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REVIEWS - LETTERS - REPORTS

QUALITY OF SERVICE PROVISION ASSESSMENT FOR CAMPUS NETWORK

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This paper presents a methodology for assessing the quality of service (QoS) provision for campus network. The author utilizes the Staffordshire University's network communications infrastructure (SUNCI) as a testing platform and discusses a new approach and QoS provision, by adding a component of measurement to the existing model presented by Walker [1]. The QoS provision is assessed in light of users' perception compared with the network traffic measurements and online monitoring reports. The users' perception of telecommunications' network infrastructure QoS provision is critical to the successful business management operation of any organization. The computing environment in modern campus networks is complex employing multiple heterogeneous hardware and software technologies. In support of highly interactive user applications, QoS provision is essential to the users' ever increasing level of expectations. This paper offers a cost effective approach to assess the QoS provision within campus network.

K e y w o r d s: quality of service provision, campus network, user's perception, network communications infrastructures, the performance parameters and measurements, the survey questionnaire

1 INTRODUCTION

The concept of assessing QoS provision is often represented in many different ways by various specialists groups including; computer scientists, network engineers, network administrators, Internet services providers, and university business managers. QoS is one of the most elusive, confounding, and confusing topics in data networking today [2]. While research papers on QoS hardly ever questioning raison d'etre it is frequently the topic of heated debates. Why are so many publications and even workshops on a topic which is questioned vehemently while at the same time has so little impact on current products or services [3]? The term service quality may have a different meaning to different people [4]. Some managers use the term to describe how the customer is treated [5]. This is perhaps more accurately called QoS, as opposed to service quality, which could be taken to mean the entirety of outcome and experience [6]. The great majority of users are not interested in the engineering of telecommunications networks or its QoS specifications; instead they expect fast, reliable, and easy access to online resources, applications and Internet (*ie* online databases, banking services, e-commerce, e-mails, Web servers, *etc*) [7]. Most users today (*ie* clients) expect to have immediate access to various communications technologies (*ie* wireless, mobile, fibre optics, Ethernet, *etc*) using almost any software application, following the banking principle of anywhere, anytime, and anyhow [8]. In the current climate of business-driven education with a focus on the user's satisfaction it is essential that the university campus networks provide support for a large number of software applications running reliably over very complex interconnection hardware with fast system response and high security. This requires a great deal of interoperability and dynamic resource allocation within the networks. This paper is structured in the following manner. The first section presents an introduction, Quality of service layered model, four quality cycles, international standard organization (ISO) QoS framework, and assessment of QoS. Section two presents the SUNCI's information technology (IT) survey and discussion of its results. Section three presents the conclusion and acknowledgments.

1.1 QUALITY OF SERVICE LAYERED MODEL

QoS represents the set of parameters that describe the quality of a specific stream of data. QoS requires the cooperation of all network layers and network elements [10] (see Figure 1.)

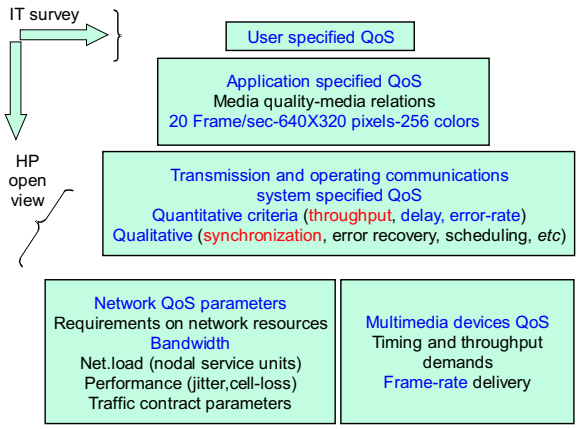

Fig. 1. QoS Model

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Other definitions include 'satisfaction', a 'relative impression of the organization and its services' and 'quality delivered'. Regardless of recent advances in QoS communications technologies, the value of users' perception on QoS provision still presents new challenges. QoS is the ability of a network element (*eg* an application, host or router) to have some level of assurance that its traffic and service requirements can be satisfied [9]. Any QoS assurances are only as good as the weakest link in the chain between sender and receiver [11]. QoS representation is studied at each layer starting from the users' applications, transmission and operating communications systems specified QoS parameters, down to network and multimedia device QoS parameters.

1.2 FOUR QUALITY CYCLES

There are two principal parties in the QoS cycle, the customers and the service providers as shown in Figure 2. For the service provider, such a division leads to planned and achieved quality. For the customers this division leads to their QoS requirements or expectations and their perception of the performance experience.

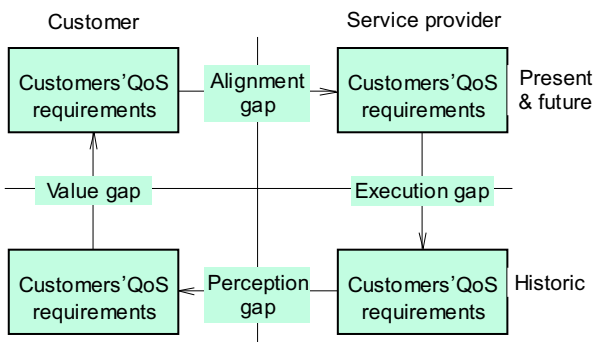

Fig. 2. Quality cycle [13]

The scale of customer satisfaction or dissatisfaction will be dependent on the difference between 'expected' and 'perceived' performance of these key characteristics or attributes. QoS offered by the service provider is a statement of the level of quality that is offered to the customer. This is the level of service that the service provider can achieve with the design of the network. The level of quality is expressed by values assigned to network performance parameters, which cover the network and network support [12]. The QoS achieved by the service provider is a statement of the level of quality achieved by the service provider. It is a record of the levels of quality that have been achieved. These are expressed by values assigned to the parameters specified for the offered QoS. These performance values are summarized for specified periods, for example, for the previous three months and/or on an annual basis. The QoS perceived by the customer is a statement expressing the level of quality experienced by the customer. The perceived QoS is usually expressed in terms of the degree of satisfaction and is assessed by the information technology (IT) survey questionnaire (see discussion in section two).

1.3 ISO QOS FRAMEWORK

The ISO has produced a draft international standard (ISO/IEC DIS 13236) "Information Technology QoS framework" [14], "is to provide a common basis for the coordinated development and enhancement of wide range of standards that specify or reference quality of service requirements or mechanisms". The framework is a structured collection of concepts and their relationships, which describes QoS and enables partitioning of, and relationships between, the topics relevant to QoS to be expressed by a common description. It is intended to assist developers of new and revised standards, which define and use QoS mechanisms, and users expressing requirements for QoS [13]. The typical QoS characteristics represent some aspect of the QoS of a system, service or resource, which can be identified and quantified. User requirements drive the QoS-management activities and originate with an application process that wishes to use a service. The requirements may be retained in an entity which may also analyse them in order to generate further requirements that are conveyed to other entities as QoS parameters, and so on. Examples of such parameters are given from network measurements: A measured value, used to convey historical information; A threshold level (*ie* the threshold for the users' perception of network QoS provision);

1.4 ASSESMENT OF QOS

The existing IT definition of QoS lacks the clarity required to express separately the service provider's and customer's viewpoints. Disconfirmation model applied to assess the SUNCI QoS provision is illustrated in Figure 3, which illustrates the enhanced disconfirmation model of customer satisfaction based on the original model suggested by Walker [1]. The advancement of current measurement technologies and the results of this paper introduce a new model by comparing the performance measurements (M) with the expected (E) and perceived (P) performance. Empirical evidence suggests [13] that there are a number of key characteristics or attributes which customers will generally evaluate to determine the quality of any particular product or service. The disconfirmation model shows that customer's satisfaction will be dependent on both the size and direction of disconfirmation, with only three possible outcomes. When 'perceived' is greater than 'expected', customers will be very satisfied; when 'perceived' is equal to 'expected ', customers will be satisfied (*ie* the product is performing exactly as expected); when 'perceived' is less than 'expected', customers will be dissatisfied.

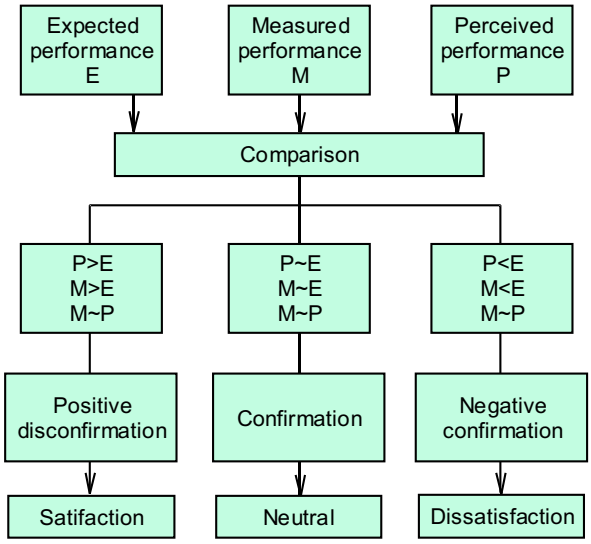

Fig. 3. The Enhanced Disconfirmation Model of Customer Satisfaction [1]

The QoS required by the customer is a statement of the level of quality of a particular service required or preferred by the customer [15]. A typical customer is not concerned with how a particular service is provided or with any of the aspects of the network's internal design, but only with the resulting end-to-end service quality [13]. It must be recognized that the customer's QoS requirements are useful, although subjective. A customer may judge the service based on his or her location, connectivity and means of access, as well as the computational processing power on his or her workstation. It is up to the service provider to translate this into something of objective use [15]. Quality as perceived by customers stems from a comparison of what they feel the product should offer (*ie* drawn from their expectations) with their perception of the actual performance of the product. When customers register with the campus network, they already have expectations of how network should perform and this will cover a whole host of criteria [13] including: Conformance to specification (user accounts and privileges, accessibility); Performance (primary network characteristics, such as utilization and error rate); Reliability (probability of the network malfunction-free performance); Availability (probability of the network being available); Simplicity (ease of use); Serviceability (speed, courtesy and competence of repair); Aesthetics (how the network looks, feels, sound *etc*) [16]. The network expectations may be considered as predictions, sometimes subconscious ones, which customers make about what is likely to happen during the use of it. In practice, this may differ significantly from the views of IT Services, whose views of quality will be based on their perspectives of the network services offered. However, the most important evaluation of quality is that carried out by the customer and network real-time measurements. This evaluation draws on expectations and expectations introduced by Gronroos [17] in defining quality within the service environment as: Quality = customer's expectations - customer's perceptions. This may be further analysed and subdivided using the disconfirmation model, if quality is 'conformance to requirements' and the real judge of quality is the customer, and then they must evaluate quality in relation to their satisfaction.

2 SUNCI'S IT SURVEY

This section presents results of the IT survey questionnaire and discusses the methodology used to create the survey. In order to assess SU users' perception of SUNCI QOS provision and their level of satisfaction, two IT surveys were conducted over a period of two consecutive semesters. The first survey was made available online to all in the SU community, during the period between November 2001 and May 2002. The second survey was conducted in October 2002 and primarily targeted SU students. The results of both surveys provided the IT management team with useful information about the users' perception. Generally there are two types of questionnaire: one to assess customer opinion of a particular service, the other to assess the overall opinion of a service provider [13]. The IT survey questionnaire was designed to address all major groups of SUNCI users, their relation to the SU, access point location, means of access connectivity, the end workstation type (*ie* PC, Mac, *etc*), the application access priorities and the critical time of network utilization for a specific type of application. Overall, the answers to questions one to nine provide the list of main user categories at SU; the answers to questions ten and eleven provide the user's usage pattern of the IT network; the answers to questions twelve to sixteen provide information about the type of application that is most frequently used and its response quality ranking; and finally the answers to question seventeen and eighteen provide information about the users' perception of the service received by the IT personnel and allow for commenting on issues that are important to each individual user.

2.1 ASSESMENT OF QOS

The total number of respondents to the first survey was 463. The total number of respondents for the second survey exceeded the previous one by 190. This illustrates that users are more likely to respond to the surveys that are presented to them directly in person instead of responding to online surveys. The total number of respondents to both surveys was 1116, which represents more than 10 percent of SU users' community. Clearly the results of both surveys illustrate that there was a high proportion of students who responded to the questionnaire. Additionally, during the analysis it was discovered that although respondents came from a wide variety of Schools and Services within the University, there was a bias towards the School of Computing and the School of Engineering and Advanced Technology. The evidence clearly shows that the greatest usage occurs at the University,

although those respondents, who do use student residencies, seem to use it as their main location. Students came from a wide range of student residencies scattered over the various campuses, but approximately half of them were located at Stafford Court. According to survey results the 56K modem was the main type of remote access connection for the majority of users. In addition there was a variety of makes and models of computers, although the majority appeared to have a Pentium processor and be less than three years old. Respondents were asked about the time of day they tended to use the University facilities. Clearly the main usage is during the day and evening. The results show the evidence that most users tend to use their computer for a significant period of time, once they are online. Respondents were asked for their perceptions on response times on a scale from excellent down to very poor. If the response was scored such that: Excellent = 10, Very Good = 8, Good = 6, Reasonable = 4, Poor = 2, Very poor = 0. The results illustrate clearly that the majority of average scores lie between 4 and 6, indicating that respondents typically see response time lying between reasonable and good, on average. The only exceptions appear to be the use of ftp transactions, which are often seen as less than reasonable, particularly at a student residence or at home. Clearly there is the perception that there is better support on-campus compared with off-campus. The results demonstrate that the respondents' perception of IT support is that it is quite good on campus, better than reasonable at residences, but worse than reasonable off-campus. The results conclude that most users tend to use their computer during the day and evening, for a significant period of time often over two hours once they are online. The majority of respondents' primary applications tend to be E-mail and the second most significant use is Web browsing. The IT services are currently focusing on application performance management.

3 CONCLUSIONS

This paper discusses the theoretical background on QoS, SUNCI current network monitoring practices, and an IT survey questionnaire. In this paper the author presents a new cost effective methodology for assessing the QoS provision with a minimum effect on network performance and its functionality, while discussing the users' perceptions of SUNCI QoS provision. The results suggest that the level of users' satisfaction of SUNCI QoS provision is reasonable and that there is a good correlation between the users' perceptions and the traffic measurement of SUNCI QoS provision. The paper promotes future research in merging the engineering and business perspectives on the QoS provision. The research methodology may be easily adapted to any telecommunications network infrastructure in the world.

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