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Trends of Wireless LAN – WiFi Quality of Service (QoS) in African Developing Countries

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Abstract— Different versions of the 802.11 standard have been released over recent years, which resulted in a considerable wireless networks and telecommunications progress for both WiFi and WiMax domains. Qualities of Service (QoS) parameters of a wireless LAN (WiFi) network are important factors to investigate as an evaluation mechanism of networks. This paper provides a review of recent published research work based on QoS parameters evaluation. Four categories were identified as part of the review. First group activities are centred around the NON-utilization QoS concepts while second group focused on WiFi network performance. Third group addressed the WiFi measurements, assessments and management, while the fourth group focused on QoS parameters with value setting approach. Detailed comparison between these four categories is presented.

Keywords— QoS, WiFi, WiMax, network, IEEE802.11

I. INTRODUCTION

Since the introduction of IEEE802.11 standard by the IEEE (LAN/MAN) standard committee on June 1997, multiple upgrades have been released. The Table 1 shows the full list of IEEE802.11 versions along with stream rate ranges for each version.

Communications devices designed based on IEEE 802.11a and 802.11g standards provide transmission rates that range from 6 to 54 Mbps while 802.11n can supports rates up to 150Mbps depending on bandwidth frequency of 20/40MHz as seen from Table 1. Recently, a new standard of IEEE 802.11ac which can support rates as high as 600Mbps which about 6X higher than 802.11n has been utilized. As the supported rate range has been increasing with new standard version, so did the transmission ranges which can be as high as 100m. However, the exact transmission range varies depending on transmission power, surrounding environment, and others parameters. The 802.11 devices operate in unlicensed bands at 2.4 and 5 GHz, where the exact available bands vary following country of operation regulations and spectrum allocation policies.

Data from the World Bank organization [2] shows a steep increase in mobile phone services and internet usage worldwide and especially in developing countries. Fig.1 shows data on three African countries (Kenya, Sudan, Ethiopia) between year over the first decade of this century and Fig2 shows internet users statistics for the same countries. Such increase in service demand will require quality of service factor considerations and optimization.

Advancements in telecommunications have encouraged service providers to consider impact of QoS parameters after service launching stage, as well as at service pre-launching stage [2]. Such factors are lumped into a category of QoS set of parameters referred to as Non-utilization QoS. Moreover, mobile cellular and internet users are increasing steadily across the world. Fig.1 depicts statistics of number of mobile users for 3 African countries extracted from World Bank archives [3]. The large user base of internet services has resulted in increase of WiFi connectivity services being wide spread and therefore the WiFi connectivity QoS will encompass connectivity performance that is critical to service users and as an indicator for competition comparisons. Furthermore, the data communicated over WiFi is critical for the user communities, and hence accurate measurement, assessment, and management of data is as critical as the performance of the WiFi network. Additionally, for better evaluation of networks, adequate setting of targeted QoS values that is relevant to the users is also crucial.

The aforementioned QoS parameters four categories, i.e.:

- Non-utilization QoS of pre-launch of service
- performance of WiFi network services
- Measurement, assessment, and management of data over WiFi network
- Accurate setting of QoS target values

Published research work that addresses these factors will be presented in this paper. The published research results, recommendations, and gaps will be discussed to serve as a guide to future research focused on QoS in the field of telecommunications. This document is a template. An electronic copy can be downloaded from the Journal website. For questions on paper guidelines, please contact the journal publications committee as indicated on the journal website. Information about final paper submission is available from the conference website.

TABLE I 802.11 NETWORK PHY STANDARDS

802.11 protocol	**Release date**	**Fre-quency**	**Band-width**	**Stream data rate**	**Allowable MIMO streams**	**Modulation**	**Approximate range**			
		(GHz)	**(MHz)**	**(Mbit/s)**			**Indoor**		**Outdoor**	
							(m)	**(ft)**	**(m)**	**(ft)**
802.11-1997	Jun 1997	2.4	22	1, 2	N/A	DSSS, FHSS	20	66	100	330
a	Sept 1999	5	20	6, 9, 12, 18, 24, 36, 48, 54	N/A	OFDM	35	115	120	390
		3.7					--	--	5,000	16,000
b	Sept 1999	2.4	22	1,2,5.5,11	N/A	DSSS	35	115	140	460
g	Jun 2003	2.4	20	6,9,12,18,24,36,48,54	N/A	OFDM,DSSS	38	125	140	460
n	Oct 2009	2.4/5	20	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2 (6.5, 13, 19.5, 26, 39, 52, 58.5, 65)	4	OFDM	70	230	250	820
			40	15, 30, 45, 60, 90, 120, 135, 150 (13.5, 27, 40.5, 54, 81, 108, 121.5, 135)			70	230	250	820
ac	Dec 2013	5	20	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2, 86.7, 96.3 (6.5, 13, 19.5, 26, 39, 52, 58.5, 65, 78, 86.7)	8		35	115		
			40	15, 30, 45, 60, 90, 120, 135, 150, 180, 200 (13.5, 27, 40.5, 54, 81, 108, 121.5, 135, 162, 180)			35	115		
			80	32.5, 65, 97.5, 130, 195, 260, 292.5, 325, 390, 433.3 (29.2, 58.5, 87.8, 117, 175.5, 234, 263.2, 292.5, 351, 390)			35	115		
			160	65, 130, 195, 260, 390, 520, 585, 650, 780, 866.7 (58.5, 117, 175.5, 234, 351, 468, 702, 780)			35	115		
ad	Dec 2012	60	2,160	Up to 6,912 (6.75 Gbit/s)	N/A	OFDM, single carrier, low-power single carrier				
ah	Est. 2016	0.9								
aj	Est. 2016	45/60								
ax	Est. 2016	2.4/5				MIMO-OFDM				

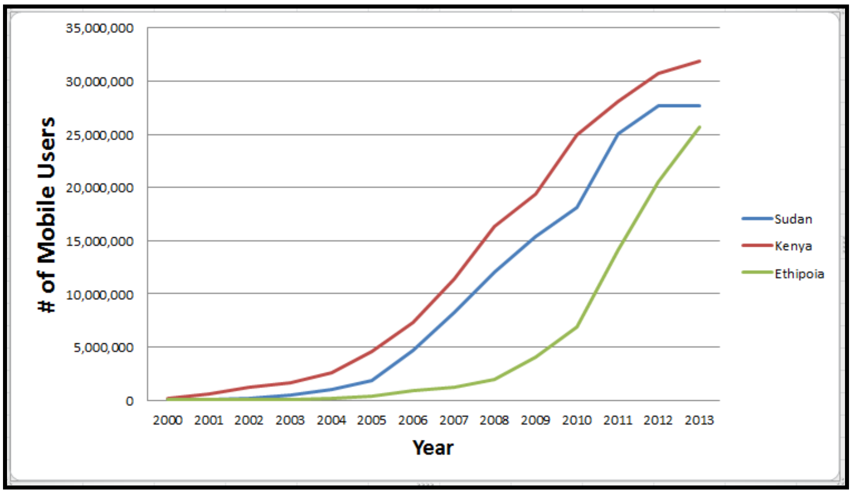

Fig. 1 The number of mobile users of 3 African countries between year 2000 and year 2013. [3]

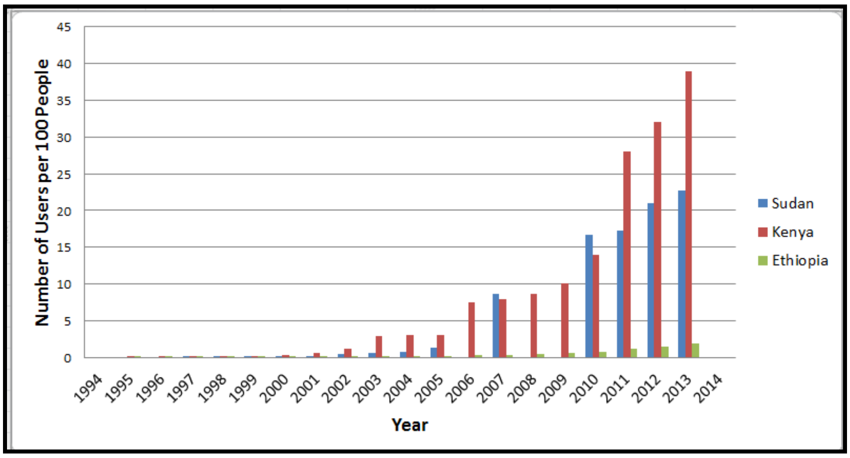

Fig. 2 The number of mobile users of 3 African countries between year 2000 and year 2013. [3]

II. NON-UTILIZATION QOS

As stated by the ITU [3], QoS performance on non-utilization stages can benefit customers, regulators, stakeholders and service providers (SPs) to monitor performance levels for the benefit of the customers and ICT industry. This group composes of three papers that taking care of QoS and customer satisfaction issues, even before launching the service. It can be noticed that the ITU has differentiated between customers and users of ICT services which helps customers to compare performance level of ICT services provided by service providers (SPs). Furthermore, the ITU has identified 88 parameters that help customer to benefit from the non-utilization stage before starting service, however the recommendation only focuses on non-utilization stage of telecommunication QoS. A. Gaafar et. al.[4], have discussed QoS contractual indicators for developing countries where a subset of 28 parameters extracted from the ITU 88 proposed set of QoS indicators listed in [3]. The paper proposes a new and updated trend for the contractual behaviour taking into consideration many factors, such as customer legal level of contractual understanding, customer awareness level, safety considerations and governmental restrictions. The proposed contractual framework is recommended to be consented and deployed by the regulatory authority considering the current status of the ICT market in the developing countries.

A. Gaafar et. al.[5] have focused on contractual aspects of QoS indicators with emphasis on telecommunication services within the developing countries which usually suffer from the lack of legal awareness and low financial income that protect customers and provider rights through inadequate contracts. The authors have proposed 12 parameters (G10–G21) to be approved by regulatory authorities to enrich and complement the ITU-T E.803 recommendation for contractual matters for QoS and customer satisfaction.

TABLE II NON-UTILIZATION QOS RESEARCH WORK SUMMARY

Ref No.	**Contribution & Opportunities**	**Weakness**	**Remarks**
[2]	• Defines QoS parameters during the non-utilization stages. • Enable users of ICT services to compare performance of service providers. • QoS performance on non-utilization stages can	This recommendation only focusing non- utilization stage of telecommunication QoS	Recommendation ITU-T E803 lists 88 parameters over the product life cycle of ICT service.

	benefit customers, regulator, stakeholders and service providers to monitor performance levels for the benefit of the customer and ICT industry.		
[4]	• proposes a new and updated trend for contractual behavior that considers factors such as customer legal level of contractual understanding, customer awareness level, safety considerations, and governmental restrictions. • proposed contractual framework is recommended to be consented and deployed by regulatory authority for developing countries..	Contractual matters of developing countries need more details.	Study is based on the ITU-E803 standards.
[5]	• Local adequate scenario is proposed for developing countries. • Considering special situations of developing countries.	Non-utilization parameters for developing countries needs more studies and investigation.	Study is based on the ITU-E803 standards.

III. WIFI PERFORMANCE

For the sake of network users it is critical to investigate the service network WiFi performance which is presented by several researchers.

C Liu et. al [6] have addressed performance and settings of selected WiFi parameters such as delay, jitter and error using network simulator, OPNET 16.0 and evaluated the quality of video conferencing linking two offices conducted over WiFi and Ethernet connections. Simulation results showed WiFi ETE delay lower than in the Ethernet, and higher traffic received within WiFi than in the Ethernet connection. These reported results indicates that the WiFi scenarios will have less delay for video conferencing in comparison to Ethernet and the network is capable of handling greater amount of traffic. However, simulation results of jitter have shown that the Ethernet outperformed the WiFi which leads to more smooth video conferencing when using Ethernet. However, C Liu et. al. [6] have not considered workstations that are conferencing over the whole time window which will affect network throughput when compared to the case of workstations that are conferencing only part of the time.

R. Paul et. al.[7, 8] have used the OPNET simulation modeler15.0 to conclude that the WiFi is adequate for a very high speed WLAN while WiMAX is suitable for high speed Wireless Wide Area Network (WWAN). Simulation results presented by [7,8] have depicted traffic sent by mobile and fixed WiFi are identical to the traffic received, in other words no loss is encountered. Moreover, WiMAX has suffered no loss when mobile WiMAX traffic sent or received. The handoff no data loss phenomena can be attributed to the fact that the WiFi network has only one AP and the WiMAX network has only one BS in each simulation scenario[7,8]. Simulations by [7,8] also shown that the WiMAX throughput is higher in case of heavier traffic and wide area range which indicates that WiMAX is capable of handling more load when compared to WiFi. It should be noted that the simulation setup performed by [7,8] considers only one WiFi network which will tender special case results that are harder to generalize. Additionally, parameters such as signal strength, and coverage area for both WiFi and WiMax were not considered which can be investigated in a more expanded research work.

N. Sulaiman and C.Y. Yaakub[9] have investigated QoS of Campus-wide WiFi Networks where the connectivity problems to WiFi networks are considered. The study included WiFi performance analysis as well as network auditing in addition to channel overlapping and saturation condition while different types of software were used to analyse the results. The results reveal that wireless networks often have performance problems that can lead to user disappointment with the WiFi based networks that are in use. Some WiFi problems stems from channel/signal clashing and overlapping, a high amount of CRC Errors, poor placement of antenna, APs that are failing very regularly, and switching over from one SSID to another. N. Sulaiman and C.Y. Yaakub[9] have posted a number of recommendations to improve network accessibility which involves rectifying the wireless problems and analysing the problems within the wired network that can cause high level of background traffic in the form of ARP and UDP packets. The authors of [9] have proposed further investigation be conducted on the network application servers that seem to function intermittently and other network and application components to improve the usability of the network. Moreover, it would be helpful if findings were presented in a tabulated format to aid perform scientific comparisons and studies.

TABLE IIIII WIFI PERFORMANCE QOS RESEARCH WORK SUMMARY

Ref. No.	**Contribution & Opportunities**	**Weakness**	**Remarks**
[6]	• WiFi showed lower ETE delay and the traffic received and sent are all higher than the Ethernet version. • WiFi showed more jitter in both cases • Ethernet would work better for a more smooth video conference. • This technology reduces time and cost,	• Workstations in the network should be examined if they were conferencing all the time. • OPNET licensing issue, and exact model number used and the	This technology reduces time and cost and WiFi is performing better than Ethernet for capable networks.

		configuration settings were not included in this report.	
[7,8]	• The scheduling algorithm is used for controlling the bandwidth efficiency and quality of service (QoS) parameters by changing the time slot duration. • OPNET Modeler 15.0 is used to simulate WiFi and WiMAX. • No loss in traffic received on both WiFi and WiMAX. • WiMAX throughput is higher in case of heavier traffic and wide area range. • WiMAX queuing delay is smaller. • The delay in WiFi router was higher than the delay in the base station.	• The simulation is done for one WiFi network. • Generalizations cannot be easily drawn. • The parameters discussed in this paper are limited. • Other parameters like coverage area for both WiFi & WiMax should be investigated to provide more insight.	Using OPNET is positive since it gives nearest results.
[9]	• The results reveal that wireless networks often have performance Problems. • Wireless problems could be attributed to : ○ Channel/signal clashing and overlapping. ○ High amount of CRC Errors. ○ Poor placement of antenna. ○ APs that are failing very regularly. ○ Switching over from one SSID to another. • The poor Internet Access was due to the client PC not being able to get an IP when switching from one SSID to another.	• Too many parameters are covered in this study with less details provided. • The results were not presented in a tabular format to help effective comparison and study.	The paper should concentrates on smaller set of parameters and provided more details
[10]	• a single WiMAX Base station BS, operating in a licensed band, serves both multiple WiMAX Subscriber Stations (SSs) and multiple W2-APs within its coverage area. • The WiMAX system provides broadband wireless access to multiple W2-AP devices in a point-to-multipoint (PMP) topology. • Each WiFi network is connected to the WiMAX BS through a WiMAX/WiFi (W2)-AP. • The connection between the BS and a SS is dedicated to a single user. • The connection between the BS and each W2-AP is shared amongst all the nodes within the Wireless LAN served by the W2-AP. • The WiMAX network guarantees secured communications service for connecting multiple scattered WiFi nodes to the Internet.	• It is clear that WiMax is better in security than WiFi • The short range that WiFi covers include corporates and companies that have confidential data, so security in WiFi sometimes is essential.	It appears that combining between WiMax and WiFi will be better scenario. However the challenge will be the WiFi poor security.

Md. Haque et. al. [10] has investigated the requirement of security when constructing integrated WiMAX/WiFi networks. The need of designing efficient links and Medium Access Control (MAC) layer protocols to optimize the QoS between the WiMAX and the WiFi components is highlighted [10]. Although combining WiMAX and WiFi can provide better service especially in the areas where wired networks are difficult to implement, the challenge will be in the area covered by WiFi network. This is true due to WiFi security requirement to be strong as in WiMax. One of the reasons of why WiMax offers high security is that it covers large areas and therefore such conditions demand strong and secure network operating conditions. The strengths of WiMAX lie in its ability to address the requirements of modern telecommunications networks and the commitment that has been shown to its development and wide acceptance by a number of leading equipment vendors and service providers. The study by [10] also indicated that the WiMAX is an excellent component to other wireless technologies that are designed to work in the LAN (WiFi) arena or that offer wider exposure, however, with more limited capacity (GSM, CDMA, UMTS, EDO).

IV. WIFI MEASUREMENT, ASSESSMENT AND MANAGEMENT

WiFi measurement, assessment and management represent an important factor to investigate where service providers would need to validate their service QoS parameters on this aspect. Several researches have been reported on WiFi measurement where various setup and techniques have been proposed and analysed. Lavrukhin, V. et. al.[11] have reported on QoS measurements performed on public WiFi networks. Results showed that the airtime parameter may be successfully used for the estimation of key QoS indicators in the Wi-Fi network. It is found to be more important than the throughput in the case of Wi-Fi network performance evaluation, and it doesn't rely on the different PHY layer transmission rates. Moreover, it is found to be a good measure of the Wi-Fi channel loading. The authors have reported on a simple method to estimate the Air Time (AT) from the existing Wi-Fi network frame capture and that it is possible to compute AT in real time which tends to simplify implementation in the SSs or APs. The authors have also proposed a model to compute frame losses from the measured AT parameter. On the other hand, Andrea Detti[12] have reported on a setup of a small test-bed formed by two STAs that are operating in ad-hoc mode 802.11b. On the STA n.1 the setup is made up for four Poisson/UDP1 greedy (i.e., 10 Mbps) sources, each source belong to a different Access Class. The sources are classified as:

- Source 1 is AC_BK
- Source 2 is AC_BE
- Source 3 is AC_VI
- Source 4 is AC_VO.

While the STA n.2 was setup of the relevant receivers. The study [11] shows that When a higher priority source begins to transmit, the output of the lower priority sources is significantly decreased and the delay is significantly increased. On the other hand, the Video and Voice access classes practically get the most of available bandwidth and have very lower delay than the other classes.

The Wifi Alliance[13], has demonstrated ability to transform multicast packets to unicast packets at the AP side is a first step towards enhancing the QoS for video delivery over Wi-Fi networks. The approach relies on increasing the retry limit which reduces the video packet loss rate, but doesn't increase the MAC overhead under different physical layer channel models. Even though it was shown that modifying the retry limit has no strong impact on the video MAC retransmission rate, this will increase the average MAC end to end delay especially when video is competing with voice and data. The limitations with approach on [13] is that it can only be applied to networks that contains limited number of devices, such a home network. The reason is that each multicast to unicast packet may be transmitted several times if more than one station requests the same multicast group which increases the necessary wireless bandwidth. Moreover, the simulation on [13] assumes no hidden terminals and no mobility in the system. Additionally, the white paper[13] analysis referenced 802.11a and 802.11e standards, but not 802.11n which supports higher data rates and that may enhanced the performance of the video transmission.

Aerofex White Paper[14] clarifies that, 802.11ac boosts up to 6X increase in data rate through the use of wider bandwidth. It is positioned as the evolution of 802.11n and expected to become mainstream by 2015[14]. Four main test challenges of 802.11ac have been considered. These are Wide bandwidth, MIMO, high density modulation, and speed of test. The paper shows the advantage of 802.11ac and its enhancement over 802.11n. Mohamed Noor et. al. have developed method to analyse jitter referred to as Generalized Extreme Value Distribution (GEV) and logistic distributions for ETE delay analysis[15]. However the study focused on jitter analysis without referencing WiFi and it would benefit the service provider to analyse statistically the QoS parameters.

ALTAI Co.[16] refers to 802.11 protocols that provide the 2.4 GHz ISM band and the 5 GHz U-NII band into 13 channels each of 22 MHZ and spaced 5 MHZ apart. The non-overlapping channels were 1,6,11. The power radiated from antenna has more interference influence than the antenna Gain. However the distance between two antennas is another factor of interference. EIRP=transmitted power in dbm + antenna gain in dbi which is an important parameter [15]. The paper focusses only on the company product. Low transmits power and high antenna gain to attain outstanding uplink performance is the best antenna scenario.

TABLE IV WIFI MEASUREMENT, ASSESSMENT, AND MEASUREMENT QOS RESEARCH WORK SUMMARY

Ref No.	**Contribution & Opportunities**	**Weakness**	**Remarks**
[11]	• QoS measurements performed on public WiFi networks. • The airtime parameter successfully used for the estimation of key QoS indicators in the Wi-Fi network. • It is found to be more important than the throughput in the case of Wi-Fi network performance evaluation • It doesn't rely on the different PHY layer transmission rates. • It is found to be a good measure of the Wi-Fi channel loading • simple method to estimate the Air Time (AT) from the existing Wi-Fi network frame capture • It is possible to compute AT in real time which tend to simplify implementation in the SSs or APs. • The authors have also proposed a model to compute frame losses from the measured AT parameter.		

[12]	• A setup of a small test-bed formed by two STAs operating in ad-hoc mode 802.11b. • STA n.1 is setup four Poisson/UDP1 greedy (i.e., 10 Mbps) sources, each source belongs to a different Access Class ➢ source 1 is AC_BK, ➢ source 2 is AC_BE, ➢ source 3 is AC_VI ➢ source 4 is AC_VO • STA n.2 is setup with the relevant receivers. The test runs for 120 seconds and the i-th source starts at (i-1)*30 s and stops at the end of test. • The OS used was Linux. • When a higher priority source begins to transmit the output of the lower priority sources significantly decreases and delay significantly increases. • The Video and Voice access classes practically get the most of available bandwidth and have very lower delay than the other classes.	The comparison of the four types is very clear and comprehensive.	
[13]	• Transforming multicast packets to unicast packets at the AP side is a first step towards enhancing the QoS for video delivery over Wi-Fi networks. • Increasing the retry limit reduces the video packet loss rate, but doesn't increase the MAC overhead. Under different physical layer channel models. it seems that modifying the retry limit has no strong impact on the video MAC retransmission rate. However, increasing the retry limit increases the average MAC end to end delay, especially when video is competing with voice and data. • The paper conclude to the facts that, Increasing the MAC retry limit reduces video packets losses and increases the MAC end to end delay. and, it doesn't increase the MAC overhead and has very little impact on the MAC retry rate.	• can only be applied to a network with limited number of devices, such as in a home network. • The paper assumes neither hidden terminals nor mobility in the system. • The paper deal with 802.11a,e . No reference to 802.11n which has a higher data rate, and that may enhanced the performance of the video transmission.	
[14]	Four main test challenges have been identified in the manufacturing environment for 802.11ac: • wide bandwidth, • MIMO, • high density modulation • Speed of test.	Disadvantages are not mentioned in this paper.	The paper shows the advantage of 802.11ac and the enhancement over 802.11n.
[15]	• showed that the jitter can be analyzed by Generalized Extreme Value Distribution (GEV) • End-to-end one way delay can be analyzed by logistic distribution. • Provided the minimum sample size for the parameter estimation of the two important QoS parameters like jitter and end-to-end one way delay.	focused only on WiMax. WiFi was not investigated.	It will certainly help the service provider to analyze Statistically the QoS parameters.
[16]	• The amount of noise interference to a station depends primarily on the number of contending sources, more than on the transmit power of individual source. • Transmitter with higher antenna gain and lower transmit power will generate less interference to other radio equipment's.	The paper focusses only on the company product.	Low transmitter power and high antenna gain to attain outstanding uplink performance is the best antenna scenario.

	• The interference of one transmitter to another is more dependent on the distance between them than the radiated power of them. • EIRP=transmitted power in dbm + antenna gain in dbi which is an important parameter.		
[17]	• Technique to assess network failures that run statistical post-processing analysis of measured data collected by nonintrusive devices. • The proposed solution can be easily implemented by already available monitoring instruments for network performance surveillance and automatic detection of anomalies. • The effectiveness of the method has been proven on real-life telecommunication systems, and results are reported. • The proposed methodology has been tested by some telecommunication companies at test-points located in the neighborhood of international routes.	• Relatively old (2003), and may need to be re-visited where new standard are in use. • Reliance on service providers to adopt technique.	Technique is easy and non-intrusive.

Matteo Bertocco et. al. [17] have devised a technique to assess network failures that run statistical post-processing analysis of measured data collected by nonintrusive devices. The proposed solution can be easily implemented by already available monitoring instruments for network performance surveillance and automatic detection of anomalies. The effectiveness of the method has been proven on real-life telecommunication systems, and results are reported. The developed statistical technique is the first attempt to give a formal solution to the problem of troubleshooting detection. The proposed methodology has been tested by some telecommunication companies at test-points located in the neighbourhood of international routes in order to perform verification of network properties. This technique if adopted by network providers could provide an insight to quality of service.

V. QOS PARAMETERS AND TARGETED VALUES SETTING

The QoS parameters and targeted values setting are critical to ensure and assess the quality of QoS parameters.

Mitesh Sharma et. al. handled the communication broadband technology showing that Broadband Technologies are very useful in all respect of life utilities. The paper introduces some Broadband management and benefits. The research clarified that just one fibre-optic strand has greater Bandwidth than the entire usable radio spectrum [18]. The Contribution covered the future of the broadband and gives a clear picture of what should be done by providers and governments to utilize this broadband technology. It also stated that wireline will always leads the bandwidth, since optical- fiber uses infra-red frequency and wireless uses radio frequency [18]. However all the work in the paper rely on theory and no case study were offered. Also it introduces four main factors.

Milosh Ivanovich et. al. [19] found that four main factors influence user perception of QoS. These are Reliability, Efficiency, predictability, and Satisfaction. An interesting future area of research would be to consider the impact of the client device itself on the user perceived Wireless QoS for a range of applications[19]. The QoS parameters are classified into four classes named Conversational, Streaming, Interactive and Background.

TABLE V QOS PARAMETERS AND TARGETED VALUE SETTING RESEARCH WORK SUMMARY

Ref No.	Contribution & Opportunities	Weakness	Remarks
[18]	The infra-red frequencies used in fiber-optic communications have far greater bandwidth than radio. The result is that just one fiber-optic strand has greater bandwidth than the entire usable radio spectrum.	All the work in the paper rely on theory and no case study are offered.	The paper covered the future of the broadband and gives a clear picture of what should be done by providers and governments to welcome this broadband technology. *The paper also stated that wire line will always leads the bandwidth, since optical- fiber uses infra-red frequency and wireless uses radio frequency.
[19]	QoS classes are:	The study is relatively	Due to the absence of the

	• Conversational – real time traffic flows, greatest delay sensitivity, e.g. voice or video telephony. • Streaming - real time traffic flows, medium delay sensitivity, e.g. one-way streaming media. • Interactive - used for interactive but delay tolerant traffic flows which require smaller data error rates, e.g. web browsing or chat. • Background – used for non-urgent, delay tolerant traffic flows that require smaller data error rates, e.g. large file download or email retrieval. Found that four main factors influenced the user perception are: reliability, efficiency, predictability and satisfaction forming the core set of measurable parameters at the User-perceived QoS layer. Reliability examines how important and useful it is to know in advance the level of network performance. Efficiency represents a measure of how quickly the system responded to requests and may be interpreted as the perceived speed of network delivery. Predictability is concerned with the degree to which the user experience followed the expectations of the user. Satisfaction measured the overall "rating" assigned by the user to each experience, taking everything into account.	old, and new trends have developed. The client devises subnet uses (802.11b) standard, which is an old standard compared to now available 802.11ac. At the time experiment 3G was not exist.	3G a "marriage" between a Personal Digital Assistant (PDA) and a mobile phone is made. Although this device did not have an integrated mobile data network capability.

VI. CONCLUSIONS

Four categories of QoS parameters that are applicable to WiFi network are discussed. These include the Non-utilization QoS of pre-launch of service, performance of WiFi network services, the measurement, assessment, and management of data over WiFi network, and accurate setting of QoS target values. A collection of published reports and journal articles on each category are identified and reviewed in details. Findings are tabulated for each category and each published work to aid running effective comparisons between scenarios and test setups, and measurements. The strengths and weaknesses of each published work are also included. This review provides the necessary background and details by performing required and comprehensive literature review, and hence helps in identifying gaps and potential areas of enhancing WiFi QoS indicators.

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