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ENHANCE QOE IN MOBILE COMPUTING VIA REPRODUCTION, DIMENSION, AND CALCULATION

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Abstract: **In mobile and pervasive computing environments, understanding and measuring users' quality of experience (QoE) is an important and challenging task. Quality of Experience (QoE) as an aggregate of Quality of Service (QOE) and human user-related metrics will be the key success factor for current and future mobile computing systems. QoE measurement and prediction are complex tasks as they may involve a large parameter space such as location, delay, jitter, packet loss, and user satisfaction just to name a few. These tasks necessitate the development of practical context-aware QoE models that efficiently determine relationships between user context and QoE parameters. In this paper, we propose, develop, and validate a novel decision-theoretic approach called CaQoEM for QoE modelling, measurement, and prediction. We address the challenge of QoE measurement and prediction where each QoE parameter can be measured on a different scale and may involve different units of measurement. CaQoEM is context-aware and uses Bayesian networks and utility theory to measure and predict users' QoE under uncertainty. We validate CaQoEM using extensive experimentation, user studies and simulations. The results soundly demonstrate that CaQoEM correctly measures range-defined QoE using a bipolar scale. For QoE prediction, an overall accuracy of 98.93% was achieved using 10-fold cross validation in multiple diverse network conditions such as vertical handoffs, wireless signal fading and wireless network congestion.**

Keywords: **Bayesian networks, context-awareness, decision theory, quality of experience, simulations, prototyping, user tests.**

I. INTRODUCTION

As the Internet is increasingly used in all aspects of daily life, the realization has emerged that privacy and confidentiality are important requirements for the success of many applications. There are several stakeholders who are interested in understanding what users think and perceive about the services being provided to them in terms of new products and applications. For example, telecommunications operators want to understand how to minimize network churn by providing better services to the users. On the other hand, network engineers require the knowledge about underlying network conditions affecting users' QoE for user-centric network optimization. Users' QoE about a particular technology, network service or an application depends on their expectations, on their cognitive, psychological and behavioral states and network parameters which vary with time and under different context and situations .For example, shows that users' QoE may differ in laboratory and real-life user environments. It is widely assumed that by maximizing network Qoe(e.g., increasing network bandwidth and/or increasing wireless signal strength) or by reducing the cost of services, users will be satisfied with the services provided to them.

Several researchers noted problems while adhering to the ITU-T P.800 recommendation for conducting subjective tests. For instance, the major problem while considering MOS as a QoE metric is that it considers arithmetic computation involving user ratings. We assert that arithmetic operations such as computing mean and standard deviation cannot be applied on subjective ratings as these ratings are categorical in nature.

The human test subjects ranks the alternatives (e.g., “excellent” and “fair”) on the categorical/ordinal scale where the distance between these alternatives cannot be known . Thus, the methods involving MOS as a metric will also be inappropriate .show that in case of subjective tests, normality of collected data (user ratings) cannot be verified. Further, due to the subjective nature of users’ ratings, parametric statistical models cannot be applied for QoE measurement and prediction. Hence, techniques involving ordinary regression analysis will also be invalid.

The authors point out that the conditions for valid statistical tests are rarely verified and documented by computer science researchers. Nonetheless, MOS is the most widely used method to assess subjective ratings in both industry and academia. These methods may not give accurate QoE estimations in real-life environments as users’ QoE is also dependent on other context attributes related to their expectations and their behavioural and psychological states argues for a multi-disciplinary approach for QoE measurement and prediction. Their approach involves living-labs testing where QoE measurements are done through the use of software tools in realistic user test environments. Their results show much lower error rates in users’ QoE ratings in case of the realistic test environments as compared to the laboratory settings. However, the problem with QoE measurement and prediction in real-life environments is that most of the parameters are uncontrollable. Further, users’ behaviour and network conditions can be dynamic and uncertain.

II. PROBLEM DEFINITION

Quality of experience (QoE) is a fast emerging multidisciplinary field based on social psychology, cognitive science, economics, and engineering science, focused on understanding overall human quality requirements. QoE is the blueprint of all human quality needs and expectations. Traditionally, technology-centric approaches based on quality of service (QoS) parameters have been employed to ensure service quality to end users. QoE expands this horizon to capture people’s aesthetic and even hedonic needs. The International Telecommunication Union Telecommunication Standardization Sector (ITU-T) defines QoE as “The overall acceptability of an application or service, as perceived subjectively by the end-user”.

Unlike ITU-T’s definition, which only links QoE with subjective human perception, we consider objective human factors as equally important aspects of QoE. We define QoE as a blueprint of all human subjective and objective quality needs and experiences arising from the interaction of a person with technology and with business entities in a particular context. For understanding user and/or customer requirements, it is pertinent to know the communication ecosystem where various actors interact to produce the service life cycle. The term *ecosystem* has been used in various fields. In ecology, it is defined as “a system involving the interaction between a community of living organisms in a particular area and its non living environment” . A cultural ecosystem is defined as “a collection of living things and the environment in which they live” ; similarly, we define a communication ecosystem as “the systematic interaction of living (human) and non living (technology, and business) in a particular context.” A conceptual diagram of a communication ecosystem is presented.

A communication ecosystem incorporates different disciplines such as technology, business, context, and human behavior. Human-to-technology interaction in a communication ecosystem develops the user experience model to understand user requirements with respect to technology. Various technological aspects such as service features, end-user device functionalities, and Qoeparameters influence the feelings, perception, and performance of a user.

A. Problem Analysis

In existing system, Stability and recoverability, two main problems in routing QOE traffic in mobile networks. The first issue is stability. With most ad hoc wireless networks that support QOE, each node acts as a router. In many distributed reactive routing schemes, if a node does not know the QOE parameters of its neighbors it broadcasts the route request packet and the neighboring nodes share their QOE parameters using broadcast packets. The broadcast packets used to discover the QOE parameters of nodes’ neighbors and negotiate QOE paths can flood the network. The second issue is minimizing the QOE impact due to network failures. If a supporting node fails when traffic is routed through multiple hops then, in the worst case, the connection must be rerouted from the source. This global fault-recovery method requires that the source renegotiate a new QOE path, which is costly in computation and communication. If multiple sources were using the failed node in QOE paths then each source must negotiate a new path. Despite its cost, this failure method appears to be common.

B. Problem Solution

In this proposed system, we propose a credit-based incentive mechanism for heterogeneous networks with both wired and wireless nodes. We consider a P2P streaming network where each peer can serve as an uploader and a downloader at the same time. When a peer uploads data chunks to other peers, it can earn certain credits for providing the service. When a peer downloads data chunks from other peers, it has to pay certain credits for consuming the resource. A peer's net contribution to the network is reflected by its accumulated credits. A Stackelberg game is formulated to provide differentiated service to peers with different credits. Particularly, peers' heterogeneity and selfish nature are taken into consideration when designing the utility functions.

The main contributions and key results of this paper are summarized as follows.

• A credit-based incentive mechanism based on Stackelberg games is proposed for P2P streaming networks. To the best of our knowledge, this is the first work that applies the Stackelberg game to the incentive mechanism design for P2P streaming networks.

• Peers' heterogeneity is taken into consideration when designing the utility functions for the Stackelberg game. Thus, our incentive mechanism can be applied to heterogeneous P2P networks with wired and wireless peers having different connection bandwidths.

III. PROCESS FLOW

A. Node Authentication Module

Authentication is any process by which a system verifies the identity of a User who wishes to access it. Since Access Control is normally based on the identity of the User who requests access to a resource, Authentication is essential to effective Security. Authentication is the process of determining whether someone or something is, in fact, who or what it is declared to be. In private and public computer networks (including the Internet), authentication is commonly done through the use of logon passwords. Knowledge of the password is assumed to guarantee that the user is authentic. Each user registers initially (or is registered by someone else), using an assigned or self-declared password. On each subsequent use, the user must know and use the previously declared password.

B. Node Clustering Module

FDCB (Fully Distributed Cluster Based) constructs non overlapping clusters based on bandwidth and delay factors for each link. To achieve efficient fault tolerance, FDCB is augmented so that the cluster-head has complete "cluster-state" knowledge. The cluster-head has connectivity awareness for all cluster nodes. This awareness includes knowledge of all QOE connections currently supported by each cluster member, each member's resource availability, and the cluster topology.

C. Qoe Routing Module

The QOE routing scheme used by EFDCB (Extended Fully Distributed Cluster Based) is Clustered Fisheye State Routing (CFSR). CFSR proposes a clustering framework to reduce redundant broadcast routing control messages. For FSR, the frequency at which node i sends its link state information to node j depends upon the distance from i to j.

D. Fault Tolerance Module

The QOE capabilities provide fault tolerance and fast recovery when links fail on an intermittent or permanent basis. This method avoids the costly process of rerouting the traffic from the source. The second technique uses multilevel path redundancy, which establishes multiple paths for the same connection.

E. Performance Metrics Module

The system performance metrics in this analysis are connection recovery time, number of dropped packets, throughput, and amount of sustainable flow bandwidth. Connection recovery time is the time to reestablish a failed connection from the moment data traffic stops are maintained.

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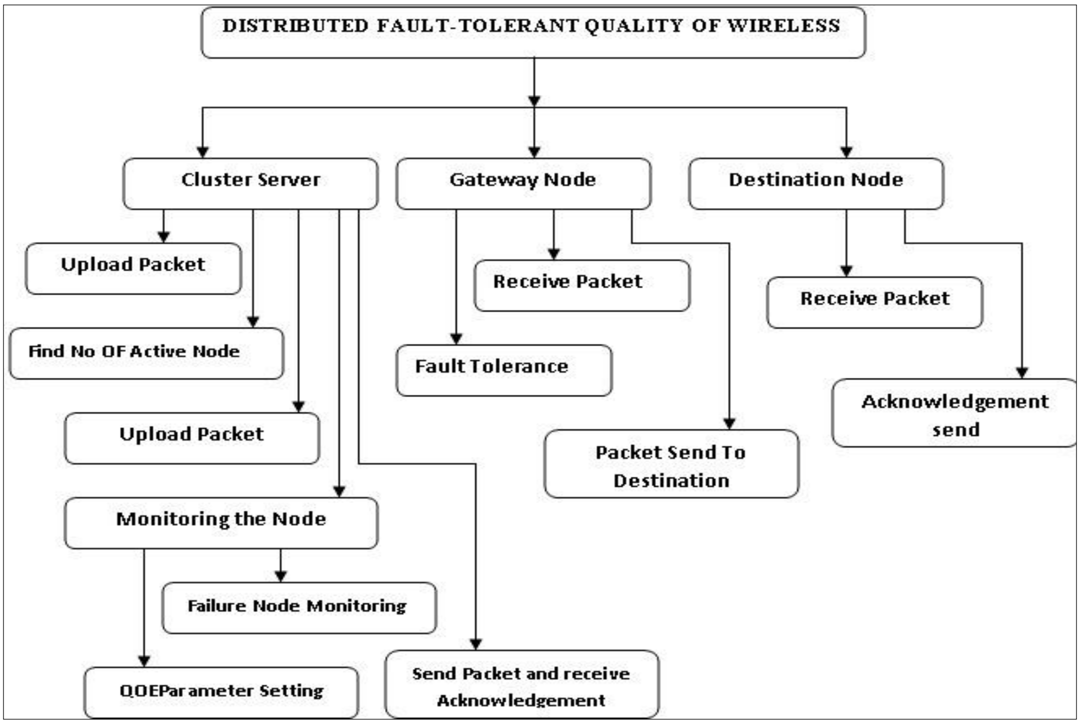

Figure 1: Process Flow

IV. EXPERIMENTAL RESULTS

A. Implementation

Implementation is the most crucial stage in achieving a successful system and giving the user's confidence that the new system is workable and effective. This type of conversation is relatively easy to handle, provide there are no major changes in the system. Each program is tested individually at the time of development using the data and has verified that this program linked together in the way specified in the programs specification, the computer system and its environment is tested to the satisfaction of the user.

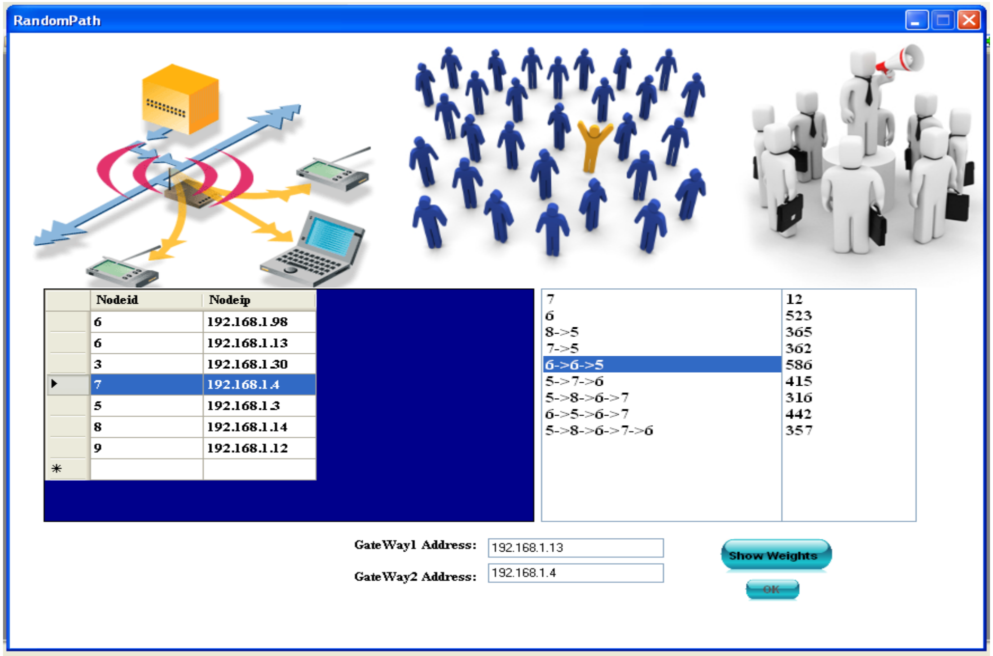

Figure 2: Process of QOE calculation

Figure. 2 show the network setup in this experiment. The center part of the topologies used in experiments is the mix cascade of different number of layers. Each sender on the left side has four flows traversing the network. We arrange paths of traffic flows so that each link in the cascade e has some number of traffic flows. To simulate the cross traffic in the mix network, four larger aggregates of flows are added to the network.

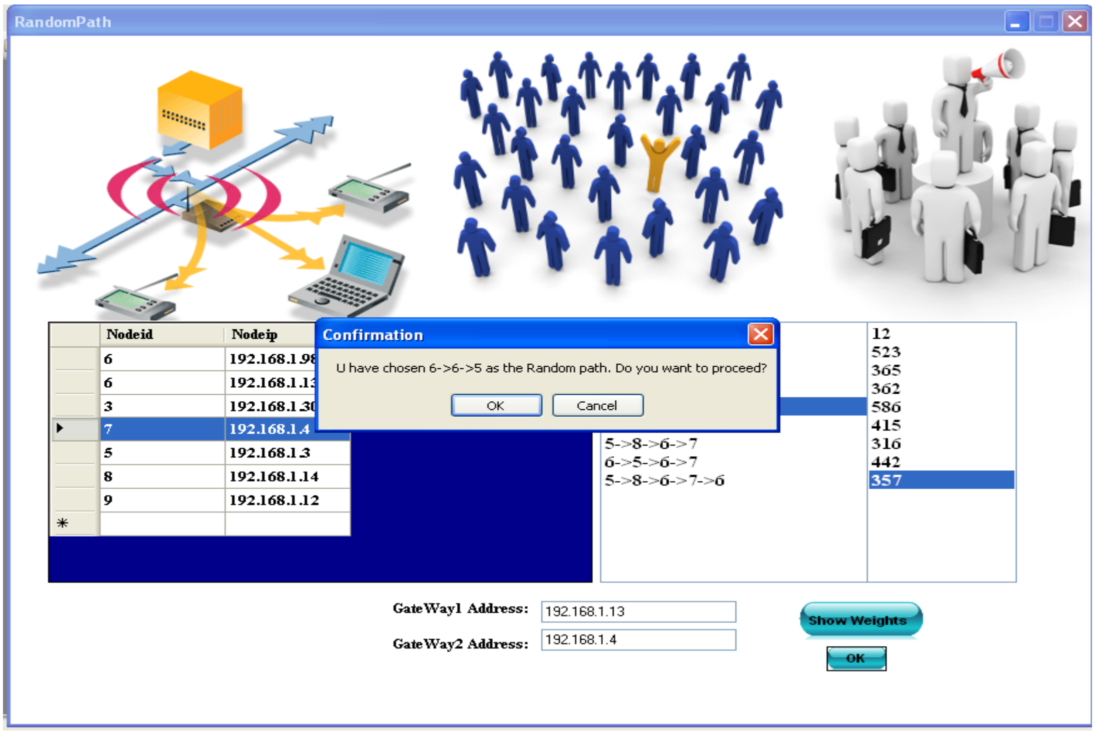

Figure 3: Routing Packet

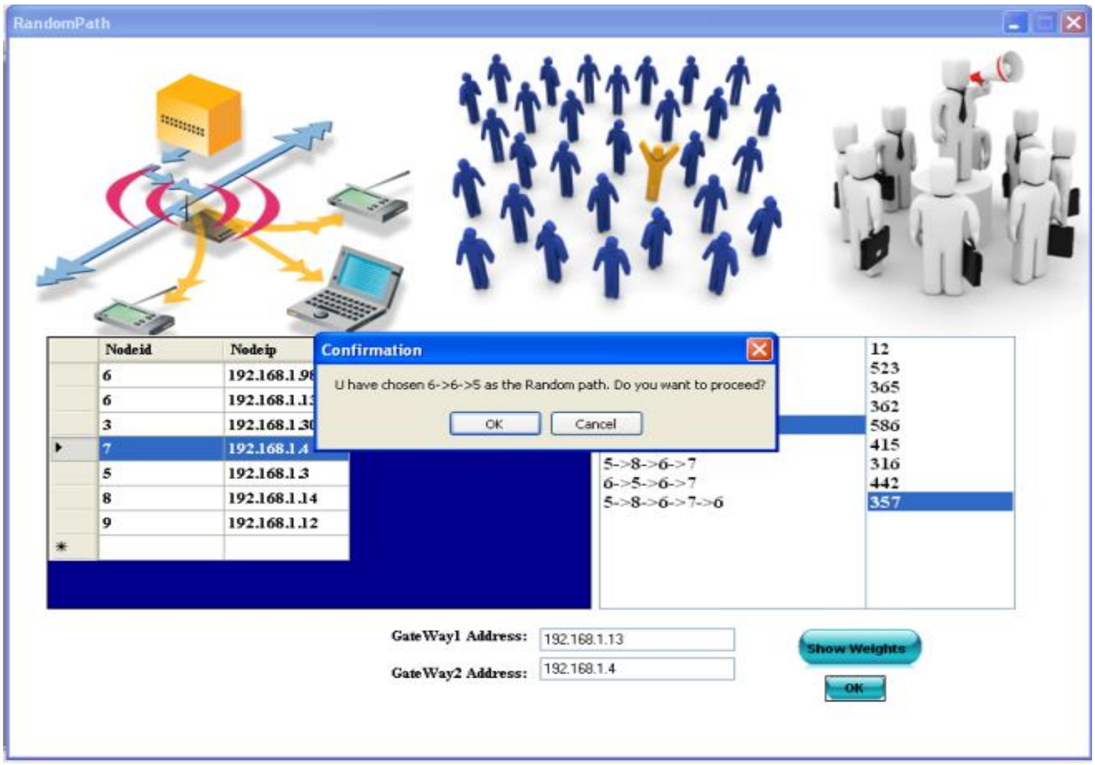

Figure 4: Routing Path Detail

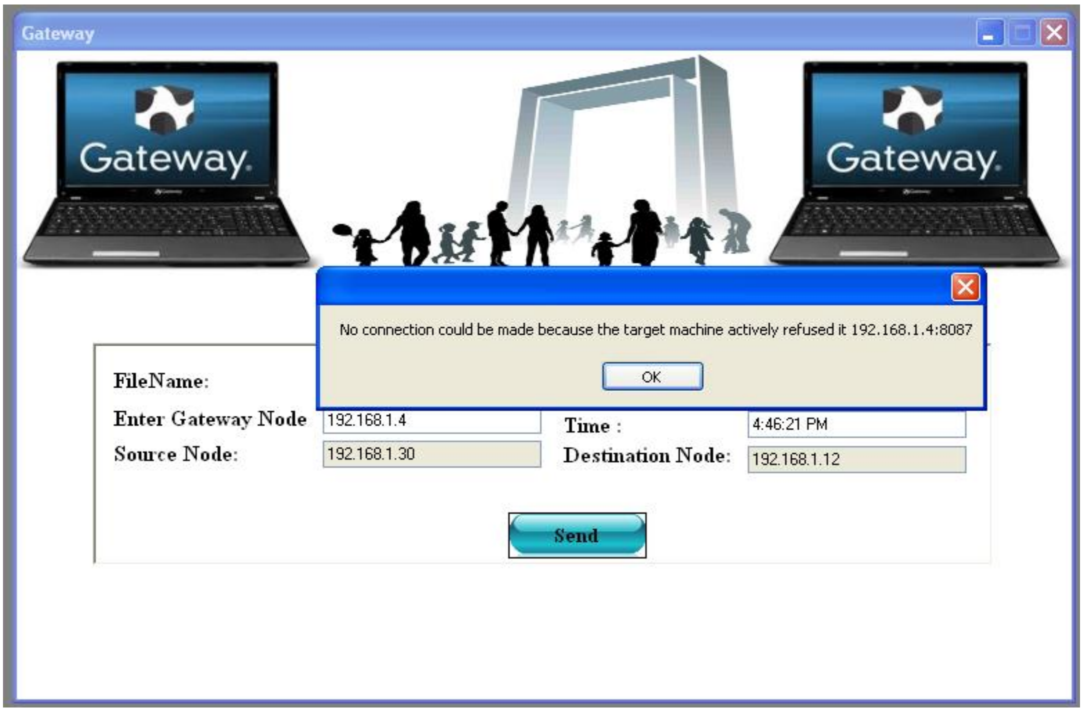

Figure 5: Alert Connection Failiure

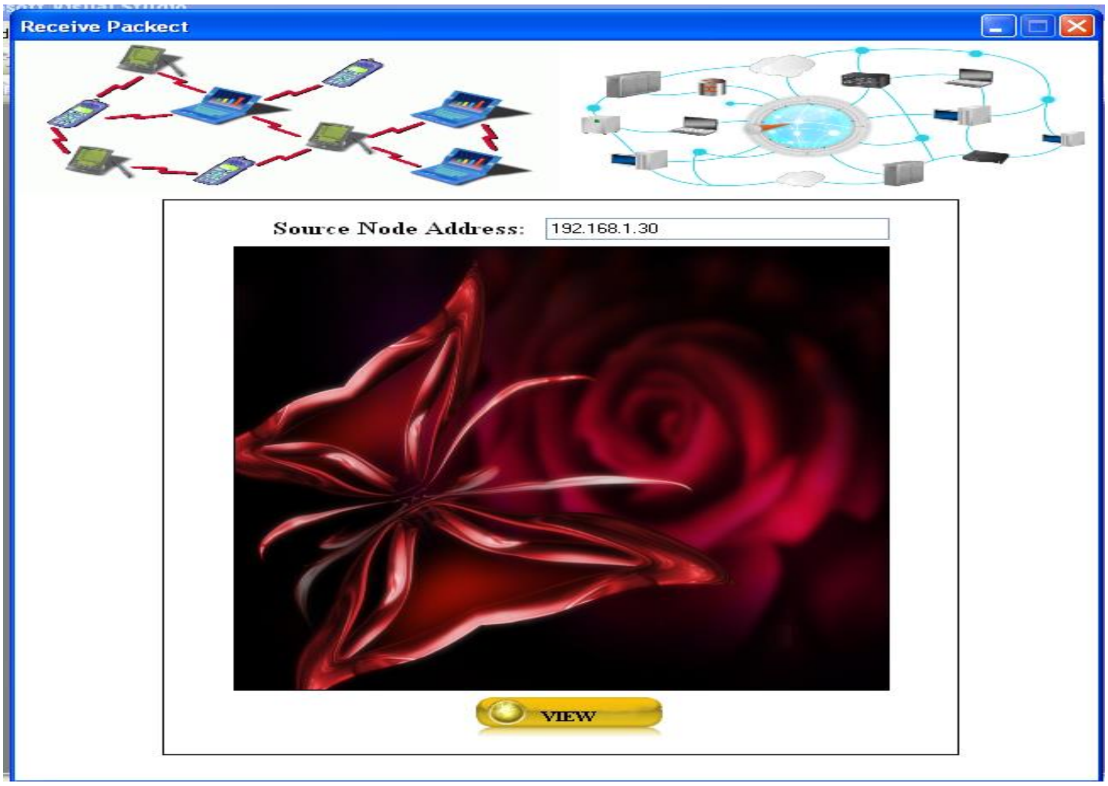

Figure 6: Receive Packet Successfully

V. RESULT AND DISCUSSION

Moderation is a process that could alter the strength of a causal relationship. Human attributes (age, gender) and human roles (customer or user) are considered moderating factors that could alter the strength of a causal relationship. For example, people belonging to different age groups may have different levels of tolerance toward Qoedegradation. Or a customer who buys a VoD service has a different QoE requirement than a user who is using a free VoD service. Thus,

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moderation process segments or individualizes a global QoE factor into subcategories based on age, gender, user or customer roles, and so on. Unlike mediation, there is no need for prediction factors and moderation factors to be correlated, and that correlation has no special interpretation.

However, if prediction factors and moderation factors are too highly correlated, there can be estimation problems. The causal relationship between the prediction factors and QoE factors is a permanent link, while mediation and moderation processes are optional and are instantiated if more accuracy and an in-depth view of QoE is required. During actual experimentation we have switched between the activities and observed the results of the measures for the different situations. Figure 4 provides support measures for the three activities. In this experimental run we have started with the user presenting first for 15 minutes then attending a colleague's presentation for 15 minutes and finally participating in a discussion or general meeting on the topics presented (again for 15 minutes). Interpretation of the results reveals matching support levels with the actual activity taking place. At the time the user is presenting, the support for this particular activity averages around 0.9 whereas support for other situations is significantly lower.

A change in the situation towards the user only attending another's presentation results in a drop of the 'User Presenting' situation to support levels below 0.4, and a rise in the support for the 'User attending a presentation' situation to levels around 0.9. Similarly, when a discussion (equivalent to a meeting) over the presentations involving our user is starting right after the second presentation, the support for 'User in a meeting' situation rises to 0.9 and support for the former situation drops significantly. The successful results of this experiment can be partly contributed to observing assumed behaviors associated with the defined activities, such as having the lights switched off during presentations and on during the following general discussion, or controlling the presentation shown from the user's notebook.

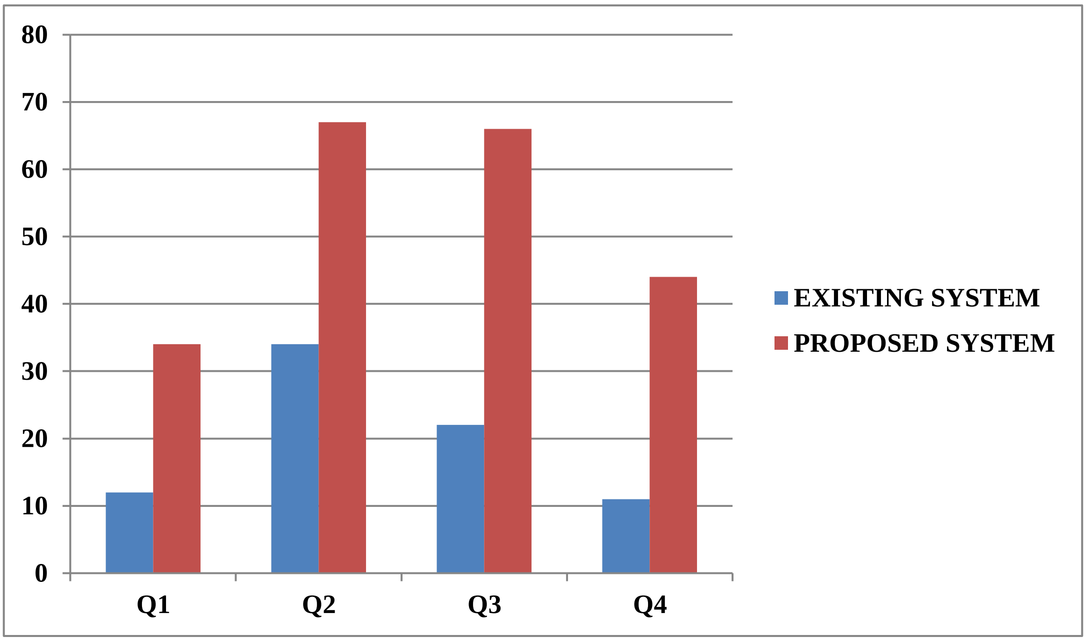

Figure 7: Experimental Result

VI. CONCLUSION

As the era of human-centric service and product design and delivery flourishes, the focus is shifting toward a multidisciplinary human-centric quality of experience approach. In this article, we have proposed a holistic QoE model by bringing all disparate pieces of the communication ecosystem together to understand total QoE. Once this link between QoE and other domains of the communication ecosystem is established, we obtain an authentic and complete assessment of human quality of experience requirements. This model is not meant to be proscriptive, but to provide taxonomy of the relevant variables and their interactions in order to aid practitioners in thinking more broadly about QoE. Instantiating the model will depend heavily on the context in which it is applied: specific variables will be more important and lend themselves more easily to measurement. Our goal is to provide a high-level model that can be adapted to many specific contexts and to encourage future research that examines these cross-domain relationships.

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