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A Quality of Service Framework for Internet Share Trading

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Abstract

The recent Quality of Service (QoS) architecture proposed by the Internet Engineering Task Force (IETF) enables a set of new network services providing possible solutions to improve the quality of the Internet-based services. The interest of this research is to find a customizable QoS network solution for the Internet based share trading business by deploying these QoS architectures in order to address the quality issues in the Internet Share Trading Business. The construction of the QoS theoretical framework begins with the identification of the Internet service capabilities required by the Internet share trading business through a case study. The appropriate QoS architectural design is selected through matching the existing QoS architectures with the identified service capabilities. The QoS technological strategies and QoS capabilities are thus derived from the selected QoS architectural design. Additionally, the effectiveness of the proposed QoS architectural design is evaluated against the current implementation by using computer simulation.

1. Introduction

With the increase in Internet service availability that occurred during the 1990s, the Internet has become more frequently integrated into business practices. It has lowered worldwide communications costs for individuals and businesses and opened up unprecedented opportunities and challenges for conducting business. This integration has also brought new threats to businesses relying on the Internet due to such issues as the varying quality of Internet service. Internet share trading business is a typical example of an online business affected by this issue.

The Internet related quality issues raised by the Internet share trading business have been regularly reported in the news, and discussed in academic research. Problem identified to date have included slow response times [20] [22], service unavailability during busy periods [7] [11], reliability problems [11] [21], and in the worst case, service being completely brought down by security attacks [4] [15]. These problems have also occurred to big industry players such as E*trade and Charles Schwab. Hence enhancing the quality of the Internet service available to business users is a critical issue in the industry.

The recent Quality of Service (QoS) architecture proposed by the Internet Engineering Task Force (IETF) enables a set of new Internet network services providing possible solutions to improve the quality of the Internet based services. However, the existing principle for the development of QoS solutions takes a technological focus without addressing the quality of service requirements of the business.

The interest of this paper is to find a customizable QoS network solution for the Internet based share trading business. The following research questions are specifically addressed in this paper.

- How does current IP network provide service support for Internet share trading businesses?
- Why does the current IP network fail to provide quality of service support for Internet share trading?
- How can Internet share trading business apply IP QoS techniques to solve the service quality issues in Internet share trading?

The structure of this paper is: first, a literature study is conducted to review the relevant research issues including quality of the Internet share trading business and IETF QoS architectures; Secondly, the research methodology is presented and the research framework is introduced; Thirdly, a case study is outlined to identify and specify the service capabilities required by the Internet share trading business; Fourthly the proposed QoS theoretical framework including technological strategies (or, QoS capabilities) and architectural design is discussed; Lastly, a performance evaluation for the proposed QoS solution by using computer simulation is reviewed.

2. Literature Study

2.1 Quality of the Internet Share Trading Business

In the Internet share trading business model, the Internet has been an integral part of the business. Quality of the Internet service has been emerged as a critical factor for evaluating the overall business performance.

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The Internet has enabled service channels for the business which allow online investors located at one end of the channel to access the share trading services provided by the brokerages located at the other end. This new service channel enhances the interaction between brokerages firm and online investors, totally eliminating the person-to-person contact required by traditional share trading. Hence the quality of the Internet service required by the business is characterized as end-to-end service assurance.

Currently many surveys and case studies have evaluated quality of Internet share trading business, identifying Internet-related factors of timeliness, reliability, availability and security as important for online investors to monitor. These four factors can be used to described business-required end-to-end service assurance (Figure 1).

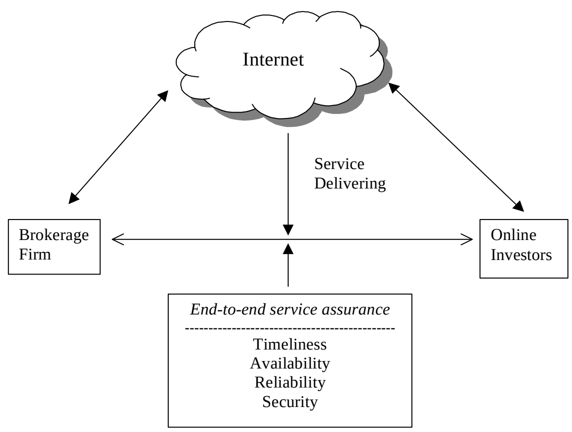

Figure 1. Quality of the Internet Share Trading Business

2.1.1 Timeliness

Timeliness is a critical attribute affecting the service quality of the Internet share trading business [14] [19] . Timeliness is also referred to as responsiveness of the services [8].

Due to the fact that share prices are subject to change, online investing services need to be delivered in a real-time manner. Even a second's delay in share transactions, may cause real money loss for the investors. Online investors expect fast responses from the system so that their share trading transactions can be processed rapidly. Currently there is no industry regulation requiring a transaction to be executed within a set period of time [19], although increasing timeliness in the service does help firms attract more businesses.

2.1.2 Reliability

Reliability, one of the fundamental requirements urged by business refers to consistency of performance [8] [23] Internet share trading business requires consistent levels of Internet service support. For example, in the US, the Securities and Exchange Commission (SEC) understands an absolute guarantee of service is difficult to implement in the Internet share trading, but it may require online brokerage firms to conform to certain statistical standards of service proactively .

Another sense of reliability refers to the accuracy of the service [17]. Internet share trading businesses should have the ability to detect and rectify any faults in order to ensure reliability of the service.

2.1.3 Availability

Availability is another important factor in the Internet share trading business [14] [25]. Online service must be accessible at all times to businesses, especially during the peak trading hours.

NASF Regulations remind brokerage firms of their obligations under SEC staff legal bulletin No. 8 to ensure that they have adequate capability to handle high volume or high volatility trading days [14].

2.1.4 Security

Security is one of the greatest concerns for Internet share trading business as the entire operations are monetary and information-based transactions [12] [4] suggests that a robust security solution for transaction processing should satisfy certain security requirements including confidentiality, authentication, data integrity and availability, all of which need to be met by the Internet services as well as the whole business.

Recent news reports continually disclose these quality issues as well as the many complaints raised regarding these issues. The complaints include slow performance [20] [22], system unavailability [11], reliability problems [11] [21], and security attacks bringing down the system [15]. These indicate that the current Internet quality does not provide the satisfactory level of service support for the business in term of these attributes such as timeliness, availability, reliability and security.

2.2 IETF QoS Architectures

Technically, the Internet Protocol (IP) plays a key role in facilitating Internet connections. The Internet is so called the network of IP networks. The current IP network applies end-to-end design principles [18]. It can only support one class of service: *best effort*. Hence the main drawback of the IP network is that it makes no guarantee about when data will arrive, how much can and cannot be delivered, and how reliably delivery will be. And it has no security feature as well.

Recent QoS architectures proposed by the Internet Engineering Task Force (IETF) such as Integrated Services (IntServ), Differetiated Services (DiffServ) and Multiprotocol Switching (MPLS) have opened up the new possibility to build new capacities of the network service which can improve the service quality of the

Internet network service. In the following sections service features of three QoS architectures are introduced.

2.2.1 IntServ

The key service feature of IntServ is to pre-reserve the required network resource in terms of user's requirements. In this way, IntServ can provide a certain level of resource assurance to meet the user's QoS requirements such as strict delays required by real time applications.

In comparison with the current IP network service, IntServ has enforced the following QoS features so as to enhance the service quality of the existing IP network services

- Resource Reservation

Resource reservation is the key QoS feature enforced by IntServ. With this resource reservation technique, IntServ can provide resource assurance for critical applications with absolute delay requirements.

- Admission Control

IntServ enforces admission control over the reservation path in order to limit the access by non-critical applications and to guarantee the network resource for critical applications.

- End-to-end control

IntServ uses end-to-end signaling protocol such as RSVP to set up the reservation path, so it thus enforces a end-to-end control function and can also dynamically response the changing traffic conditions in the network.

2.2.2 DiffServ

The DiffServ architecture has provided an alternative resource allocation scheme in order to enforce service differentiation [5]. Network resources are allocated to traffic streams by a service provisioning which mainly includes classifying and policing the traffic upon entry into a Diffserv network and forwarding that traffic within the network. Hence, Diffserv can provide relative service guarantee to meet different user's QoS requirements.

The main QoS feature of Diffserv is that it can enable traffic prioritization which prioritizes the network service for use by different types of businesses and different users. Since this resource prioritization function is mainly implemented at the point of traffic aggregation, it can be referred to as per-hop based resource prioritization [2].

2.2.3 MPLS

MPLS was originally developed as an alternative approach to support IP over ATM. It allows IP routing protocols to take direct control over ATM switches

The key technique of MPLS is known as label switching, which uses a short fixed-length label encoded into the packet header and used for packet forwarding. All the labels assigned by end points construct a Label Switched Path (LSP). By using the label switching forwarding engine, there is no need to perform routing look-ups on each node over the LSP when the data packet passes through. Thus, the MPLS network addresses the scalability issue and can support a large network.

An MPLS network needs a LDP – a signaling protocol to set up LSPs. And the LSP setup needs the routing selection to determine the next hop information. Two routing approaches can be employed for the LSP setup: one is hop-by-hop routing, still used by the current IP network and the other is explicit routing.

CR-LDP, recently developed signaling protocol uses constraint-base routing and can establish an explicit route also referred to as a constraint-based route or CR-LSP. The CR-LDP allows resources to be preempted or reserved for explicit routes based on relevant traffic parameters such as peak data rate (PDR), committed data rate (CDR), peak burst size (PBS) and committed burst size (CBS) [1].

As a consequence MPLS functions that go beyond the routing tasks can fundamentally enhance the current IP network for both features and services. It has enforced the following QoS features:

- Performance Optimization

Performance optimization can be achieved by way of traffic engineering [26, p. 10]. Traffic engineering is the process of controlling how traffic flows through a network to optimize resource utilization and network performance [6].

MPLS-based traffic engineering allows traffic to use multiple paths, rather than the single optimal path used by conventional-based networks. MPLS supports traffic engineering through the deployment of constraint based routing. The deployment of constraint-based routing not only provide route but can also meet QoS requirements [13].

- MPLS based Tunneling

MPLS can enable tunneling encapsulation by encoding a label outside the IP header. This is one of the ways to set up tunneling. The other way to enable MPLS-based tunneling is that MPLS allows multiple labels to be encoded into a packet to form a label stack. Such nested LSPs can create a multilevel hierarchy where multiple LSPs can be aggregated into one LSP tunnel [9].

- End-to-End Path Control

In the MPLS network, LSPs need to be set up by the signaling protocols before data traffic can pass by. Additionally, LSPs setup by using the route pinning option can further enforce a sense of control over the path established. In this sense, MPLS can enforce end-to-end path control that the current IP network lacks.

- End-to-end Resource Management

In the MPLS network, CR-LDP can allow resource preemption or reservation for the CR-LSP, this thus enables end-to-end resource management . It allows for resource sharing among a number of CR-LSPs which compete for the same pool for resources. The weight parameter can be used to determine the CR-LSP relative priority when assigning excess nodal bandwidth or when working under congestion conditions [1].

Table 1 summarizes the QoS features enabled by the three QoS architectures.

Table 1. QoS features enabled by three architectures

QoS Features	IntServ	DiffServ	MPLS
Resource Allocation	Resource Reservation	Per-Hop Resource Prioritization	End-to-end Resource reservation or End-to-end Resource Prioritization
Admission Control	Per-hop admission control at every node	Per-hop admission control at edges	None
End-to-end Control	Reservation Path	None	Explicit Route
Traffic Engineering	None	None	Explicit Route
Security	None	DiffServ based Tunneling	MPLS based Tunneling

3. Research Methodology

This study uses a multi-method research methodology (Figure 2.) which was adopted from [16]. It involves three phases of study: a case study in the first phase is used to identify and specify the QoS requirements of the Internet share trading business; a QoS theoretical framework is constructed in the second phase of the study in order to build theory regarding Internet QoS technological exploration in the Internet share trading investing business context; computer simulation in the third phase is used to evaluate the proposed QoS solution built based on the proposed framework.

The role of the case study in this research is to investigate service support features of the Internet service used for the Internet share trading business. The understanding gained can help identify the QoS requirements of the business in order to establish the guidelines for the construction of the QoS theoretical framework. A single case study is chosen in this research. [10] advocate the single case study as it can help in understanding the construct being studied in as much detail as possible within its context.

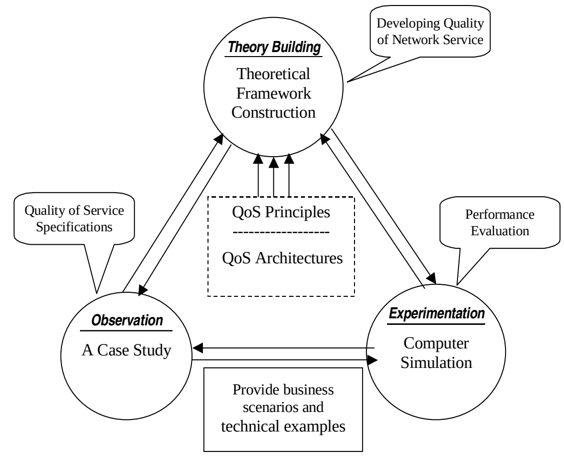

Figure 2. A Multi-method Approach

As a key part of the study, a theoretical framework construction aims to build a QoS theoretical framework, which provides both Internet QoS technology strategies and architectural design. The relevant research findings can enhance the existing Internet QoS theory. As shown in figure 2. The process of framework construction is on top of the existing IETF Internet QoS principles and QoS architectural design. This consists of two stages: building the theoretical proposition and proposing the architectural designs. The theoretical proposition is to provide Internet QoS technological strategies to meet the QoS requirements of the businesses. The architectural design is to propose a QoS architectural design to improve the service quality of the Internet for use by Internet share trading business. This architectural design is also proposed in the theoretical layer, which is a technological framework covering a set of relevant techniques. The integration of QoS strategies and QoS architectural forms a complete QoS solution.

The role of simulation in this study is to evaluate the performance of an IP network using the proposed QoS architectural design. This study uses *ns*@ as a simulation tool. It is a tool which can provide an integrated setting to construct a simulation model, execute the simulation, and analyze the results. It can map and translate the principles of QoS architectural design into the simulation model for measurement and testing.

4. Case Study

4.1 Case Descriptions

Established in 1975 in Singapore, the ABC group was one of the largest brokerage firms in Singapore. It offered total investment products and services in far eastern Asia including Singapore, Malaysia, Thailand, Hong Kong, Indonesia, and Sri Lanka, to satisfy investors' financial requirements.

ABC launched its electronic share trading system in 1996; it was Singapore's first electronic on-line trading system to harness the latest technology to complement existing trading capabilities for investors. This online trading system, called ALPHA, was initially an extranet system using remote access technologies, where investors could place share orders by directly dialing into the firm's network. Having been the first mover, ALPHA succeeded in attracting most local clients who were keen to try electronic trading. In 1997, ALPHA was upgraded to support Internet based share trading so that investors could place orders through Internet channels.

ALPHA has been one of the successful cases of online business in Singapore. Through ALPHA, the firm has widened its reach and increased its brokering volume, which in turn has broadened the brand and appeal of its name. However, it has not performed well consistently. ABC received many investors' frustrated calls and many complaints regarding the business operation. The following examples illustrate some of the difficulties:

- Investors cannot trade shares at the price they hoped, due to the transmission delay. This is because the share price has already changed before the ALPHA system could process the order and route it to the share market.
- Investors cannot get real time up to the minute share prices since live quotes cannot be delivered in a timely manner.
- Investors wait too long for confirmation. Sometimes investors might end up buying twice as much stock as they intended.
- The order transaction is terminated half way through, due to system or transmission errors.
- Investors cannot access their accounts during busy periods.

Senior management at ABC understood that service quality enforcing only at ABC was not able to solve ALPHA problems. The Internet service is the key here, hence managers expect to find a cost-effective Internet solution to improve the quality of ALPHA. Managers brought up many issues regarding the Internet service support from the Internet service provider (ISP).

One thing is certain, quality issues always occur unpredictably. Breakdowns in service quality are mostly linked to market volatility, which is associated with sudden rise in trading volume. This specifically causes many concurrent access requests for the ALPHA system which obviously generates network congestion. This subsequently affects the business performance. Hence, the questions raised here are:

Could ISPs monitor and control such situations?

Can ISPs prevent the occurrence of congestion from the outset?

In addition, managers have always tried to compare the Internet based ALPHA with the initial extranet based ALPHA. The Internet can reach more customers and offer a more rapid and flexible way of share trading, so it provides more business opportunities. However, it lacks the privacy and security that the extranet ALPHA possessed. The extranet allows the registered members to access the investing service thus enabling private communication to provide the business with privacy during the transmissions. There are fewer security risks on the Extranet as well. Questions raised here are:

Can the Internet enforce such private communication?

Can the Internet add in more security features?

Furthermore, the share trading business is a mission-critical business and business data generated are time-sensitive; it needs a guaranteed level of network service to ensure a satisfying level of service quality. However, such a guarantee is difficult to achieve since the Internet is a publicly shared network and ABC has to compete with other businesses for network resources. Managements' concerns here are:

Can the Internet promise ABC better services for their online investors?

Can the Internet prioritize its mission critical data against other types of data?

4.2 Case Analysis

The case study presents specific examples of the Internet share trading business. The above mentioned quality issues show that the current Internet cannot provide a satisfactory level of service quality for the Internet share trading business in terms of quality attributes such as timeliness, availability, reliability and security. Table 2 lists several specific examples regarding these quality issues.

Table 2. Quality Issues for Internet Share Trading

Quality Attributes	***Issues***
Timeliness	Slow transactions Delay in real time quotes
Availability	Service halt halfway Web site down Account Inaccessible
Reliability	Discrepancy in transactions
Security	Account being misused Account being accessed in an unauthorized way

The case study also indicates that these quality issues always occurring unpredictably. These issues are the potential risks to affect the Internet share trading businesses in attaining the consistent level of business performance. Moreover, the current Internet seems not to have the relevant service features to improve this situation, which is summarized as follows:

- Lacking monitoring and control

It seems that ISPs cannot provide effective monitoring and control for Internet services in order to prevent the occurrences of the service quality problems in a more proactive way.

- Lacking service prioritization

This case suggests that ISPs can only provide one standardized Internet service for all customers. In this sense, the ISP cannot provide a customer oriented service. However, business data generated from online investing which is a kind of mission-critical data requires a higher service priority than non-mission critical data.

- Lacking performance tuning

Because the volume of the share trading business is very unpredictable due to the volatile nature of the business and traffic demands on the Internet, it is very difficult for the Internet to maintain a stable and predictable level of service quality at all times. Hence, in this turbulent environment, the business requires new performance tuning tools that can quickly detect and correct the performance problems so that a consistent level of service quality required by the business is maintained. Moreover, the connection between the firm and the ISP is a common gateway where much network traffic aggregates and is easily congested by the network traffic during peak hours. The case shows that ISPs did not have such service features which can effectively minimize the possibility of congestion.

- Lacking security

It is agreed that the current Internet lacks adequate security features, particularly for the sensitive financial data generated from the Internet share trading business. Hence it is necessary to enhance the security on the Internet and implement new security mechanisms.

5. Framework Construction

5.1 Design Considerations – Meet the Service Requirements

The case study above shows that the current IP network lacks certain service features and capabilities to provide a satisfactory level of service quality for the Internet based share trading. Therefore it cannot provide a preferred service for the business, it cannot consistently allocate enough network resource for the business, and it cannot dynamically adapt to the changing traffic conditions.

In this situation, it is necessary for the Internet to build new service capabilities for the Internet share trading businesses. These capabilities are also the specific requirements for building a customized QoS solution by deploying QoS architectures. In the following sections service capabilities are discussed and QoS architectures are evaluated accordingly.

5.1.1 Service Prioritization

The Internet share trading business is characterized as a mission-critical business. Mission criticality usually refers to a map of urgency and importance [9]. It requires a higher priority of Internet service support than a non-critical business.

The Internet needs techniques which can prioritize the network services to be used by different types of businesses. This is necessary because the Internet is a public-based network and business applications of the Internet share trading need to compete for the same pools of network resources with other types of applications.

Specifically, this network service prioritization can be performed in terms of critical levels of the business or specific QoS requirements. QoS requirements can be specifically described using QoS measurements such as delay, jitter, throughout and loss.

As discussed above, the IP network services are required to prioritize the network services so as to provide better quality of service for the Internet share trading business. By investigating the QoS architectures, both DiffServ and MPLS architectures can enforce resource prioritization by using resource allocation techniques. A DiffServ network can enforce per-hop based traffic prioritization, which focuses on classifying and policing the traffic, whereas the traffic prioritization enabled by an MPLS network service is on an end-to-end basis.

By investigating the requirements of Internet share trading businesses, it was decided that both prioritization ways were useful in this business context. First, since the Internet share trading business is a typical one-to-many online business, the traffic aggregation point such as the first node linking to the brokerage firm may easily be congested by the data traffic. Enforcing per-hop traffic prioritization in this focal point can mitigate the network congestion. Secondly, end-to-end traffic prioritization is also required when Internet share trading business data has to compete for the network resource with other types of data traffic over the same network path.

5.1.2 Proactive Monitoring and Control

The Internet share trading business requires a proactive network solution to attain the network resource assurance rather than to passively adapt to the varying quality of the Internet. This requires new tools to monitor and control the network traffic in response to the varying situations. All three QoS architectures can enable this capability.

An IntServ network can pre-reserve a network path with the required resource for a traffic flow or a application so that the absolute service guarantee over this network path can be achieved. A DiffServ network can enforce monitoring and control by controlling the amount of traffic of each forwarding class at the edge of the network. An MPLS network provides an explicit routing mechanism that can support constraint based routing. Constraint based routing can exercise monitoring and control by assigning pre-defined constraints such as bandwidth allocation to CR-LSPs being generated.

All the three QOS architectures can monitor and control the service in a proactive manner since they all require the QoS provisioning to specify the service profiles being committed before they enforce the service.

MPLS can enforce end-to-end path control by using explicit routes while DiffServ can enforce per-hop control. Since the Internet share trading business needs both a per-hop and end-to-end solution, both MPLS and Diffserv can be applied in this business context.

5.1.3 Active Performance Optimization

The Internet is required to proactively monitor and control the network services. This function specifically needs to regulate and adjust the traffic loads passing over the network channel in terms of the above service prioritization policy. This can effectively minimize the network congestions always occurring in the current Internet. Moreover, it ensures that the business application of the Internet share trading business can receive the amount of network resources required.

More specifically, the Internet needs performance optimization techniques which can effectively optimize the network performance. The specific goals include:

- allocate enough network resources for the business
- select the network path with the required network resources
- select an alternative network path when congestion taking place on the original path selected

The process of optimizing the performance of networks through efficient provisioning and better control of network flows is often referred to as traffic engineering. By searching proper QoS architectures, MPLS is the only QoS architecture which has this service capability. By using constraint-based routing, MPLS can perform traffic engineering to maximize the utilization of resources in the network or to minimize congestion in the network. Specifically, MPLS-based traffic engineering can "*route traffic around congested hot spots and optimize resource utilization across the network*" [26, p. 156].

5.1.4 Private and Secure Channel

The Internet share trading business requires both privacy and security in order to protect sensitive financial data from possible network layer traffic. To achieve this objective, the business requires a public shared IP network that is also capable to provide VPN services. VPNs must be implemented using the tunneling mechanism. Both QoS architectures DiffServ and MPLS, support tunneling mechanisms to enable VPN over the Internet.

MPLS can manage a large number of tunnels than DiffServ. This is because MPLS can support more traffic differentiations due to a finer level of forwarding granularity; whereas DiffServ only supports a small number of forwarding classes based on per-hop behaviors defined. Hence MPLS is a preferred architecture to implement VPN over the public IP network so as to provide a private and secure channel for the Internet share trading business.

5.2 Framework

Figure 3. illustrates the proposed QoS framework which consists of two parts: QoS architectures and QoS capabilities.

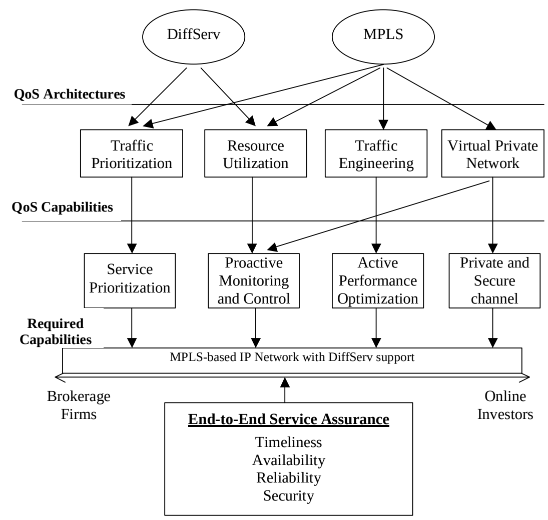

Figure 3. The Applied QoS Framework

5.2.1 QoS Architectural Design

MPLS is an important emerging technology for enhancing IP for both features and services. MPLS is a suitable mechanism to provide traffic engineering since MPLS allows sophisticated routing protocol capabilities as well as QoS resource management techniques to be introduced to IP networks. Hence with the advent of DiffServ and MPLS, IP traffic engineering has attracted a lot of attention in recent years.

MPLS-based Traffic engineering can provide the traffic engineering tools that are prerequisite for DiffServ. In the other hand, DiffServ can provide per-hop QoS enforced at the edge of the network so that the amount of traffic flow can be controlled. Therefore, it is likely that the combination of DiffServ/MPLS will play an important role in the provision of some form of quantitative service guarantees in the Internet. [13]

The proposed MPLS-DiffServ architectural design is similar as the functional architecture proposed in [24]. The idea is that a MPLS-DiffServ service can support fine-grained traffic differentiation and policing in the edges of the network through the notion of IP pipes. Packet forwarding on an aggregate basis is based on the packet service class. In the core of the network, individual pipes are not distinguished and pipe level information is not maintained.

5.2.2 QoS Capabilities

The above MPLS-DiffServ architectural design has combined the QoS features of both MPLS and DiffServ. This can enforce the following new QoS capabilities which can provide QoS-enabled IP network services.

- Traffic Prioritization

Both MPLS and DiffServ can build this QoS capability. MPLS enforces end-to-end based resource priorities while DiffServ enforces per-hop based resource prioritization. This proposed QoS design can enforce the traffic prioritization on both end-to-end basis and per-hop basis.

- Resource Utilization

Both MPLS and Diffserv can enable this QoS capability. MPLS enforces this capability by end-to-end path control while DiffServ enforces this capability by per-hop control. Both architectures want to exercise control for the available network resource. Both can use traffic policing tools to regulate the traffic flow, providing both statistical bandwidth allocation by using through combining the function of traffic engineering as well as providing guaranteed bandwidth allocation [24].

- Traffic Engineering

This QoS capability regards MPLS-based traffic engineering. With the support of the powerful MPLS function - explicit route mechanism, MPLS enforces the provision of network resources along the network paths and allows the traffic flow to use multiple path rather than single optimal path. In these ways, it optimizes the over network performance.

- Virtual Private Network

This proposed design chose MPLS-based VPNs. CR-LDP can establish CR-LSPs across the network. Each CR-LSPs can be viewed as a tunnel. Importantly, this VPN is QoS enabled which can ensure resource assurance along each tunnel.

5.3 Framework Analysis

The construction of the QoS theoretical framework is done through mapping the business-required service capabilities into the QoS design. Therefore the QoS architectural design and QoS capabilities enabled by this design can meet the quality of service requirements of the Internet share trading business. The following sections discusses how this applied QoS framework can be employed to address the quality issues in the Internet share trading business are discussed.

The quality issues regularly occurring in the share trading business are related to timeliness, reliability, availability and security of the IP network service. In the above-mentioned QoS framework, four capabilities can be enforced by the proposed MPLS-DiffServ architectural design that can solve these quality issues. The details are discussed below.

Traffic prioritization can prioritize the network services to be used by the Internet share trading so as to ensure the sufficient resource allocation required by the business. In addition, it also allows the Internet share trading business to preempt the network path with the required network resource.

Resource utilization can provide the specific tools to proactively monitor and control traffic flows to ensure the business will get the committed network resource over the paths between brokerage firms and online investors.

Traffic engineering enabled by MPLS based explicit route mechanisms can dynamically optimize the performance of the overall network. This ensures effective link utilization so that the business can select the network path with the sufficient network resource or can select the alternative network path when network congestion is taking place on the original path selected.

VPNs can be used to construct the private channels over the public network. These private channels only allow the authorized members of the brokerage firms to be accessed.

All these QoS capabilities can improve speed, reliability and availability of online investing services. In addition, VPNs can enhance the security and can effectively prevent denial-of-service security attacks.

6. Performance Evaluation

Based on the above-proposed framework, the proposed IP network solution should deliver service with lower delay, lower jitter, higher throughput and lower loss compared to current IP networks. However, this is the assumption subject to performance tests. Hence a performance study was carried out by using the computer simulation tool *ns* version 2.1b8a (http://www.isi.edu/nsnam/ns). In order to make the study worthwhile, two simulations were conducted, including both the proposed IP network service and the current IP network service. Performance of the proposed IP network was evaluated through the comparisons of two sets of simulation results by using the measures mentioned above: delay, jitter, throughput and loss

Figure 4. shows the general simulation model built by using *ns* simulator version 2.1b8a (*ns*2). It contains the

details regarding IP network behaviors includes topology, traffic model and protocol design

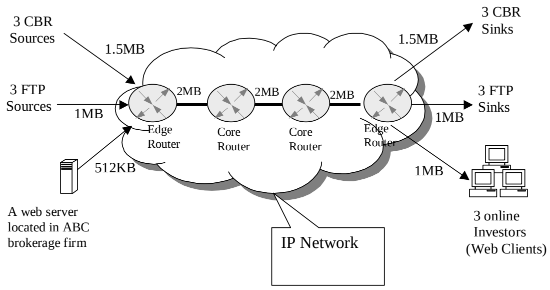

Figure 4. General Simulation Model

In order to make a fair comparison for the performance of two types of Internet services, the two simulation models apply the same topology and traffic sources. The key differences between the two simulations are the service functions and associated functional architecture implemented in the routers.

The simulation results presented in Figure 5. shows that the proposed IP network with QoS support can consistently provide better performance than the current IP network.

7. Conclusions

The paper has established an applied QoS theoretical framework for the Internet share trading business. This framework provides some practical guidelines for fast and secure Internet services with high reliability and high availability so that the quality issues raised in the Internet share trading business can be addressed.

One contribution of this paper is the identification of the service capabilities required by the Internet share trading business. Taking into account these business-required capabilities, the applied QoS theoretical framework constructed can provide the relevant QoS capabilities that match with the identified service capabilities required by the Internet share trading business. This has opened up a broad research perspective for developing a customizable QoS solution for electronic commerce, not just limited to the Internet share trading business.

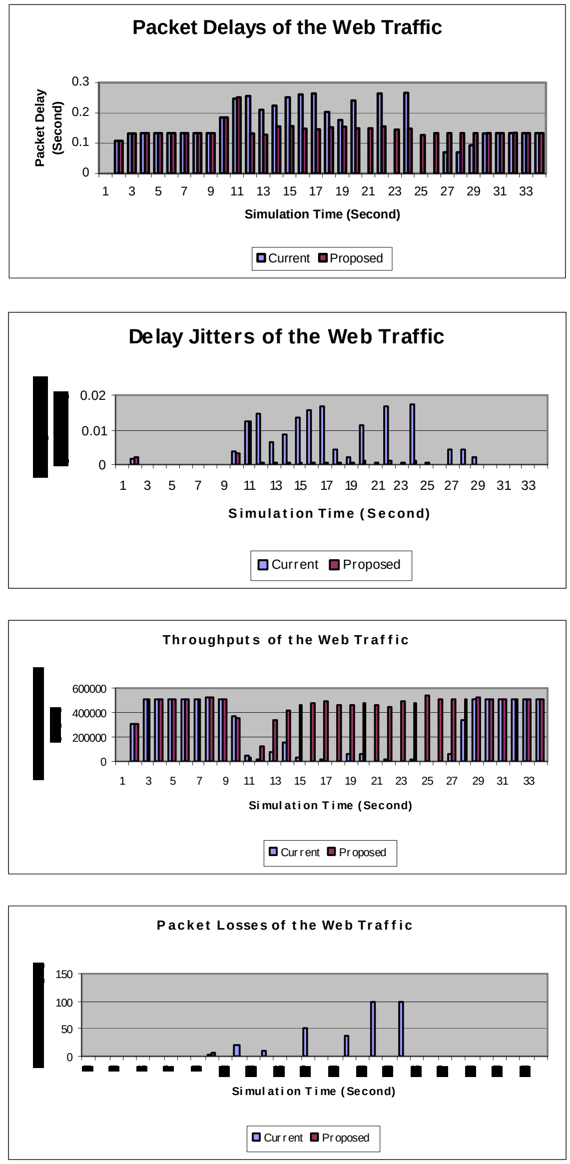

Figure 5. Simulation Results

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