

An Overview of QoE for 5G Networks

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ABSTRACT

Next Generation Mobile Communication is a paradigm in which smart devices and heterogeneous network of different technologies will be merged to implement the concept of ubiquitous computing in Internet of Things (IoT). This coming era of 5G network is demanding dynamic resource sharing and context sharing with seamless high speed connectivity everywhere. In short the users want to experience a bundle of joy from tinny devices. All of the above is possible by designing 5G system in QoS and QoE are of same value. Difference between QoS and QoE, parameters to evaluate QoE, methods to collect QoE related information and artificial intelligence approaches to achieve QoE are discussed in this research article. Moreover, connection of QoE with user's emotion and previous experiences are also explored in QoE.

Keywords: 5G, Heterogeneous Network, QoE, QoS

1. INTRODUCTION

Evolution of wireless technology from 1G to 5G is a journey of communication technology which starts from connectivity and leading towards a fully connected and complex environment like Internet of Things (IoT). Ubiquitous computing in a complex and completely connected IoT is increasing data traffic speed and capacity. Users are using multiple devices for connectivity and computing. nature of services vary from connectivity (multimedia call, email and instant messaging) to smart access and control to smart devices connected and controlled by user with the help of personal area network (PAN). User's expectations about quality of service vary from service to service. QoE is referred as how well users application work with the help of connectivity provided by network [1].

5G network is aimed to provide QoS in complex, fully connected ubiquitous environment. Performance evaluation of 5G network is done by analyzing KPI (key performance indicators). QoE refers to the providing quality of service according to user's demand. Emerging technologies of 5G like Massive MIMO, Programmable Logical devices and Dynamic Spectrum Sharing will improve QoS but at the same time increase the number of use case scenarios which make a ubiquitous network with user centric services difficult to implement. 5G is supposed as base of fully mobile and connected environment, empowers value creation towards end users, through existing consistent experience, enabled by

sustainable business models. 5G is a system of things and user centric services. "5G is supposed to be a smart network, smart enough to provide data rates to user with respect to their requirements rather than providing peak data rates every time .

2. QoS & QoE

QoS for wireless network is measured with the help of hard metrics reflecting (KPI). Usually availability and reliability stands for QoS (highest data rate). QoS is analyzed on technical measures like peak data rate, spectral efficiency, packet loss, delay, jitter and other parameters which can present the negative or positive QoS. QoE is the user's perception of services acquired. QoE is subjective measure, it is very difficult to measure qualitative values on the basis of user's preference and nature of application. Any service rendered with very low QoE results in user's disappointment while on other hand if we utilize maximum resources for all services then it will cause wastage of resources. Once QoE is achieved and approved by user then to provide consistent QoE becomes more critical as user have high expectation on the basis of previous experience [1].

QoE is check on all these parameters with respect to user's personalized services and his context. International Telecommunication Union Telecommunication Standardization Sector ITU-T P.10/G.100 defines the QoE as "level of user's acceptance towards application and services is referred as QoE". European Network on QoE in Multimedia

Systems and Services. Qualinet defines QoE “level of end user’s delight towards services. While services are directly dependent on network, devices and context based facilities provided by core network (service vender)”[2].

3. Parameters to Analyze QoE

A. Consistency

Consistency of services, that is providing QoS without any interruption and variance.

B. Personalized Services

Providing personalized services to end user, personalized services refers to subscribed services (call and internet packages, mobile data usage packages).

C. Resource Consumption

User’s preferences are in terms of resource utilization. Personalized services with high quality demands implementing additional checks on core and edge networks which will result in additional signaling and more battery power consumption. “to maintain resource and energy cost per QoE unit is another challenge in 5G.

D. Security

In 5G wireless network is supposed to provide QoS with highest user perceived value. It also implies better resource utilization of service provider; dynamic spectrum sharing is designed to provide fast access to user while utilizing white spaces of licensed spectrum at the same time. But user requirement are complex to predict. What if user need faster access but with higher security and privacy? In that case D2D communication may increase the chances of security breach. A simple solution is additional protocols which will cause delay and decrease user perceived value of service (QoE).

E. Context Aware Communication

5G network communication should be context based. User context can be personal context, application specific context and environment specific context. Fig. 1 shows different factors of context and key performance indicator to asses QoE of 5G networks.

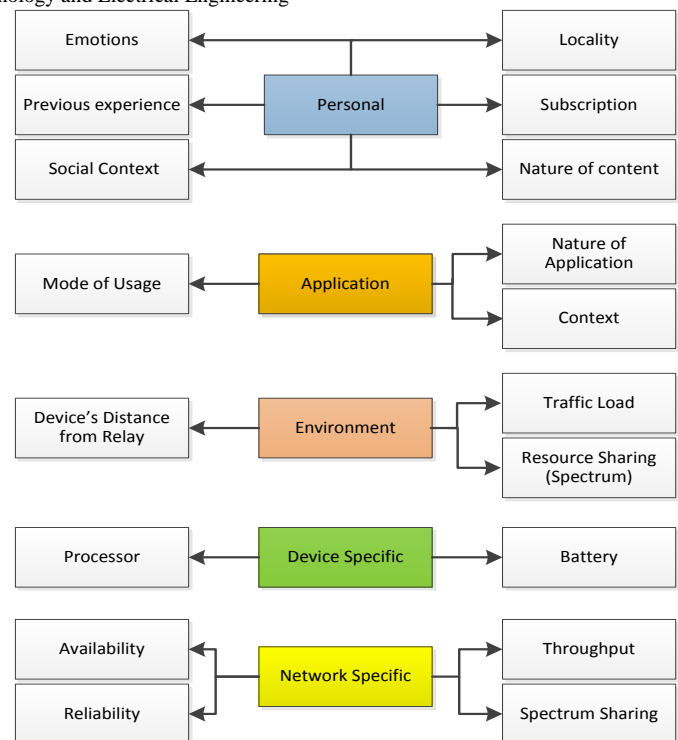


Fig.1 Context awareness factors and KPIs

- Personal Context refers to both personal context of user like any user related information which can add on in providing personalized services like demographic & locality of user, nature of content transmitted during communication. User’s location, activity and previous experience can be used to design detailed personal context theme [3].
- Application specific context specifies the QoS required running those applications. Such as video streaming, web browsing, online gaming and cloud based applications. More over mode in which application is running also make context awareness critical like real time video streaming is more expensive in terms of data rate to ensure optimum resolution.
- Environment context refers to the conditions in which services are delivered as device’s distance from access /relay point, data traffic load and availability of alternative resources. [3]
- Device specific context such as remaining battery power, processor’s capability and other device specification [4].

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- State of network as air link load, availability, reliability, throughput and spectrum and context sharing mechanism.
- Context awareness is the first step towards QoE. Now next step is the context sharing between applications, network and devices [4].

4. Factors Affecting QoE

QoE is a qualitative measure of user's satisfaction level with services and applications. Users interact with wireless services in certain scenarios and environment which directly affect degree of user's satisfaction. If QoS for a specific application is measured on pre assumed standard then user's feeling will have no weighted in QoE. So QoE metrics must include user, service and environment related factors [2].

- User-Related Factors: For example in online video streaming if user is not satisfied with buffering speed then the pauses will affect user's mode and that bad experience is supposed to be reflected on its perceived value of services. User related factor also include user's perception and past experience. In online video streaming if user is pausing video repeatedly then it means user is not satisfied with data rates and buffering is slow. If user switches the web setting to basic view then again web service and network are providing throughput lesser then the expected value. On the other hand if user is viewing online video in full screen mode it means user is getting better services and perceived value is high. Matrix which define pattern of user's actions and their correlation with perceived value can better reflect the QoE [2].
- Environment-Related Factors: Environment related factors includes the environment in which services providing framework is working as hardware, software and allocated resources which directly affect the capability and QoS of service provider. Environment in which user is acquiring the services as user's devices hardware and software related issues, nature of application, associated time frame and user's capability

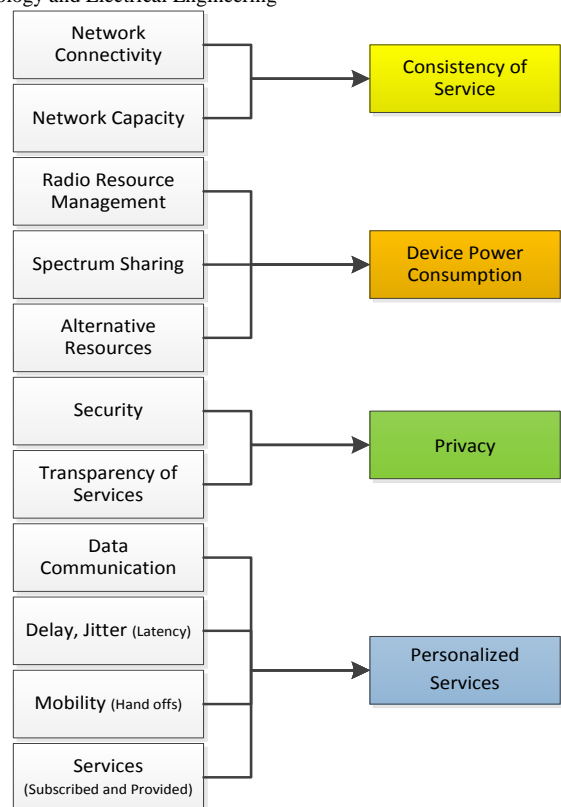


Fig.2 Mapping of QoS into QoE

directly affect the QoE [2].

Fig. 2 is representing basic mapping of parameters of QoS into QoE metrics. Security, privacy, resource management and consistency of services are the parameters which are interlinked and we can map QoS parameters to achieve QoE targets but two highlighted factors of QoE personalized services and context aware communication are remained unaddressed in existing service evaluation parameters. Consequently to clarify the concept of achieving QoE targets first we have designed a context aware communication work flow in 5G.

5. QoE Evaluation Method

A. Subjective Evaluation Methods

In subjective methods user is directly involved in evaluating the QoE. User is directly asked to evaluate quality of experience and their satisfaction level associated with acquired services. These methods are direct and yields accurate results. But it's quite expensive and difficult to get first hand data of personal experience. User's experience is obtained by 'MOS' (Mean Opinion Score) of degree of user satisfaction. That MOS can be collected from different user groups such as novice or expert

user with respect to specific application. Subjective methods are complex and depend on User Experience which is beyond the control of service provider.” Users owning smart devices have become more critical about QoE.

B. Objective Evaluation Methods

Objective methods evaluate QoE on the basis of correlation models. Correlation models are designed to predict user’s perceived value on the basis of user’s actions performed while acquiring services. Numeric quality matrices are used to evaluate QoE. The data used in numeric quality metrics is collected from application service in the form of reference throughput (input and output signals for specific user). Measures used in objective methods are air link traffic statistic, packet loss and latency[5].

6. AI Techniques for Subjective and Objective Analysis

More robust and alternative approach for evaluation is use AI techniques and statistical pattern analysis to predict user’s perceived value. For subjective evaluation real time data of user can be used to predict QoE but for model training and increasing accuracy we need a lot of historic data to train predictive models. Models may fall in three basic categories with respect to user’s perceived value. The categories are network traffic model, user’s application based model, and data rate model (bit rate).

A. QoE Optimization Techniques

Radio resource management techniques are evolved on the basis of user perceives level of satisfaction.

- Traffic classification: Nature, importance and demand of data being transmitted during services is used to classify network traffic.
- Dynamic bandwidth allocation: In a context aware network band width limit will be changed dynamically on the basis of subscribed services, user’s preference, location of user and quality of signals in user’s area.
- Dynamic Spectrum sharing: Spectrum sharing between licensed and unlicensed spectrum owners has emerged as affordable and feasible technique to improve quality of

experience. Licensed spectrum offers longer range services while unlicensed spectrum offers higher data rate. As the mode of application and user’s requirements change dynamically spectrum sharing can provide better services in an effective resource utilization strategy[6].

B. Applications to Evaluate QoE

Evaluating QoE for all scenarios while considering wireless network’s performance with respect to all services is not feasible .so a full reference model is impractical and will not objective oriented solutions to improve QoE. A partial solution of application specific QoE is quite practical and attainable. In such model application specific QoS data can correlate to the QoE matrices .more over user’s views about QoE while using specific application are reflected by different mediums.

C. Live Video Streaming

In live video streaming we can apply different artificial intelligence algorithm can be used to estimate QoE parameters. K NN, Decision trees and Random forest are some of tried and tested algorithms. Objective parameters of live video streaming will rely on two major factors:

- Video quality which depends on both network and encoder.
- Resolution of video depends on user’s device and application and physical layer of network.
- QoS parameters to analyze live video streaming depends on Resolution, Encoder parameters, Packet loss rate and Mean burst length and time.

7. QoE Mapping System Design and Analysis

Video QoS matrices are used to build a correlation between QoS & QoE. Fuzzy logic rules along with human reasoning are used as base for designing fuzzy logic. Ultimately video quality matrices is converted into MOS (mean opinion score)[7].

A. Cloud Computing Applications

Mobile cloud computing services are more user centric and communication between user and network is more interactive , robust and demanding as user expect easy access and high speed computing from cloud services. In MCC it is feasible to

provide personalized services by implementing emotion aware service evaluation.

The idea of emotion awareness is strongly backed by the fact that smart phone, smart devices and other wearable sensors based devices deploy intelligent applications. User's emotion can be sensed by defining the relationship of user's emotions & behavior with device usage .But user emotion specific data produced by it is usage pattern in not sufficient to build an inference engine for QoE evaluation. Collecting detailed subjective data is required which is performed by interacting with user manually and mapping results into inferences.

B. Data Collection

Mobile usage statistics are gathered from mobile statistics data collected from mobile sensors so QoE data collection is directly dependent on QoE. Emotion oriented data collected from devices can be physiological, social, historical or multimedia driven emotional data. Wearable devices data provide information about user's context and his current health status (health care). Physical conditions also have impact on user's behavior, state of mind and expectation towards services.

C. Preprocessing of data

Collected data must be preprocessed before making inferences. Uncertain, incomplete and noisy data is removed and formatted to obtain meaning full and reasonable data. Consistency and reliability checks are performed so that computing and storage resources are not misused on corrupted data. Data compression techniques are also used to effectively store multimedia contents.

D. Data analysis

User's emotion are perceived by analyzing text, image ,video and other sensor based data .or historic social network driven data is used to make inferences about user's emotions. Once such system is designed and implemented then it can help users in diverse ways as:

- For old people it can gather data related to their physical and mental well-being.
- People relieved from healthcare facility can be served with customized services to maintain their health [8].

7. Conclusion

Analysis and evaluation of user's level of satisfaction while trying to figure out the factors influencing this feeling. Achieving all subjective and objective measures is not an easy task. A centralized context sharing mechanism is now considered as an integral part of next generation mobile networks design. In context sharing it is still a question mark that with increasing demand of air link resources for communication is it feasible to dedicate resources on a subjective level information sharing. Choice of mode of QoE analysis "subjective & objective" is a tradeoff between accuracy of information and resources constraint. In a nut shell to achieve QoE in next generation mobile network we are supposed to design a network which have dedicated resources and convenient methods to collect QoE information on run time basis and converting into input to improve QoS from user's perspective.

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