VIDEO QUALITY IMPROVMENT IN 5G USING FUZZY LOGIC

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Abstract - *As there is increase in the growth of video transmissions over wireless networks, an adequate mechanism to increase the resiliency to packet loss with QoE support is essential. The mechanism adopted should be able to provides the capability to enhance video transmissions in dynamic networks, and consequently, improving the video quality, without adding unnecessary network overhead and maximizing the QoE. As the resources in the network are already scarce, this approach leads to a better usage of the wireless resources for video delivery. It can be made possible by using the redundancy scheme which is based on key human visual system and video characteristics, namely, GoP size, frame type, and position, as well as the levels of motion activity in each video sequence. Besides that, the network state, i.e., packet loss rate, was also considered.*

Key words - Network data analytics function (NWDAF), Fuzzy logic, MATLAB, Operation administration and maintenance (OAM), Long term evolution (LTE)

1. INTRODUCTION

Quality of Experience (QoE) for Internet Streaming Video is that the estimation of a provider's service quality from a customer's point of view. As 5G is predicted to support a number of service types, assured QoE across multiple users and repair types is extremely important. QoE values are used to monitor quality of a service and quantify the improvements to customer experience before they complain or leave. We address the matter of QoE for video streaming in 5G networks. The target is to be ready to address the difficulty of QoE for Video streaming during an LTE/5G heterogeneous network. The QoE is evaluated at the NWDAF node within the 4G/5G Network. QoE analysis at the NWDAF has got to affect a huge amount of knowledge collected at each network node and therefore the UE. We'd like a mechanism to filter data at each node and pass it to NWDAF entity. QoE maintenance is additionally complex because it depends on tons of parameter inputs which can not necessarily be available. Therefore, the order to supply the top user with the simplest quality of experience (QoE) for video streaming, this project has been developed and simulations are made.

2. PROBLEM STATEMENT

As 5G is expected to support a host of service types, assured QoE across multiple users and service types is very important. QoE maintenance is also complex as it depends on a lot of parameter inputs which may not necessarily be available. To handle qualitative aspects of user experience, in this paper we make use of Fuzzy logic algorithms to deal with user experience factors. The QoS / KPIs are used along with user experience factors to address the issues of QoE. The fuzzy algorithms will also address issues of possible information uncertainty at the NWDAF level given that the evolving NWDAF specifications does not provide all possible information about the radio access network.
The two important video streaming parameters that will have to be controlled are

1. Video Rate
2. Freezing.

Some of the parameters that affect Video Rate and Freezing are the: -

1. Link Context (SINR, Bandwidth Availability)
2. 5G cell availability, number of handovers
3. Switching between LTE and 5G termed as mobility context (as the 5G cells will be sparse in the initial deployment)
4. Traffic Context
5. UE Context (Available Buffers etc.)

We do not consider the human factors (ex: tendency and frequency change in view angle). The above parameters are monitored and mapped to required video rates and possible Freezing probabilities to take corrective actions.

3. FRAMEWORK - NWDAF

The framework we use is the NWDAF (Network Data Analytics Function) framework. NWDAF is a new 5G core network function. The NWDAF provides analytics to 5GC NFs, and OAM. Analytics records are either statistical information of the past events, or predictive statistics. Distinctive NWDAF instances could also be present within the 5GC, with possible specializations per sort of analytics. The consumers decide about how to use the information analytics provided by NWDAF. The communication between 5GC NF(s) and therefore the NWDAF happen within a PLMN (Public land mobile network). The NWDAF has no knowledge about NF application logic. The NWDAF may additionally use subscription data for statistical purpose.

3.1 Procedures to Support Network Data Analytics

This procedure is employed by any NWDAF service consumer (e.g., including NFs/OAM) to subscribe/unsubscribe at NWDAF to be notified on analytics information, using Nnwdaf_AnalyticsSubscription service defined. This service is additionally employed by an NWDAF service consumer to switch existing analytics subscription(s).

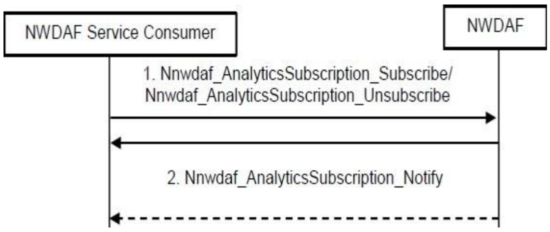

Fig - 3.1: Procedure to Support Network Data Analytics

3.2 Procedures for analytics subscribe/unsubscribe by AFs via NEF

NEF controls the analytics exposure mapping among the AF identifier with allowed Analytics ID, and associated inbound restrictions (i.e., applied to subscription of the Analytics ID for an AF) and/or outbound restrictions (i.e., applied to notification of Analytics ID to an AF).

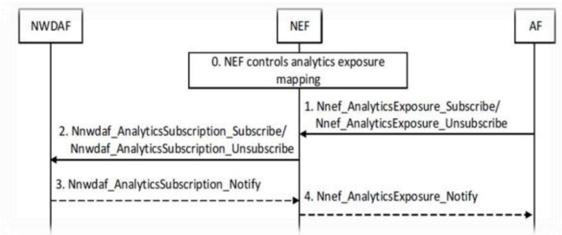

Fig- 3.2: Procedure for analytics subscribe/unsubscribe by AFs via NEF

4. TOOLS USED

4.1 Fuzzy logic

In fuzzy mathematics, fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1, both inclusive. It is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. Fuzzy logic is all about the relative importance of precision and is an appropriate way to map an input space to an output space. Mapping input to output is that the start line for everything.

4.2 Symbolic logic toolbox software

You can create and edit fuzzy inference systems with symbolic logic Toolbox software. These systems can be created by using graphical tools or command-line functions and can also be generated automatically by using either clustering or adaptive neuro-fuzzy techniques. If we've got access to Simulink software, we'll simply test our fuzzy system during a diagram simulation environment. The toolbox also allows you to run your own stand- alone C programs directly. This is often made possible by a stand-alone Fuzzy Inference Engine that reads the fuzzy systems which is saved from a MATLAB session. We'll modify the standalone engine to create fuzzy inference into our own code.

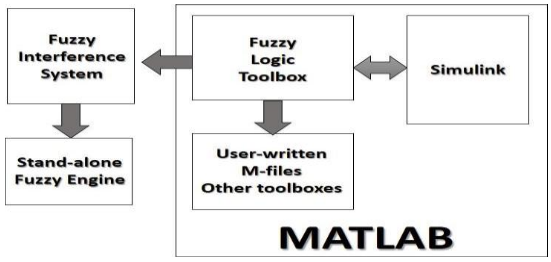

Fig - 4.2: MATLAB Environment

4.3 Fuzzy Inference System

Fuzzy Inference System is the key unit of a symbolic logic system having deciding as its main work. It uses the "IF…THEN" rules alongside connectors "OR" or "AND" for drawing essential decision rules.

The output from FIS is usually a fuzzy set regardless of its input which may be fuzzy or crisp. It is necessary to possess fuzzy output when it's used as a controller. A defuzzification unit would be there with FIS to convert fuzzy variables into crisp variables.

4.4 Functional Blocks of FIS

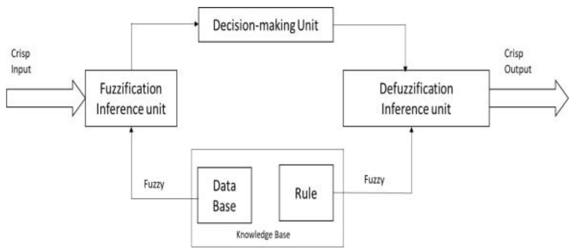

Fig - 4.4: Functional Blocks of FIS

A fuzzification unit supports the application of several fuzzification methods, and converts the crisp input into fuzzy input. A knowledge base - collection of rule base and database are formed upon the conversion of crisp input into fuzzy input. The defuzzification unit fuzzy input is finally converted into crisp output.

5. RESULT ANALYSIS

5.1 TEST CASE 1

5.1.1 Membership functions

It is now necessary to define the packet loss rate set. The main idea with this activity is to quantify the packet loss rate against the video quality in terms of QoE. This means that a loss rate of 10% can be characterized as low to us, but it could be unacceptable to other types of applications, for example a voice over IP (VoIP) call. To define this set, a number of network simulations with different packet loss rates and a broad collection of video sequences were carried out. On average, the video quality was considered good when the network losses were between 0% and 10%. A reasonable quality was perceived between 5% and 20%, and over 15% the quality decreases rapidly, becoming unacceptable. Based on that, three categories were defined, namely “low”, “median”, and “high”, as shown below

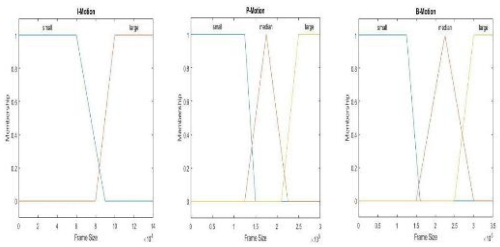

Fig - 5.1.1: I-frame, P-frame and B-frame

5.1.2 Packet loss and Redundancy

A further step is to define the redundancy amount set. This set will aim to establish the output value for the redundancy amount. Several experiments were conducted and with the aid of human knowledge in the field to specify what would be a “small”, “median”, and “large” amount of redundancy. Figure below displays the graphical representation of the membership function found. The activity is straightforward, if a video sequence has low levels of motion activity and the packet loss rate is also low, then the redundancy amount added by the algorithm is also low.

The same idea holds true for “median” and “high” characteristics as depicted below. After the conception of the rules and sets, they need to be loaded in the Fuzzy Logic Controller (FLC). Once the FLC is defined, it will calculate the degree of membership of each input information, resulting in a precise amount of redundancy on the fly.

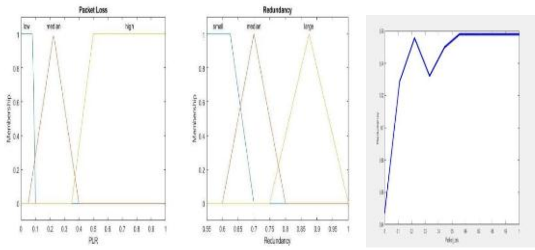

Fig - 5.1.2: Packet loss and Redundancy

From the above graph, it is understood that when the packet loss is less than 10% then the redundancy added is small, while when the packet loss is between 10% and 35% the redundancy added is higher, whereas for the packet loss above 40% highest number of Redundancy bits are added in order to maintain better video quality

5.2 TEST CASE 2

5.2.1 Membership functions: -

Similarly, based on the linkage distance between the clusters, the linkage difference considered in this case is small, the I-frame data was divided into two clusters “small” and “large”. On the other hand, the P- and B-frame data were divided into three clusters, namely “small”, “median”, and “large”.

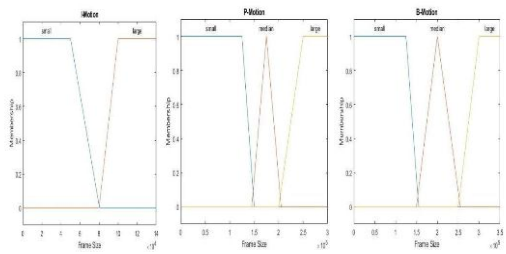

Fig - 5.2.1: I-frame, P-frame and B-frame

5.2.2 Packet loss and Redundancy

The video quality was considered good when the network losses were between 0% and 10%. A reasonable quality was perceived between 9% and 20%, and over 38% the quality decreases rapidly, becoming unacceptable. Based on that, three categories were defined, namely “low”, “median”, and “high”, as shown above. This set will aim to establish the output value for the redundancy amount. Several experiments were conducted and with the aid of human knowledge in the field to specify what would be a “small”, “median”, and “large” amount of redundancy. Figure below displays the graphical representation of the membership function found.

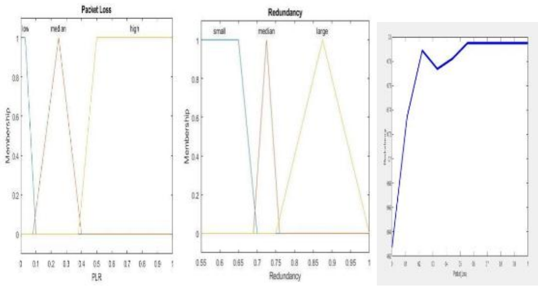

Fig - 5.2.2: Packet loss and Redundancy

From the above graph, it is understood that when the packet loss is less than 10% then the redundancy added is less the 70%, while when the packet loss is between 10% and 30% the redundancy added is higher, whereas for the packet loss above 40% highest number of Redundancy bits are added in order to maintain better video quality

6. CONCLUSION

The experiment results exhibit that our mechanism was able to improve the video quality without adding an unnecessary amount of redundancy when PLR is up to 20%. And PLR between 20% to 50% a considerable amount of redundancy as added, and for PLR above 35% the maximum redundancy was added in order to maintain the video quality, it provides a good tradeoff between network overhead and quality improvement and was only possible because our mechanism adds a certain amount of redundancy considering the video characteristics and the network state.

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