An Advanced QoS Index Framework for a Next Generation Internet Application

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ABSTRACT

Telecollaboration (TC), a next generation Internet application would demand particular Quality of Service (QoS) requirements in order to function properly for which best-effort (BE) delivery becomes inadequate. This paper proposes a solution for this in terms of redefining the wealth of new business trends (business system perspective), user needs (participant perspective), technological issues (network infrastructure perspective) and pedagogical approaches (participant’s collaborative outcomes perspective) when evaluating the performance of this new mode of collaboration. However the impact of technology plays a major role in this context. This paper introduces a new framework for QoS index over the better than best effort Internet Protocol (IP) network that focuses on importance of use of mathematical modelling for the investigation of QoS aware IP traffic issues. This could be done by measuring and mapping the performance indicators of network traffic into varying nature of application along with user behaviours. This work concludes with the possibility of opening new avenues for the examination of operational and research perspectives of new theories of current Internet QoS complexity on its most attractive and unique features with the potential explanation in genuine networking terms.

Keywords: Quality of Business, Quality of Efficiency, Effectiveness and Satisfaction, Quality of Service, Quality of Experience, Quality of Collaboration, and Telecollaboration Quality of Service.

1. INTRODUCTION

Telecollaboration (TC) has been viewed as both an extension of traditional collaboration and the next phase of Information and Communications Technology (ICT). Over the past few years, Internet Protocol (IP) services have changed dramatically and permeate our lives. Internet products and services under development could be deployed within the enterprise market so quickly that it would fundamentally alter the way that we collaborate with geographically remote users. The TC business system could exhibit features that include application sharing whereby participants are able to read, write and collaborate through document/spreadsheets and agree together on the correct content. Some of the additional applications of this technology may include real time modelling and the simulation of complex systems, online editing of video content, online medical diagnosis, walking a remote group of people through a presentation for online engineering and science related projects; and sharing a white board to brainstorm ideas in an online classroom. For these to happen, participants of TC need to share browser windows, presentation notes or slides, white boards, audios, shared videos and various other real time visualisations and animations.

Figure 1: Vision of CeNTIE’s TC project at UTS

Researchers continue to argue that there are numerous pedagogical and technical obstacles to overcome, in a network based collaborative learning environment that directly influence the participants’ collaborative learning outcome. A literature review reveals that telecollaboration is now considered to be a multi-disciplinary field that includes understanding aspects of not only technology and pedagogy, but also factors including business strategies and user behaviours. A four dimensional aspect of TC as shown in Figure 1 is the central vision of CeNTIE’s (Centre for Networking Technologies for the Information Economy) TC project at UTS (University of Technology Sydney). This enables the participants to provide them with a ubiquitous telecollaboration in a virtual collaborative space through distributed services and networks with a well-defined local infrastructure (domain) for participant satisfaction. The main objective of this paper is to introduce the role and purpose of creating QoS index framework in the IP router context and to elaborate how it could assist the participants of a TC session in achieving collaborative outcomes with the total Telecollaboration Quality of Service (TQoS). We then outline
the potential TC business models with an identification of
their individual needs. Following this, we focus on domain-
based workflow for derivation of QoS metrics involved in TC
business systems. Finally, the paper describes the objectives
of QoS index framework with the identification of associated
research issues in this emerging field.

2. THE POSITION AND RELATIONSHIP OF QoS
INDEX FRAMEWORK WITH
TELECOLLABORATION QUALITY METRICS

Telecollaboration applications and services need guaranteed
QoS. This is crucial in terms of enabling those applications
with traffic being differentiated by user, application and
network resources being assigned to guarantee many levels of
service. This leads to an increasingly important area of new
measures of Quality metrics for developing and incorporating
the TC business system for the achievement of effective
collaborative outcomes.

As shown in Figure 2, the quality metrics are divided in to
main categories, which include performance (subjective
approach) and diagnostic (objective approach). Performance
metrics are sub divided into three categories; business-
focused Quality of Business (QoB), user-focused Quality of
Experience (QoE) and outcome-focused Quality of
Collaboration (QoC). Whereas the diagnostic metric is
classified as a network focused Quality of Service (QoS) that
results from the QoS index framework. As the information
economy is insisting on three main components; business
infrastructure, processes, and outcomes (that are collaborative
in nature), it becomes necessary to understand the
relationship that exists between those QoB, QoE, QoS and
QoC metrics for the total TQoS analysis. It is a modified
version of Aad van Moorsel’s model (2002) to fit into our
multidimensional approach of TC. Figure 3 shows us a
modified version of Aad van Moorsel’s model (2002) that fit
into our four dimensional approach for achieving TQoS by
adding a new QoC metric. It shows a business flow through
QoB that could be achieved through strategic business
planning, for the description of a functions based
collaborative structure. Whereas the service flow in this
environment is due to actual QoE which, is perceived by
users through measurement of QoS. Development of a new
set of metrics called quality of efficiency, effectiveness and
satisfaction (QoEES) plays a crucial role here to measure the
QoS and map them into equivalent QoE metric.

Figure 3: Relationship of Internet-based Quality Metrics
of Telecollaboration

It also shows that QoC is a result of both QoS and QoE.
However, the relationship between them depends on available
resources and level of collaboration among the participants.
As our metrics lead to total collaborative flow through TQoS
it is emphasised that QoC is directly proportional to TQoS

3. TELECOLLABORATION BUSINESS MODELS
TOWARDS A TOTAL TQoS

For the scenario development of typical TC business system
models, we can consider that ACBC (American Commercial
Banking Corporation) is a banking corporation specializing in
a range of financial services for customers in the US, Europe,
Middle East and South East Asia. It is assumed that currently,
they are looking to expand their scope of operations to
include nations within the Oceania region, in particular
Australia. Sydney is currently their first location of choice
and a regional branch within the Sydney CBD is to be
established with other branches to follow in other locations,
pending a review of the company's performance in the
Sydney market within the next few months. As part of their
planning process in terms of implementing any of the planned
developments, ACBC’s head quarters would like to implement
an Internet-based telecollaboration business system for
remote collaboration involving managers, staff members from
around the globe with market reviewers in Sydney. The TC
business models can be developed based on three levels of
collaboration; basic, intermediate and advanced, with the
identification of their individual functions and services.
Telecollaboration business system implementation of ACBC
can be categorised into B2B (Business to Business) and B2C
(Business to Customer). It is expected that at the basic level
of TC business system (such as role rotation etc.) the
participants will have the ability to communicate with other
participants through a variety of electronic media such as
presentations that incorporates images and sound, web pages,
and portfolios. This Business to Customer (B2C) model is
based on ACBC’s use of TC business system for the analysis
of current Australian market and product targeting that
involves collaboration through role rotation along with
contribution of participants towards a common/shared goal.
Role rotation could potentially be happening in groups. The breakdown of groups could include regional managers with the general manager; product targeting group with an expert; current Australian market analysis group and team leader of the product targeting group; and the regional Manager with the Australian market analysis group. The collaborative outcomes made by individual groups of this model could contribute to the group of regional managers to aid in their decision-making process with the general manager of ACBC. The expected outcome of this model will include a modified updated system identified by ACBC, suitable for the Australian market in particular.

Whereas the models at intermediate level (such as interactive groups etc.) could help the participants of ACBC for situations like, analysing the implementation/migration of existing software/data system that includes analysing infrastructure and equipment requirement through B2B scenarios. The participants can use a suite of applications to manipulate and analyse data/information, while allowing them to interact and collaborate using online collaborative tools such as threaded discussion groups, newsgroups, electronic list management applications, online chat, and audio/video conferences. Aside from these features, they could exhibit an ability of their participation to demonstrate competence in a collaborative environment by evaluating the authenticity and reliability for the effectiveness of the collaborative processes used. Participants of this model can design, adapt and use session goals (that addresses the business strategies) for the development of information for problem-solving in collaborative environments. The technology plays a crucial role in this process to increase each participant's ability to plan, locate, evaluate, select, and use information to solve problems and draw conclusions. This includes use of technology as a tool for assessing group work and for providing feedback to other groups. The business model at this level also give the participants an opportunity to optimize the session goals (common/shared) based upon the infrastructure resources available to achieve the expected outcomes in the public/shared workspace available within the model. It even enables the participants of ACBC to monitor and reflect upon the results/outcomes of using technology in instruction and adapts the process accordingly for an efficient integration of the above system into ACBC's current mode of global operations.

The advanced level of TC business model of ACBC (such as dynamic interactive groups, grow and shrink etc.), which is a combination of B2C and B2B scenarios, will be applied for situations like, analysis on new/alternative options/solutions for the implementation of new information systems. The model would enable participants to join/leave to collaborate with other groups and resource specialists to form expert groups with the support of this technology-enhanced process (such as grow and shrink). For an example, participants may collaborate on interdisciplinary or multidisciplinary issues to contribute to enhancing the outcomes of the overall group. Expected outcomes of this model of ACBC will include an efficient transition of their current Management Information Systems (that needs to be accessible via online interfaces not only to ACBC staff and management, but also to its customers) over to the new location and a very straightforward, cost-effective entry of ACBC into the Australian market with minimized downtime and use of resources. It is not likely that all service providers, participants and businesses will adapt exactly the same business model and business strategy. Therefore, collaborative structures that we develop must be flexible enough to accommodate and support a large variety of business models and provide inter operability between multiple network domains using those models. However, it is emphasised that all the collaborative activities that take place within this context are sub divided into network-centric, process-centric, user-centric, application-centric, knowledge-centric, task-centric and outcome-centric for the purpose of scenario developments.

### 4. DOMAINS-BASED WORKFLOW FOR DERIVATION OF TELECOLLABORATION QUALITY METRICS

**Business**

As shown in Figure 4, this domain provides taxonomy for the workflow of collaborative business characterization (Daniel A. Menascé, 2000). It starts with the development of TC business system model (of non-financial nature as described in section 3). This is followed by the identification of TC functions that become the basis for development of functional models for the proposed business models as part of many different client-server interaction implementations. Next is to define evolution plan for the proposed business and functional models. This approach serves the purpose of identifying the Quality of Business (QoB) metrics, which decides the resource units necessary for meeting the quality of requirements of TC business system.

![Figure 4: Workflow in Business Domain of Telecollaboration](image)

**User Behaviour**

This domain focuses on capturing user behaviour (such as access, service usage pattern of participants based on collaborative business structure etc.) and constructs models...
that are used for answering what-if questions at the participant interactivity level (Daniel A. Menascé, 2000).

It is our intention to describe the performance model structure along with its boundaries and descriptions of systems involved. This is emphasized with further examination of requirements needed for management resources for telecollaboration application, through a resource management model. Creation of QoS index framework plays a vital role not just in this domain, but impact on other domains to achieve total TQoS as explained in section 5.

**Pedagogy**
Some educational psychologists note that user perceptions of the QoS they receive, affects not only the participant’s collaborative outcomes/achievements but also their confidence in using telecollaboration tools. This affects their continuing participation in the process of telecollaboration. This domain analyses the cognitive impact on the participants of the collaborative environment such as TC session. It mainly focuses on the necessity of analysing collaborative outcomes of the businesses and participants through the measure of QoC metrics as shown in Figure 7. The cognitive and non-cognitive perspectives of QoC could impact on the users’ concept of the business’s stature and contribute the businesses collaborative outcome. This includes validation and verification of the relationship between the quality metrics QoS, through QoS translation, QoS control mechanisms, and QoS management mechanisms for the achievement of QoEES. Cognitive aspects reflected by pedagogical views of future TC users could be better described, defined and understood by introduction of quality of efficiency, effectiveness and satisfaction (QoEES) metrics. This occurs as a result of careful and balanced use of qualitative and quantitative approaches. The amalgamated measurable objectives then would assist in resolving traditional pedagogical problems that are subjective in nature. The intention in this domain is not just to highlight the pedagogical issues involved but to validate the effective and efficient use of underlying technology (for applications similar to TC) that is often not addressed by the educational psychologists.

**5. THE OBJECTIVES OF QUALITY OF SERVICE (QoS) INDEX FRAMEWORK**

The academic and trade literature that we have reviewed so far have almost completely ignored the innovative application of the future such as TC. In particular, it is advisable to find the network invariants of this traffic by exploring the statistical characteristics of how a telecollaboration session would generate network traffic that could be parameterized
for analytical models, which are both simple and parsimonious. Currently it has not been shown that all the telecollaboration traffic that we are expecting in the future will share the same or similar characteristics. This new framework idea for QoS index over the better than best effort Internet Protocol (IP) network was initiated to enable the IP community to make sense of IP traffic issues, besides assisting participants of a TC to set realistic expectations before an application is deployed, and verify its performance during operation, both in an intuitive and understandable way. This work aims for an intuitive and rigorous physical explanation in a networking context of the mathematical concepts (as shown in Figure 8), thereby shedding new light on features of realistic IP networks that have largely gone unnoticed in the past.

The framework focuses on the use of mathematical modelling for the investigation of QoS-aware IP traffic issues by measuring and mapping the performance indicators of network traffic into ever changing nature of application along with user behaviours (measurement of QoS metrics and map into QoE metrics) in an interactive environment such as TC where collaborative outcome becomes the central notion of total TQoS. In other words this work deals with the dimensioning and evaluation of IP networks for the application like the telecollaboration software under development at UTS due to its ever-changing nature from the QoS point of view.

This study concludes by examining the operational and research perspectives of the new theories of Internet QoS complexity on its most attractive and unique features with the potential explanation in genuine networking terms. As the information age will be driven by the mutually-dependent drivers of changes in technology, business environment and new services, the integrated QoS index frame work like ours could assist this transition and move into a new framework by minimizing the complexities involved by providing a holistic view of network traffic.

For this to occur there arise a need to develop a framework that is understood by cognitive and non-cognitive aspects of businesses, users and technologies. However we also realize that there are other factors such as telecollaboration terminology, design changes, revenues, multicultural aspects, multilingual aspects, security, privacy aspects, user-interface element issues, interoperability, compatibility, use of comprehensible standard issues, ecological aspects and ethical aspects that might affect our business models, workload characterizations, performance evaluation techniques and traffic control methods that we have taken into consideration which will have huge impact on collaborative outcomes. By resolving those issues, we potentially could open new areas for future researchers in this emerging field of technology transition.

### 6. IDENTIFICATION OF RESEARCH PROBLEMS RELATED TO QoS INDEX FRAMEWORK

Mathematical Modelling approach used as part of QoS index creation of the performance evaluation of TC business system is shown in Figure 8. Traffic that emanates from a user (whether cells, bursts or connections) is described by source models. According to different time-scale activities, source models are classified such as continuous time or discrete time, inter-arrival-time or counting process and state-based or distribution-based. It is also important that some source models are associated with a corresponding queue model such as the model used in fluid flow analysis.

Figure 8: Mathematical Modelling Approach involved in QoS Index

Queuing models are generally used for describing the relevant queuing behaviour of IP packets. Mechanisms such as buffer sharing and partitioning, packet discard, queue scheduling are used for differentiated performance analysis to cope up with multi-service requirements guaranteed by the network. Finally to provide end-to-end performance guarantees flows, connections and aggregates need to be treated with mechanisms such as admission control, policing, dimensioning and configuration of the same. The mathematical model shown in Figure 8 presents a sequence of steps that flow in two directions. The order of demonstration would assist us to understand the problems involved in the performance analysis and traffic control. Whereas, the flow order of creation of QoS index would enable us to build the framework. This section outlines a broad outlook in terms of possible research avenues and issues in IP based self-similar network traffic research. Due to the scope and depth of these issues, they are categorised into three main areas of workflow characterization, performance analysis and traffic control as follows (Kihong Park and Walter Willinger, 2000).

**Workload Characterization**

Characterization of static and dynamic structural properties of internet needs a focus on self-similar burstiness in the network traffic through the realisation of network performance as measured by packet drop, queuing delay, and jitter at multiplexing points. These performance measures are affected by a multitude of factors; variability of steamed real-time Variable Bit Rate (VBR) video, patterns and their durations of connection arrival, the make-up of files being transported, control actions in the protocol stack and most importantly the user behaviour that drives this TC application. The workload-modelling framework that is discussed at section 4.2 would be able to capture the source behaviour and structural properties of the network system under study. The research challenges that we have in this domain are to identify, quantify and model the network invariants (that are nothing but slowly changing system traits) in the midst of this rapidly growing Internet network infrastructure that are relevant to the QoS index and performance evaluation. Characterization of multifractal traffic, spatial (structural) workload and synthetic workload are the potential areas where we can come up with new ideas for QoS indices according to the user requirements.
Performance Evaluation
Performance analyses of queuing systems with infinite buffer size can be focused here with self-similar input that could give fundamental insight of queue length distribution decay rates. This could be achieved through provision of asymptotic queuing results. For example, in the resource-provisioning context, this is interpreted to mean resource dimensioning can be used for buffer sizing, which is an ineffective policy relative to bandwidth allocation. However, research on finite buffer system and their delimiting nature impacts on the correlation structure at large time scales and their influence on queuing require further examination. Performance evaluation needs to be focused not just on first-order performance measures (such as packet loss rate and queuing delay etc.) but also on second-order performance measures (such as jitter etc.) for a user-specified QoS. This would be very useful for QoS index measurement and mapping purposes. It is also realised that self-similar burstiness would negatively impact on second-order performance measures and multimedia traffic control. Self-similar workloads with their slow convergence properties may have problems when carry out our performance analysis in equilibrium. For instance, the disconnections between steady state techniques and performance evaluation of short- and medium-duration TCP flows need to be dealt with in a careful manner. They are the sorts of side issues the researchers would have to deal with as part of performance evaluation and QoS index creation.

Traffic Control
Traffic control has been seen as an extension of performance analysis in the resource provisioning context and the exploitation of correlation structure of internet traffic at large time scales from the multiple time scale traffic control perspective. Resource provisioning advocates a small buffer/large bandwidth resource dimensioning policy that could lead to multiplexing gains when flows are aggregated. But from the multiple times scale traffic control perspective resource provisioning can achieve those performance gains by exploiting the correlation structure. That leads to workload-sensitive traffic control to rate-based congestion control for an application. For detecting and exploiting large time scale property structure, short-duration connection management, packet scheduling, end system support, and dynamic control with self-similar call arrivals and/or heavy-tailed connection durations requires use of spanning novel mechanisms which accommodates a broad area for further study. However, we realise that there needs to be some comprehensive treatment of cross-section of issues spanning traffic modelling and measurement, performance and behaviour analysis and traffic control mechanisms for self-similar network traffic. The justification of interest in this area comes from lack of balance between the traditional, evolutionary and revolutionary concepts and changes for theoretical and practical boundaries of importance to future Internet-based TC environments.

7. RELATED WORK AND ACKNOWLEDGEMENTS
There has been a great deal of research, out of which there are many frameworks available for analysing and designing e-business sites from the three dimensional approach of infrastructure, e-business processes and e-commerce transactions in the electronic economy. Implementation issues of those models are addressed in several projects. But none of which offers a four dimensional approach towards total TQoS with an introduction of new measures and metrics like ours that maintaining a balance between the TC business systems’ cognitive and non cognitive aspects for the achievements of collaborative outcome analysis. The network analysis in terms of indexing provides a framework with an approach that closely follows the treatment that reflect CeNTIE TC project team’s personal biases at UTS which is one among the recent ICT initiative of the Australian federal government. The authors would like to take this opportunity to thank the other members of CeNTIE TC team at UTS for their valuable participation in the discussions and feedback on various aspects of scenario development and functional requirements of the TC business system.

8. CONCLUSION
The conclusions of this work will be primarily based upon the investigation of existing academic research and development, as well as industry. This would enable us to identify the relevant potential developmental challenges for the future enhancement in this emerging field and apply them to distributed environments in general. The result of this work is to inform researchers about how to reverse a perceived QoS trend among the stakeholders involved in TC who prefer to approach TC as process-centric, network-centric, user-centric, task-centric, application-centric, knowledge-centric or outcome-centric.

9. REFERENCE