide Release 3.1, 2012)

3.2 7 Signal Monitoring System Keywords

Below are the monitoring system keywords

- Sapphire Eye
- Sapphire Carat
- Sonar
- Sapphire Loupe

3.3 Sapphire Eye

Sapphire Eye is a monitoring station for WLAN environments which uses advanced broadband antenna technology that creates a very large coverage area to monitor performance and quality in WLAN and the surrounding radio frequency environment.

It continuously monitors the selected or managed WLAN channels via passive listening to data traffic that uses the IEEE 802.11 protocol and a general analysis of the radio frequency spectrum in the coverage area that does not have any impact on network performance. (7signal Sapphire Carat User Guide Release 3.1, 2012).

3.4 Sapphire Carat

Sapphire Carat is a centralised management tool that allows the user to manage the Sapphire Eye monitoring stations, runs interactive and real-time measurements, configures and manages automatic measurements, and also generates the reports of the measurement results. It stores profiles used or previously used in the automatic testing of a monitored or managed network. (7signal Sapphire Carat User Guide Release 3.1, 2012).

3.5 Sonar

Sonar tests the performance of the network against the test server. The Sapphire Eye connects to Sonar to measure the Quality of Service (QoS), uplink and downlink provided by the network. (7signal Sapphire Carat User Guide Release 3.1, 2012).

3.6 Sapphire Loupe

Measurement results are reported via Sapphire Loupe which is the performance and Quality of Service (QoS) analysis tool in the Wireless Quality Assurance (WQA) solution. This cannot be used to control Sapphire’s functions and measurements only used for reporting. (7signal Sapphire Carat User Guide Release 3.1, 2012).

4 NETWORK TOPOLOGY

The Network Topology is a hierarchical tree that displays the Sapphire monitoring station in the setup and the access points in the network layout. Figure 2 shows the hierarchy tree display in this thesis consisting of five different categories for various monitoring purposes. For the purpose of this thesis, the network topology is descriptive based on the location namely; Organization, Savonia as the project, Q-building as the location, Deji bench as the service area and Eye deji as the monitoring eye.

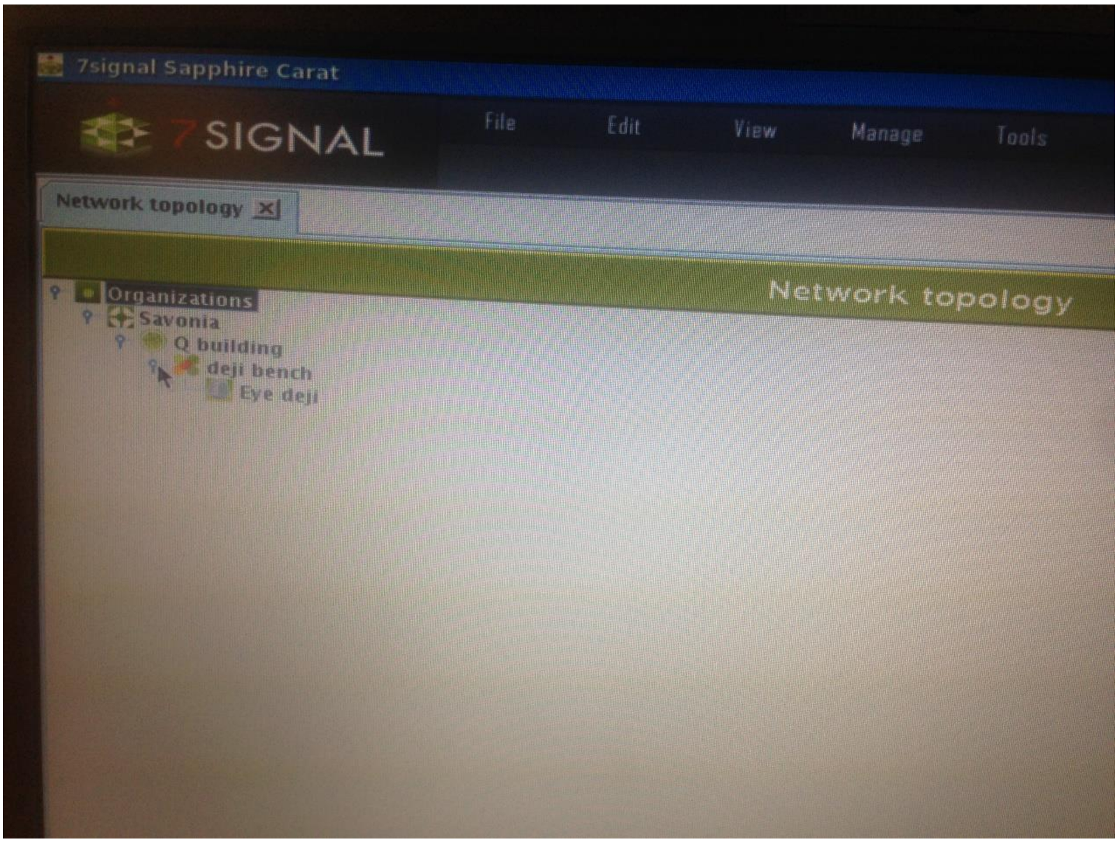

FIGURE 2. Network Topology (Olumuyiwa Ayodeji, 2014).

4.1 Wireless Network Scan

After the initial setup was done, a wireless network scan was carried out using the initial scan option to be able to scan all the available networks in the environment. The search was done using all the available 7 antenna headings in the system and selecting all frequency bands so as to be able to have a larger coverage area. In the scan option, there are different types of scan that can be done depending on the purpose of the scan, fast scan can also be done but will not give a larger coverage area as the initial scan. An initial scan is suitable for the first wireless network scan in a new network environment. Figure 3 shows the wireless network scan interface and Figure 4 shows all the available networks in the environment.

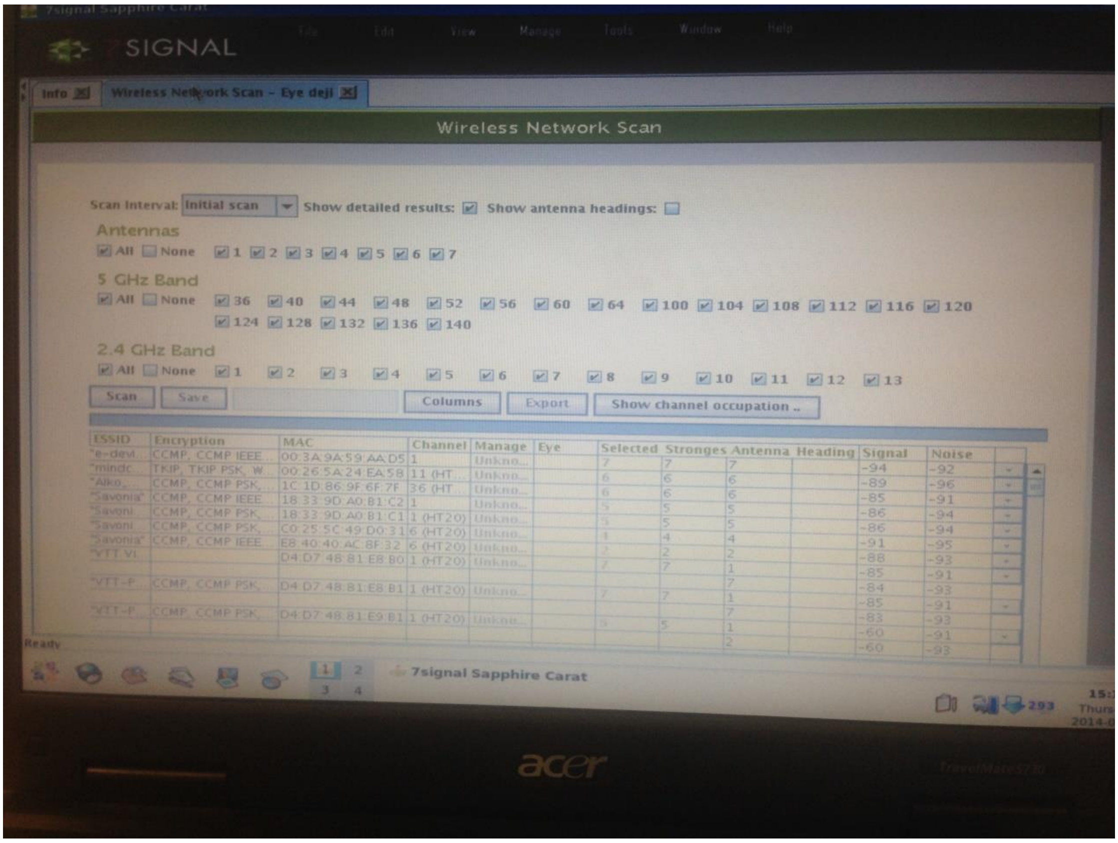

FIGURE 3. Initial Scan of Wireless Network (Olumuyiwa Ayodeji, 2014).

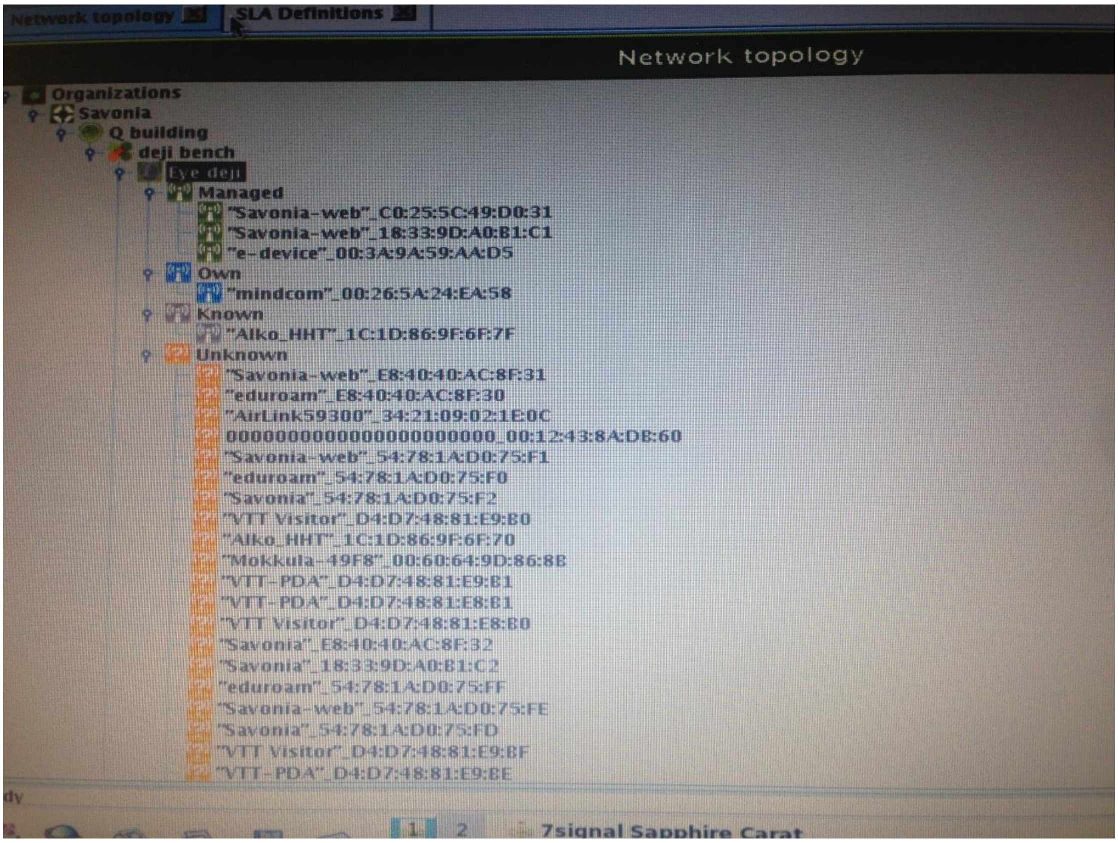

FIGURE 4. Initial Scan showing all available Networks (Olumuyiwa Ayodeji, 2014).

4.2 Channel Occupation

Channel Occupation shows the graphical representation of the available networks within the 2.4 GHz frequency band after the initial scan was done. Each network is represented with a unique color coding showing the signal strength and network quality with their transmission rate.

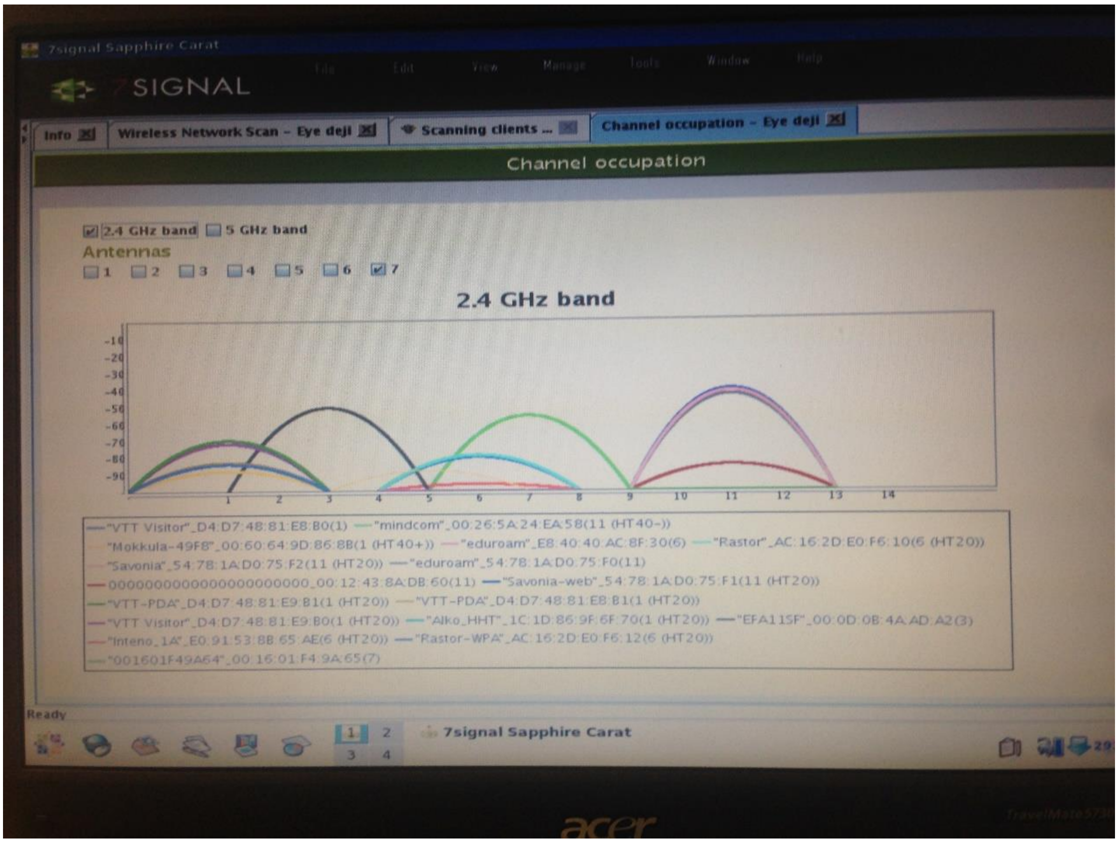

FIGURE 5. Graphical Representation of Initial Network Scan (Olumuyiwa Ayodeji, 2014).

4.3 Client Scan

In the network topology, client scan can be performed to view the performance of the client's network or manage the network. An extensive scan was carried out on a managed network as shown in Figure 6 which shows that Eye deji was able to scan it via antenna 1 with the signal strength to be -37dBm and noise level of -90dBM. Clients scan results also show the Mac address of the network and the access point, but for this scan, the result shows antenna 2 to be the strongest antenna to scan the managed network with the mac address of 04:F7:E4:53:39:50 and the access point of

54:78:1A:D0:75:FD on channel 52, which simply means it has a signal strength of -33dBM and a lower noise level of -91dBM.

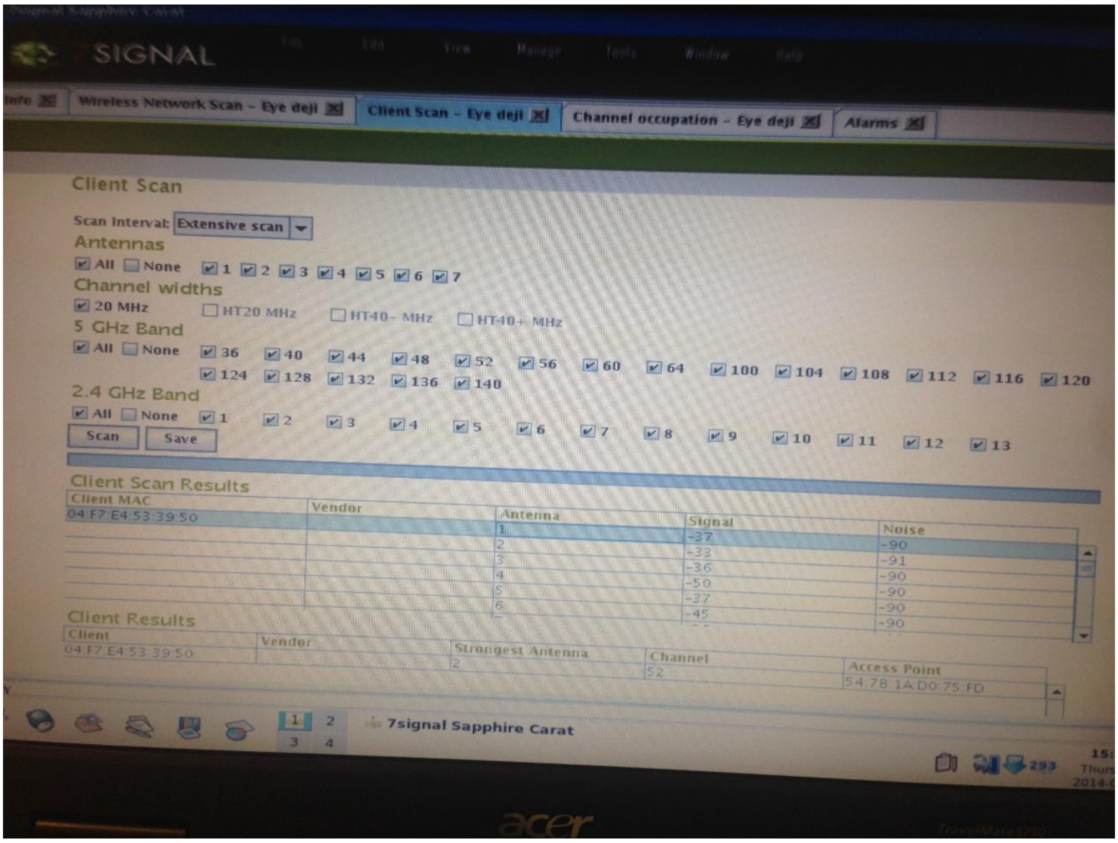

FIGURE 6. Client Scan Result using Extensive Scan Interval (Olumuyiwa Ayodeji, 2014).

4.4 Spectrum Analyser

The monitoring station also supports spectrum analyses which enables to monitor and analyse the signal strength of the frequency. The spectrum analyser results in Figure 7, show the result of spectrum analyses of antenna 1 with different frequency transmission rates and potencies. The timestamp shows the time log and date for each spectrum at different intervals while the WLAN channels indicates the frequency transmission rates ranging from 2400 MHz -2442 MHz with different colour coding (orange-Black) from -35 dBm to -1010dBm. The spectrum analyser is capable of displaying all the spectrum results of the 7 antennas.

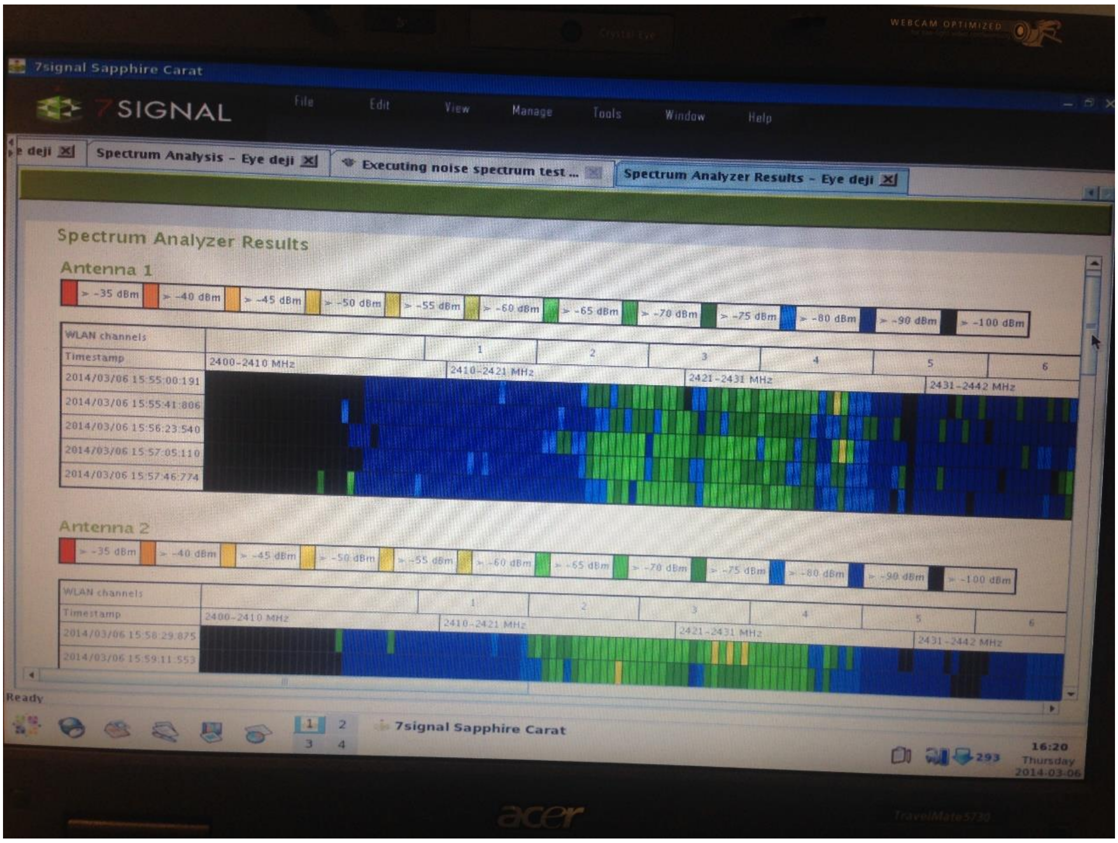

FIGURE 7. Spectrum Analyser Results (Olumuyiwa Ayodeji, 2014).

4.5 Noise Monitor

Noise monitor allows to monitor the noise around the monitoring station. In this thesis, Eye deji was used to monitor the noise level surrounding the monitoring station. Figures 8 and 9 show results and graphical representation on antenna 1 respectively. Graphical representation of antenna 1, Figure 9 indicates the noise level is minimal ranging from -90dBm to -100dBm. The blue colour indicates the maximum noise level while the red indicates average noise level which is not present in this graph.

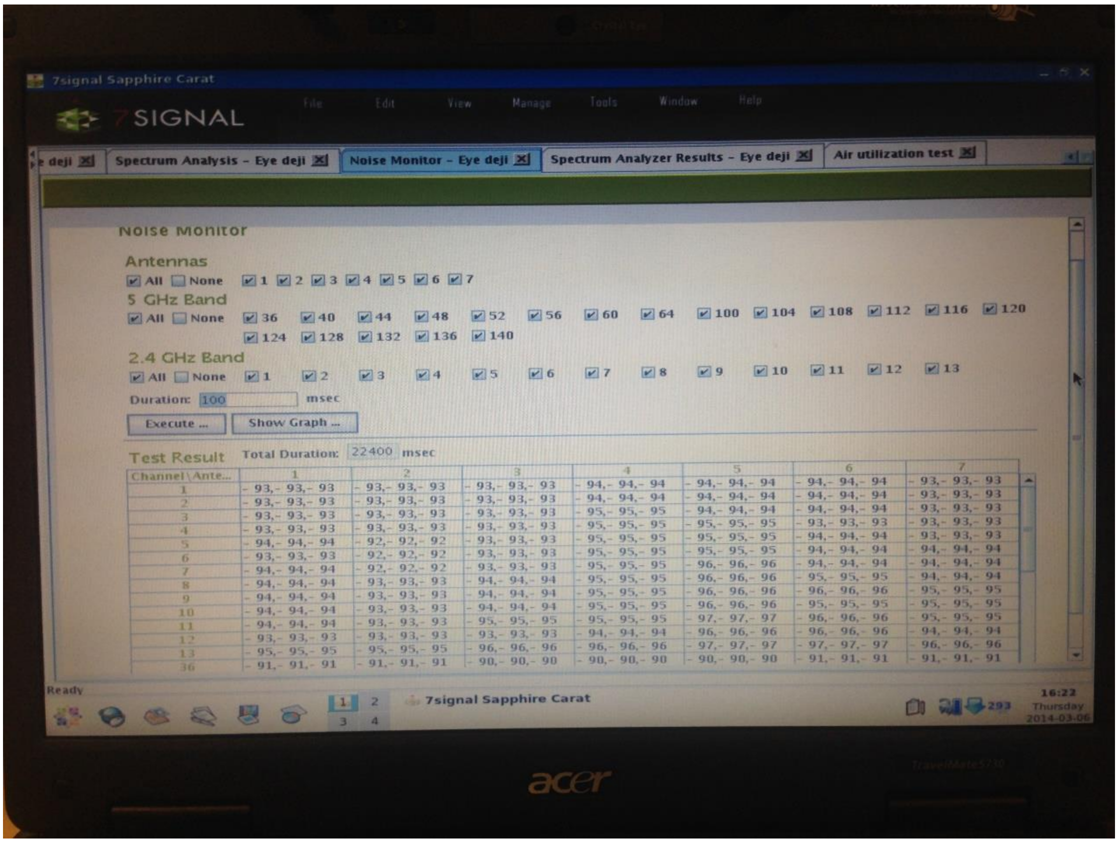

FIGURE 8. Noise Monitor Result (Olumuyiwa Ayodeji, 2014).

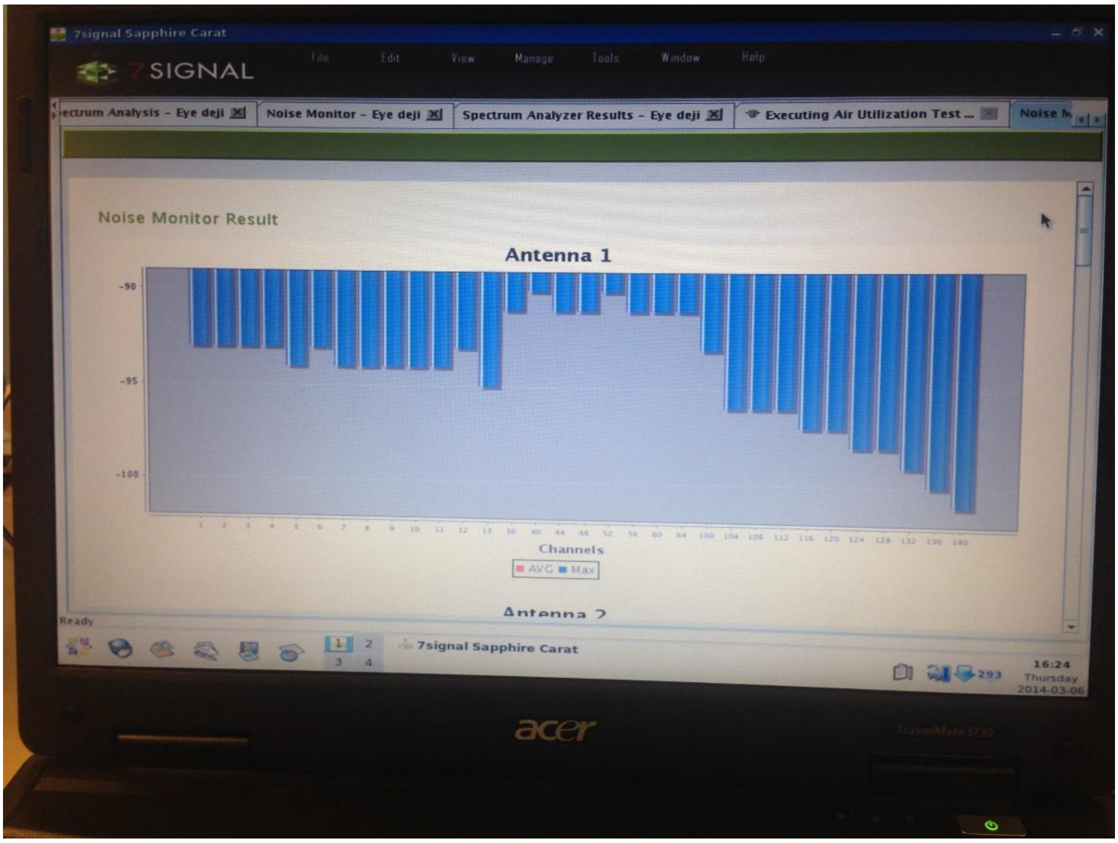

FIGURE 9. Graphical Representation of Noise Monitor Result on Antenna 1 (Olumuyiwa Ayodeji, 2014).

4.6 Air Utilization Test

Air utilization test is used to monitor and capture spectrum heavy users such as extensive use of legacy codec – in the WLAN network. (7signal Sapphire Carat User Guide Release 3.1, 2012).

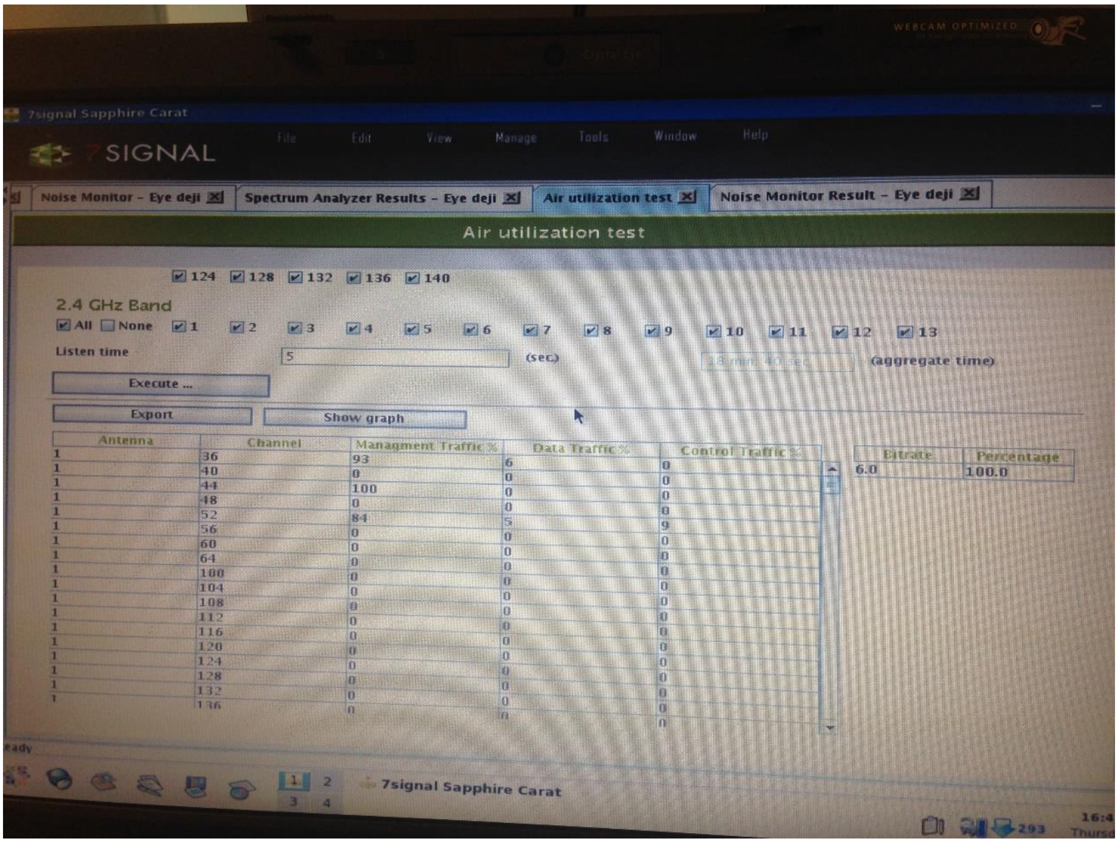

FIGURE 10. Air Utilization Test (Olumuyiwa Ayodeji, 2014).

Figure 11 is the pie-chart view of the air utilization results which shows the frame type distribution on the left and codec distribution on the right.

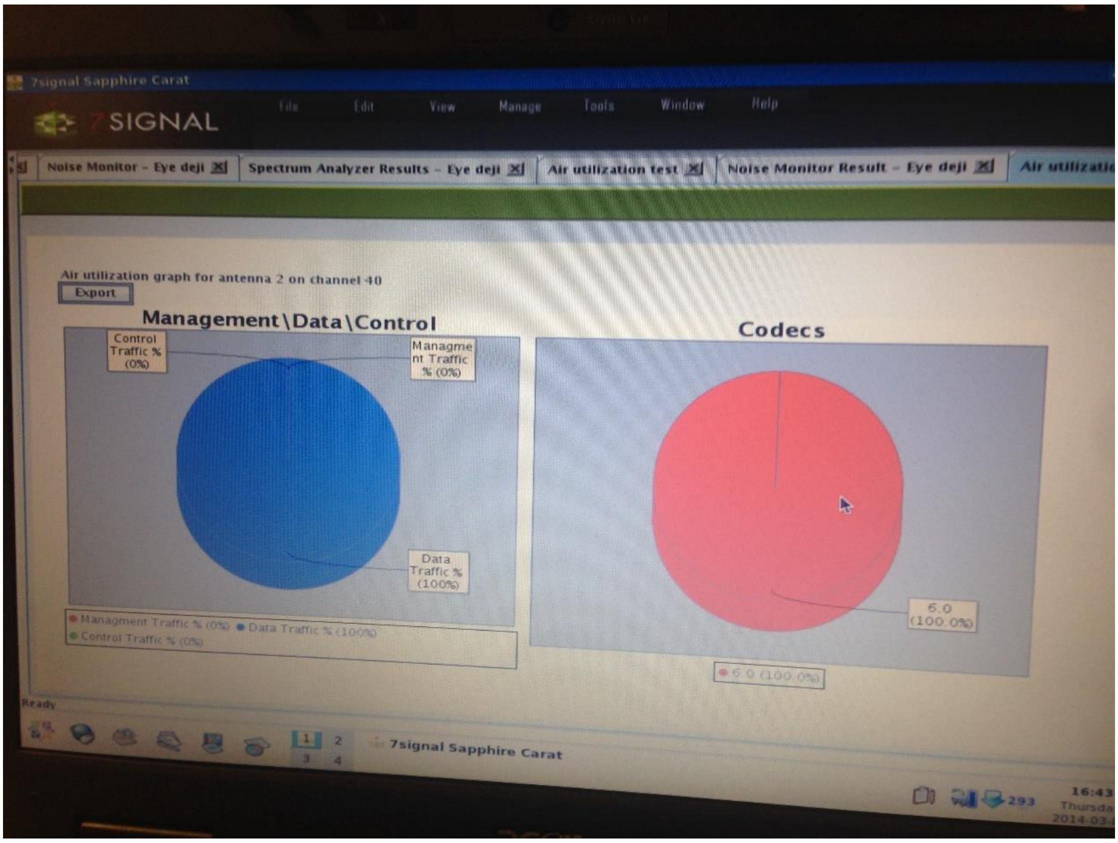

FIGURE 11. Air Utilization Graph for Antenna 2 on Channel 40 (Olumuyiwa Ayodeji, 2014).

4.7 Optimal Antenna Selection

The optimal antenna selection test is used to verify the suitability of the selected antenna. Due to reflections, the network scan can show similar results for different antennas. However, during transmission of data to an access point, the differences between antennas become significant. This test is worth running if more than one antenna shows similar results. (7signal Sapphire Carat User Guide Release 3.1, 2012).

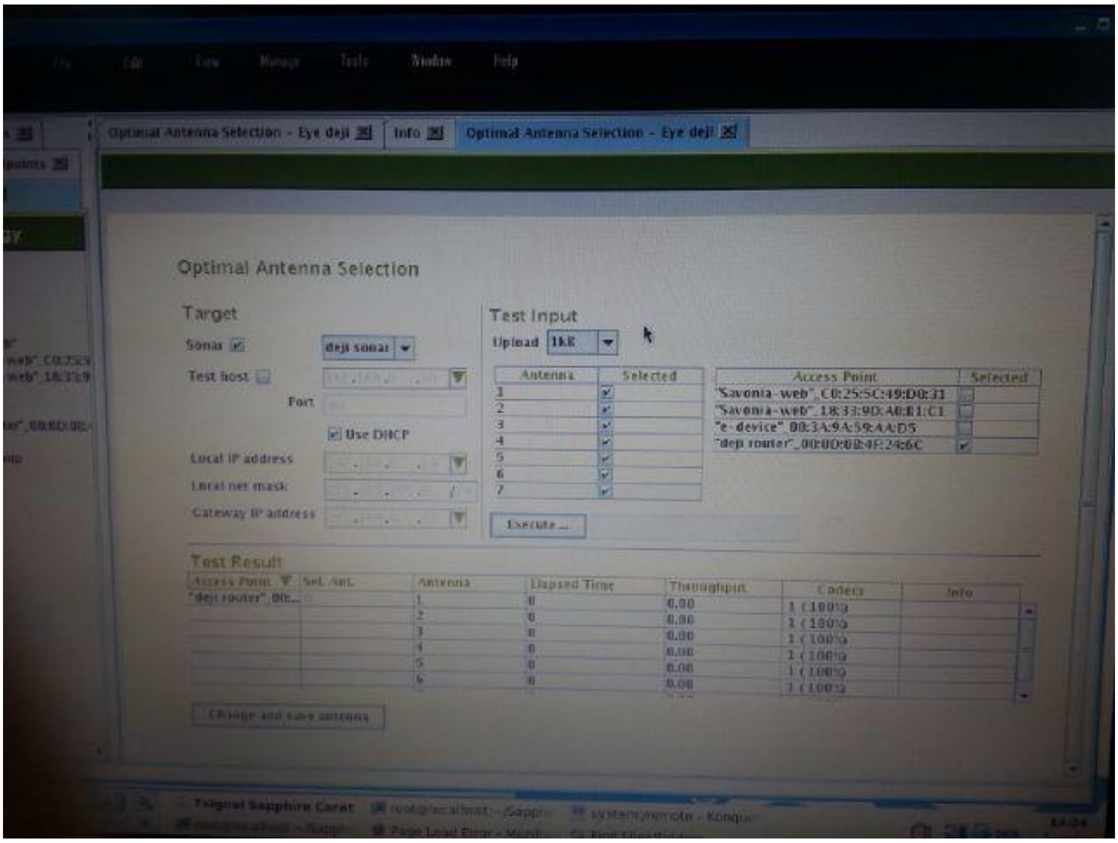

FIGURE 12. Optimal Antenna Selection (Olumuyiwa Ayodeji, 2014).

4.8 FTP Download Test

The FTP download test gives an indication of an access point's FTP or UDP downlink capacity. (7signal Sapphire Carat User Guide Release 3.1). In the project, the download test was run on the monitoring station using the Sonar to view the downlinks in a tabular form which shows the time from 549ms to 747ms, throughput from 14.57Mbps to 10Mbps and traffic category as BestEffort (0).

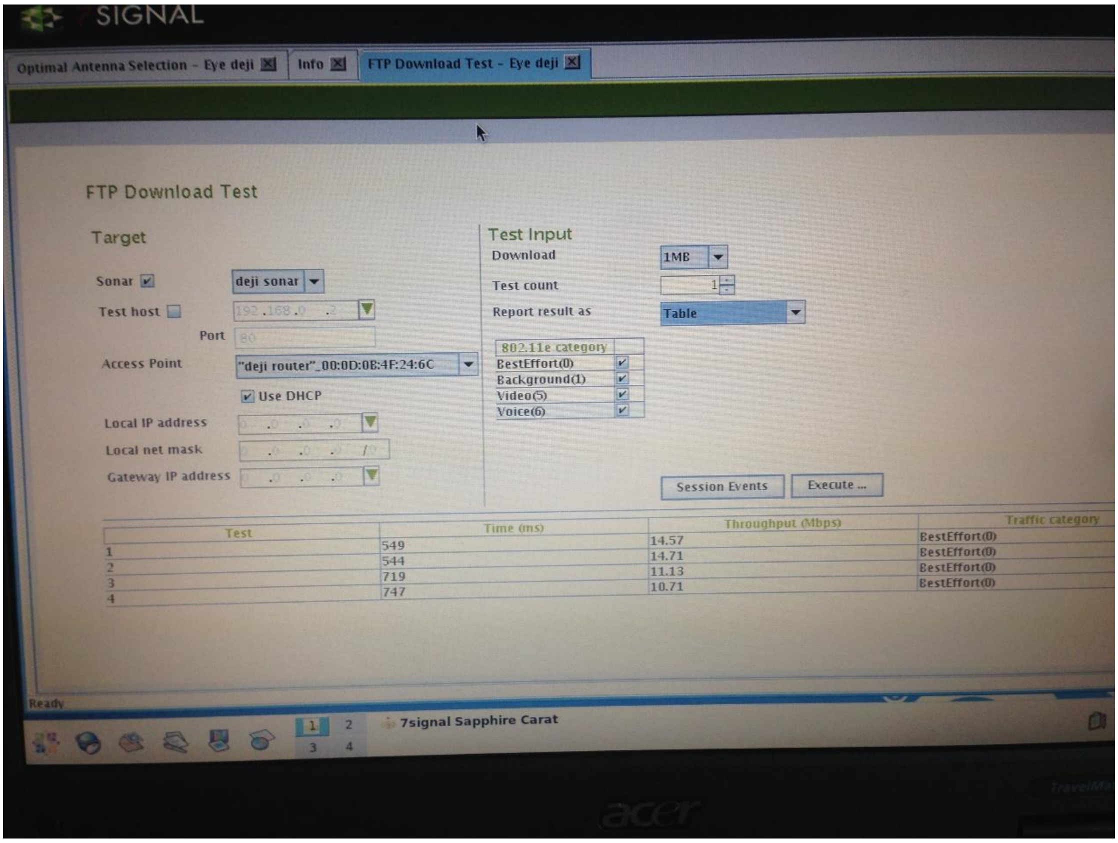

FIGURE 13. FTP Download Test (Olumuyiwa Ayodeji, 2014).

Figure 14 and 15 show the graphical throughput and time view of the download test respectively.

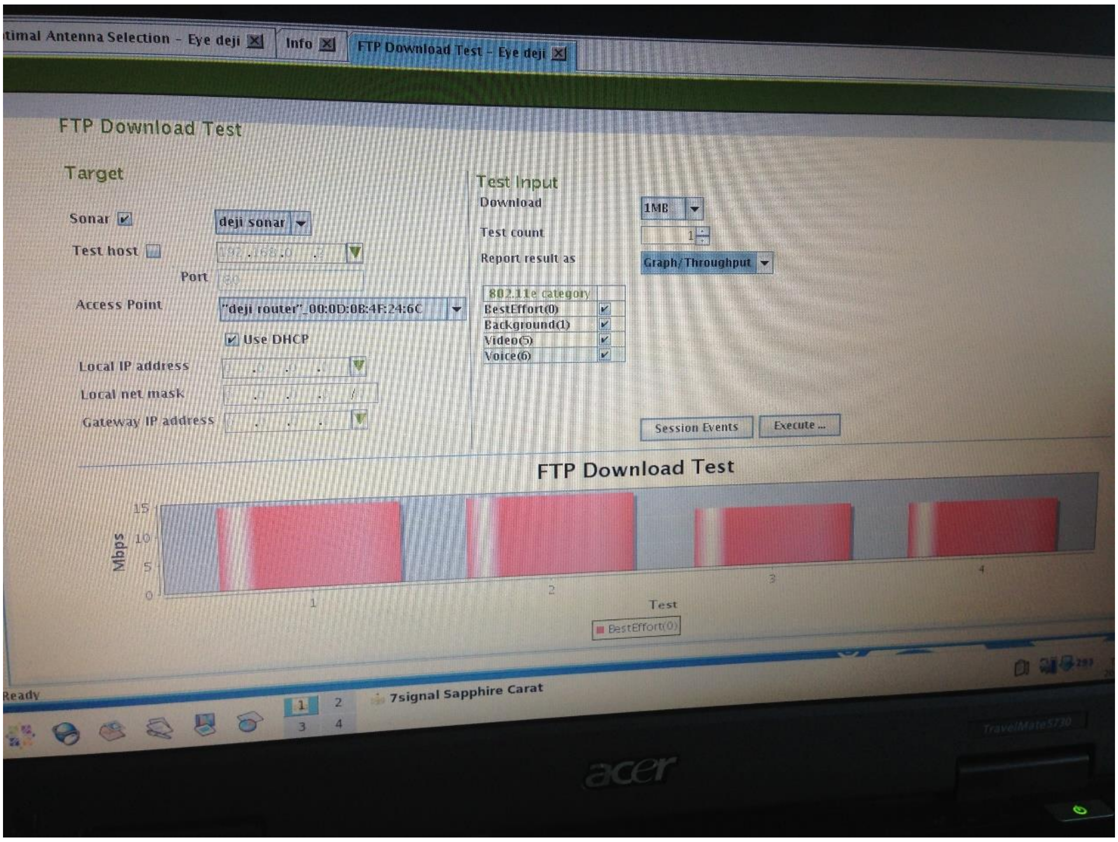

FIGURE 14. FTP Download Test Graph / Throughput (Olumuyiwa Ayodeji, 2014).

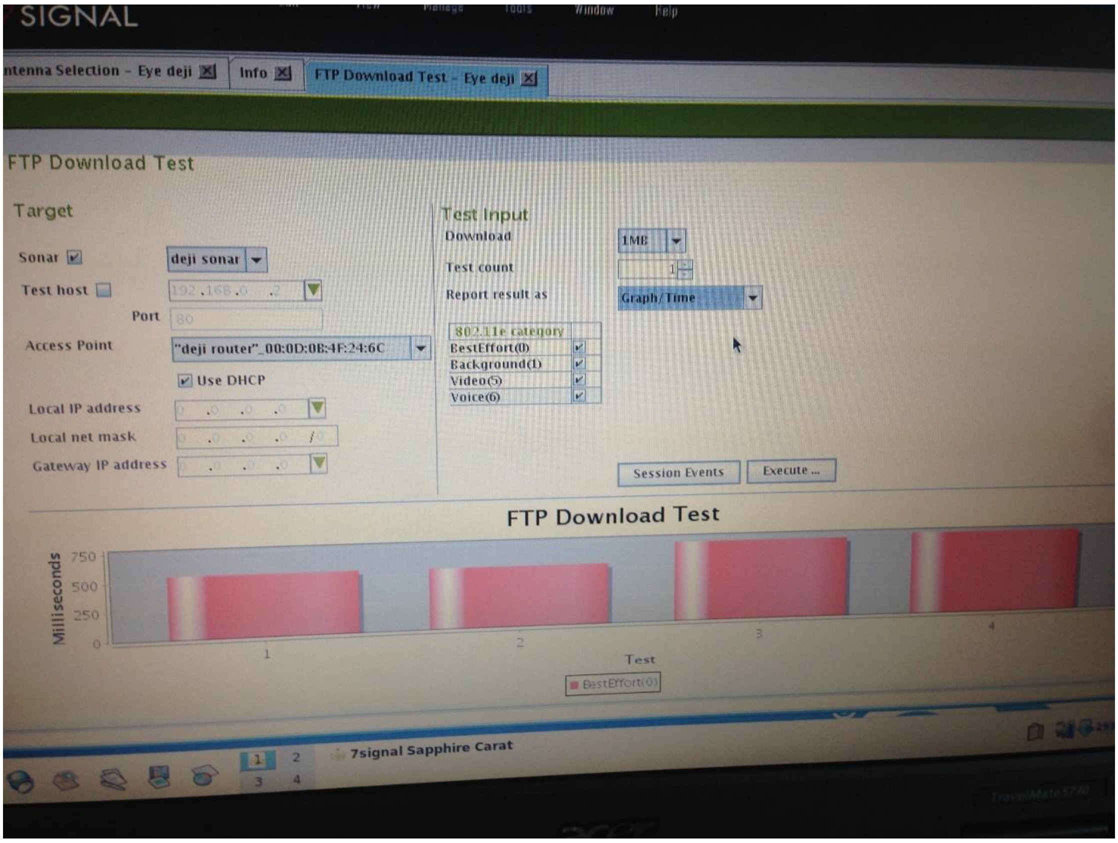

FIGURE 15. FTP download Test Graph / Time (Olumuyiwa Ayodeji, 2014).

4.9 FTP Upload Test

FTP upload test gives an indication of an access point's FTP uplink capacity. (7signal Sapphire Carat User Guide Release 3.1, 2012). In the project, the upload test was also run on the monitoring station using the Sonar to view the uplinks in a tabular form which shows the time from 611ms to 1164ms, throughput from 13.09Mbps to 6.87Mbps and traffic category as BestEffort (0).

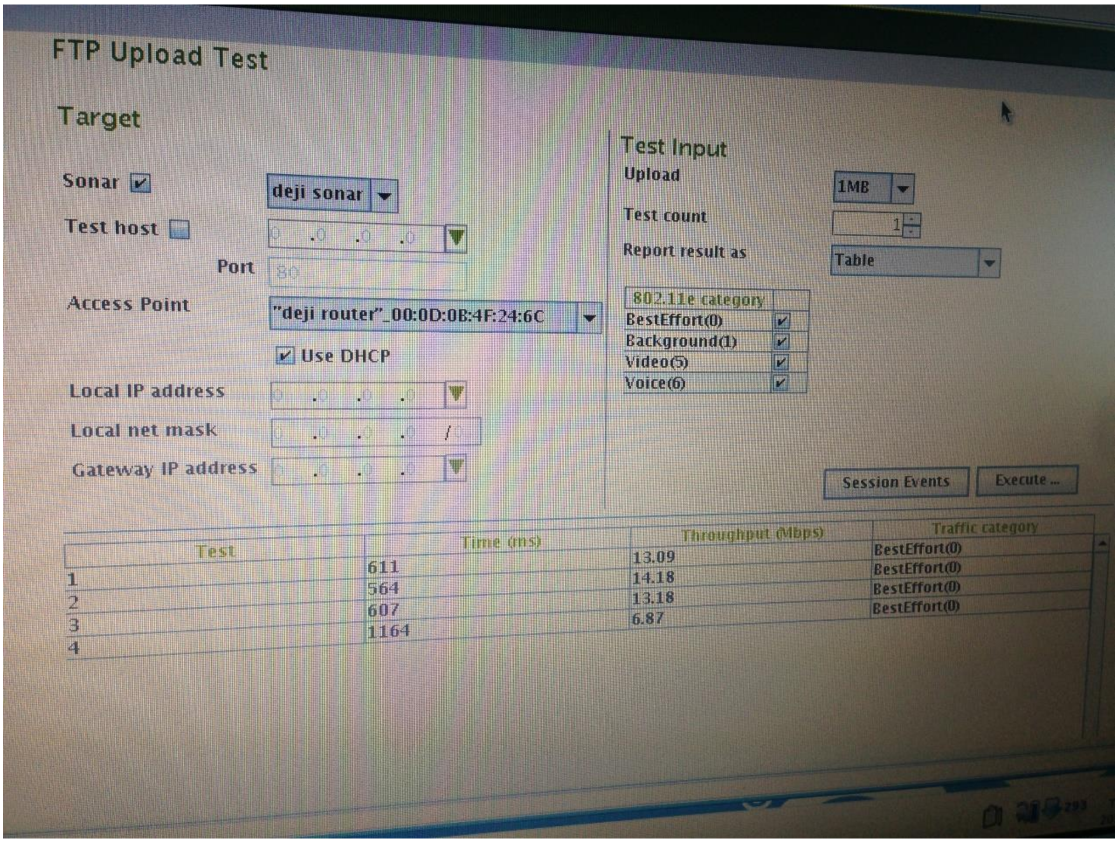

FIGURE 16. FTP Upload Test (Olumuyiwa Ayodeji, 2014).

Figure 17 and 18 show the graphical throughput and time view of the download test respectively.

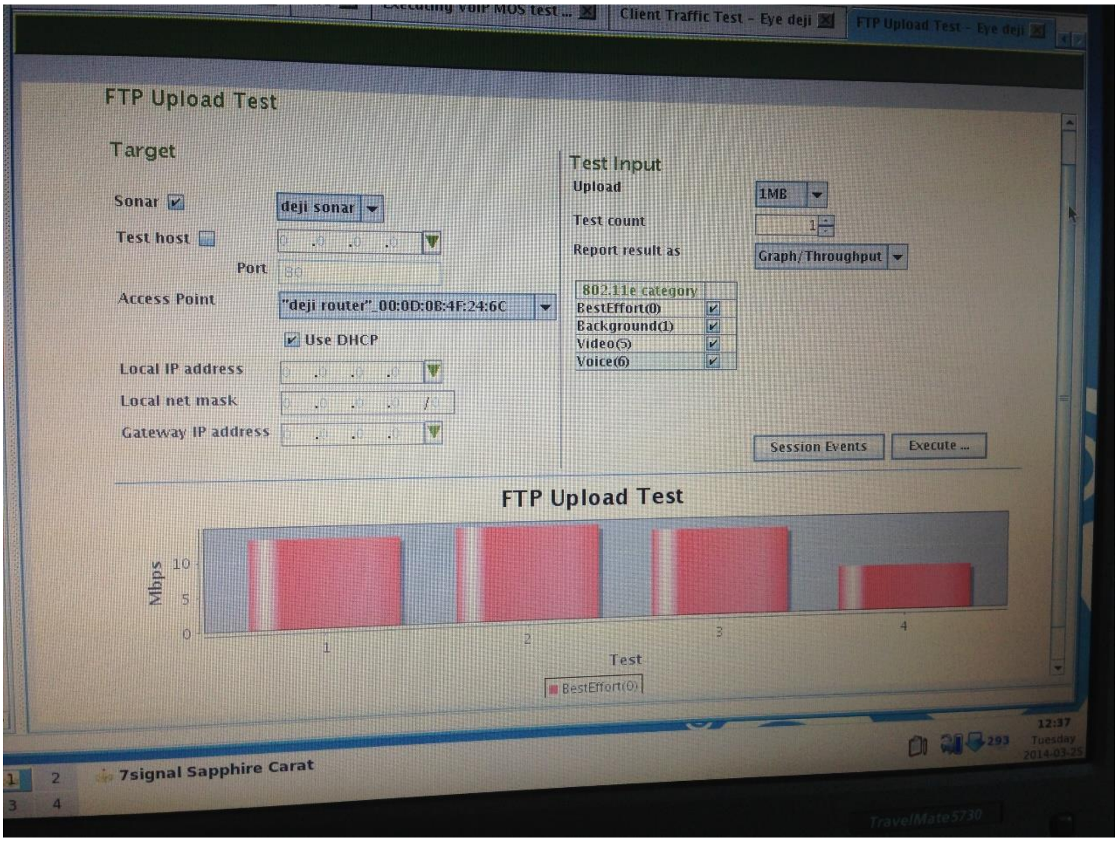

FIGURE 17. FTP Upload Test Graph / Throughput (Olumuyiwa Ayodeji, 2014).

FIGURE 18. FTP Upload Test Graph / Time (Olumuyiwa Ayodeji, 2014).

4.10 Ping Test

Ping test indicates the accessibility of a device, when the ping test is run on the monitoring station using the Sonar, it sends a request in packets to the device and receives a response in packets and latency time. This means the device is reachable and functioning well. Figure 19, shows the result of a ping test carried out on Eye deji during the project and the result table shows the test time to be between 1ms and 3ms and category to be BestEffort (0). It also shows the attach time to be 2173ms, the IP retriever time to be 5080ms and IP address of the device 192.168.0.9 with gateway address not available. Figure 20, shows the graphical representation of the ping test. Indicating the usage activities on the device with different colours, BestEffort represented by red, Background –blue, Video –green and Voice –yellow.

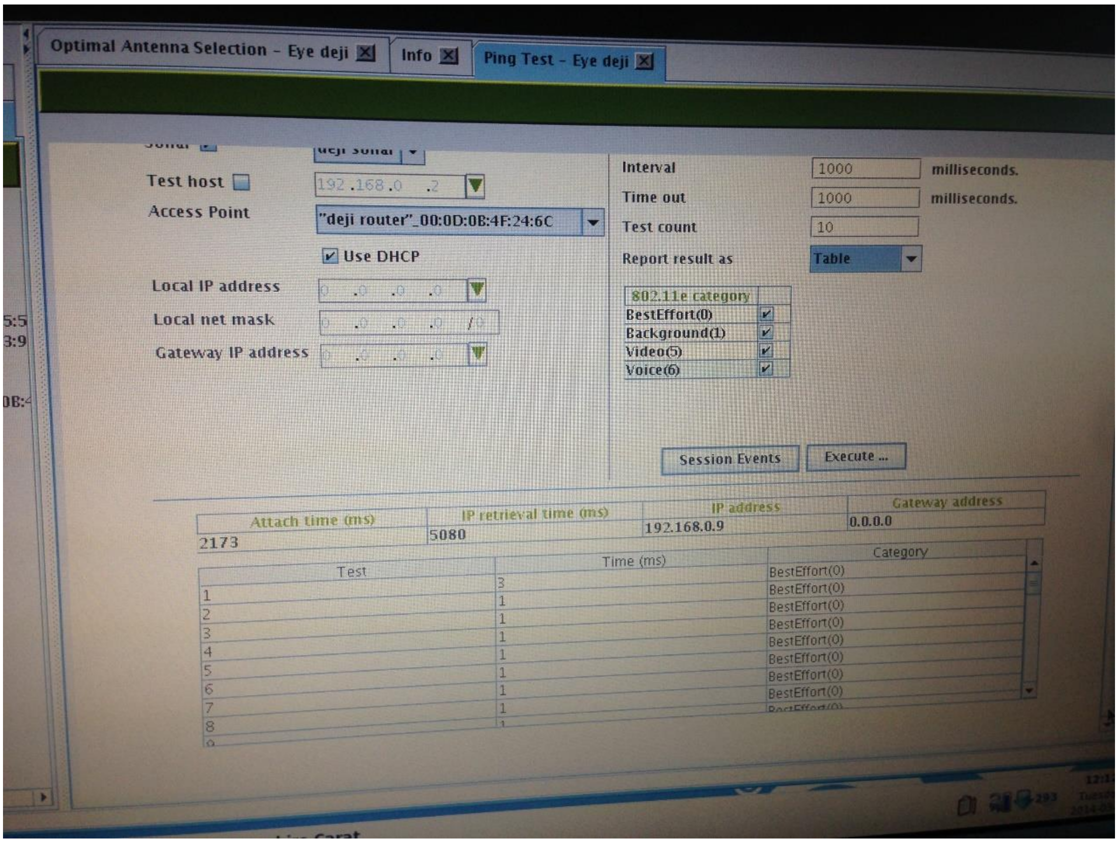

FIGURE 19. Ping Test Table (Olumuyiwa Ayodeji, 2014).

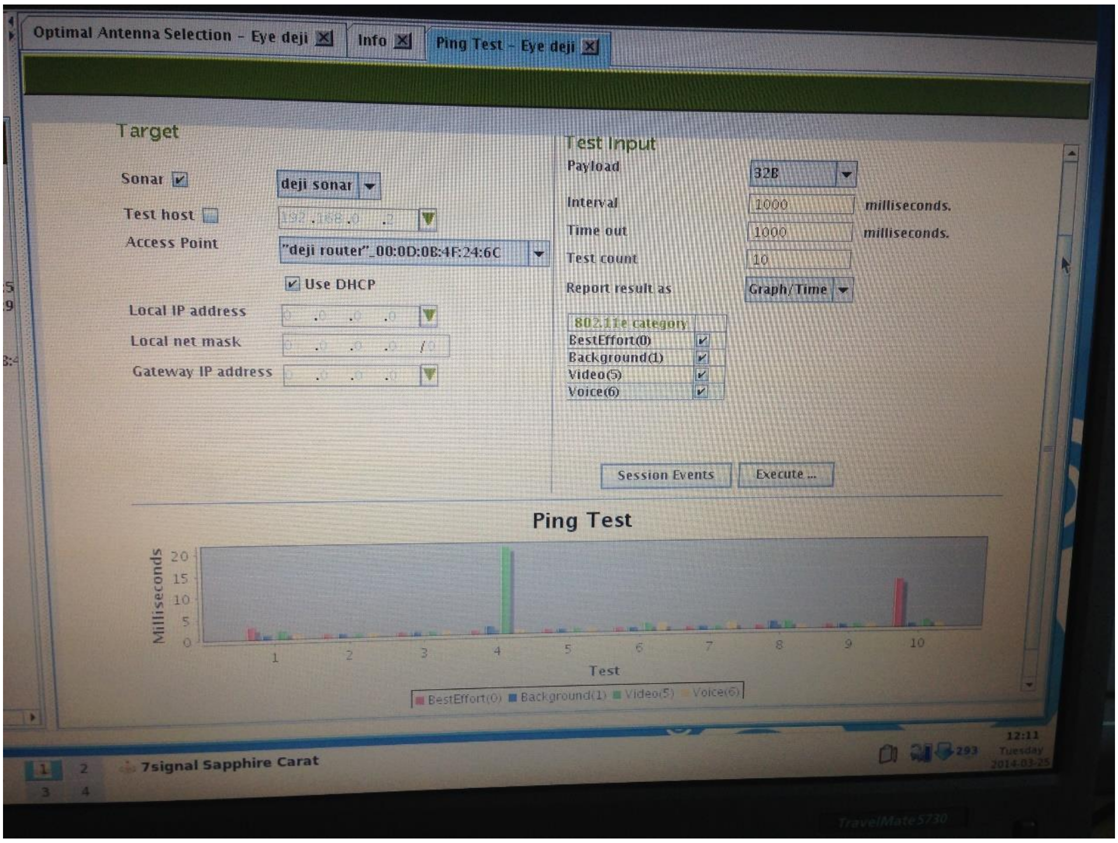

FIGURE 20. Ping Test Graph / Time (Olumuyiwa Ayodeji, 2014).

4.11 Traceroute Test

The traceroute test is used to check and identify routing problems, firewall that maybe blocking the access to the host and also help to perform network troubleshooting so as to resolve any network issues easily. (7signal Sapphire Carat User Guide Release 3.1, 2012).

Figure 21 is the result of the traceroute test performed on the monitoring station during the project, showing all network parameters needed for troubleshooting.

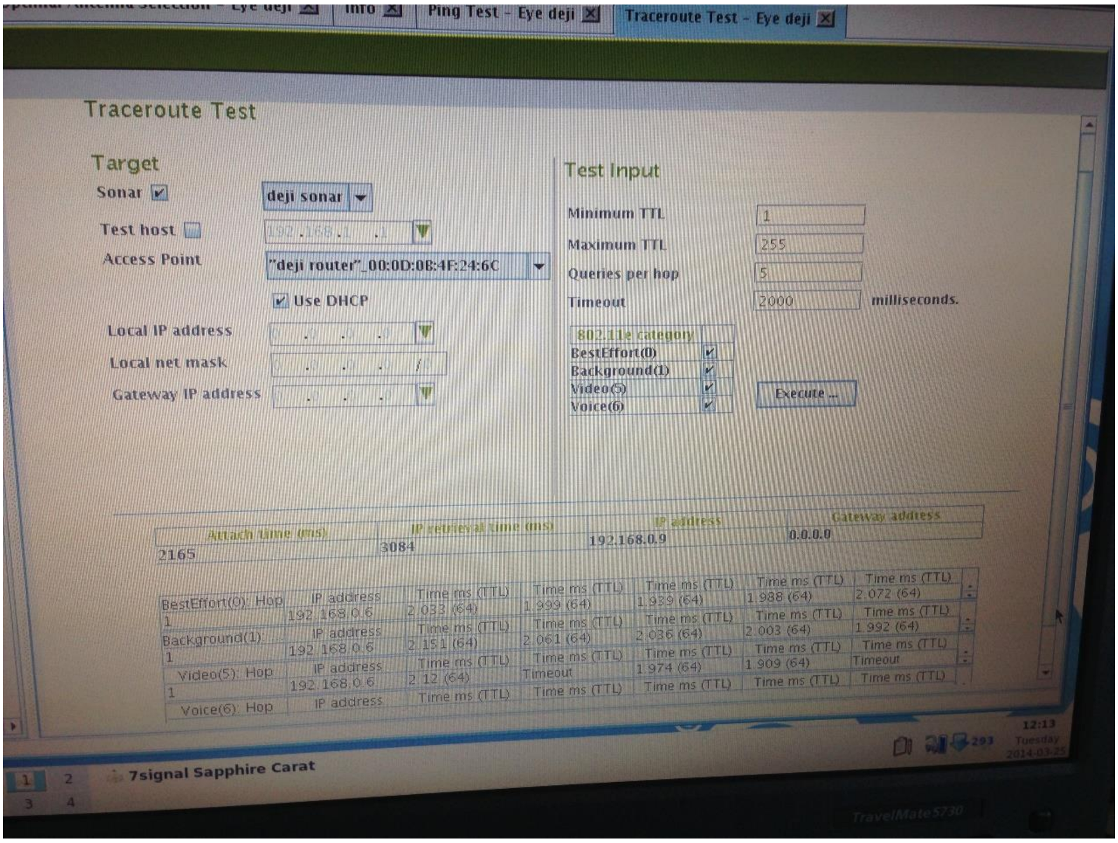

FIGURE 21. Traceroute Test Result (Olumuyiwa Ayodeji, 2014).

4.12 Access Point Traffic Test

The access point traffic test listens to radio traffic in the Sapphire Eye’s coverage area and also gathers different kinds of information. (7signal Sapphire Carat User Guide Release 3.1, 2012). As shown in Figure 22, the preferred access point ‘deji router’ was selected in the purpose of this project to be able to listen to the radio traffic if the monitored areas and the result is seen as displayed.

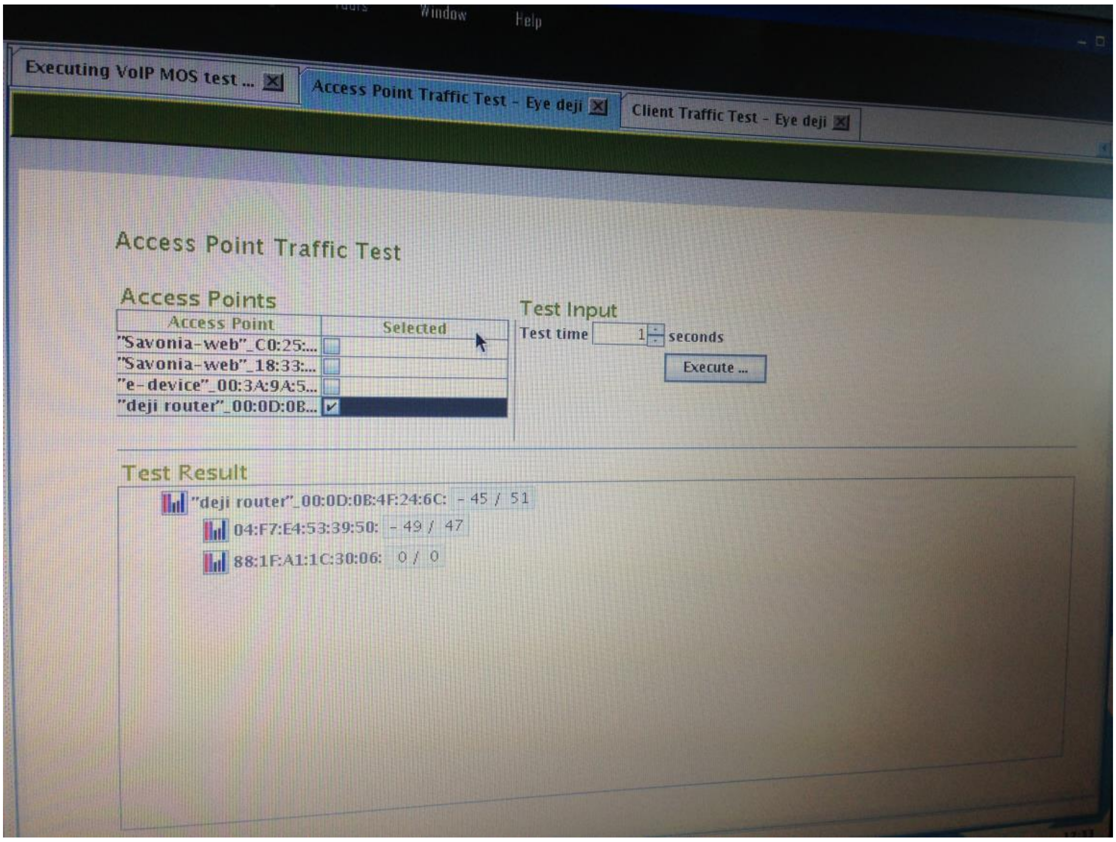

FIGURE 22. Access Point Traffic Result (Olumuyiwa Ayodeji, 2014).

4.13 MOS Test

MOS is used to create a VoIP call between the Sapphire Eye and Sonar. Both the uplink and downlink call quality can be measured. (7signal Sapphire Carat User Guide Release 3.1, 2012). Before the test, the access point was selected and the report result as 'graph' to be able to get a graphical view and analyses of the result. Figure 23 shows the VoIP MOS test result in tabular form. This gives a clear analyses of the test parameters and the radio signal characteristics, codecs and the BestEffort (0) MOS result.

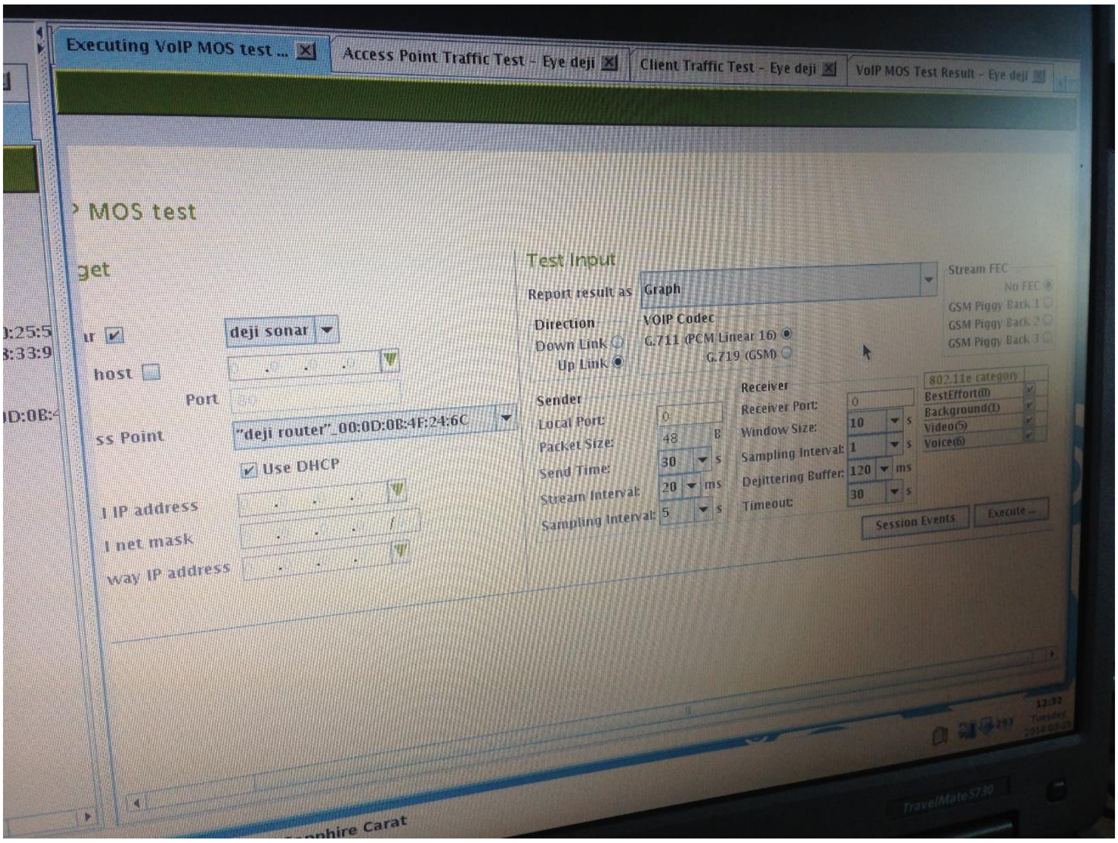

FIGURE 23. MOS Test (Olumuyiwa Ayodeji, 2014).

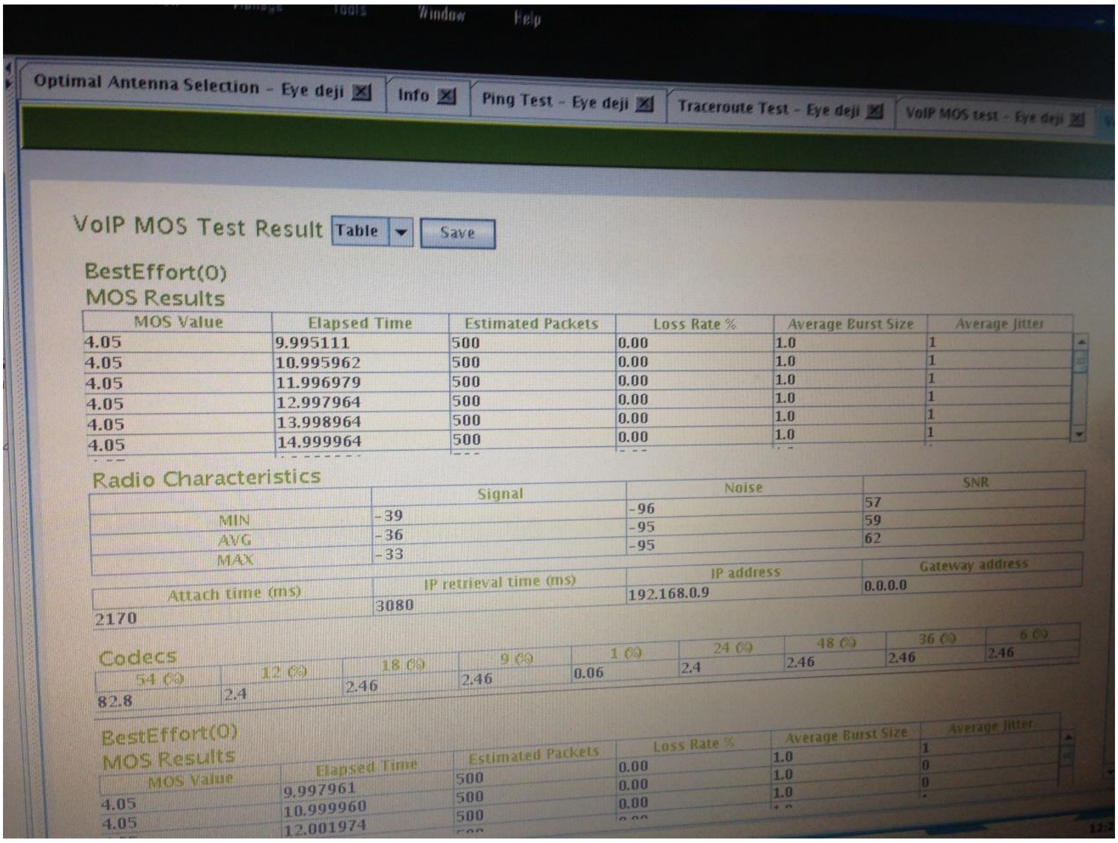

FIGURE 24. VoIP MOS Test Result (Olumuyiwa Ayodeji, 2014).

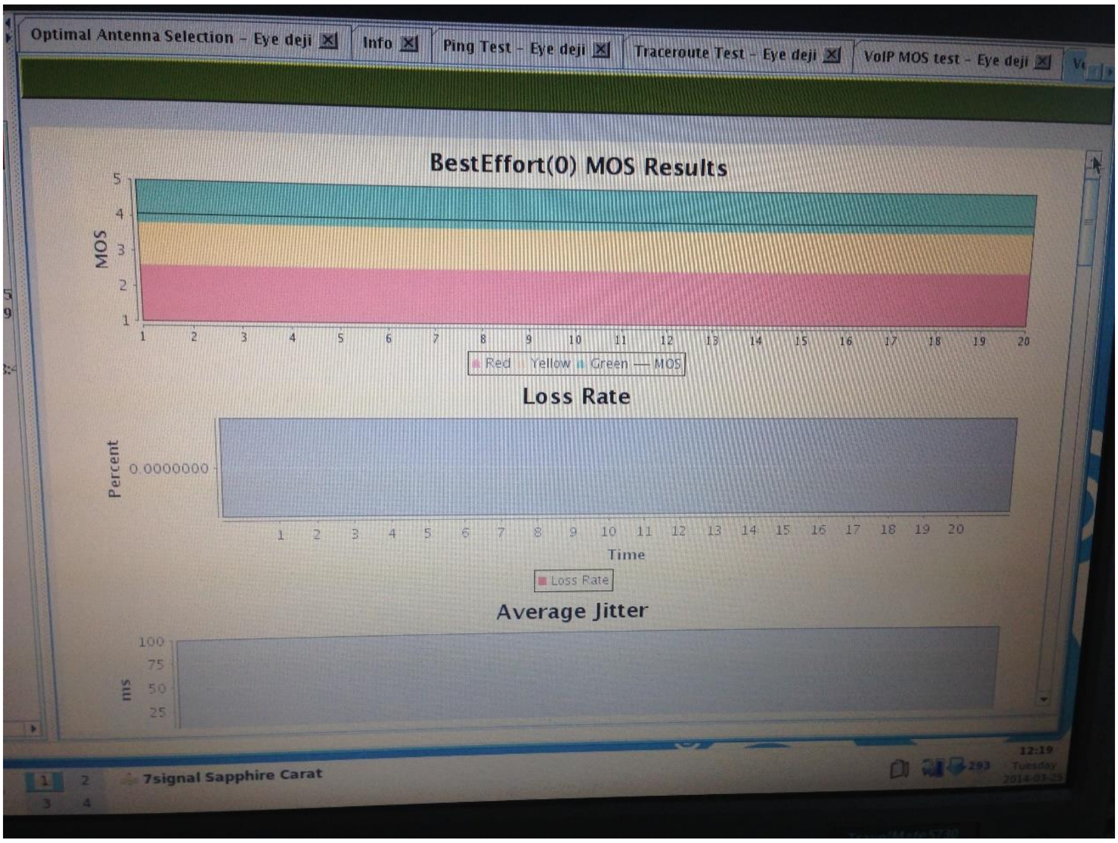

FIGURE 25. MOS Test Result –Graph (Olumuyiwa Ayodeji, 2014).

FIGURE 26. VoIP MOS Test Result –Graph (Olumuyiwa Ayodeji, 2014).

4.14 Elements of the results image:

• MOS result: The distribution of MOS values related to test duration. The colour coding indicates quality.

• Loss Rate: Packet loss as a function of test duration.

• Average Jitter: Variation in delay as a function of test duration.

• Codec: The distribution of codecs used during the test. If only one result is visible, the codec was not changed during the test.

• Levels: Signal and noise levels during the test, averaged over the duration of the test.

• SNR: Signal/noise ratio during the test, averaged over the duration of the test.

(7signal Sapphire Carat User Guide Release 3.1, 2012).

5 RESULTS

The 7 signal monitoring station, it is essential to generate results after tests have been carried out to enable the user to analyze and give reports of the network performance quality. In the process of reporting, there are some key components that are being monitored in order to be able to give an adequate report. In the monitoring system, while Sapphire Eye is used for monitoring WLAN in the environments, it is important to remember that Sapphire Carat is a centralized management tool that allows the user to manage the Sapphire Eye and make some configurations. Sonar tests the quality performance of the network against the test server to measure the QoS uplinks and downlinks and the Sapphire Loupe reports the measured results performance and QoS in the WQA solution.

5.1 Sapphire Loupe Interface

Sapphire Loupe as a browser based application is used in the viewing of the results and saving, so using the Sapphire Loupe needs authentication, the user has to login with a predefined username and password, which allows access rights to reporting parameters. Figure 27 shows the reporting interface of the Sapphire Loupe application.

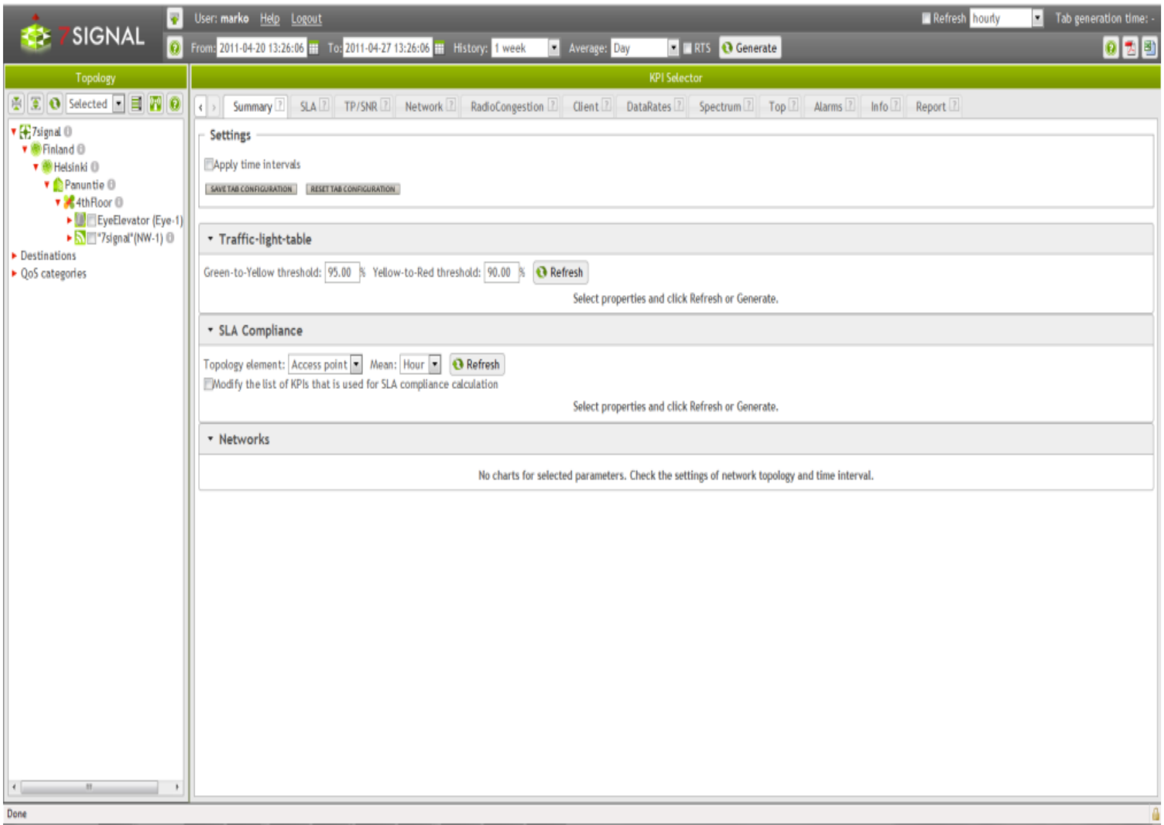

FIGURE 27. Sapphire Loupe Interface (7signal Sapphire Carat User Guide Release 3.1, 2012)

5.2 Key Performance Indicator (KPI)

In the monitoring system, to be able to achieve the desired results for a particular report, there is a minimum standard for the performance of each network signal and the standards are set based on the expected results. Therefore, each KPI defines a particular type of boundary value and percentage values for the amount of measurement samples that can fall out of the basic standard. To know the type of KPI, this is basically determined by the measurement samples and values or under the required boundary value as predefined.

Table 2, shows the SLA calculation values based on targeted KPI (7signal Sapphire Carat User Guide Release 3.1, 2012).

TABLE 2. SLA Calculations against KPI

Boundary value	Above 5,5 Mbit/s	The threshold value for KPI.
Green level	99,0%	At least 99,0% of measured samples must attain an upload throughput of at least 5,5Mbit/s in order to attain the green level for the KPI in question.
Yellow level	95,0%	If the percentage of measured samples that satisfy the boundary value criteria falls between 95,0% and 98,99% the yellow level is attained.
Red level	below 95,0%	If the percentage falls below 95,0% the service level can be considered unfulfilled.

Figure 28, shows the KPI lists of some of the monitored wireless networks and their performance level.

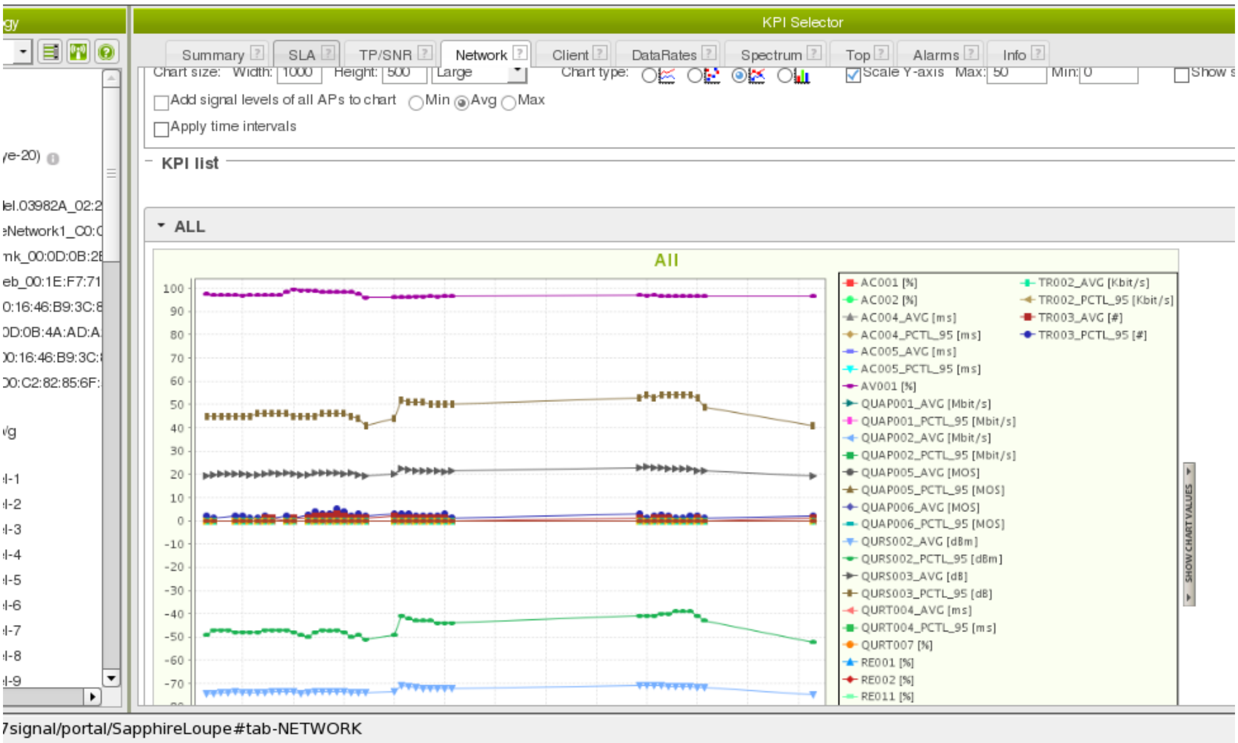

FIGURE 28. Key Performance Indicator Result (Olumuyiwa Ayodeji, 2014).

5.3 Service Level Agreement (SLA)

In order to be able to get a uniform result in the monitoring system, there is a Service Level Agreement in place for each Key performance Indicator. SLA groups a number of KPIs and their required target values which is a combination of different KPI values and statistical rules, this results in a higher-level view on the quality of the network. The SLA is a communication medium between the service provider and the customer. In Figure 29, the SLA of different Access Points are displayed, this show how the network results are reported via Sapphire Loupe in the reporting application.

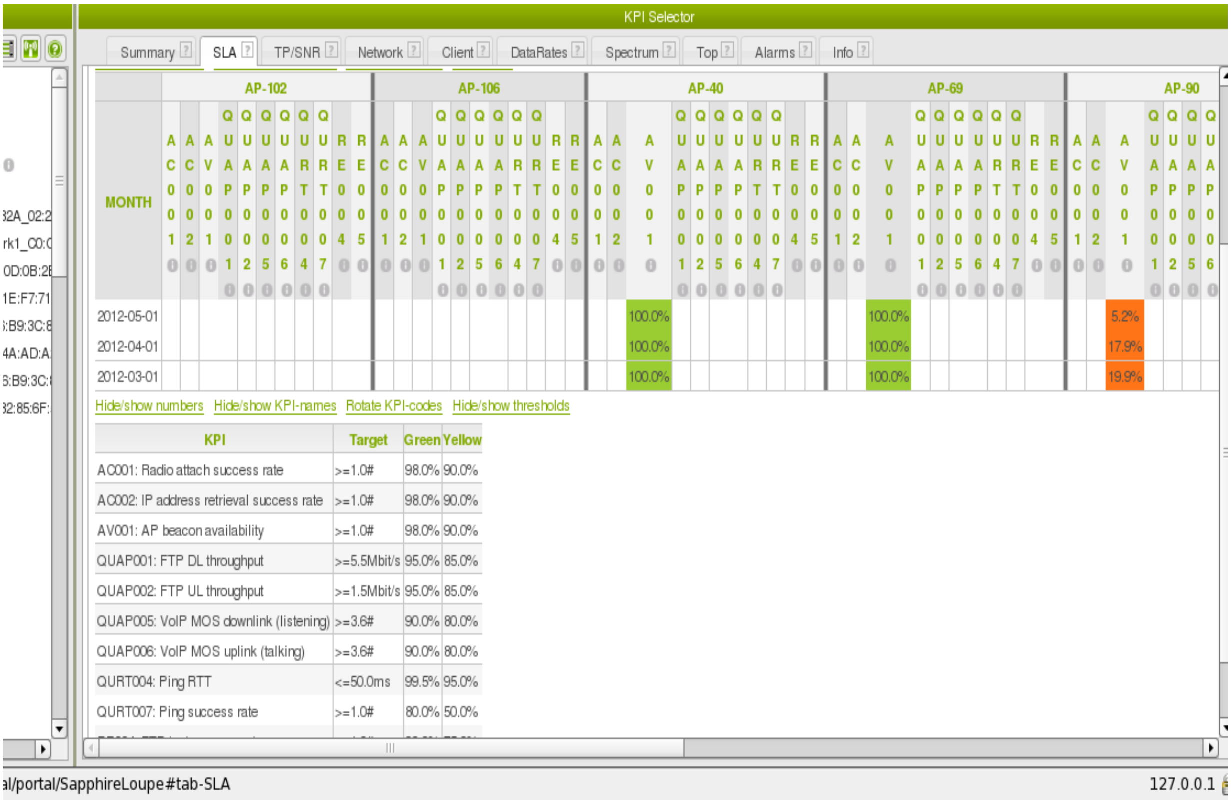

FIGURE 29. Service Level Agreement View (Olumuyiwa Ayodeji, 2014).

5.4 Client Network Performance

Client Network Performance is a distributional view to indicate the network performance, it show the data usage result for different months for the purpose of analysis and the data can be exported to spreadsheet or PDF for further reporting analysis. Figure 30 shows the details of the report.

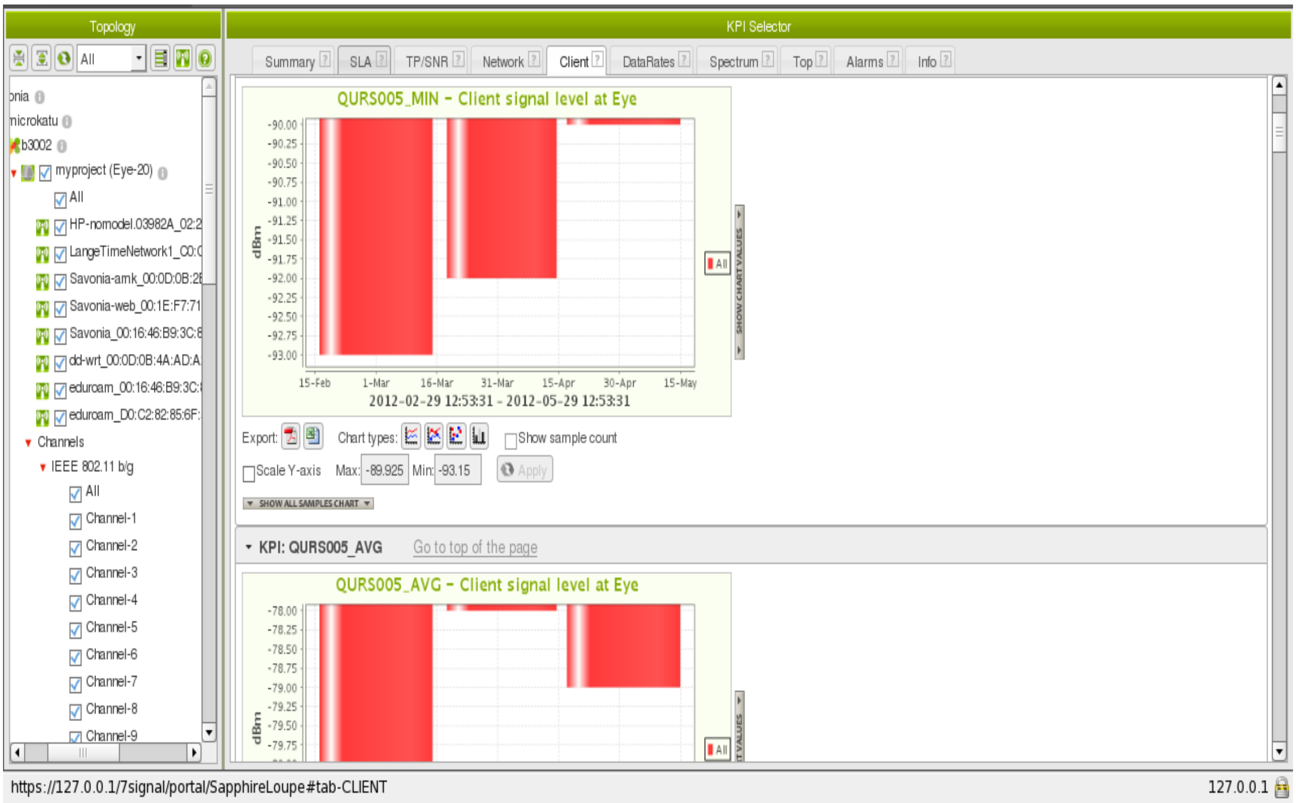

FIGURE 30. Client Network Performance (Olumuyiwa Ayodeji, 2014).

5.5 Spectrum

Spectrum displays all the available network channel performance at a glance, decoding each network with a unique colour coding. This indicates the frequency spectrum in which each network is transmitting. From Figure 31, it is visible that the networks are performing at their best performance level. The spectrum analyzer also helps in troubleshooting process as it will be clearly visible to locate the under-performing network after running the test.

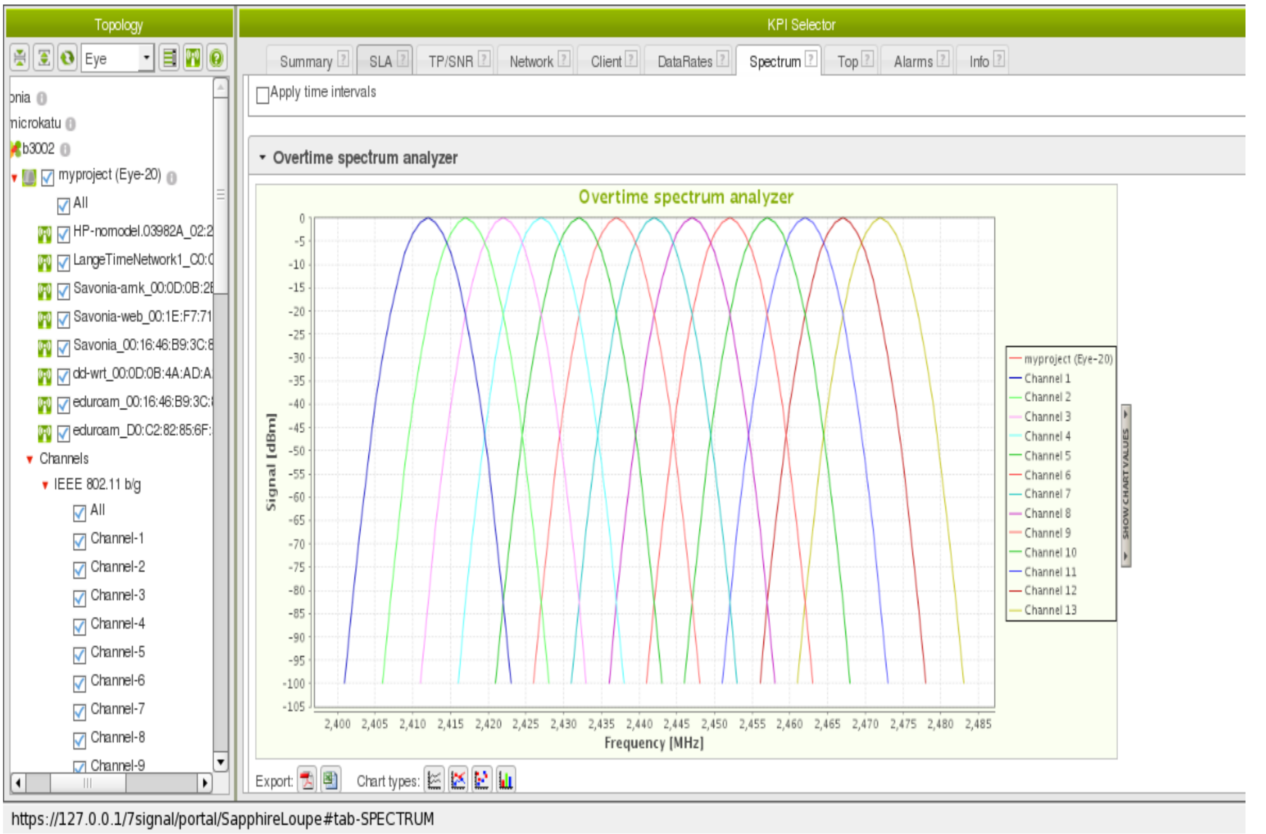

FIGURE 31. Overtime Spectrum Analyser (Olumuyiwa Ayodeji, 2014).

5.6 Top

Top shows a one-time view of selected access points and it allows easy comparison between access points.

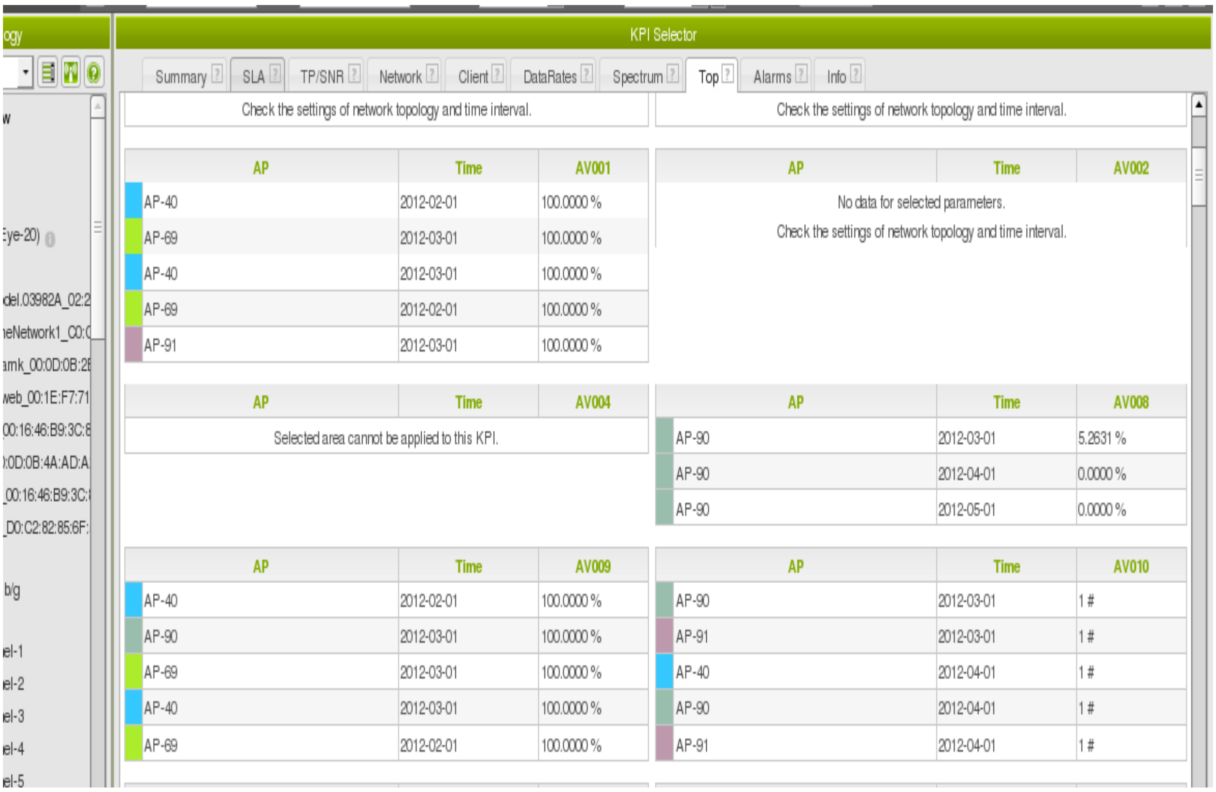

FIGURE 32. Top View (Olumuyiwa Ayodeji, 2014).

5.7 Alarms

Alarms can be caused by different reasons either by network severity or network downtime. It is important to set network alarm for each monitored wireless network in the monitoring system. This helps to know the status of the network and the cause of the alarm in case something goes wrong with the networks being monitored. It makes troubleshooting much easier.

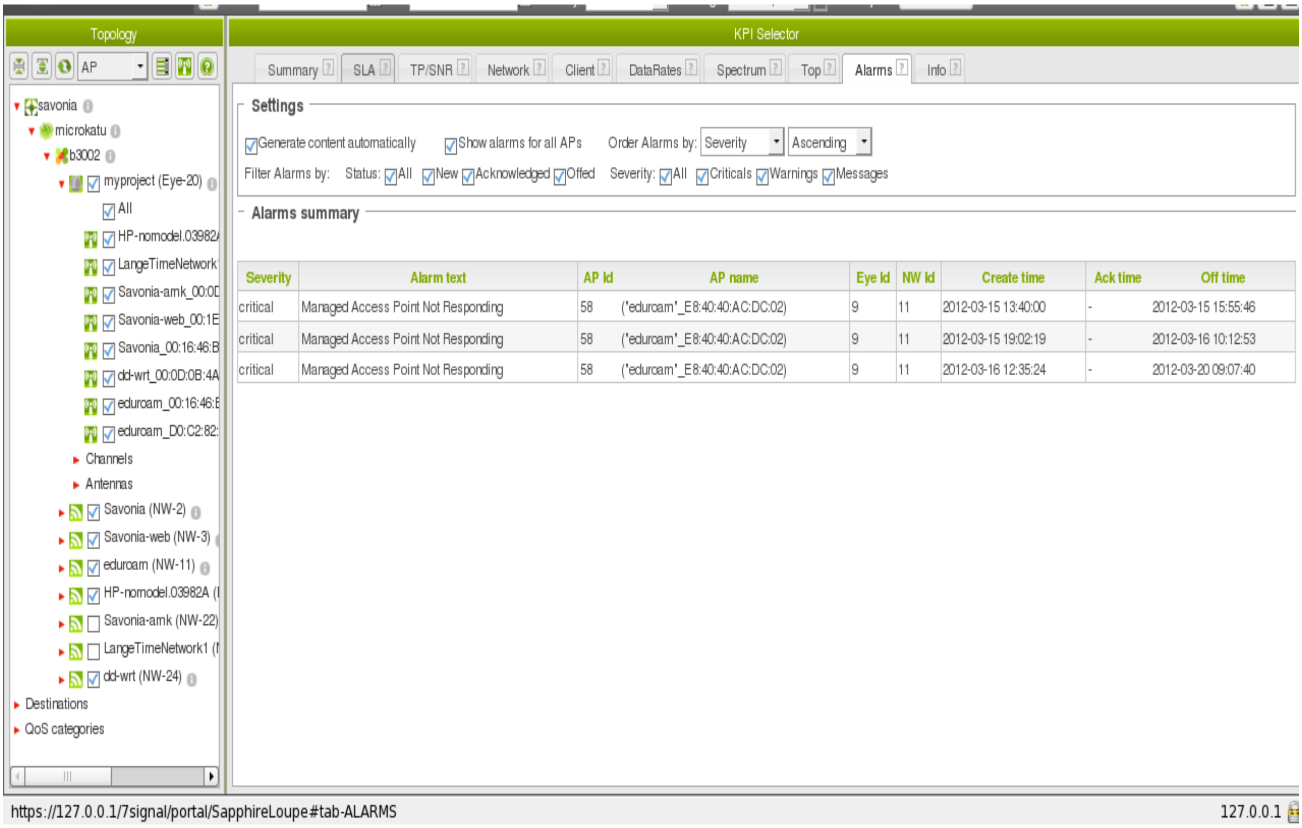

FIGURE 33. Network Alarm Summary (Olumuyiwa Ayodeji, 2014).

5.8 Info

Info displays detailed information of the network elements. It can be generated automatically based on the network topology tree selection according to the desired view.

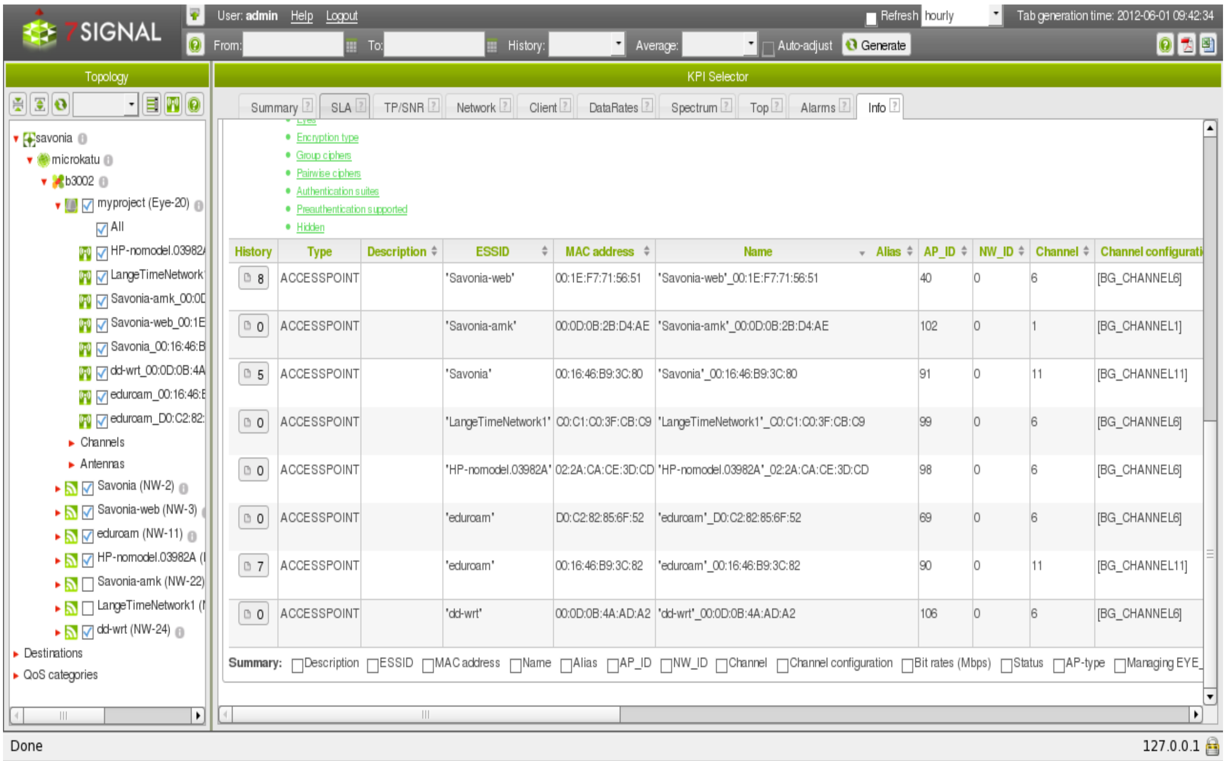

FIGURE 34. Info View (Olumuyiwa Ayodeji, 2014).

5.9 Reports

Report view is used for generating pre-defined reports. The essence of this is to show environmental statistics from the selected area. Interface (7signal Sapphire Carat User Guide Release 3.1, 2012).

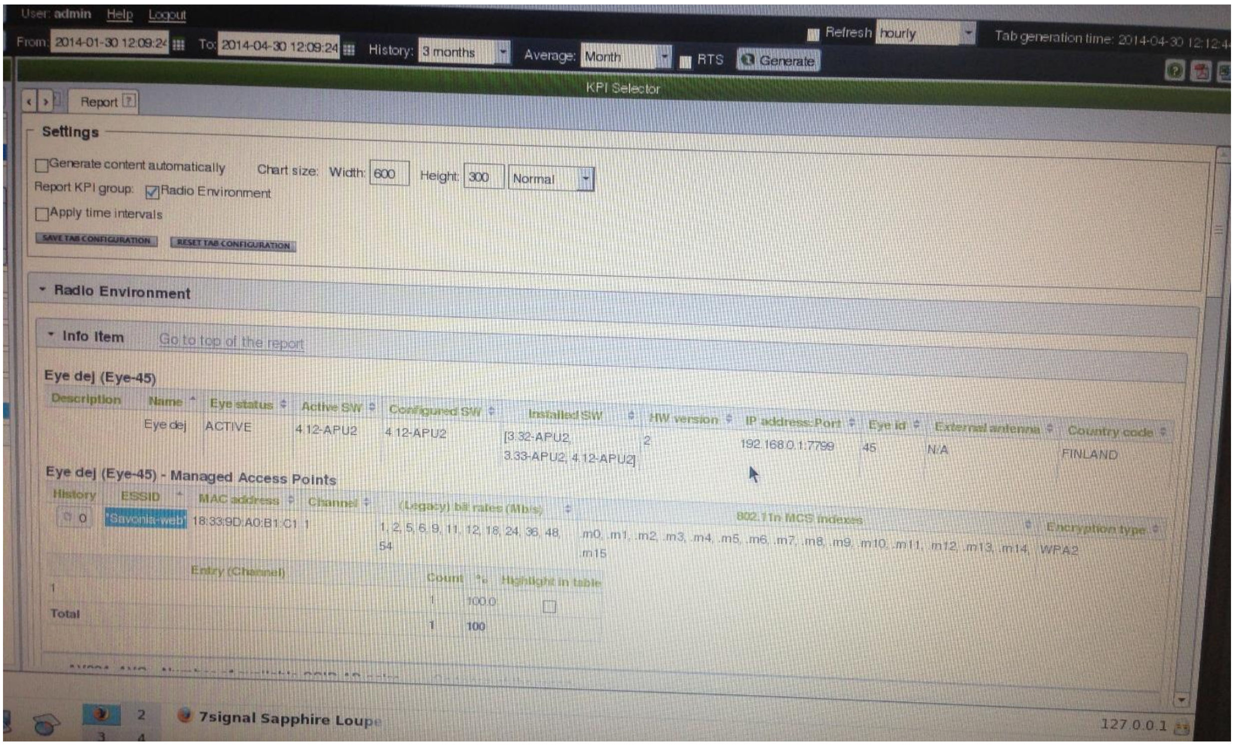

FIGURE 35. Report View (Olumuyiwa Ayodeji, 2014).

6 CONCLUSIONS

This project has been able to throw light into managing WLAN using 7 Signal monitoring station, it has been able to point out some significant network problems and adequate troubleshooting tips. The skills to measure, analyze and report monitored networks in the surroundings using an automated reporting application have been drastically worked on and greatly improved and the deployment of the monitoring system now looks easier and better with the experience gathered during the project work. Managing WLANs is assured with this technique of Wireless Quality Assurance which gives in-depth knowledge of different wireless network behaviors and their characteristics. Also the primary aims and objectives of the project which were familiarizing oneself with the 7 Signal Sapphire monitoring system, measurements of real-time connections and the Quality of Service were all achieved. In general, there was a complete realization of WLAN usability, deployment, behavior and monitoring both from the end user's perspective and the administrator.

REFERENCES

7 signal Ltd 2006 [electronic guide] [accessed March 2014] available from:
7signal Sapphire Carat User Guide Release 3.1

Computer Networking Notes 2010-2014. [web] [accessed March 2014] available from: www.ComputerNetworkingNotes.com.

HP Wireless Networking Glossary [web article] [accessed April 2014] available at: http://h71036.www7.hp.com/hho/us/en/pclc/articles/connectivity-networking-glossary.html

IEEE.org, *IEEE* [webpage] [accessed April 2014] available from: http://www.ieeeghn.org/wiki/index.php/Wireless_LAN_802.11_Wi-Fi

Intel Networking Devices, *Standards, Build, Configure, Design, and Implement* [web article] [accessed April 2014] available from: http://www.intel.com/content/www/us/en/standards/802-11-wireless-lan-standards-study.html

University of Glasgow IT Services [webpage] [accessed April 2014] available from: http://www.gla.ac.uk/services/it/informationsecurity/policies/wirelesslanpolicy/