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PERSONALIZED QUALITY OF EXPERIENCE (QOE)MANAGEMENT USING DATA DRIVEN ARCHITECTURE IN 5G WIRELESS NETWORKS

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PERSONALIZED QUALITY OF EXPERIENCE (QOE) MANAGEMENT USING DATA DRIVEN ARCHITECTURE IN 5G WIRELESS NETWORKS

by

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The thesis titled “PERSONALIZED QUALITY OF EXPERIENCE (QOE) MANAGEMENT USING DATA DRIVEN ARCHITECTURE IN 5G WIRELESS NETWORKS” prepared and presented by “Zahraa Qasim Abed AL-EZZI” was accepted as a Master of Science Thesis in Electrical and Computer Engineering**.**

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Zahraa Qasim Abed AL-EZZI

Signature

DEDICATION

I devote and pledge this research work to my supervisor who is salient for guiding me through whole research work as well as my family for always assisting me in my hard time.

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ABSTRACT

PERSONALIZED QUALITY OF EXPERIENCE (QOE) MANAGEMENT USING DATA DRIVEN ARCHITECTURE IN 5G WIRELESS NETWORKS

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The objectives of this research are to use Data Driven Architecture to manage personalized Quality of Experience (QOE) in 5G Wireless Networks that use less energy. The present project will be a component of a larger current research. that reflects on an issue that several companies face while implementing an Enterprise Architecture to facilitate the analysis of heterogeneous resources all across enterprises. With the exponential increase of digital data use and video conferencing as the most common network, both telecommunications companies and their customers place a premium on available bandwidth in phone carriers. For QoE adaptation and higher levels of customer, the ability to actually assess visual Quality of Experience is critical. Machine learning were used to build simulations QoE regarding the network Qos, both connectivity and fifth - generation (5) variables, in this study. To find the information set to train, a 5G model that represents the current traffic information environment was developed. To collect the QoE information required to practice the predictions, an unbiased method for image QoE evaluation was being used. For Performance of Encounter estimation, Svms, Random Forest, Boosted Regression Trees, and Neural Network nn were selected as machine learning methods. And it has been shown that they have a high level of accuracy. Wi-Fi parameters were also examined for their effect on QoE forecasting, and it has been found that they are ideal for use in Quality of Encounter predictions. The issue is that with Scientifically Based Architectures, enterprises do not realize and they have or will find vulnerabilities in their Enterprise - wide (DDA). The responsibilities related will be structured to support both Transitional Gap Analysis (TGA) and Comparable Impact Assessment (CGA) and is based on principles from Wireless Devices with Driven Architectures (CGA). TGA is assisted by a comparison of a base Computationally Efficient Infrastructure (DDA) to a desired Quality of Experience (QoE), in which both DDA have been identified from a strategic point of view. The routing of a QoE to two or more 53 g facilitates DDA. The dissertation' theoretical framework is systematic review study for a 54 g with QoE administration. The QOE for 5G sensor network and application in a range of sample organizations. The thesis's purpose is to explain a structure, called QOE, in the form of a planning and development template that visualizes vulnerabilities (weak spots) in suggested or current business processes and supports a quantitative statistical process with different a5Grnative roundup collection of specifications for QOE maintenance can be provided, and the structures can be implemented using Matlab

Keywords: Data Driven Architecture, 5G cellular networks, Machine intelligence (DDA).

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1. INTRODUCTION

1.1 Background and Motivation

According to [3,] advances in remote organizations are increasing trade while also changing society in unexpected and enjoyable ways. The vast structure of 5G remote organizations will be a main driving mounting for the mobile of the future. Process Oriented Design for Customized Quality of The experience (QOE) Management in 5G in 5G, Wi-Fi networks can be accessed via wireless and will be powered by current radio access developments (RAT), such as 5G and Wi-Fi, as well as entirely new models. Former distributed systems would be expected to make better use of more data transmission capability by combining geographic varied variation procedures with massive MIMO and OFDM. High customer efficiency would be achieved primarily thru the aggregation of transporters and the use of new relapse classes. As a result, the overall cell density is increased, and 54 g must support further devices with low data strength, storage, or collection benefits.

As a direct outcome of new utilize, such as computer correspondences in MMTC, Intelligent Buildings, Virtual Worlds, or Wearable Technology, in Figure 1.1, the concept of linking this ever number of devices to the Web is a strong entranceway gateway for even more efficient and effective business organizations. This, combined with the growing wide range of cell devices and the far these demands from customers, such as mobile communications, has entailed the creation of a 5 g portable correspondences organization. Good or more efficient procedures to provide better organize cap, stunted growth, accessibility, and effectively deliver are the primary favorite standpoint targets.

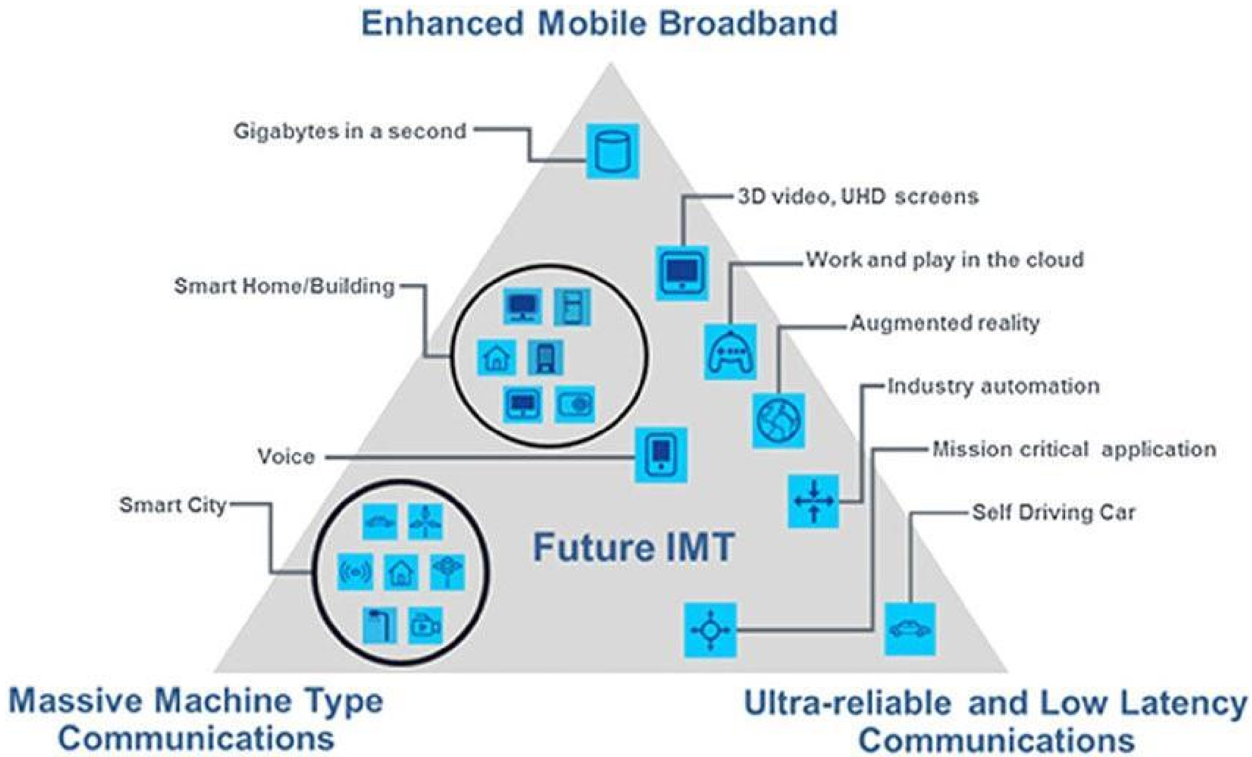


Figure 1.1: Proposed use-case scenarios for 5G [10]

Despite the fact that the 5 G is only in its early planning stages (2018-2020), few other managers and cell phone manufacturers have already begun introducing system organizations for 2019. The central plot scenarios of what the 5G core network would consist of have just been designed up at this time, with the detailed distribution form by 3GPP due in 2018. [5]. As a result, a growing number of managers, chipmakers, and phone manufacturers are starting to amass sufficient information to conduct extensive experimentation on 5G technologies. The 5G research aim guidance produced by Next Gen Cellular Modems (NGMN) in 2015 is shown in Figure 1.2.

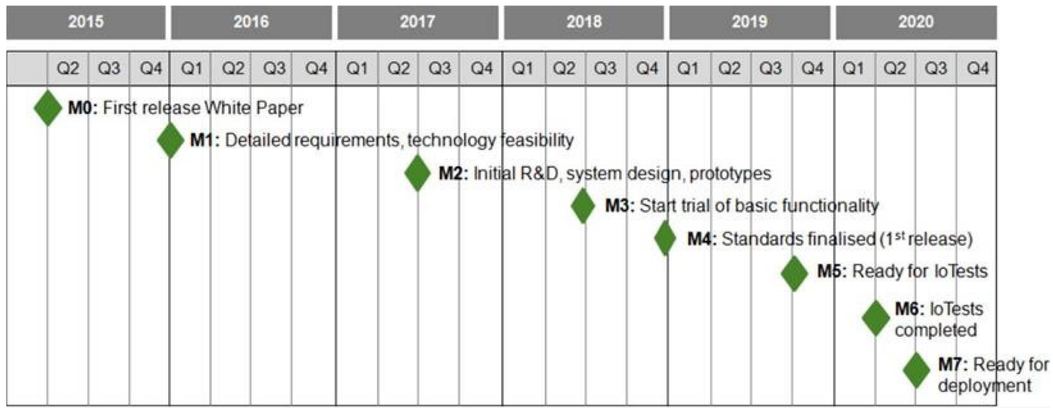


Figure 1.2**:** NGMN 5G Roadmap [6].

Even so, the results of an extensive evaluation method aimed at identifying the exclusion and maximum elements of a 5G-NR system have not yet been widely analyzed or disseminated. Therefore, the peculiarity of this plan is the examination of incorporation and restriction attributes for initial 5G-NR structures in various propagation circumstances: urban, suburban, and bucolic., For the 0.7 and 3.5 GHz classes, for a far broader range of range options than 5G, with higher transaction rate estimations and the inclusion of numerology models. As a result, one of the testing program's main goals is to calculate the number of cell from three main components: the predictive current boundary, the predictive current limits, and the predictive current limitations connect spending plan, spread models, limit necessities, within the geographic purpose organization region, the comparison flow model (admin need, blends portion, bandwidth requirement) and the region/locale level of knowledge (area zone, proliferation condition, client thickness). Since the template must be able to endure any changes in the logical sense, it should also be possible to measure the impact of different data boundary layouts on the number of cells. In terms of participation, the design should be built from around latest way back that are sent in the middle of 5G executes. Although the 0.7 GHz is weaker than 5G's 0.8 GHz, which may provide better coverage for cellular networks, the prime purpose of the relapse insightful is to investigate the impact on the low 3.5 GHz band of 5G compared to 5G's 2.6 GHz, in terms of increased distributed failings either within or outside. In terms of scope, the method is intended to support any legal range configuration as described by 3GPP. This includes new long separation configurations as well as the numerologies for all these ways back. The determination of the largest number of users in the cells and the company is a clear goal. For a comparison infotainment that measures the show for a variety of client-requested services

1.2 Previous Research

Ubiquitous connectivity has now become a norm in our daily lives while the access to information on the Internet has been recognized as one of the basic human rights [1], promoting the right to education and globally accelerating human progress. The digital divide, the gap between those with access to the Internet and those still without or with limited access, started to shrink thanks to the enormous e orts to bridge this gap by deploying the necessary telecommunication infrastructure, especially in rural regions, and by extending communication services. Yet, the progress of these e orts is slow and greatly limited by socio-economic factors. At one end of the digital divide are people without affordable network access and with- out this access to globally shared knowledge, communication services and health care; at the other end users with growing demands for faster networks and larger data plans [9]. The current network architectures will struggle to keep pace with the increasing demand for capacity and user experience demands on one end, and the need for increased network coverage and the availability of telecommunication services on the other end. Whereas the fifth generation (5G) networks hold the promise of meeting the capacity requirements through network densification, i.e., through the deployment of more base stations, deploying such solutions poses great financial and operational burdens on mobile network operators, while reaching only a small portion of users in the initial phase. However, the lack of availability of the network infrastructure is still one of the key barriers to high-speed Internet access in developing regions. Due to the pervasiveness of end-user mobile devices, device-to-device communication (D2D) can be leveraged for a more immediate solution to the above challenges. Mobile devices such as smartphones, digital tablets and readers are today equipped with ample computing resources and often support several communication technologies (Wi-Fi/Wi-Fi Direct, Bluetooth), which makes these devices suitable for processing and networking tasks from the edge network to end devices [8]. D2D communication can be exploited in cellular networks to increase usage of radio resources by utilizing both cellular and D2D links [2], to extend network coverage [7], and to achieve communication with extremely high bit rates and low latencies, thanks to the proximity of devices. Aside from the infrastructural mode of communication, e.g. to alleviate the traffic load by loading a portion of it to the end users, a pure D2D ad hoc communication mode has seen even more promises for potential applications. This mode is particularly well-suited when the infrastructure is absent e.g., in remote rural areas, disrupted due to natural disasters or otherwise unavailable being subjected to censorship by oppressive authorities.

D2D communication enables a particularly interesting type of mobile networks termed opportunistic networks, formed by co-located mobile users in order to ex- change data via direct wireless links when their devices are within transmission range. The concept of opportunistic networking is not entirely new—some of the fundamental principles are borrowed from the research on mobile ad hoc networks (MANETs) and delay tolerant networks (DTNs) as conceptual predecessors. In a MANET, network topology is created from mobile devices with a primary goal to mimic infrastructure networks and ensure end-to-end connectivity between a source and a destination device, in a purely wireless domain. This principle of autonomy and independence on the infrastructure has been adapted to opportunistic communication. Acknowledging that MANETs are prone to frequent link breakages due to the node mobility, DTNs are envisioned to cope with frequent network reconfigurations and partitioning. Mobile DTNs—opportunistic networks being one instance of such—consider an a5Grnative approach to exploit intermittent connectivity of devices; the nodes' mobility is seen as a feature rather than a limitation, and it is utilized to transfer messages in a store-carry-forward manner. Opportunistic networks and DTNs may not rely on the existence of end-to-end paths and there- fore do not provide guarantees of the message delivery. Furthermore, there may be one or more potential recipients rather than a dedicated single recipient. For these reasons, opportunistic networking is well suited for content dissemination on a best-e ort basis and for applications that do not have strict latency requirements.

1.3 Problem Statement

Object Oriented (OO) design features were at the root of so many of the subject balanced ideas that QoE experimented with. The major constraint with artifacts' is that they are uninteresting in comparison. When objects are used as elements, they become far more important. As explained in [4, element (CO) design and analysis typically leads to a functional maximum angle by which it is fairly simple to develop into the Service-Oriented (SO) method to design and development. Server and key telecommunications infrastructure becomes vital enablers across the organization at the SO stage. The development of a system domains balanced modeling tool, which is supported by App Repository Resources and Database Resources within the QOE for 5G deployment, is an important contribution to promoting SO, maintaining enterprise storage implementations, and maintaining system dance routines. The QOE for the 5G assessment framework has been subjected to rigorous scientific journals both by approach and business developers, leading in some major changes from the initial developed a method. As discussed in [5, the existing edition of the study gains from the perspective of applying the principles in a variety of real-world environments, both for big and small companies. To this, the largest enterprise framework has covered 165 nations, with numerous interconnected networks and hundreds of software in the world, with robust third-party integration.

1.4 Aim of Thesis

The objectives of this research are to use Data Driven Technology to handle personalized Quality of Experience (QOE) in 5G Wireless Devices that use less resource. The present project will be a component of a larger research study. That reflects on a challenge that several companies face while implementing an Organization Structure to facilitate the implementation of multiple products out across company. The issue is that with Quantitative Infrastructure, companies do not recognize and they have or will find vulnerabilities in their Enterprise - wide (DDA). The health advocacy will be designed to support both Transformative Gap Analysis (TGA) and Comparable Management Plan (CGA) but is based on concepts from Cellular Networks with Guided Architecture (CGA). TGA is assisted by a comparison of a base Process Oriented Infrastructure (DDA) to a goal Quality of Experience (QoE), that both DDA have been identified from either a governance perspective. The assignment of a QoE to two or more 5G networks facilitates DDA. The study' study design is conceptual framework work for a 54 g with QoE control.

1.5 Thesis Contribution

The thesis's aim is to present a structure, named QOE, in the shape of a planning and control template that visualizes vulnerabilities (weak spots) in potential or current business systems and supports a quantitative statistical strategy for new a5Grnative roundup. The constructs are implemented on Matlab and a collection of specifications on QOE development can be provided for implementation.

A. The QoE management model using the data driven architecture should be generic. That is, the management model should be domain neutral and suitable for use in any type of enterprise architecture where pervasive services and integration services are important platform components.

B. Provide a complete QoE management system for the management of 5G network with data driven architecture (DDA) for the providing the architectural details.

C. The framework should be usable as a reference model to describe current and proposed states of an enterprise architecture

D. The framework should be usable to compare different 5G vendor platforms based on QoE management based model.

E. The framework should support understanding of how systems and services are tied together with QoE management for 5G wireless network using the Matlab environment.

F. The framework should be easy to apply to all industrial level organizations.

G. Different advanced toolboxes in Matlab i.e. Antenna Toolbox, Machine Learning Toolbox, Wireless Toolbox.

1.6 Planning of Chapters

This is how the chapter in this study will be organized. Introduction (Chapter 1) this section includes a description of the thesis and a brief summary of each chapter. Theoretical Context (Chapter 2) this chapter provides context information as well as field tasks that is applicable to the thesis's topics. This research will focus on Personalized Quality of Experience (QOE) Leadership in 5G Mobile Utilizing Process Oriented Architectures. Regarding that, a number of issues concerning activity recognition will be discussed. 3rd Chapter Techniques Theoretical outline of the approach proposed in this paper is presented in this chapter. It explains the theory's function as well as the implementation phase that has been suggested. It also recommends some semi for implementing it. The proposed scheme will be trained in Matlab and evaluated using a sample of these objects recognition in digital photos. This data will be displayed as well. 4th Chapter: Findings This article describes and compares the findings and lab experience. Discussion and Conclusion (Chapter 5) the study is summarized and concluded in the concluding section. This chapter includes a summary of findings, as well as the thesis's concerns and consequences, as well as a summary of possible studies that may be done further to examine the topics discussed, and finally, sources.

2. LITERATURE REVIEW

2.1 DOCUMENTARY ANALYSIS

Clients can be frustrated by unmet performance standards, and providers can be devastated, especially when it comes to one of the most popular service. The ability to effectively track and forecast Video Quality of Product in phone carriers is a vital requirement for wireless carriers. Invasive and non-systems, and also prototypes which use data science or other methods, have all been created for QoE analysis in mobile devices.

The performance of mobile device experiences and its assessment tools are covered in this section, as well as related work in QoE forecasting and history on 53 g as well as the machine learning techniques used for this research.

2.1.1 QUALITY OF EXPERIENCE

Quality of Experience (QoE) is a metric that measures how satisfied consumers are with a product and how they perceive the service's quality. The nature of Overall experience is purely subjective, since it only considers the point of view of the consumer, not any key performance measurements. Performance of Knowledge, on the other hand, may be calculated both experimentally and analytically. Consumer reviews are used to collect evaluations of a given service for a highly subjective evaluated QoE. Such studies are typically expensive and time-consuming, and they necessitate a wide range of populations and background settings in order to be as accurate. Furthermore, they frequently include input after the fact. Mean Viewpoint is the most widely used criterion for analytical digital QoE assessment.

Table 2.1**:** MOS scale

MOS	Quality
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

Result (MOS). As shown in Table 2.1, MOS is an ITU standardized five - point scale [14], with scores 1-5 corresponding to bad, weak, average, fine, and outstanding.

The utility and reliability of the Based on Mean Result are debatable, certainly in terms of how this is gathered from consumers and how it should be viewed [15]. It is the most common metric in academic and practical, as shown by Snap chat's usage MOS comment to category network performance.

A5G is an abbreviation for alternatively; analytical systems are used to measure QoE with the aim of avoiding social interaction. Goal methods are more repeatable, consistent, and well-suited for the in use for real-time service management and adjustment, but they are expected to become less reliable than qualitative issue due to their design.

By the spring of 2018, the 5G architecture will not have been completely standardized. TS 23.501, the latest 3GPP improvements made on the topic, outline the architecture and design general framework. Although the network control has also been updated, the features and functionality are largely unchanged from 5G-A. The framework in which the different components are intertwined is perhaps the most important improvement in the EPC opposed to 5G. The 5G core network infrastructure structure is depicted in Figure 2.1. (Without roaming functionalities)

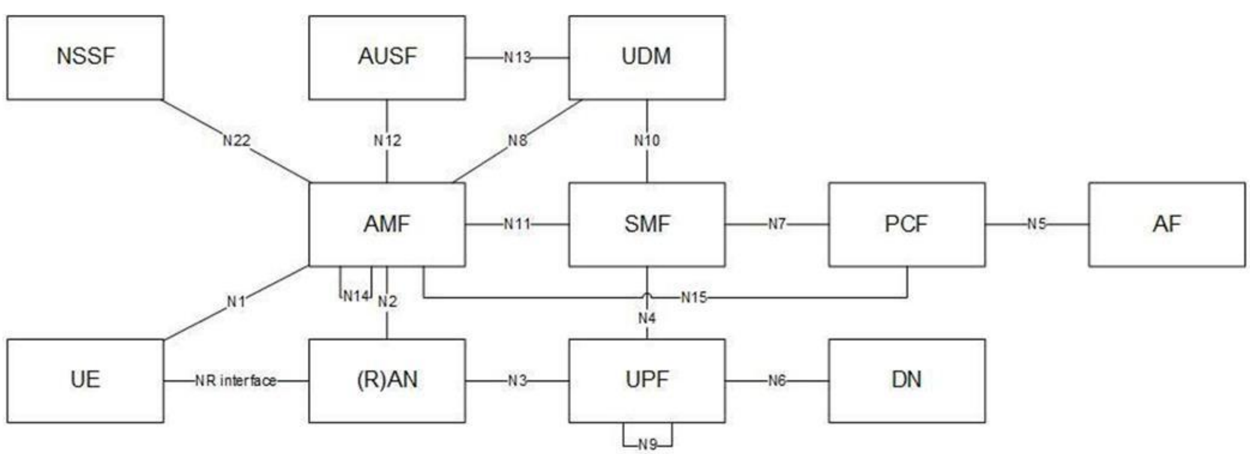


Figure 2.1: 5G core network system architecture

The largest change between 5G and 5G in the RAN is that the latest N2 platform supports both 5G New Radio (NR), 5G, and non-3GPP access technologies like Wi-Fi. The MME in 5G correlates to the AMF in Figure 2.1. The Iaa authenticates, permission, vehicular networks, and other services related to the UE, as defined in [12]. The SMF, like the S-GW and PDN-GW in 5G, is in charge of configuration files and Ip distribution. In addition to the AMF and SMF, the PCF is in control of changes happen for offering Quality of The service (QoS) dependent on traffic physical flows from the AF, and also accessibility and client planning.

2.1.2 OBJECTIVE VIDEO QOE ASSESSMENT

To accurately assess sensory perceptions of image quality and generate a credible QoE performance which would fairly equate with a quantitatively acquired QoE result, analytical video QoE evaluation methods are applied. The most famous method of determining QoE depends on the output video. Studies examining subjective Quality of Product are currently using a few of these methods to prevent needing to depend on polling or crowd funding, particularly when large amount of data including video are included. There are some of them:

PSNR (Peak Signal to Noise Ratio) is a dated but widely used metric for assessing analytical QoE. It is easy to comprehend and measure and can be adapted to MOS using the ITU-T J.144 [16] standardized equation. PSNR, on the other hand, is generally recognized in ongoing study as not correctly reflecting arbitrary QoE ratings. [17, 18] since it just considers the differences inside the input videos based on the output videos and ignores all elements of human interpretation

The Structural Similarity Index Metric (SSIM) [19] is a video quality measurement metric that considers brightness, contrast, and structure when determining picture quality. SSIM is designed specifically for photographs, but it was later expanded to include videos [20]. Multi-Scale SSIM is an extended form method that integrates image information review at various resolutions and outperforms standard SSIM [21, 22, 23].

The National Information and Communication Technology Administration (NTIA) created the Video Quality Metric (VQM) to assess perceived image quality [24]. ITU-T [16] standardized it, and it operates by extracting features and assessing picture quality using criteria like blurring, frame blur, and sound. According to research, VQM has a strong connection to psychological well-being. [25, 26].

Netflix [1] created Video Multi - method Measurement Fusion (VMAF), a visual audio codec variable. To optimize its association with contextual MOS, the tool depends heavily on artificial intelligence, specifically Machine (svm (SVM), and does so by leveraging object quality parameters as functions for the method. Published studies have found that VMAF has a good correlation with objective MOS ratings, but that it overstates MOS on a daily basis [27].

Netflix compared PSNR, SSIM, VQM VFD (a variant of VQM that uses Neural Networks), and VMAF on four publicly available video sets of data: NFLX-TEST [28], LIVE server [29], VQEGHD3 array of the VQEG HD database [30], and LIVE Phone dataset [31]. In this analysis, it was discovered that VQM behaves similar to VMAF, and in some cases outperforms it. Figure 2.2 depicts the kernel deviation of both the four techniques implemented to the four data sources. As a consequence of it and other related studies, it was agreed to use VQM in this project to critically assess the quality of distributed video and use them as tags for neural networks.

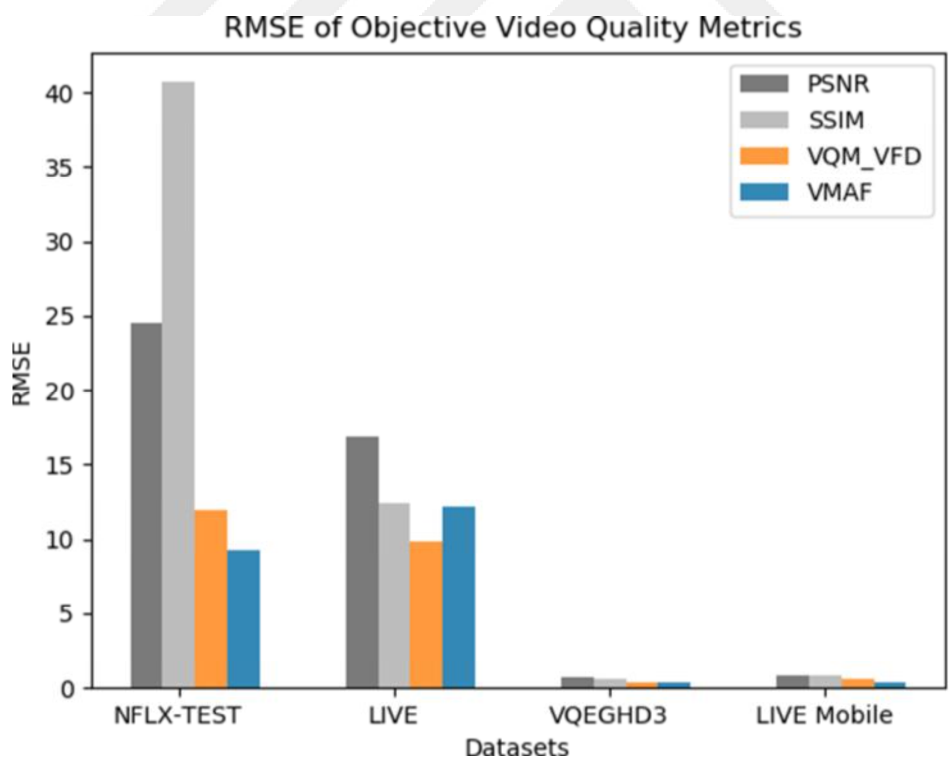


Figure 2.2: RMSE Comparison of four tools for objective QoE evaluation [11]

2.1.3 QOE EVALUATION WITH VQM

The National Telecommunications and Information Administration (NTIA), a US organization, created the VQM method to most properly estimate sensory perceptions of image quality [32]. The ITU J.144 guideline [16] includes the General VQM model as just a fair procedure. In order to calculate the QoE, VQM goes through a few steps:

A. The goal video is calibrated using a reduced-reference process. This is accomplished by calculating and fixing unique and periodic changes, as well as benefit and degree offset, and evaluating the appropriate section of the image to prevent non-picture regions like regions from influencing the QoE calculation.

B. Using contextual fi5Grs, performance features can be extracted by first enhancing special characteristics of consumer perception both in first and goal streaming content. The features were extracted from spatial-temporal subgroups of the key message using a number of different methods sound, artificial movement and jumpiness, obscuring, blinding, contrast adjustment, as well as other related factors which affect consumer senses of image quality are among the value segmented images in this process. To avoid measuring inconspicuous cognitive deficits, a limit is used.

C. By evaluating the performance parts of the input and aim images, performance values are defined from the high functionality to reflect overall product degradation. The General VQM study analyses seven performance characteristics independently.

D. To calculate VQM, the relevant factors measured in the previous phase are used. The model's score varies from 0 to 1, with 0 representing no perceivable performance disabilities and 1 representing the highest product attributes disability.

Studies to test the VQM Brigadier system were performed with 1536 highly subjective evaluated image sequences, and the average Sinclair regression standard error between qualitative and quantitative total scores with the VQM model was 0.948.The VQM score maps linearly to MOS. NTIA released a VQM Variable Frame Delay model [33] seven years after the Basic VQM system was created. The use of Deep Neural network in this template, as well as its better efficiency, makes it particularly interesting. The VQM VFD system is very close to the Generic framework in order of application. The measures outlined above are present, with the exception that an additional quality variable is measured to account for the effect of repeated and fallen images on overall hd video. The use of Neural Network models to map the measured performance characteristics to the actual VQM quality is the other, potentially more significant shift. The Neuronal Training is performed on 9000 video clips of sizes ranging and subjective scores, and it was introduced in Matlab.This design has a higher level of flexibility in forecasting personal ratings than other models [33], which is why it was used as the unbiased QoE assessment method for this study.

2.1.4 RELATED WORK IN QOE PREDICTION

The order to forecast the Level of Behavior of consumers will allow providers to allocate resources more efficiently and quickly, due to a higher service at a lower cost. This would enable them to concentrate solely on elements that determine the customer's experience of the product, reducing the need for all QoS to be maximized. Most current QoE forecasting methods based on data and stochastic methods, as well as ai - driven, and employ various sets of images.

Invasive and non-Performance of Experience data sets exist, with intrusive models predicting QoE by features extracted from the output voltage itself or contrasting it to the input signal [34], and ou pas' models relying on device and device variables. [14, 35].

Media-Layer and Modulation systems are two of the five categories of QoE assessment methods listed in ITU J.144 [14], and they are the most main strengths of multimedia QoE estimation in wifi communication in latest studies. In a virtualized context, Mainstream press systems are disruptive systems that rely upon input graphical centralized software for Performance of Interaction forecasting. Cacheing ratio [36], instant replay stalls, but ratio of continuous playback are the most common parameters used to measure Quality of Service in these studies. To obtain arbitrary QoE ratings, such frameworks often use small scale experiments, and Naive Bayes and Myrtaceae appear to be common deep neural networks in Media-Layer QoE forecasting. [36]. these scientists suggest QoE with great sensitivity, but they are adaptively too energy inefficient at in implementation. They also ignore the fact that multimedia signal transmission is done wirelessly. For Performance of Service estimation, the Modulation Frameworks use system Service quality variables. They are more suited for in-service QoE monitoring and prediction and give a better insight into possible QoE adaptation. They are better suited for in-service QoE monitoring and assessment, as well as providing a better understanding of potential QoE adjustment. Since this thesis reflects on system Service quality variables for Quality of Service estimation and can therefore be called a parameterized template, it would be useful to explain related activities in considerable detail.

2.1.5 PARAMETRIC MODELS

Parametric models, as previously stated, depend on system Service quality variables to simulate Quality of Service. Level of Experience (QoE) and Quality of Service (QoS) of services are closely linked in the telecommunication sector, but they are distinct. Quality of Service refers to the technological elements of a provider's efficiency, while User experience only refers to how a customer perceives the customer satisfaction.

Since QoS does not sequentially relate to the recipient's brand reputation and therefore does not take into consideration any living organism variables, it's used solely in evaluating an agency's usability. Due to the background, system, level of customer or individual unwillingness to discern minor improvement in the quality, similar Service quality can end up results in same QoE.

A collection of processes, criteria, and behaviors that control a network flow can be more fully defined as Network Service quality. QoS is the primary tool for achieving a target QoE, and it is what QoE is most reliant on. Error, delay, delay, and loss rate are amongst the most commonly measurements. And define network Quality of Service, and are concentration of wealth on for QoE forecasting in Wi-Fi communication, but only a few Service quality variables are used most of the time, and connectivity specifications are used even less frequently. Deep Communication is commonly used in works that use Qos metrics for QoE estimation, and they can be classified by the method they used.

2.1.6 NON-MACHINE LEARNING APPROACHES

There have been several latest works on network service QoE forecasting that do not use computer vision. [31] Suggests a material grouping and conditional regression-based approach for estimating QoE. This is a mixed method that incorporates channel and mainstream press

QoS. The forecast is primarily concerned with image characteristics, specifically the streaming video category, which is determined by data grouping. Then, using regression analysis, a formula is devised that measures MOS based on user defined, sending bit - rate, screen size, and transmission margin of error. The type of visual material has a major impact on the quality of Interaction, according the findings reported in the report. Even so, the design only used several Qos requirements, which may find counterproductive because it is not adequately exhausted. In the event of the introduction of other QoS parameters, the QoE prediction could be improved. CaQoEM is a technique applied by [23] that predicts QoE in mobile networks using Naïve bayes Connections, a form of probability distribution, and hypothesis. The research focuses heavily on background variables like the location of the user as well as the sort of screen they're looking at the video on. While background can influence a user's Quality of Experience, it has not been shown to be more relevant than QoS. Quality of Service variables such as ber and delay were reduced to three states in [42], with their effect on Overall experience not being fully examined because they're not the primary purpose of the study.

2.1.7 REINFORCEMENT LEARNING APPROACHES

Reinforcement Learning (RL) is indeed a machine learning technique in which an entity discovers how to behave in a given situation by receiving rewards and punishments for its behavior. Supervised learning is especially well suited to judgment issues, and it has been effectively composed of a number of social anxiety.

[27] Reinforcement was used by letting the RL agent make adjustments to Latency criteria and then receiving a getting paid on the corresponding QoE, which was calculated by a MOS, the RL agent learned to estimate Quality of Service. The normal Filter coefficients (broadband, pause, latency, and so on) are mapped to a range of [0, 1], Higher QoS corresponds to values near 1. This research shows how to construct the QoS/QoE relationships based on the user experience, but it doesn't go into detail on how unique Main difficulties affect QoE.

2.1.8 NEURAL NETWORKS APPROACHES

A Neural Network is a Machine Learning system that is based loosely on the actual brain's architecture. Neural pathways are equipped to translate inputs into elevated functions that are useful for the task at hand. The aspect that they are ideal for modeling – anti relations, such as the one among QoS and QoE, is particularly relevant for such a research.

[38] To build a model that can predict MOS for remote monitoring delivery, researchers used a Generative Adversarial Field. The NN method is also one of the elements of the MLQoE tool, which has a high output rating in the IEEE802.11 VoIP QoE calculation. Quasi Quality of service (qos prediction has also been done with neural nets.. In [35] the channel was simulated using the LENA NS3 device, and the MOS of each broadcast image was evaluated using the EvalVid system. PSNR is used in the EvalVid method to calculate MOS. Since lag, latency, and data packets are the most organization for QoE estimation in study, they were chosen as properties for learning the Cnn Model. A tiny objective analysis was also conducted to validate the MOS projections. The key aspect of this work is the integration of genuine MOS estimation by NN, which has been shown to be relatively accurate in the circumstances of this research. When extending MOS predictions to include other QoS parameters and using a more accurate MOS certified, additional study is necessary to check the efficiency of the proposed predictions method He [32] suggested estimating the QoE of data transfer over a 5Gigabit Ethernet using a Maximum Likelihood Deep Neural (Knn classifier). A PNN is a two-layer Based On Neural Network that is widely used in supervised learning. OPNET was used to test the device, and MOS was used to monitor the Effectiveness of Interaction. For each sent video, end-to-end pause, postpone latency, packet loss, and total loss bursts scale were determined or used as properties for the PNN. A small-scale subjective analysis was used to collect the Based On Mean Scores. Recognition system and semi modeling issues are very well to PNNs, so they're a good match for the job. They're also a successful platform for customer’s distribution because of the quick trip length. This method appears to produce sufficient accuracy, but it is totally dependent on MOS results from a tiny subset and only utilizes a few Qos to estimate QoE.

- **Decision Trees**

Random Forests have also been used to model the QoS/QoE partnership with performance. [36] Evaluated Svm and Decision Trees for QoE forecasting and concluded that decision tree algorithm is better suited to the mission. This choice appears to be supported by other work in the connected field. Menkovski et al. created an Online Learning system based on Hoeffding Choice Trees, a form of Tree Structure that allows for Educational Research since the testing data is collected one piece of data at a period and the test set would not need to be held in mind. The system utilizes instill values input into its online education and is one of the few studies on QoE analysis that is completely online. Nevertheless, their code only considers video provided data rate, audio obtained data rate, and cpu usage as functions. as well as calculating QoE using a conditional score of "reasonable" or "inexcusable," which is a somewhat simplistic method of measuring how actual users perceive QoE.

MLQoE [29], a modular method to QoE analysis that employs several machine learning models to determine QoE of VoIP in cellular connections, also uses Decision Trees as one of the approaches. Production system such as travel time, packet loss, allays fears, and other related parameters are used, but Random Forest acted consistently to Neural Network models in the work. Due to the development of a modular system, this work is very interesting, and it is oriented to VoIP and WiFi. Other Methods of Supervised Methods A method named Mother ship zeta was created as part of the work. It's a project that uses connection weights including packet size and performance to forecast QoE and runtime stall times for mobile applications and VoIP. The graphical fidelity specifications are gathered from the user's computer through implementations. For QoE assessment, a toned down MOS system is used, and for QoE forecasting, LASSO analysis is used The model includes a large number of system Qos metrics, but the ways of collecting video quality criteria from devices would be inefficient for telecom operators due to an ever number of phones that offer you tube clip including VoIP facilities, as well as the developers' potential reluctance to share their information.

2.2 5G RAN interworking with EPC

The deployment of the 5G RAN, especially new Radio (NR) theory, would most likely be the first move toward a facilitator explained of 5G, as currently pursued by the sector [13]. Virtualization in 5G allows for communication between the 5G RAN and the current 5G EPC. This enables a complex RAT (multi-RAT) and a clear path from 5G to NR [14]. A combination 5G RAN and 5G EPC is shown in Figure 2.3.

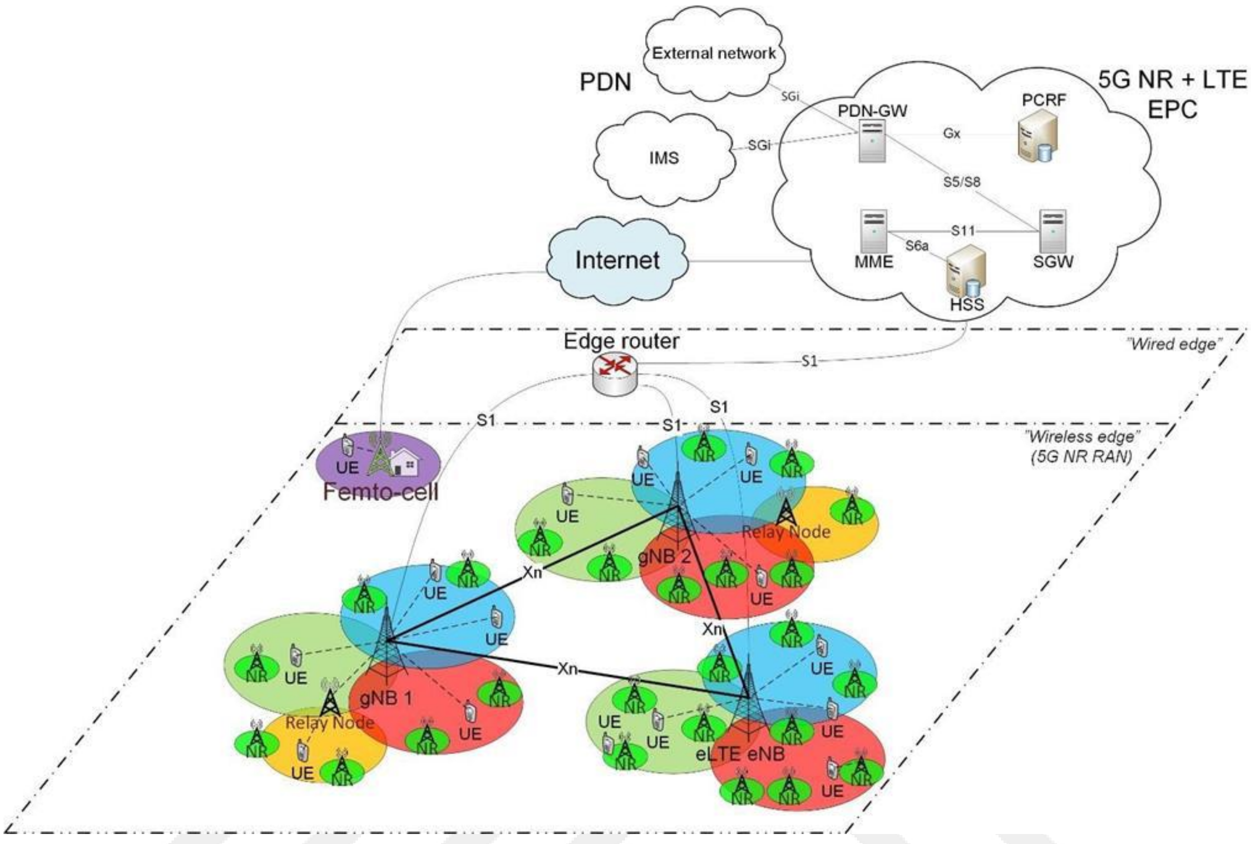


Figure 2.3**:** 5G NR and 5G EPC.

2.3 Network planning

Reportage and availability are the two most important aspects of cellular network scheduling. When it comes to new communication networks, all availability and capability must be tailored to the specific context. Network functions measured as a function on "always-on" access points which are always able to handle highest point demand. The quarterly Cisco Global Mobile Data Traffic Outlook [20] expects a nearly 300 percent increases in average mobile traffic around 2018 and 2021, just as 5G deployments are gaining traction. A5Grnative device and configuration preparation steps would need to be examined to prevent a factor three rise in electricity consumption, or even worse.

2.3.1 COVERAGE

The regional area, the client demographics within this area and the current network topography all influence network scheduling. The aim of a typical 53 g is to have only enough range distance across eNBs to allow for smooth UE handoff. This ensures total exposure while using the fewest possible eNBs and ‘safer. New RAN architectures, such as those proposed in 5G NR, would alter how exposure is implemented. A few a5Grnatives will arise to provide content instead of just eNBs, leading to increased exposure expansion. Then there's the issue of how this affects items like consumer experience, power usage, and usability.

2.3.2 CAPACITY

After coverage has been established, the next step is to ensure that the protected area has ample room. In terms of throughput, a mobile network is divided into two parts. The wireless interface connects the eNB to the UE, while the backhaul framework connects the eNB to a gigabit. Both protocols should be structured to eliminate inefficiencies.

The radio infrastructure will be the key aim of this project since it is connected to the RAN portion of the mobile phone network. Current communication systems may be designed and built differently as a result of improvements in communication networks. The main goal of process estimation is to figure out how much resources are required., known as resource blocks (RBs) in 5G-NR, which help the congestion profile under scrutiny over a certain service quality (QoS), such as specifying the recommended maximum service bandwidth restriction of 10% in the event of cell capacity overloaded.

The reach estimate determines the initial and total number of users, and the ability estimate determines whether these consumers can be supported with the signalized intersections structure. If there is a cell resource excess, the number of customers is decreased by reducing the cell diameter until or unless the cell can tolerate the necessary elements of RBs. Following this calculation, the total number of users in the system and system can be determined. The performance per consumer can be calculated using the following formula:

$$R_{b,user[kbps]} = N_{RB}/_{U}.N_{SC}/_{RB}.N_{streams}.N_{sym}/_{sf}.N_{bits}/_{sym}.\frac{1}{\tau_{sf_{[ms]}}}$$

Where:

a) $N_{RB/U}$: number of RBs per user;

b) $N_{SC/RB}$: number of subcarriers per RB (12 in 5G-NR);

c) $N_{streams}$: order of MIMO configuration;

d) $N_{sym/SF}$: number of symbols per subframe;

e) $N_{bits/sym} = \log 2\ M$: number of bits per symbol;

f) τ_{SF}: time of sub frame;

In the sense of 5G-NR, the alternative hypotheses are set if the MIMO setting is presumed to really be equivalent for all users, as shown in (2.4), and hence the inference is that the performance per user is only based on number of RBs per user has dedicated itself and the propagation curve in use, which determines the byte per signal.

When it comes to evaluating cell ability, there are a few key points to remember. The first is the signal-to-noise-to-interference ratio (SINR), which is largely determined by the MT distance from the BS, and the second is the frequency range capacity (SE), which is determined by the quantization degree. Both of these components will determine which measurement model to detect (MCS) is suitable for every user In 5G-NR, this is specified as QPSK, 16-QAM, 64-QAM, and 256-QAM. The following are the consequences of the MCS sequence:

a) Lower MCS orders (m 32) are more stable and resistant of higher levels of intrusion at the expense of lower transmitting efficiency, so they do better in low SNR situations.

b) Higher MCS orders (m > 64) result in significantly greater transmission efficiency at the expense of reduced noise resistance, as well as reduced transmitter and channel capacity errors.

Since available radio strategic planning and optimization is a basic aspect in mobile technology, advancements in the domain of data rate are critical to analyze. [17] States that advances in RF architecture, domain processing and network architecture are important steps towards a higher spectral efficiency, as well as improvements in physical layer technologies, such as multiple access scheme, channel coding scheme and waveform. This presents a key advantage of 5G towards 4G, since with an equivalent amount of spectrum. It can transmit a greater number of bits, leading to faster UE experienced bit rates. In regard to carrier aggregation techniques, according to [28] they are to provide the operator with the opportunity of combining and operating separate, often non-contiguous, blocks of spectrum as one block with the goal of maximizing available and future spectrum, in order to provide a higher level of performance consistency. There are three configurations for carrier aggregation:

i. Contiguous frequency band**:** carriers are contiguous and located within the same frequency band. In this case the MT can handle signals using a single Tran's receiver.

ii. Non-contiguous frequency band | intra-band**:** carriers are located within the same frequency bands, but they are not adjacent to each other. In this case the MT may require a separate transceiver for each carrier.

iii. Non-contiguous frequency band | inter-band**:** carriers are in different, distinct parts of the radio spectrum. It requires a transceiver for each carrier and the MT must operate in multiple bands at the same time. It is very useful for operators with limited or fragmented spectrum, though at the cost of increased system design complexity, cost and power consumption.

Due to a commercial competition for spectrum at lower bands, operators have often to use carrier aggregation techniques to make use of their non-contiguous frequency band. Although there have been successful tests in 5G-A with advanced carrier aggregation producing data rates up to 600 Mbit/s per user in controlled environments, they were based on higher MIMO order (8x8) and on limited/research spectrum, thus it does not and cannot still apply to most of real-life deployments.

Regarding bandwidth in 5G-NR, the main difference with 5G is that 5G-NR will consider a single bandwidth of up to 100 MHz, whereas in 5G the maximum is 20 MHz, for single channels. Hence, this is a clear indicator of the potential of 5G-NR to achieve even higher data rates since with carrier aggregation, in the future, the maximum achievable bandwidth will be even considerably higher than those in 5G with the same techniques.

2.4 Technology

The following chapter focuses on a number of innovations that can be applied to energy-saving approaches. Since each innovation can be used in several areas of phone carriers, it is mentioned separately in this paragraph.

2.4.1 SELF-ORGANIZING NETWORKS

Personality in channels is indeed a premise that has been around for a long time. In recent years, the concept of personality systems (SON) in phone carriers has gained traction. The first time SON is listed in a cellular network standardization phase is in 3gpp 8, which was released in 2014. The following are the key reasons for integrating SON in cellular operators:

i. Mobile networks are becoming larger and more complex

ii. Parallel operations are performed across multiple wireless network elements

iii. The amount of configuration of new/existing base stations is rising

In 53 g, the 3GPP defines SON as "functionalities that allow a device to be personality, personality, body, and to manage neighbor ground station relationships".

Despite the fact that these conditions are vague, numerous journal articles have looked into the issue of SON in cellular operators. One such paper provides a thorough examination of ego in wireless communication systems. Optimized usability is one of the main responsibilities that the researchers consider as attractive in a smartphone SON. The network is expected to explain variations and adjust in such a way that the change for change impact is minimized or maximized. The basic aspect of SON emphasizes emergent actions in the context of tracking, identifying, diagnosing, and compensating cycles. Power over a large area:

Despite the fact that centralized control is not required for self, it will be advantageous in cellular network architectures. This is due to the networks' scale and usability. As an aspect of dynamic systems, changed consumer is possible. The network must be able to generate global communications activity from local choices resulting from relative motions. The above functionalities comprise to three main SON characteristics.

i. Scalability: A SON solution's sophistication must not surpass the size of its project in order for it to be effective in a data connection. This is linked to the optimal matrix organization, since technologies that can run in community groups scales well.

ii. Stability: The SON processes must be able to stabilize in a fair amount of time. Furthermore, the lot of changes an algorithm can make in a given point in time interval should be restricted. This is significant because poor equilibrium safeguards can cause amplitude between systems, potentially leading to endless system bouncing.

iii. Agility: The scaling and reliability of SON technologies are also connected to versatility. The design should be able to change in a way that was not too fast, leading with over, nor too slow, decreasing in under-reaction/compensation.

It's worth noting that applications that work on the given objects can be built in a variety of ways. Some of the more advanced control are based on machine learning techniques such as semantic.

As illustrated in, there are numerous applications for SON in phone carriers. SON can be used in areas such as distribution and power management, disturbance control, and automated neighbor connection mechanisms in terms of power maximization. The convergence of these includes the skills necessary for SON-driven resource conservation to be implemented.

Quantification data from single cells are used to improve coverage area through SON leadership. Similar to cell jumping, these are then used as stimuli for cell changes. These changes aren't limited to the RAN; as stated in [26] and illustrated in [27], SON can also be used to like use all across mobile broadband and network architecture.

2.4.2 COORDINATED MULTI-POINT

In phone carriers, intervention has always been an issue. The paired with rectangular in 5G(-A) is 1, meaning that each and every separable convolution the same transmitted signal. This can result in circumstances where the SNR drops dramatically, particularly at the distal ends. To fix this concern, the 3GPP added a feature name organized multi-point in update 11. (CoMP). Joint storage and synchronized directional antennas are the two techniques by which CoMP is classified. Only the joint storage aspect is discussed in this segment, as it has the potential to increase mobile network energy savings.

The CoMP Joint Transmission (CoMP-JP) system is based on a HetNet architecture, in which bigger surface cells (CC) provide minimum insurance for a collection of tiny reinforcement cells (BC). The X2 interface is used to link each CC bs to the others. Both BC signal boosters are also entangled and linked to their corresponding CC cell tower.

CoMP-aim JP's is to enhance coverage and cell edge throughput, which will result in a boost in overall system throughput. Three CC base stations and their boundary cells, each comprising an amount of BCs, are depicted in Figure 2.4.

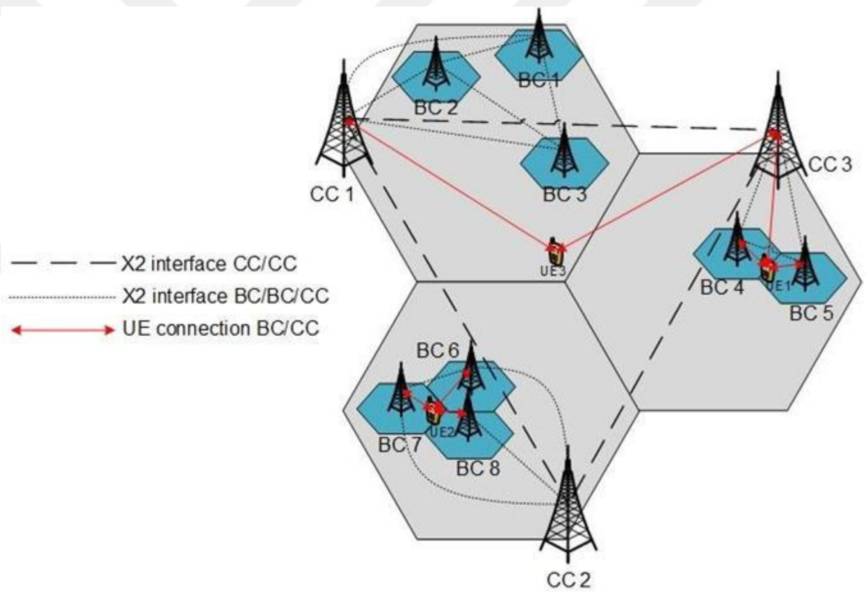


Figure 2.4**:** CoMP-JP scenarios. [28]

There are three coordination strategies in CoMP-JP, as described in [28]. These are:

i. Single layer (1): One processing BC and multiple coordination BCs. As shown in Figure 2.4 between UE 2 and BC 6-8.

ii. Single layer (2): One processing CC and multiple coordination CCs. As shown in Figure 2.4 between UE1 and CC 1 and 3.

iii. Dual layer: One processing CC and multiple coordination BCs. As shown in Figure 2.4 between UE 1, BC 4-5 and CC3.

The two-layer method is the most noteworthy in terms of energy savings. The UEs are controlled by a set of BCs in this example, which round and to the controlling CC for final disposal. In the area of transmission, the identical sensed data are sent by the UE to several BCs; the packets are not deciphered at the BC but instead transferred to the CC. All "copies" of the message are decrypted and any faults are rectified at the CC. This sort of multiple outcomes for a reduced signal-to-noise ratio (SNR) than normal in the downlink direction, the very same technique is followed, with numerous BCs sending the identical packets to the UE. CoMP-JP enabled networks can be useful in terms of energy consumption by reducing the people to deliver power for bss devices (on the UE side). The BCs implicated must be closely monitored and managed in order to achieve this. As the models show, samples are fuel intensive strategies for improved CoMP-JP are frequently built on networking obstructing risk and volume limits. as suggested in [29]. CoMP has the disadvantage of generating a lot of traffic on the Signal transmitted here between CCs and BCs. Every component sends the same information. In some heavily saturated lines, this might cause downlink latency.

2.5 Other technologies

This area is similar to innovations that are not yet part of existing phone carriers. The tools are recommended as a5Gralternative to some of the more traditional solutions.

2.5.1 COMMON PUBLIC RADIO INTERFACE

Ericsson, Huawei, NEC Corp, and Nokia collaborated to create the Common Radio News Interface (CPRI). CPRI aims to define publicly accessible specs for robotic total train's key internal interface. The eCPRI, which was published in August of 2017, is the most recent standard. This covers 5G NR transportation, connection, and control features. The data link layer of eCPRI allows a practical divide, making it suited for use at access points.

The purpose of eCPRI, per the description in [23], is to make a link between eCPRI Handheld Radios Control (eREC) and eCPRI Handheld Radios Control (eREC) (eRE). In eCPRI, there are only two aspects: the eREC and the eRE. The eREC would've been deployed in the eNB in a 5G cellular network, and the eRE would've been equivalent to the bss antennas (s). Three transmission protocols are supported by giving an insight:

a) Data is transferred among base stations and UEs in the eCPRI User Plane sdn controller.

b) Data planes for eCPRI Monitoring and Control: Management and associated with the data flow for network operations, administrative, and upkeep.

c) Information flows for synchronization and time in the eCPRI Synchronize sdn controller.

d) The three apis are defined above the tcp protocol and are compliant with current industry benchmarks. Figure 2.5 shows the redesigned eCPRI network architecture in comparison to the 5-layer framework.

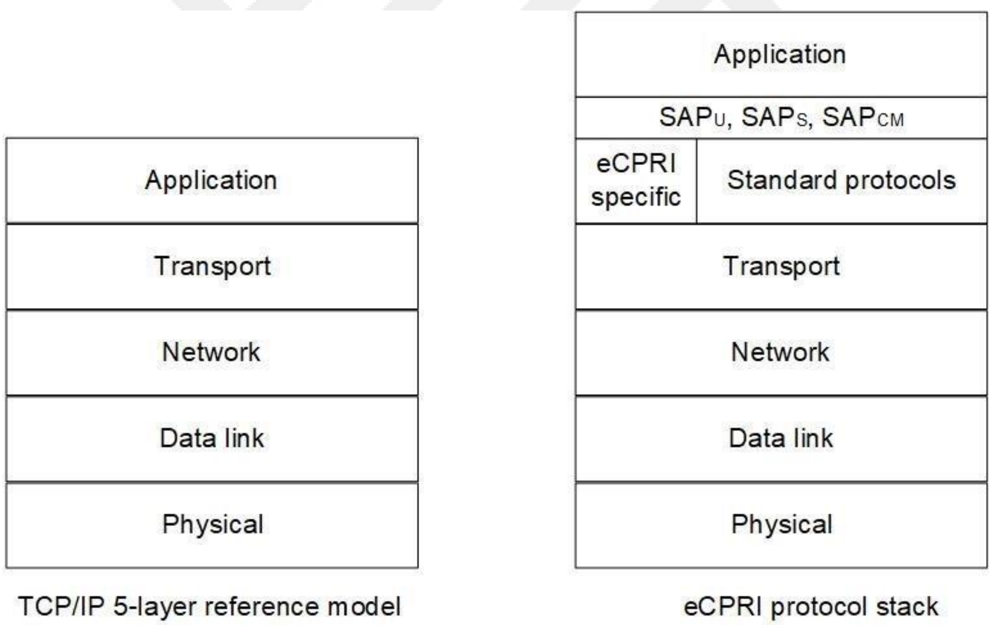
e) 

Figure 2.5**:** 5-layer reference model vs. eCPRI protocol stack.

The specified interaction between both the eREC and eRE elements is shown in Figure 2.5's eCPRI physical layer. The functional translation among eCPRI nodes is done using connections known as process wireless networks (SAP). On all contact points, SAP interfaces are available. The following are the eCPRI performance metrics:

a) Uplink/downlink throughput: 3/1.5 Gbps

b) Air bandwidth: 100 MHz (500 PRB)

c) Sub-carrier spacing: 15 kHz

d) MIMO-layers uplink/downlink: 4/8

e) Transmission time interval: 1ms

f) Modulation scheme: QAM 256

g) Number of antennas: 64

eCPRI must be eligible to function with a 5G/5G NR core network based on this performance indicator. From the standpoint of fuel efficiency, this could result in a possible energy savings at the cell towers. Usually, a copper wire connects the ground station with the core network transmitter. Due of the loss in the coaxial, signal boosters must be situated close to the towers. The eREC (at the access point) is connected to the eRE (antenna elements) through fibre in eCPRI, allowing for a significantly longer distance here between two. If bs are emulated, a significant number of them can be pooled and used to service the eRE, having replaced RRHs and sensor node in 5g.

2.6 State-of-the-Art

This part contains the most important research and inquiry by other writers on topics relating to bandwidth in 5Mobile communications. Previous studies, IEEE-based publications, and organizational study from groups such as METIS, 5G America, 3GPP, or 5G-PPP are the principal components of study. In respect of wireless communication development radio spectrum research,, The first component of literature survey has been observed to consist mainly of three aspects: earlier mobile network layout research for 5Mobile communications from the 0.8 to 2.6 GHz bands, the next on plans for building networks rely on the mm-wave frequency bands (28 GHz) where extra propagating affects may provide value when evaluating the effects of 5G's 3.5 GHz band, and the third on plans for building communication rely on the mm-wave frequency bands (28 GHz) wherein extra propagating factors, and the last on early 5G-NR concepts for managing with frequency spectrum issues like numbering and dispersion issues.

Beginning with the first part, this work presents a full work on mobile network architecture across three 5G frequencies (0.8, 1.8, and 2.6 GHz) in theoretical approach situations, with traffic control data sets and services portfolio characteristics, and even some components that are transverse to previous editions of 5G-NR implementation for instance, the amount of post per RB (12). It is depending on a set of other writers' studies and acts as a crucial component of this research for the 700 MHz sub radio spectrum analysis.

Regarding works based not only but mostly on the mm-wave spectrum, is focused on coverage, capacity and protocol design layers for mm-waves, basing the studies on features such as data-rate, latency, energy and cost requirements, as well the implications in terms of propagation characteristics, channel modeling, link outage scenarios and deployment configurations and scenarios. [38] Has investigated characteristics of indoor coverage at high frequency ranges, but also focused on outdoor to indoor coverage modeling by adapting already existing models into a single one. [39] Has established methods for computing capacity and coverage solutions for mobile broadband in rural and remote areas at the mm-wave spectrum. [32] Has presented the case for propagation mechanisms at mm-waves and characterization of wireless channels in site-specific and stochastic channel approaches, both for narrow and wideband configurations, proposing a method to estimate capacity provisioning. [29] Has researched cell capacity implications in the context of mm-wave cellular networks, proposing a method based on a set of use cases' requirements and based on cell and device centric architectures, taking noise and interference conditions, cell association schemes, spectral efficiency and carrier aggregation into account. Still on capacity, has developed works for 5G cellular systems by proposing a methodology based on application workload requirements, such as outage probability and throughput, to create a network system model. Since massive MIMO will be, along with mm-waves, the main facilitator for much higher capacity in 5G, has been found to provide a comprehensive study on massive MIMO and mm-wave coverage and capacity implications in the context of 5G cellular networks. Has compiled the most comprehensive studies made on coverage for a wide spectrum range, including both cm and mm-waves. The methodology is based on aspects such as characterization of scenarios, antenna modeling, different types of pathless, fast fading and other additional modeling components, and the main works on channel models are described:

a) METIS - has proposed 5G requirements in terms of frequency range, bandwidth, massive MIMO and polarization modeling, and performed channel measurements at various bands between 2 and 60 GHz with different channel model methodologies, map, stochastic and hybrid models, covering a wide variety of scenarios.

b) ITU-R M and NYU Wireless have performed studies in propagation and atmospheric loss on mm-waves, focusing on dense urban environment, proposing characterization in the context of blockage modeling, wideband power delay profiles and physics-based path loss model.

c) mmMAGIC has undertaken channel measurements in the 6 to 100 GHz range, while IMT-2020 is doing similar work based on China.

In broader terms, regarding general 5G network schemes, MiWEBA is focused on the study of millimetric waves in the access radio, fronthaul and backhaul contexts, in a variety of scenarios. The group has performed analysis on the use of mm-waves in micro-cells for dense radio-access areas in indoors and outdoors, to infer the technical feasibility of network increase capacity. The Fantastic 5G project has researched the primary key indicators needed to be achieved to improve capacity, coverage, reliability and latency for networks operating below 6 GHz, based on 5G E-UTRAN for model simulations. The Sungkyunkwan University of South Korea has developed a model that computes capacity and coverage for millimetric waves in the 27 GHz band, in an urban scenario. The Polytechnic University of New York has presented a project on the implementation of mm-waves for future 5G networks, having as underlying modeling interface an open source software NS-3, capable of simulating 5G-network parameters with a 1 GHz bandwidth. At last, the works that relate more to the frequency spectrum in the scope of this thesis and network characteristics, such as numerology or MIMO, presents a simplified but comprehensive overview on 5G deployment considerations, from use-cases to frequency bands' implementation roadway, as well as interoperability architectures with 5G core network. [36] proceeds to study the requirements for new channel models, from frequency bands, bandwidth, types of antenna arrays, mobility and handover issues, as well as presenting an experimentation and validation method for typical outdoors propagation scenarios in micro and macro-cells and outdoor-to-indoor penetration loss. For this method, it considers elements such as signal blockage, path loss models and shadow fading, and agglomerate studies on different perspectives regarding the multi- numerology schemes in 5G-NR, based on a number of technical configurations such as the power difference for edge users of different numerologies, being an early technique in the numerology- management context, through the use of allocation fairness. Similar work on the numerology field is presented by [38] and [39]. Concerning experimentation on the 3.5 GHz band propagation effects and MIMO antennas, there have been field trials by [18], [18] and [16], the last one proposes an antenna configuration allowing for MIMO configuration in small devices for 3.5 GHz.

3. METHODOLOGY

Predicting Quality of Product in 5G Wireless Networks Using Data Driven Infrastructure is a difficult task. Depending on the application, program kind, aims, and nature of the data used for the projection, there are a range of techniques to build and execute a QoE forecasting models. The methodology chosen for this project will be described and covered in this section The study design employed in this dissertation is architecture computational modeling for a 5G network with QoE control.

Because iot device has been identified as know the purpose for predicting User experience, it was vital to keep it in mind when building the assessment method at the heart of this research. The major elements make up the process as a whole:

A. Network Service Modeling: A 5G cellular technologies was chosen as the wireless channel. An input selection of tools and tags is necessary in order to train a Machine Learning technique. A database of Qos requirements and their associated QoE ratings was generated in a 5G simulator for this study

B. Output Video Quality Evaluation: After film has been delivered through the considered system, it must be analysed to generate a standard QoE score so that the Training Data can be trained. The NTIA VQM QoE input vector was adopted for this project.

C. Machine Learning Models: Svm Machines (SVM), Randomized Forrest Highest Accuracy Tree, and an Open - loop Genetic Algorithm were among the Machine Learning approaches used to estimate QoE. After that, the programs' performance in comparison and rated.

3.1 5G Simulation

Model of a 5G wireless connection was constructed for this research in selecting the sample needed to estimate video Quality of Product; nevertheless, modeling is not the only way to collect the data needed for QoE predictions. Recorded video database and subjectively surveys are widely used in the studies that fall within the social website of QoE forecasting mentioned in the previous chapter to analyze the QoE of the movies from such sources. This type of obtrusive method, as previously highlighted, is not very feasible for the in installation, and it also ignores the impact links between social and settings have on QoE.

It is also feasible to gain access to the entire given data of QoE and its accompanying Main Elements, and doing so would impose stringent limitations on the Qos requirements that are accessible and the kind of QoE measurement that is provided.

The goal to keeping the results up to date drove the selection of a wifi router. Numerous things influenced the decision to go with 5G. To begin with, mobile networks have surpassed Wi-Fi in usage, as per numerous US studies. This is due to the widespread availability of low-cost data caps. 5G also has the largest percentage of all mobile bandwidth, and this is expected to live for at least the next 5 years. By 2022, 5G is believed to reach for only 3.4 percent of all data networks. Although there are several system modeling systems that give tools for 5G modeling, MATLAB was developed in this project since it provides all of the required abilities and concepts. Furthermore, it has a great reputation in the internet sector. For 5G modeling, the LENA 5G component was combined with MATLAB. LENA is the open source network simulator.

A model of a 5G wireless router was constructed for this research in questionnaire survey needed to estimate video Quality of Service; nevertheless, modeling is not the only way to collect the data needed for QoE predictions. Recorded video libraries and personal surveys are widely used in the works that fall within the social website of QoE predictions preceding chapter to assess the QoE of the movies from those sources. This kind of intrusive technique is not very viable for an in implementation, as discussed in the preceding book. It also ignores the impact of settings tab and topologies on QoE.

It is also feasible to gain access to the entire sample group of QoE and its accompanying Implications, and doing so would impose stringent limitations on the Qos metrics that are provided and the type of Quality of service (qos metric that is provided).

The goal to keep the data up to date drove the selection of a Wi-Fi router. Many reasons influenced the decision to go with 5G. To begin with, cellular networks have surpassed Wlan in usage, as per various US studies. This is due to the widespread availability of low-cost data caps. 5G also accounts for the majority of all wireless data. It is expected to remain this way for at least the next five years. By 2022, 5G is believed to reach for only 3.4 percent of any and all data networks.

Though there are many network modeling systems that give tools for 5G modeling, MATLAB was designed and fabricated since it provides all of the requisite skills and models. Furthermore, it has a solid reputation in the internet sector. For 5G simulations, the LENA 5G module was combined with MATLAB.

3.1.1 5G SIMULATION IMPLEMENTATION

The 5G model for this study was created using the LENA 5G-EPC Plugins and Matlab. It was designed to comprehensively understand the current mobile network design and the background in which a video is transmitted over a 5Gigabit Ethernet. The simulation was needed to create the Qos specifications as well as the graphical traces of the broadcasted web traffic.

- **Topology**

The design of the simulator is simple. The EPC and 5G variants have been developed and linked. There is only one eNB in existence. After that, a probability distribution of UEs, varying from triple and 70, is built and linked to the eNB. All of the UE systems are set to move in mid-air and are positioned at different depths from of the eNB.

- **Network Traffic**

Regarding the construction of the building, the device is able to mass transport. This entails both providing the clip wherein the QoS data are collected and creating empty traffic. To begin, the UEs are classified on the basis of programmer they are operating. During test, one UE, which could be referred to as the main UE, will relay the video, which will be checked for QoE after, as well as the water's QoS set of data. Meanwhile, the rest of the UE is producing flow.

A random component of the UE is streaming a clip. The percentage varies from 30 to 50 percent. to model ongoing and prospective traffic data environments, and 80% to reflect existing and anticipated data usage ecosystems Vo5G nodes make up 0% to 20% of the total, with the remainder providing daily internet traffic. At each UE, unusual ideas are built to generate all of this flow. The IP array is mounted on all UEs, and web server is established between different servers and the EPC PGW server. The Gercom Evalvid model for NS-3 is being used for the main UE's data transmissions. On the UE, the Evalvid server is mounted, and on a target network, the Evalvid database is assembled, with the visual trace transmitted to the main UE.

The NS-3 Evalvid framework functions similarly to a standard NS-3 application, allowing video to be sent over the channel from a remote computer to a UE via UDP socket. An image trace file is used to send the video over the internet. Detail in this article, we'll go over how to make a trace file from an available for viewing clip. For 5G main live streaming, the Evalvid NS-3 package is favored over other NS-3 software because it generates the transmitter image time series, which allows trying to recreate the obtained video easy.

The aim of the virtual program's user intervention was to construct a simulated content delivery schematic diagram in a cell connection. As a result, the context UE travel was designed to be as realistic. The NS-3 UdpTraceClient class was used to allow web browsing for all nodes in the ambient netflix network. UdpTraceClient emulates a netflix program by varying input its energy density centered on a frame specified direction of an MPEG4 file, and is ideal for situations where the broadcast clip does not need to be replicated. The camera statistical significance used came from the Telecommunication Communications Organization's visual feature trace collection. The On Off App in Matlab will template Freight forwarders. which produces congestion in an On/Off fashion, with data produced during On occasions and none during The off cycles. The deployment was based on models one where received signal has an active ON cycle of 0.352 moments but an inactive OFF period of 0.65 second on average. We'll presume that the codec in use is G.711, which produces 64kb performance and that packetization delay is 20ms, which would

Table 3.1: QoS parameters collected during the simulation

QoS parameters	Possible Values
Number of UE	3 - 70
% Video UE	30-80 %
% Voice UE	0-10
GBR	40 - 400 kbps
QCI	4, 6, 8
Lost Packets	N/A
Delay (seconds)	N/A
Cumulative Jitter (seconds)	N/A

Resulting in a 172-byte package with a 160-byte envelope and 12 RTP header bytes in the OnOFF Request, this will be used as the packet parameter.

The information on the UEs is meant to resemble internet traffic in that bytes are sent at frequent moments in both the transmitting and receiving locations at the same time.

Bearer-lever QoS can be configured using the Lena device. It helps you to build a holder with specific GBR, MBR, and QCI values. Table 3.1 shows that 3GPP enables for three different QCI objectives for attenuated streaming media, with only one of them providing a Fixed Data Rate... For the main UE, a designated holder is formed, which then is designed to be arbitrarily allocated to one of the three QCIs. The GBR also is randomized in the region of 40kbps to 400kbps in the case of QCI 4 that is a drastic range not indicative of sustainable business GBR levels. Even so, this scope is chosen primarily to see the true implications of GBR on QoE, particularly because GBR specifications are set by 5G telecom operators. A few of the Customer experience criteria were collected using the Flow Monitor unit. Data packets, accumulated latency, and lag of the central content delivery programmer are among them. During experiments, all of the criteria were transmitted into a CSV format. The results collected for each approximation are mentioned in Table 3.1.

Latency, pause, and network congestion are all clear QoE predictor variables that are often found in QoE computer models. Other criteria are Bluetooth, and one of the factors explored in this study is their impact on QoE. The amount of UE per eNB and the proportion and those who use big system services provide context into how future overload and varying levels of demand per eNB impact a specific user's Product quality. The GBR constraint is particularly fascinating because it is set by internet services, putting it completely into their influence and allowing for QoE adaptations. Although shielded video can be given one of 3 different QCIs, the QCI impacts the importance at which the fluid is handled and therefore can offer input into how this impacts stream QoE. At various stages of the design, other factors were also taken into account. One of them would be Total Bit Rate (MBR), which would be a committed GBR holder's permissible heart. Through quick reduction and gray level selection from Decision Tree and Neural Network Plants, it was learned that such existence had no effect on QoE across many instances of the QoS feature collection. Later on, some mainstream press criteria must be met, but they have been withdrawn to keep the semi strategy. For added fun, those mathematical expressions were tweaked. In a residential setting, the pathless method was set to adopt the Okumura-Hata logistic regression design. The Martinelli application is frequently regarded as one of the most reliable models that predict route deviation in cities

The simulation's development was a pretty complicated aspect of this project. NS-3 does indeed have a wide range of skills, which, due to lack of pair programming and social services, made getting the application right a challenging task. The implementation took a number of simulations before reaching a point where it worked as anticipated.

3.2 Video QoE Evaluation

To use QoE scores like marks for data mining techniques and analyze their efficacy, QoE results for all of the objects emitted in the application must be obtained. The quality of life can be measured both experimentally and analytically. In due to data batch size, analytical assessments paired with the 5G implementation will be very limiting It is incredibly difficult to interview sufficiently researchers to access a complete information gathering, unless it's in a safe setting, since using interactive knowledge and techniques will cause additional abnormalities to the clips, resulting in inaccurate outcomes. The majority of research that use samples to obtain QoE ratings have much less than 50 participants, with the majority of them having just over 20. Since this range of interviewees is unrealistic for a given data with over 3000 images, analytical QoE analysis was chosen.

There are several methods available for evaluating unbiased QoE. PSNR, SSIM, and VQM, and other VMAF, a younger method that is rapidly spreading, are the four most common ones in research. PSNR is known to be the least useful strategy, whereas VQM and VMAF have a reasonably high association with qualitative QoE ratings, according to similar topics.

3.3 QoE Evaluation Process

To submit a clip over the web, you must first select the clips you want to send. The clips selected were from Product Digital Cinema Collection and featured species. The images are in Popular Intermediary Formats (CIF), which means that they are 352x288 pixels in size. The clips have a screen resolution of 30 fps, a length of about 20 minutes, outstanding quality, and no scene cuts or audio.

Though CIF is not the widest aperture based on mobile content, it is adequate and is widely used within video distribution analysis. High res would have a detrimental effect on test performance parameters and QoE evaluation times, resulting in a much shorter collecting data. Since VQM needs a source video clip, it was critical that the video be of superior standards in order for the subsequent QoE result to be calculated properly

The need of submitting your video over the NS-3 logical database, it was important to build the you tube video time series in order to send it over mobile medium. The stack regression analysis has four sections: stack key, sample form, transmission time, amount of material (if block classification is used), and the time the circuit created the file. Table 3.2 contains an extract first from file called.

Table 3.2: Video Trace Frame File

Frame Index	Frame Type	Frame Size	Segment Number	Time Sent
1	H	15535	16	0.019
2	P	12305	13	0.036
3	P	13548	14	0.081
4	P	13111	13	0.115
5	P	14077	14	0.134
6	P	15105	15	0.166
7	P	14250	14	0.216

For the development of analytical calculations, the clips are translated from AVI to MP4 using an MPEG4 codec by the FFMPEG operating system tool, which preserved all of the initial quality attributes such as width, screen resolution, and operating frequency.

The traces of the full clip were collected using the Evalvid toolset's trace new situation. The source MP4 video also was transferred to raw YUV using the FFMPEG method, as this is the format used for image analysis. When the clip is sent out, the Evalvid NS-3 method features a tight end time series with 3 points: period did receive, screen id, and payment in order. By referencing the original frame repeat and the actual MP4 file, the recorded video is reimagined in MP4 format using the Evalvid set of tools. FFMPEG is then used to translate it to pure YUV. This process had to be run for each model, so shell script was used to simplify it. The VQM VFD tool NTIA VQM software is free for commercial and – anti use and can be installed from their websites to test the images. The batch - oriented tool could only be used with a GUI that allows the user to pick the YUV videos to be processed, specify the originally file, or and choose the form of VQM template, which in this case was VQM VFD. Tests demonstrated that the system is incapable of handling and over 500 samples and takes between 4 and 5 years to make. The result was a hyphen file containing VQM ratings for each shot.

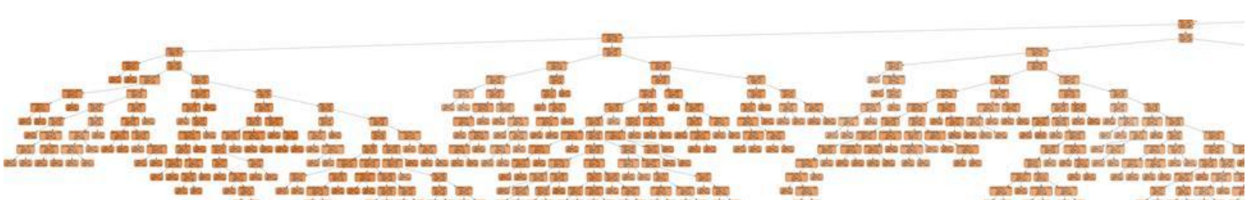


Figure 3.1: Left Half of Example Random Forest Tree

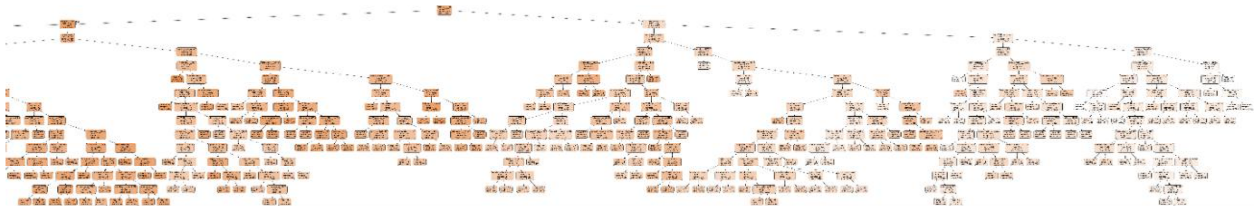


Figure 3.2: Right Half of Example Random Forest Tree

3.4 MACHINE LEARNING Techniques

Machine learning techniques are extremely useful in the creation of predictions. Four famous directed learning techniques that are well-suited to semi simulation issues were used as the simulations to use in this study. Svm was the name of these implementations (SVM), Random Multilayer Perceptron, Woods, and Support Vector This segment will go over each of these equations and their applications in depth.

3.4.1 SUPPORT VECTOR MACHINES

A common supervised learning is Support Vectors (SVM). Separating hyper plane classification algorithms are SVMs. Linear SVMs, in specific, look for a subspace in the lgbtq youth that subdivides into class and maximizes the difference across sample points of multiple categories that are nearest to this dividing hyper - plane. For example, when there are two classes and the data is two-dimensional, this would consist of finding a line which separates the data into the two classes and where the two vectors of

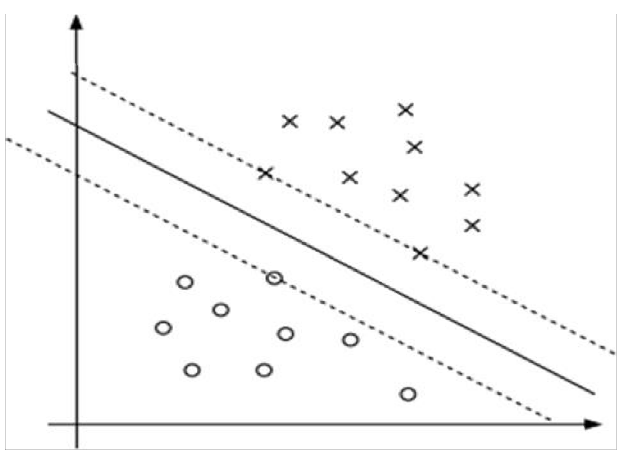


Figure 3.3: Linear SVM

For instance, if the dataset is nine and there are 2 types, this will include having a line that represents the population into to the three classifiers and where the two sequences of multiple categories nearest to the lines are the longest apart. Figure 3.3 depicts this.

The majority of state of the art methods can indeed be isolated sequentially. SVMs can be used to deal with all these data sources by projecting them into a steeper space and then learning the Euclidean distance in that room. Figure 3.3 illustrates when to expand information into micro spaces so that it can be separated sequentially. Finding this Euclidean distance in experienced a great, on the other hand, would easily prove intractable if performed in a haphazard manner. This can be done using a kernel function, in which the method is retooled such that the larger area is not directly represented.

The kernels trick can be used to quickly learn a search space. A matrix, which is a component of multiple vectors k (x, y) and provides a measurement of distances variables, must be described in order to use the kernel trick. The Kernel function is a common framework that allows students to learn a finite volume splitting hyper place whereas only computational central pixel in the initial d data space.

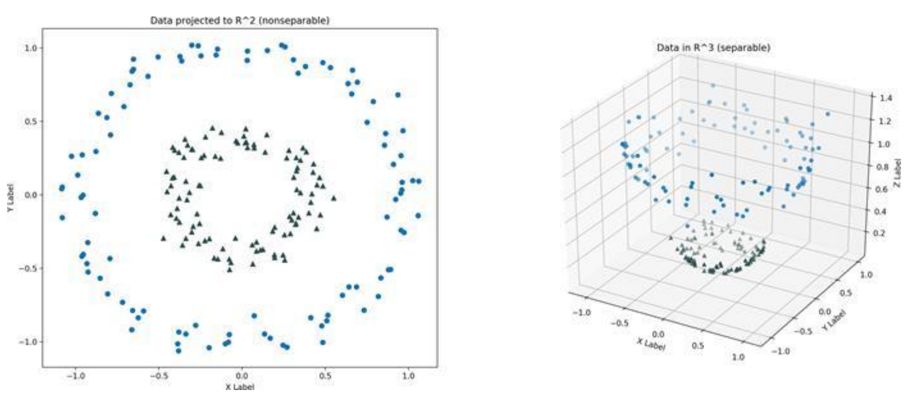


Figure 3.4**:** Example of data projected into 3 dimensions for classification with SVM. Recreated from [12]

3.4.2 RANDOM FOREST

Naïve bayes is a training data algorithm that takes an assortment of Random Forests to construct the model. In a nutshell, a Feature Selection acts by implementing a list of norms to be used for judgment from the class labels set's feature extraction. It can be thought of as a series of yes/no queries that inevitably lead to a projected category or constant quality. The form of Decision Tree determines the details of how and why the queries, or pieces of branches, are chosen. The cuts of modules are most usually utilized in distinction situations to optimize the decline in Gini Defilement of their responses. The possibility of a selected randomly part of the set getting wrongly named if it was identified by a series of observations in the array is represented by Theil Imperfection, a reasonably easy statistical definition. The (MSE) is a widely used metric in inference to assess the consistency of a break. In a Logistic Regression, the system finds thru all the potential defects for each vertex to find the one which reduces Gini Impurity or Ssim the most, and then selects that attribute to break on. This slicing procedure was repeated indefinitely till it tree exceeds full width, at which point - cell sends only specimens from one classification and is fully null but has the smallest probability lowest possible MSE.

Random forests have the disadvantage of someone being different feature tools that can match chaos with in sample well, culminating in very distinct tree being trained for slightly separate differences in the datasets. As a consequence, the training samples is severely over fitted, and higher productivity is low.

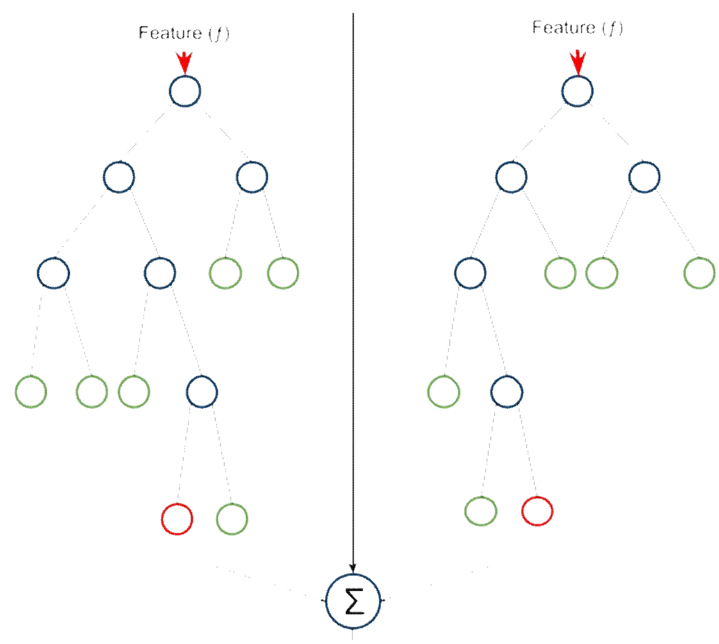


Figure 3.5: Random Forest with two estimators. Created with reference to [17]

An approach to countering over fitting for high variance machine learning models is bagging, where an ensemble of models are trained on different random samples of the dataset. Random Forests is the application of bagging to decision trees. The algorithm selects a random subset of training data for each Decision Tree, and selects a random subset of features for splitting nodes. When a tree in a Random Forest picks a random sample of training data points they are drawn with replacement, which is known as bootstrapping, and the predictions of each tree in the Random Forest are averaged at test time. This procedure is known as bootstrap aggregation, or bagging. An illustration of Random Forest with two estimators is shown in Figure 3.5.

3.4.3 NEURAL NETWORKS

Neural Networks (NN) are a long established machine learning algorithm that have recently become very popular as it has become possible to train very large Deep Neural Networks. A Neural Network can be made up of several layers, which are in turn made of nodes. The nodes are supposed to roughly model human brain neurons in their function. A node in the Neural Network receives inputs, which have associated weights that represent the input's importance relative to the other inputs to this node and then the node computes its output based on its Activation Function (e.g. a sigmoid) using inputs and their weights.

This work uses a simple Feed forward Neural Network. A fully-connected Feed forward Neural Network, or a Multi-Layer Perceptron, usually consists of an input layer, hidden layer(s) and an output layer. The input layer does not perform any computation and just passes the information onto the hidden layer. Hidden layers and output layers do perform computation, with the last hidden layer's nodes passing their outputs to the output layer, which produces the final result value. In a Feed forward Neural Network nodes from adjacent layers are linked by weighted connections, or edges, and the information only goes in the

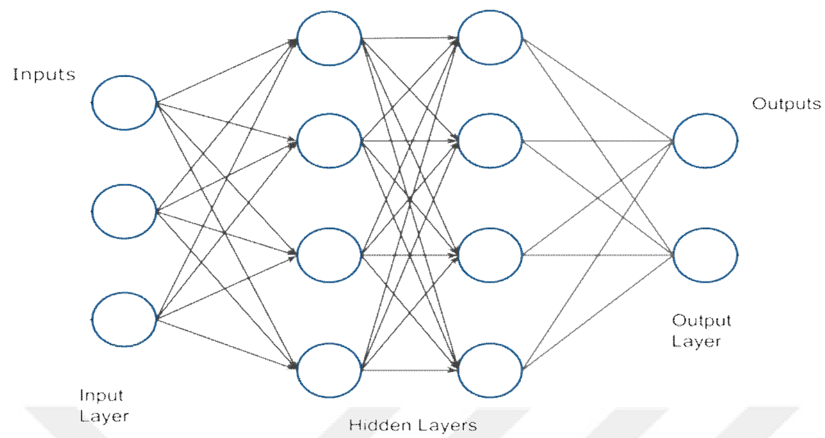


Figure 3.6: Feed forward Neural Network. Recreated with reference to [8]

Forward direction, from one layers to another, hence the name feed forward Neural Network. A simple illustration of a Feed forward Neural Network is show in Figure 3.6. Neural Networks typically use Back Propagation to learn the weights of the Network. In Back Propagation, the weights start off being random. Every input in the training data set is propagated through the NN, and the output is compared with the corresponding label. Then, based on the error the weights are adjusted using the gradient descent optimization algorithm. This process repeats until the error is low enough, and after it terminates the NN has learned all of its weights and can be used for its intended purpose.

3.4.4 APPLICATION OF MACHINE LEARNING

The four Machine Learning Algorithms picked for this work were Support Vector Machines, Random Forest, Gradient Boosted Trees and Neural Networks. The first three models were implemented using Matlab. The QoS data and the corresponding QoE MOS were split randomly into 70% for training and 30% for testing, and the QCI classes were one-hot encoded and data was normalized. For the SVM implementation, the Support Vector Regression model was used with the RBF kernel. While classification might seem like a good fit since the MOS scale is discrete and has 5 possible values, this problem is more suited to regression algorithms since the

MOS values were left fractional to keep them more granular and descriptive. The model was trained on the training data set and then tested.

For the Random Forest implementation feature scaling or one-hot encoding is not important so the data was left as is. To tune the model a grid search was performed to find the most optimal number of estimators (number of trees) and the maximum depth of a tree. An example of a tree created by the Random Forest algorithm after training on the QoS parameter data set is presented in Figure 3.1 and Figure 3.2.

A similar process was performed for Gradient Boosted trees, except that the learning rate

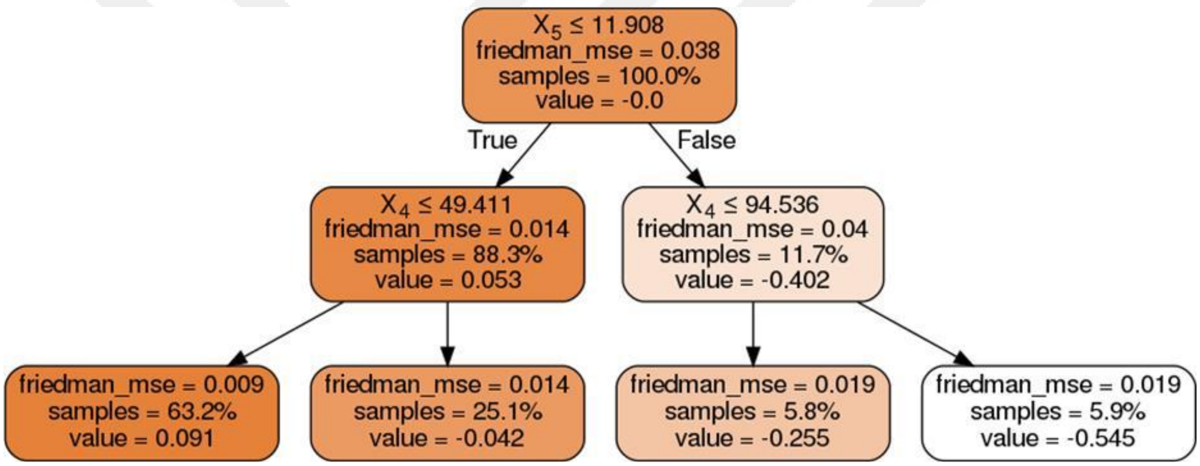


Figure 3.7**:** Example GBT estimator

Parameter also had to be tuned. It should be noted that no significant boost in error minimization was achieved through parameter tuning, but neither was it expected. It was mainly performed to make the model perform as well as possible, even if it was just a gain in a couple of percent of accuracy. For the Neural Network implementation Tensor flow and Keras API were used. All of the data was first normalized to aid the training process. Then, with the help of the Keras API a Neural Network with four layers was built, including two densely connected hidden layers using the Rectified Linear Unit (ReLU) activation function, which is a simple and computationally fast activation function, and an output layer with one node. The Mean Squared Error loss function was specified, which is commonly used for regression problems. The model was then trained with the normalized training data set, which only took a few minutes since the data set is reasonably small, which resu5Gd in a Feed forward Neural Network model ready to be tested.

4. RESULTS

The findings of the multiple machines learning models' QoE projection are discussed in depth in this portion. The role of wifi features in QoE prediction in 5G Cellular Networks using Computationally Efficient Infrastructure is also investigated. This section also includes an assessment of the findings and the kinds of work. Svm Machines, Random Forest, Machine Learning, and Gradient Boosted Tree are the four formulas used in this study to estimate QoE. The models were tested using a set of data that included channel QoS data from online video experiments as well as the QoE MOS of each clip transmitted. All model specification developed for this study behaved fairly well and had excellent result when it came to predicting User experience. The Sum of Square Error (MAPE) points of the templates are seen in Figure 4.1. The Sum of Square Error (MAPE) is a measure that calculates standard deviation by measuring the error function by the expected value. MAPE benefits is that it is a parameter that comes with free variation of various signal processing model' results. The Integral Absolute Error is reduced from 100 in Figure 4.1 to indicate the templates' precision Only the Dnn achieved a score of over 90%, but other structures did well as well, with Gradient Boosting Devices doing the worst with less than 85% performance. The Mean Square Error (RMSE) levels are shown in Figure 4.2. The experiment is called RMSE.

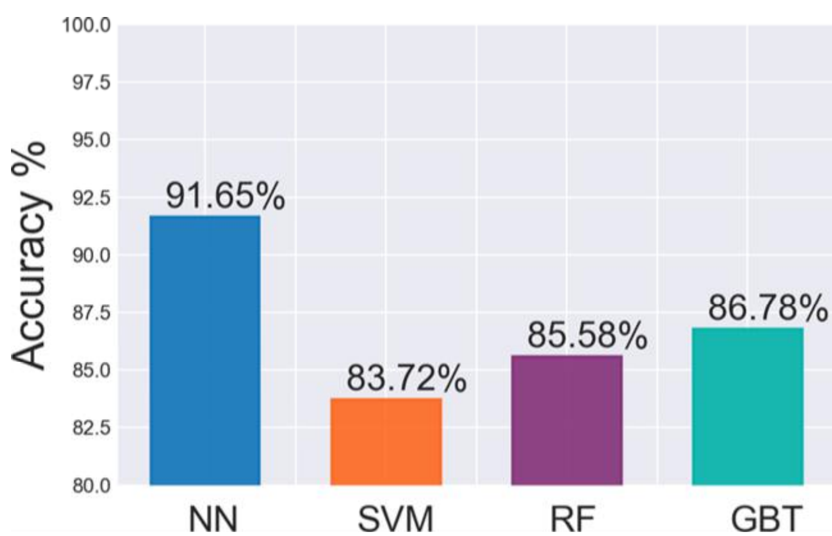


Figure 4.1**:** Accuracy Comparison of the four ML models

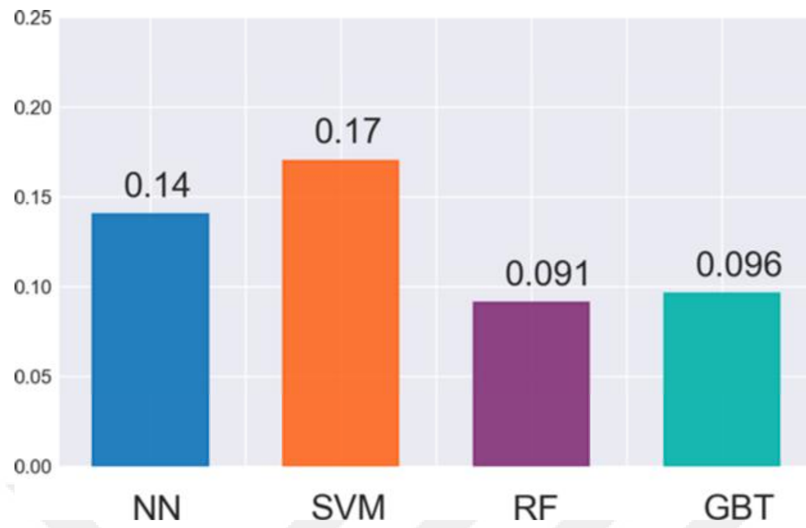


Figure 4.2**:** RMSE Comparison of the four ML models

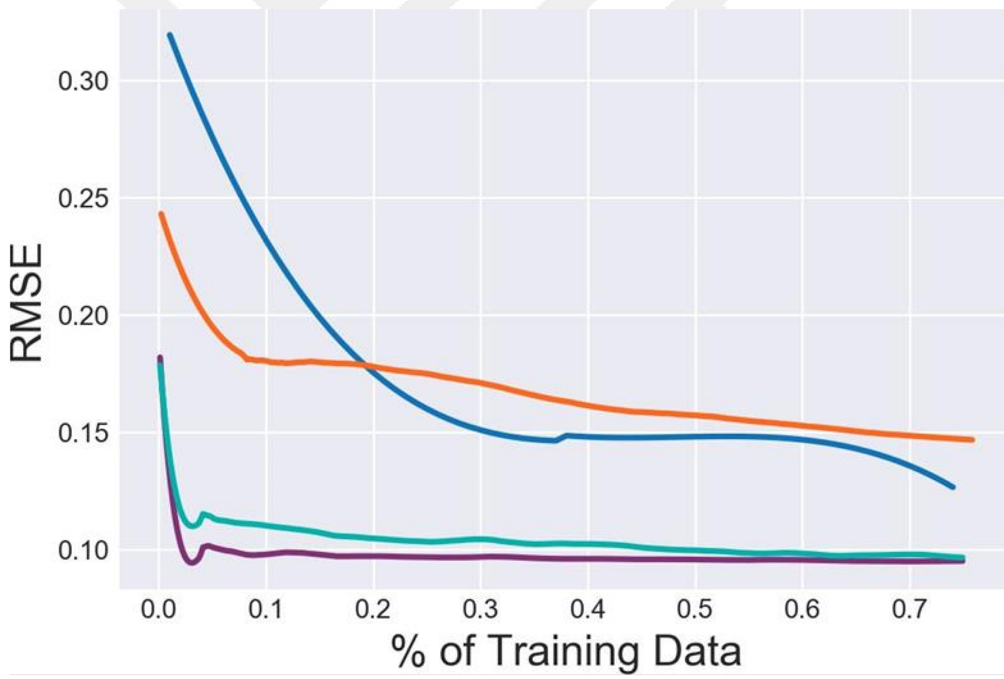


Figure 4.3**:** Influence of number of training samples on RMSE

The difference between the expected and actual amounts is the point difference. The RMSE is a widely used metric for evaluating correlation simulation results because it is measured in a same unit as the mark results. The lower the RMSE, the more accurate the design is. Since RMSE penalizes larger errors more harshly than small pieces, it produces a completely different image than MAPE. Out of the existing models, SVM clearly works worst. In terms of the MOS scale, Naïve Bayes and Gradient Boosted Trees reach just under 0.1 RMSE that is very fair. Although the RMSE of Machine Learning is not essential, it is not entirely desired.

A total of 5000 tests were performed, with each model being trained on 75% of the full data set. The defined as the number of test data and the Mape Error is depicted in Figure 4.3. In the case of Classifiers and Machine Learning, the amount of training data has greatly reduced failure

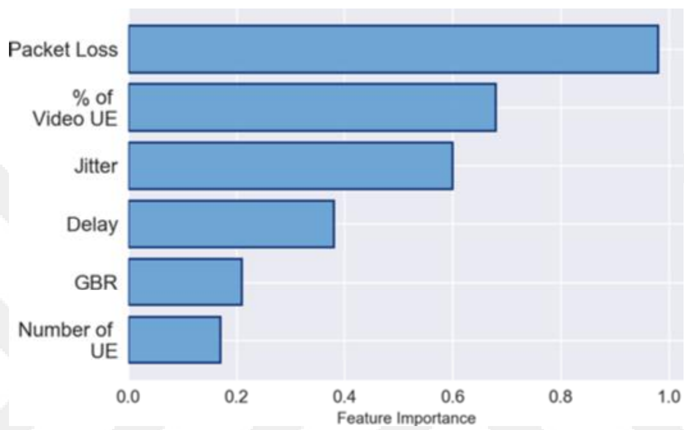


Figure 4.4**:** GBT Feature Importance

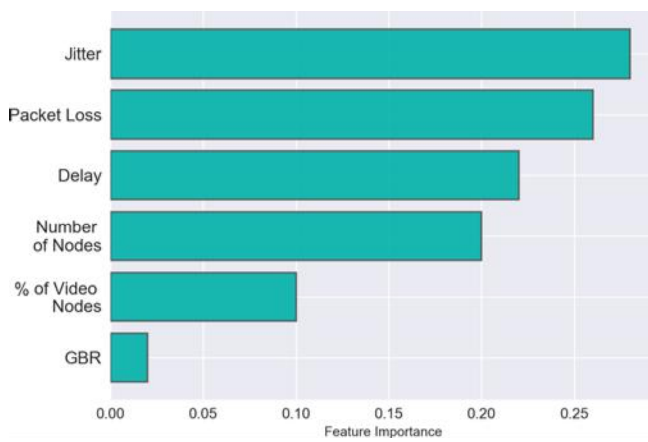


Figure 4.5**:** RF Feature Importance

4.1 Feature Importance

Decision Tree and Boosted Regression Trees both offer gray level removal. When deciding breaks in the system, the element primary advantages include a value for how important a unique characteristic was. The function responsible for new of the Support Vector Forests and Decision Tree designs are shown in Figures 4.4 and 4.5, accordingly.

The function main aspects in the two approaches are indeed very unique, and that's most likely due to the two projects' varying divided estimation process. Both systems appear to be influenced by packets, pause, and latency. The effect of the numbers of Cruising on the context road conditions was too small to even show up mostly on graph. Even

Table 4.1: Pearson Correlation of wireless-specific parameters and delay, jitter and packet loss

	Jitter	**Delay**	**Packet Loss**
Number of UE	0.95	0.90	0.91
% of Video UE	0.9	0.82	0.83
GBR	0.22	0.23	0.24

Despite the fact that VoIP has a top importance than data, the good turnover of foreground VoIP data in a same container must've not impacted streaming video QoE. QCI does not seem to have played a role in predicting QoE.

Both in designs, the maximum count of UE and the video streaming UE are significant. In Support Vector Trees, the amount of UE video content appears to have a significant impact on QoE. The amount of UEs linked to the eNB has a greater influence in Decision Tree than other connectivity variables. GBR may have had some effect on QoE estimation based on the two estimates, but not a substantial amount. Out of the Bluetooth Qos metrics, the number of UE per eNB and the amount of UE playback appear as being the most important.

The similarity between any of the inputs is something that this design does not take into account. The number of users and the number of video streams in those ties, in specific, can influence lag, buffering, and network congestion. To determine this, the Correlation analysis among lag, compression, and loss rate, as well as the number of UEs, was estimated, percent of GBR and UE internet content Table 4.1 displays the results. The comparisons here between numbers of UE and the percent of Image UE are very strong, implying a possible linear importance of attributes, which may suggest that certain one set is required for QoE forecasting.

To answer this question, all of systems were modified on two different feature sets: one that included lag, latency, and network congestion, and the other which included all wifi variables. Figure 4.6 depicts the RMSE of the findings.

Neither of the RMSEs have significantly affected by the addition to the one with all of the functions. This suggests that two documents may be used to estimate QoE separately of one another.

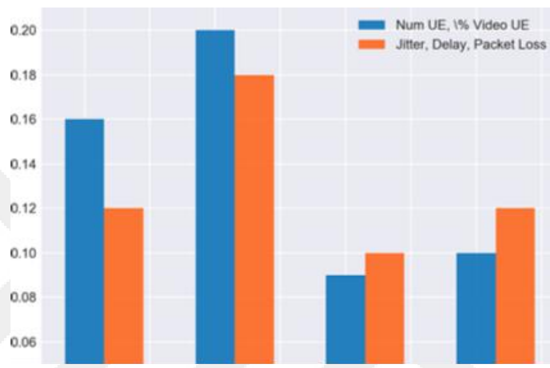


Figure 4.6**:** RMSE of Wireless vs Delay, Jitter, Packet Loss Parameters

5. DISCUSSION

The findings are encouraging and suggest that ml algorithms are used to forecast QoE. The amount of UE per eNB and the sum of these UE video streaming appear as being the most significant broadband metrics in QoE projection, but they are not further relevant than pause, error, and network congestion. The discovery that a moderately operating template can be built with pause, latency, nor packet drop variables and only bluetooth specifications, such as the numbers of UE per eNB and the ratio of UE per eNB internet streaming, is useful in situations in which only certain sets of information are accessible or can be accessed more conveniently. Even broadband variables, nevertheless, rising QoE video prediction is probable. The machine learning methods used have no definite champion, but Decision Tree and Boosted Regression Forests have the lower R value and the fastest sharing links

The reality that 5G Topology specifications had no impact on the QoE versions' results is a huge let down. Since GBR is determined by telecom operators, it could also be used successfully in QoE development.

One interesting aspect of the model is whether, as seen in Figure 5.1, the MOS of the clips generated in the simulations appears to be spread between possible features. It's also worth noting that no MOS (Mean Opinion Score) 1 data was gathered. This would be an issue if this model is presented with data that was not created by this simulation. It is also an indicator that the current 5G simulation parameters cannot cause extreme distress to a video. However, even in

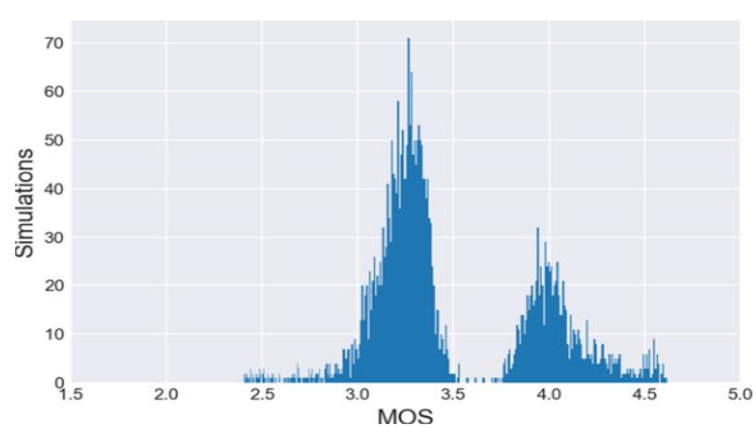


Figure 5.1: Distribution of MOS scores

This would be a problem if the model was given data that was not produced by the simulator. It's also a sign that the latest 5G services and technical aren't capable of causing corresponding image discomfort. Even in information investigation, moreover, the number of true MOS of 1 is very small. We created a disabled clip data gathering explicitly for qualitative MOS assessment. As a result, the lack of these grades may not have been a major concern. As a result, the lack of several MOS 2 properties is typically troubling in term of this model's order to forecast all QoE. This suggests that when designing the simulation, more emphasis should have been put on capturing the integer overflows. This phase, on the other hand, reflects the non-linear association between QoS and QoE.

It's also worth noting that the designs depend entirely on an objective instrument to assess QoE critically Despite the fact that VQM is commonly used during research but widely respected, the use of unbiased QoE scores may weaken the template if used in practical systems, and qualitative QoE scoring are required to check the model accuracy developed in this study. Eventually, in terms of the overall project, a lots of time were spent developing the 5G prototype. Although this is beneficial to template output in terms of function value, using a shared large dataset will allow for more time to develop machine learning techniques in depth, especially additive and digital education. Knn and Boosted Regression Trees have the lowest RMSE scores in this study. Broadband criteria, such as the numbers of UEs per eNB and the percent of UEs, were discovered to have an effect on QoE estimation. If required, video will be used for reasonably accurate QoE prognostication; though, such methods do not include advantages over simply predicting QoE with latency, latency, and network congestion. In general, anns were effective in predicting QoE.. Machine Learning Models were found to be the least suitable of the four for QoE forecasting, with Decision Tree and Slope Improved Forests having a lower RMSE ratings. Broadband criteria, such as the numbers of UEs per eNB and the percent of UEs, were discovered to have an effect on QoE prediction. If required, iot device can be used to forecast QoE with a high degree of accuracy. However such models do not provide an advantage over just using delay, jitter and packet loss for QoE prediction.

6. CONCLUSION

In this paper, a method for Customized Quality of Experience (QOE) Control in 5G Wireless Networks using service quality parameters was developed leveraging Scientifically Based Design and machine learning algorithms. The 5G simulator was created to reflect a practical interference cancellation case, complete with realistic context traffic or delivery conditions. Filter coefficients that are widely used to characterize a system, such as lag, latency, and network congestion, were retrieved throughout each test, as well as Wi-Fi and 5G-specific criteria which are often overlooked in related research.

The image QoE data set was compiled by performs a specific task each video distributed in each model with a method that has a strong connection with arbitrary QoE results. Multiple Machine Learning classifiers are trained using the data: Machine (svm, Random Forest, Highest Accuracy Trees, and Back - propagation Linear Regression. After analyzing the effects of these prototypes, it was found that all of them, with the exception of Support Vector Machines, perform well and have low error rates. Even when the classifier is trained solely on Wi-Fi parameters, these parameters are determined, demonstrating that these parameters have an impact on video QoE. And should be taken into account when predicting QoE in cellular connections. Mobile virtual metrics that are especially influential in QoE analysis are the numbers of UE linked to an eNB as well as the ratio of them watching content Using Wi-Fi specifications alone for QoE estimation, on the other hand, does not provide a benefit through using pause, buffering, and network congestion only.

6.1 Future Work

In the current implementation, the 5G simulation only allows for the evaluation of UDP video streaming. It might be of interest to extend the simulation to TCP video streaming since Quality of Experience of TCP and UDP video is affected differently by QoS impairments, and a lot of modern mobile video is TCP-based. The models presented in the work would benefit from subjective QoE scores. A Reasonably-sized data set of QoE scores would allow for proper model accuracy verification. A large-scale study for subjective QoE evaluation of all videos in the set would be extremely beneficial for the models' accuracy and potential real-world application;

however it might be particularly ambitious and potentially unachievable due to the number of videos in the data set.

Extending the models to be used for online QoE prediction and monitoring in its present state could be possible if the pre-trained models are used to predict QoE. However, this approach would not be considered fully online since it would not be learning real-time and would be reliant on data it was initially trained on for QoE prediction. It would be of interest to explore the use of incremental learning models, such as Incremental Support Vector Machines or Gaussian Process regression for more insight on in-service deployment.

REFERENCES

[1] J. K. Author, “Title of chapter in the book,” in Title of His Published Book, xth ed. City of Publisher, Country if not USA: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx.

[1] J. Qiao et al., “Video Quality Provisioning for Millimeter Wave 5G Cellular Networks with Link Outage,” IEEE Trans. Wireless Commun., vol. 14, no. 10, 2015, p. 5692–5703.

[2] M. Ismail and W. Zhuang, “Statistical QoS Guarantee for Wireless Multi-Homing Video Transmission,” Proc. IEEE Global Communications Conference (GLOBECOM), USA, Dec. 2013.

[3] Y. Cheng, A. Leon-Garcia, and I. Foster, “Toward an Autonomic Service Management Framework: A Holistic Visionof SOA, AON, and Autonomic Computing,” IEEE Commun.ag., vol. 46, no. 5, 2018, pp. 138–46.

[4] K. Brunnström et al., “Qualinet White Paper on Definitions of Quality of Experience,” European Network on Quality of Experience in Multimedia Systems and Services (COST ActionIC 1003), Lausanne, Switzerland, Version 1.2, Mar. 2013.

[5] K. Laghari and K. Connelly, “Toward Total Quality of Experience: A QoE Model in a Communication Ecosystem,” IEEE Commun. Mag., vol. 50, no. 4, Apr. 2012, pp. 58–65.

[6]Available online: https://www.mobileeurope.co.uk/press-wire/15016-ngmn-publishes-second-white-paper-launches-new-5g-projects

[7] T. Hosfeld et al., “The Memory Effect and its Implications on Web QoE Modeling,” Proc. 23rd Int’l. Teletraffic Congress (ITC), USA, Sept. 2011.

[8] S. Thakolsri, W. Kellerer, and E. Steinbach, “QoE-Based Cross-Layer Optimization of Wireless Video with Unperceivable Temporal Video Quality Fluctuation,” Proc. IEEE Int’l. onf. Commun. (ICC), Japan, Jun. 2011.

[9] T. Hossfeld et al., “Quantification of Youtube QoE via Crowdsourcing,” Proc. IEEE Int’l. Symposium Multimedia (ISM), USA, Dec. 2011.

[10] Available Online: https://www.subex.com/are-you-5g-assured-4-game-changing-business-assurance-trends-to-evolve-with-5g/

[11] Ioannis Katsavounidis Anush Moorthy Megha Manohara Zhi Li, Anne Aaronet. "Toward a practical perceptual video quality metric". https://medium.com/netflix-techblog/toward-a-practical-perceptual-video-quality-metric-653f208b9652, 2016.

[12] Eric Kim. "Everything you wanted to know about the kernel trick (but were too afraid to ask)".http://www.eric-kim.net/eric-kim-net/posts/1/kernel_trick.html.

[13] Cheng, X.; Tang, C.; Zhang, Z. Accurate channel estimation for millimeter-Wave MIMO systems. IEEE Trans. Veh. Technol. 2019, 68, 5159–5163.

[14] Li, L.; Wang, D.; Niu, X.; Chai, Y.; Chen, L.; He, L.; Wu, X.; Zheng, F.; Cui, T.; You, X. mmWave communications for 5G: Implementation challenges and advances. Sci. China Inf. Sci. 2018, 61, 021301.

[15] Seker, C.; Güneser, M.T.; Ozturk, T. A review of millimeter wave communication for 5G. In Proceedings of the 2nd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), Ankara, Turkey, 19–21 October 2018.

[16] Ji, H.; Kim, Y.; Lee, J.; Onggosanusi, E.; Nam, Y.; Zhang, J.; Lee, B.; Shim, B. Overview of full-dimension MIMO in LTE-Advanced. IEEE Commun. Mag. 2016, 55, 176–184.

[17] Niklas Donges. "The Random Forest algorithm". https://towardsdatascience.com/the-random-forest-algorithm-d457d499ffcd, 2018.

[18] Larsson, E.; Edfors, O.; Tufvesson, F.; Marzetta, T. Massive MIMO for next generation wireless systems. IEEE Commun. Mag. 2014, 52, 186–195.

[19] Ding, Z.; Liu, Y.; Choi, J.; Sun, Q.; Elkashlan, M.; Lin, C.; Poor, H.V. Application of non-orthogonal multiple access in LTE and 5G networks. IEEE Commun. Mag. 2017, 55, 185–191.

[20] Dai, L.; Wang, B.; Ding, Z.; Wang, Z.; Chen, S.; Hanzo, L. A survey of non-orthogonal multiple access for 5G. IEEE Comm. Surv. Tutor. 2018, 20, 2294–2323.

[21] Ding, Z.; Lei, X.; Karagiannidis, G.K.; Schober, R.; Yuan, J.; Bhargava, V.K. A survey on non-orthogonal multiple access for 5G networks: Research challenges and future trends. IEEE J. Sel. Areas Commun. 2017, 35, 2181–2195.

[22] Dai, L.; Wang, B.; Yuan, Y.; Han, S.; Chih-Lin, I.; Wang, Z. Non-orthogonal multiple access for 5G: Solutions, challenges, opportunities, and future research trends. IEEE Commun. Mag. 2015, 53, 74–81.

[23] Naqvi, S.A.R.; Hassan, S.A.; Pervaizy, H.; Ni, Q. Drone-aided communication as a key enabler for 5G and resilient public safety networks. IEEE Commun. Mag. 2018, 56, 36–42.

[24] Li, B.; Fei, Z.; Zhang, Y. UAV Communications for 5G and beyond: Recent advances and future trends. IEEE Internet Things J. 2019, 6, 2241–2263.

[25] Aldababsa, M.; Toka, M.; Gökçeli, S.; Kurt, G.K.; Kucur, O. A tutorial on non orthogonal multiple access for 5G and beyond. Hindawi Wirel. Commun. Mob. Comput. 2018, 2018, 9713450.

[26] Papoulis, A.; Pillai, S. Probability, Random Variables and Stochastic Processes, 4th ed.; McGraw Hill: New York, NY, USA, 2012.

[27] Jung, J.-H.; Lee, J.; Lee, J.-H.; Kim, Y.-H.; Kim, S.-C. Ray-tracing aided modeling of user-shadowing effects in indoor wireless channels. IEEE Trans. Antennas Propag. 2014, 62, 3412–3416.

[28] Hosain, F.; Geok, T.K.; Rahman, T.A.; Hindia, M.N.; Dimyati, K.; Ahmed, S.; Tso, C.P.; Rahman, N.Z. An efficient 3-D Ray tracing method: Prediction of indoor radio propagation at 28 GHz in 5G Network. Electronics 2019, 8, 286.

[29] Mart Inez, A.M.; Egger, P.; Carvalho, E. Geometry-based stochastic channel models for5G: Extending key features for massive MIMO. In Proceedings of the 2016 IEEE 27th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications-(PIMRC): Fundamentals and PHY, Valencia, Spain, 4–8 September 2016.

[30] Pessoa, A.M. A Stochastic channel model with dual mobility for 5G massive networks. IEEE Access 2019, 7, 2169–3536.

[31] Baum, D.S.; Hansen, J.; Galdo, G.D.; Milojevic, M. An interim channel model for beyond-3G Systems. In Proceedings of the IEEE 61st Vehicular Technology Conference, Stockholm, Sweden, 30 May–1 June 2005; pp. 3132–3136.

[32] Liu, L.; Clqude, O.; Juho, P.; Katsuyuki, H.; Pertti, V.; Francois, Q.; Fredrik, T.; Philippe, D.D. The COST 2100 MIMO channel model. IEEE Wirel. Commun. 2012, 19, 92–99.

[33] Wang, C.-X.; Bian, J.; Sun, J.; Zhang, W.; Zhang, M. A survey of 5G channel measurements and models. IEEE Commun. Surv. Tutor. 2018, 20, 3142–3168. 3GPP TR 38.901 Version 14.3.0 Release 14. Study on Channel Model for Frequencies from 0.5 to 100 GHz. 2018.

[34] Huang, J.; Wang, C.-X.; Feng, R.; Sun, J.; Zhang, W.; Yang, Y. Multi-frequency mmWave massive MIMO channel measurements and characterization for 5G wireless communication systems. IEEE J. Sel. Areas Commun. 2017, 35, 1591–1605.

[35] Ju, S.; Kanhere, O.; Xing, Y.; Rappaport, T.S. A millimeter-wave channel simulator NYUSIM with spatial consistency and human blockage. In Proceedings of the 2019 IEEE Global Communications Conference (GLOBECOM), Waikoloa, HI, USA, 9–13 December 2019; pp. 1–6.

[36] Samini, M.; Rappaport, T.S. 3-D millimeter-wave statistical channel model for 5G wireless system design. IEEE Trans. Microw. Theory Technol. 2016, 64, 1–19.

[37] R. Hasan, R.; Mowla, M.M.; Rashid, M.A.; Hosain, M.K.; Ahmad, I. A statistical analysis of channel modeling for 5G mmWave communications. In Proceedings of the 2019 International Conference on Electrical, Computer and Communication Engineering (ECCE), Cox's Bazar, Bangladesh, 7–9 February 2019; pp. 1–6.

[38] Cheng, X.; Li, Y.; Ai, B.; Yin, X.F.; Wang, Q. Device-to-device channel measurements and models: A survey. IET Commun. 2015, 9, 312–325.

[39] Zeng, Y.; Wu, Q.; Zhang, R. Accessing from the sky: A tutorial on UAV communications for 5G and beyond. Proc. IEEE 2019, 107, 2327–2375.