A Framework for QOS Selection Technique in Data Networking

By

Mr. Banatus Soiraya

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
in Information Technology
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ABSTRACT

Today communication is an essential thing of our life ,Especially computer technology is applied for data network communication that will be important strategy key for success including technology for guarantee quality of service such transfer variety of file format (text file ,picture file, voice , video file by real time etc..)

But we frequently find reluctance to use QoS technique approach the main reason as we can't select appropriate QoS technique to the right application.

And we have no standard methodology for the selection QoS technique.

This thesis is applied by Combined Utility Function process for analyst and creates the general framework for selection of QoS Techniques. By considering main factor for decision both qualitative and quantitative aspect, the step of thesis is done by exploring QoS Techniques in a present by cost, performance and significant criteria to create the value assigned diagram .

Decision maker will fill in the value in that diagram for analysis process. The result of this case study will be analysed with cost-benefit for more reason.

Case study in this thesis is SITA Company, which provides online information about airline in the whole world. This solution will be better than the existing which uses the experience of expert of each organization.

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CHAPTER 1

INTRODUCTION

1.1 Background

Today we use Information Technology (IT) all of the world and in our life with almost government or private organization.

It will improve efficiency for work to more efficient work .It make the faster data searching such customers can order the product from abroad within 2-3 minutes by information super highway or internet.

An effective network provide more than just connectivity between endpoints .As you add application and leverage the convenience of networking your network must be intelligent enough to recognize and prioritize mission-critical and delay-sensitive traffic. This ability to deliver data base on such policies as important on time is called the quality of service (QoS) capability of the network .

Nowadays we use variety of application for the organization.

- Real-time , mission –critical cooperate data- financial transaction ,customer orders, warehouse and shipping records, manufacturing statistics and control data, research and development CAD/Code files ,and so on
- Delay-sensitive data-interactive application such as server and mainframe logins , packetized voice video conferences ,and data collaboration such as electronic whiteboard and client GUI sharing
- Bulk data transfers - system backups, overnight data synchronization and delivery
- Unknown data –Uncontrolled or unknown traffic such as user-initiated application(networked games and shareware ..for example)

Organization consider many factors when defining the QoS for an application.

Basic for common criteria are as follows

- Mission-critical versus non –mission-critical-Dose this application directly affect my organization's profits and sales? How will my customers perceive the delays in this application .

- Delay-Sensitive versus delay-insensitive –How easily does the user of the application perceive delay? Even if an application is not mission-critical, it may require minimal delay because a human is interacting with it in real time.

- Political versus apolitical-Whose data is this? What users should get better service from the network?

For those variety application above will direct effect with infrastructure of the network .Complexity of the network will increase troublesomeness of process . Example by transmission the data via internet with multiple ISP .We encounter with the complexity of QoS more than single ISP .Because each ISP has proprietary of ISP no standard for QoS management and reluctance for using QoS Technique.

Statement of Problem

-Large amount of QoS technique and product :QoS techniques were implemented on their own objective and strengths but they also have some disadvantage and weakness. For example in some task we must reserve minimum bandwidth otherwise low priority application won't use the resource at all . As such we don't apply strict priority queue for congestion network link because we hardly use that low priority application.

-Difference in requirement each organization differs in all aspects. Their requirements for QoS techniques are by no means similar. Critical requirement for some, may not be the concern of the other. For example Auction business need real-time application differs from routine company (can wait for collect file).

-Difference of focus on evaluation criteria: for the product or approaches that meet the same requirement, there are many of criteria that can be used to evaluate their features, such as performance ,ease of use and cost. Organizations different in the importance to these criteria.

The organization know the best for what they need ,but they mostly have no idea of how to choose .The objectives of this paper give a general model for selection of appropriate QoS technique.

1.2 Objective of Study

The main objective of the study is to define a general framework for selecting the suitability of quality of service technique approaches or product that meet the quality of service requirement of organization. Outcomes of the selection indicate the level of suitability which can be used to support decision making of the organization.

The model proposed should be flexible enough for wide range of requirement.

For this study we need to use criteria to evaluate product or technique .These criteria will be considered carefully on the effect to the organization in many points .And we may find the combination of each technique together for better selection.

1.3 Scope of the thesis

For this thesis will focus on studying QoS in data networking. It frequently finds in business organization such enterprise business , service provider and private organization.

This framework will give an information that is enough for decision in QoS for criteria unless complex mathematic model for decision. In this design will concern for usage with non-computer expert person but any one such management person or end user can use it too.

For more reasonable framework we will test this framework in case study. That we will refer in the later chapter of this thesis.

Research Methodology

1. Study and consolidate information to design model for selection QoS in variety type of QoS in present.
2. Analyst business model that will classify with QoS such Enterprise business , Service provider and private organization
3. Applied theory and principle for design framework and decision making process by Combined Utility Function.
4. Design framework
5. Evaluation the result of this framework, that will apply in case study
6. Program Coding according to each value assigned diagram.
7. Conclude
8. Prepare document

CHAPTER 2

LITERATURE REVIEW

2.1 Quality Of Service

Currently, IT has an essential thing for our life .Mostly organizations have many new techniques to beat the competitor. Information is a value thing besides gold.

If whoever got it first, he would be the leadership in that industry.

So if we had the efficient techniqe for this,we would have advantage as the other.

The Quality Of service (QoS) is the collective effects of sercie performance which determine the degree of satisfaction of user of the service.Thus the QoS requirement and the performance guarantees the service.

Generalized QoS Processing Model[13]

To bulid QoS into a system involves

-the construction of a generalized QoS framework,
-QoS specification which captures application QoS requirements,
-mapping of QoS requirements to resources,
-QoS mechanisms which realize desired QoS behavior.

QoS Specification

An application's QoS requirements are conveyed in terms of high-level parameters that specify what the user requires .QoS specification is different at each system layer and is used to configure QoS mechanisms at each layer.Possible system layers are

-protocol- transport, network
-network
-middleware
-operation system –scheduling,resource management,real-time support
-distributed platforms-CPU ,memory/buffers,devices
-application

QoS specification encompasses requirements for

-performance-expected performance characteristics are needed to establish resource commitments.
-synchoronization-characterizes the degree of synchronization rquired between

related services, events or information flows

-level of service –specified the degree of resource commitment required to maintain performace guarantees,
-cost of service –the price a user is willing to incur to obtain a level of service,
-QoS management –the degree of QoS adaptation that can be tolerated and scaling actions to be taken in the event the contracted QoS can't be met.

QoS requirements are assesed to determine if they can possibly be met.If, for example, the level of service requested can't be provided, the user can be asked if a certain level of degradation is acceptable before proceeding further.

QoS requirements are used to derive resource requirements for entitees such as computation,communication,and storage,They are successively mapped into quantitative QoS parameters relevant to various system layers that can be monitored and controlled.

QoS parameters may be oriented towards.

-performance-sequential versus parallel processing,delays data rate
-format-transfer rate ,data format,compression chema,image resolution
-synchronization –loosely versus tightly coupled, synchronous versus asynchronous
-cost-platform rates ,copyright fees, connection and transmission rates
-user-subjective quality of images ,sound,response time.

Each QoS parameter can be viewed as a typed varable with bounded values,and the values are subject to negotiation between the system layers.

QoS Enforcement

To provide and sustain QoS, resource management must be QoS-driven. In allocating resources, the resource management system must not only consider resourece avilability and resource control policies,but also an application's QoS requirements measured in terms of the QoS parameters. To ensure the contracted QoS is sustained ,it must monitor QoS parameters and reallocate resources in response to system anomalies.Prior to allocation resources, the system layers negotiate to determine if they can collectively ensure that the requred QoS parameters can be consistenly satisfied.Negotiation involves

dynamic adaptation and the transmission and transaltion of QoS parameters between the layers as the layers enter into different types of agreements,e.g., gruaranteed,best-effort,or predictive.If negotiation ends in agreement,the application is launced.After resources are allocated ,QoS mechanisms at each layer guarantee the contracted QoS, and the resource manager gurantees the sustained availability of the allocated resourece,This requires monitoring resource availability and its dynamic characterristice,e.g., meauring processing workload an network traffic ,to detect deviations in the QoS parameters .When their adjustments to compensate(e.g., reschedule shared resources to satisfy allocatoins or switch to an optimized implementation of an object/service),then the application is notified, e.g. ,application handlers are called .The application can either adapt to the new level of QoS of scale to a reduced level of service.

Extending QoS to the Internet

RSVP ,the emerging standard for QoS negotiation over IP , is a network control protocol for establishing and maintaining Internet integrated service reservations that allows Internet applications to obtain both best-effort and real-time QoS for their data flows.Hosts and routers use RSVP to deliver QoS requests to all nodes along the path of the data stream,typically resulting in a reservation of bandwidth for that particular data flow.RSVP is designed for use over both Ipv4 and Ipv6 ,the next generation Internet protocol.Ipv6 offers a choice of QoS level beyond the single "best effort" delivery service offered by Ipv4.With these added QoS capabilities, still in the experimental stage of development ,Ipv6 will provide a better range of support for real-time data traffice.

2.2 Implementing Internet QoS: A Big picture[15]

The big picture of the emerging Internet QoS can be summarized as follows

1.Customers negotiate SLSs with ISPs.The SLAs specify what services the customers will receive. SLAs can be static or dynamic.For static SLAs,customers can transmit data at any time.For dynamic SLAs,customers must use a singaling protocol such as RSVP to request for services on demand before tansmitting data .The Bandwidth Brokers in the customer domains decide how applications share the services specifed by th SLAs. The DS fields of packets are marked accordingly to indeicate the desired services.

2.The ingress routes of ISPs are configured with classification,policing and re-marking rules. The egress routers of ISP networks are configured with re-shaping rules. Such relies may be configured manully by network administrators or dynamically by some protocol such as LDAP or RSVP.ISPs must implement admisssion control in order to support dynamic SLSs.Classification,marking.policing and shaping/reshaping are only done at the boundary routers.Core routers are shielded from the signalling process. They need only implement two queues with strict priority.They process packets based solely on their DS fields.

3.With MPLS ,LSPs are setup between each ingress-egress pair,At the ISP ingress routes ,labels and COS fields are determined from the classification and routing results.MPLS headers are then inserted into the packets,Core routes process packets based on their labels and COS fields only. Labels are removed before packets leave a MPLS domain.

4.Constraint Based Routing can be use to compute the routes subject to QoS and policy constaints. The goal is to meet the QoS requirements of traffic and to improve utilizatin of the networks.

5.MPLS and Constraint Based Routing can be used together to control the path of traffics so as to avoid congestion and improve the utility of th networks.

2.3 Traffic Management in QoS Network :Overview and Suggested Improvement [48]

Almost ten years ago developers of the Internet began to predict a growth in the demands the network applications impose on the network with respect to the quality of transmission. The growth was related to the widespread appearance of work stations capable of encoding and decoding audio and video data in real time. That is, the encoding-decoding process is not visible to the human. Naturally, after such techniques become available, it was found reasonable to develop a way to transmit the encoded video and/or audio data over a network between work station. Until that point the Internet was seen primarily as a transport for non-real-time traffic such as email and ftp. Thus ,the network did not have to provide rigid bounds on delay and loss of the packets. An exception was the telnet traffic, but this did not present a challenge to the Internet because of its modest volume. However the new real-time applications potentially exhibit relatively large demands on the speed of the network, as well as on the delay and loss parameters . In this new scenario the best-effort nature of the Internet could not satisfy the applications' demands for strict delay and loss bounds per every real-time data flow. The term "best-effort" means that the network provides quality of transmission expressed in the delay and loss parameters that results form sharing the network resources equally between all the flows submitted to the network. Meanwhile the new applications need a network that can allocate its resources according to the demands of each flow. The network would also need to control the use of its resources so that the transmission quality of already allocated flows is not degraded by newly established allows .Another requirement on the network would be its ability to control individual flows so that none of them captures more resources than the network is ready to allocate to it. With all these

questions in mind the Internet into a network that could efficiently support the demands of different types of network applications.

In this work the author reviews the best known developments in the field of guaranteed transmission service ,or QoS(Quality of Service),of the Internet an gives his own suggestions for improvements to some of them. In particular, the author outlines an error in widely used interpretation of the leaky bucket algorithm that is used to describe the worst-case pattern of network flows. Another improvement proposed by the author is a variable ATM cell format that allows a reduction in the ATM transport overhead by factor of more than two Finally ,the author suggests a simple scaleable congestion management method that allows fairs treatment of flows in a congested link. The main idea underlying this method is penalizing the youngest flows while not keeping complex per-flow states as some in QoS frameworks.

2.4 QoS Policy Framework[12]

In recent year. The Internet has evolved from its legacy best-effort character to support differentiated service to different applications and customers. This is a result of considerable increase in deployment of IP based network services such as Video-conferencing .Internet telephony ,audio/video streaming, virtual private networking etc .which have specific performance requirements such as delay or jitter bound. Bandwidth reservation guaranteed delivery of business critical data an so on. Internet traffic differentiation in turn dose create some incentive for unauthorized usage or stealing of available resource. Certain malicious user may want the better service for their traffic without paying the higher price for the same. Such a free-for-all QoS implementation may lead to chaos and possibly result in even worse than QoS 'police' to enforce these rules an 'judges' to decide when they apply .All these elements together form what is known as QoS policy framework, an essential component of a QoS-enabled

network. QoS policy can be also looked upon as a subset of wider area of recent interest, namely policy base network management (PBNM).Unlike legacy and managing each network entity individually, PBNM involved configuring and controlling the various operational network operator with a much simplified and automated control over all the network.

2.5 QoS Oriented Measurement in IP Networks[41]

This report brings overview of QoS specification in IP networks .It focuses on the measurement of QoS related characteristics and introduces the method of multipoint passive measurement. Detail in QoS parameter, QoS parameters in ITU-T

Performance Criteria	**QoS Parameters**
Speed	Delay Throughput
Accuracy	Probability of error Probability of mis-insertion
Dependability	Probability of loss

Table2.1: Performance criteria and QoS parameters

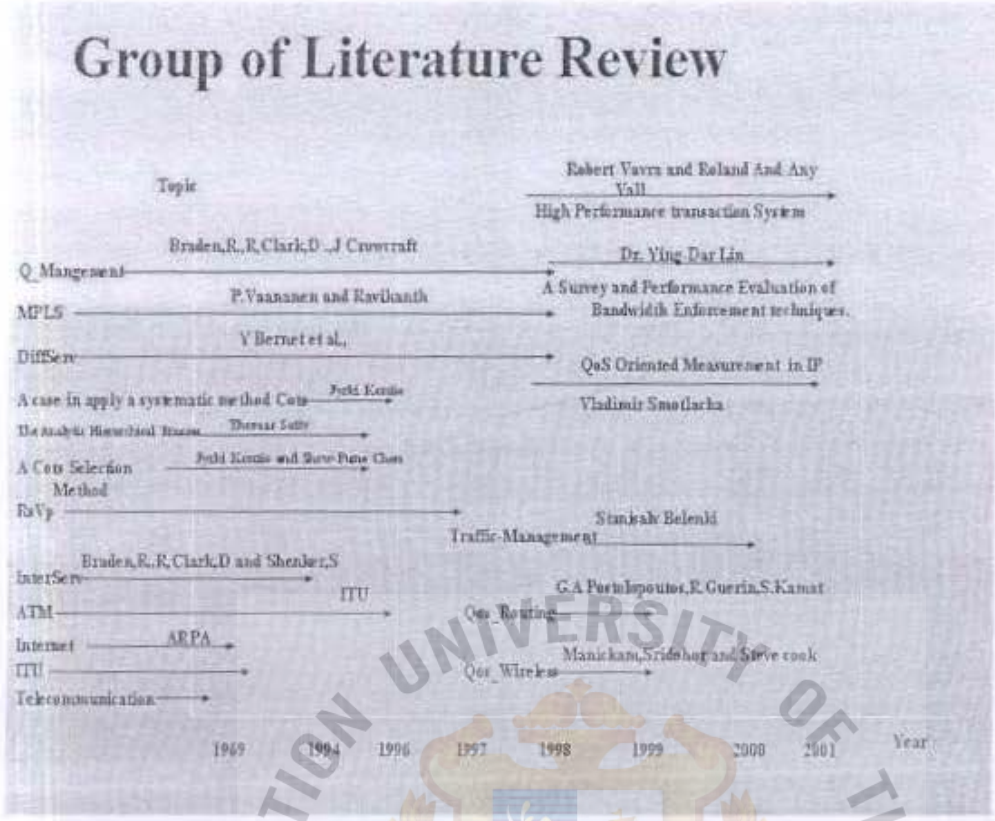


Figure 2.1 Group Of Literature Review

2.6 Combined Utility Function[36]

Given a user's non-fuctional requirements (NF-requirements) and a set of componets that meet the NF-requirements ,the goal is to select the best componet from all available componets with respect to theire NF-attributes.

- $A = A_1, A_2, .., A_M$, is a set of componets whic satisfy the user's requiements
- $X_1, X_2, .. , X_N$, are NF-attributes that specify the quality of a componet.
- $a_{m\,n}$ is the level of attribute X in componet A_m which $(1 \leq m \leq M)$ and $(1 \leq n \leq N)$
- cv_n is the critical value of attribute X_n.There are two types of requirement related to cv_n.
  -Strict –level of the attribure in a componet (a) must be equal or higher than critical level (cv_n).
  -Flexible- a can be lower than cv_n.
- $U(x; cv_n)$ is an individual utility function that summarizes user's strength of preferences over the levels of attribute X, where$(1 \leq n \leq N)$.
- $k_1,k_2,...,k_n$ are scaling coefficients.

Under independence assumptions between attributes (X_n) ,the user's prferences between alternatives can be represented by $U(x_1,x_2...,x_n)$.Under the assumption of preference

independence. in which the user's preference pattern over a subset of attributes is independent of the levels of the complementary subset. The CUF has the additive form.$U(x_1,x_2...,x_n; cv_1, cv_2..., cv_n)$.

$$U(x_1,x_2...,x_n; cv_1, cv_2..., cv_n)= \sum_{n=1}^{N} k_n u_n (x_n; cv_n)$$

The hardest task is the evaluation of the scaling coefficients, which is done through what are called indifference experiments.

CHAPTER 3

A FRAMEWORK

Framework for selection of Quality of Service

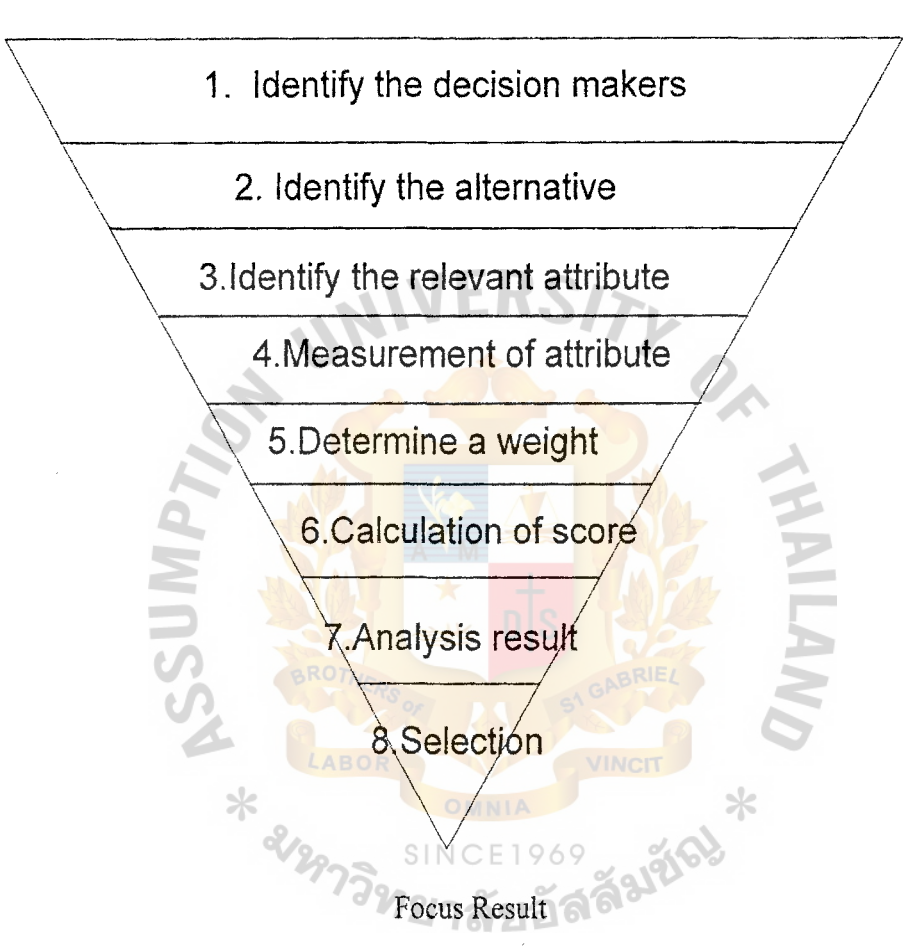


Figure 3.1 Framework for selection of Quality of Service

This framework describes a process to systematically organize and evaluate the universe of all possible exposure source and path ways to efficiently and effectively derive specific exposure scenarios necessary for screening level exposure assessment. The exposure scenarios are used to develop a quantitative assessment of exposures for the receptor of concern.

Although we can build the good model , but refine model is necessary for according to the real factor and updatable the model.

3.1 Identify Decision maker(s)

The decision makers will call committee. The committee is assembled with management person, technical person and external consultancy. Functionality of decision makers are determining of detail explanation of content ,scope, requirement and analytical. Among committee there will be establishment a head of committee namely the judge. The judge is human with particular expertise who provides their informed opinions about behavior he observes from some record of that behavior and the final decision.(In this case there is one judge.)Functionality of judge fills in the value assign diagram.

3.2 Identify the alternative in Categories and Criteria Definition Process

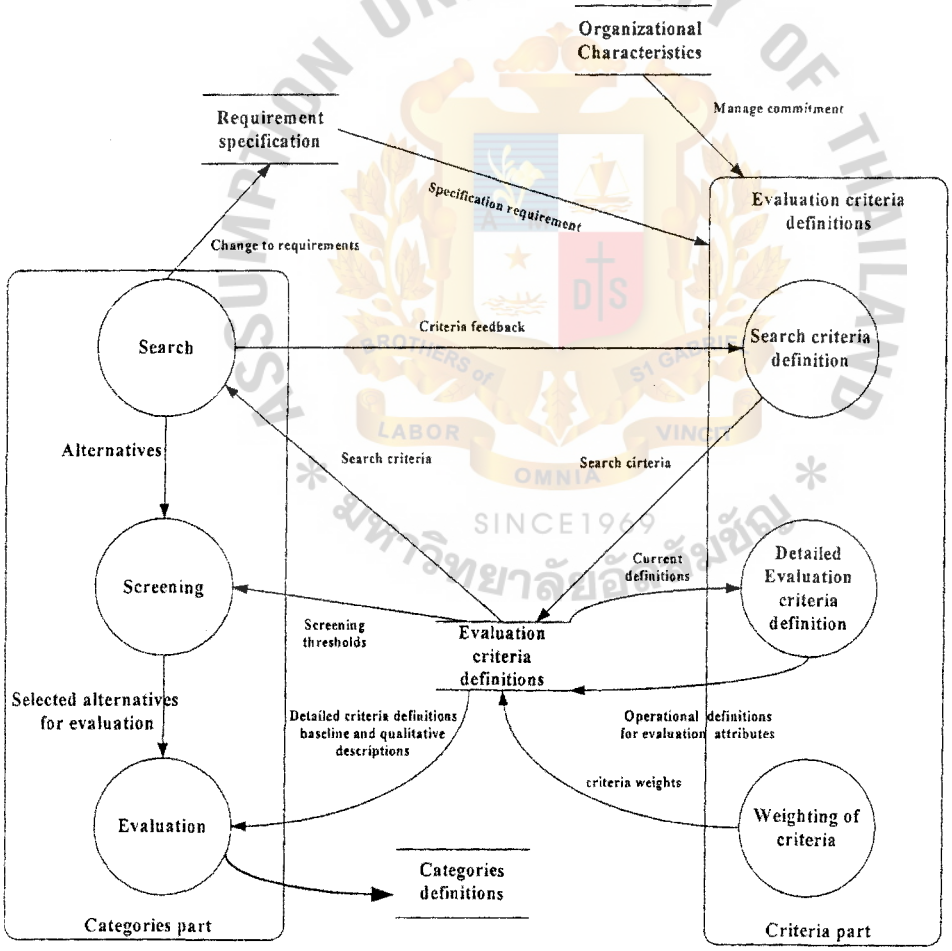


Figure 3.2 Evaluation Categories and Criteria Definition Process

The main component of Model is two parts .One is Categories and another is Criteria part. (Detail see page 13-15)

Categories will be assembling with three components.

Search is searching from the various sources such as

1. Internet Search
2. Market Search
3. User Community
4. Mailing List
5. Vendor Promotion and Publication

Screening is filtering the various searching and compares with basic theory of OSI (Open System Interconnections) 7 layers.

Evaluation is the properties of candidate components are identified and assessed according to evaluation categories.

Criteria part will be assembled with three components.

1. Search in criteria will include component's interface and quality aspect that are more difficult to isolate.

Search components	None-Technical -Cost in general -Market trend -Vendor reputation
	Technology -Architecture design and Framework -Technology Standard -Support for Integrality
	Production quality characteristic -Efficiency -Interoperability -Maintainability -Performance -Scalability -Usability

Table 3.1 Search component items

2. Detailed Evaluation criteria definition

It will illustrate data collection technique. Detail will show below this.

-Product/Approach qualification
-Study documentation
-Audit development process
-User Community
-Evaluation strategy by progressive filtering
-Comparison of each alternative

Organization Characteristics

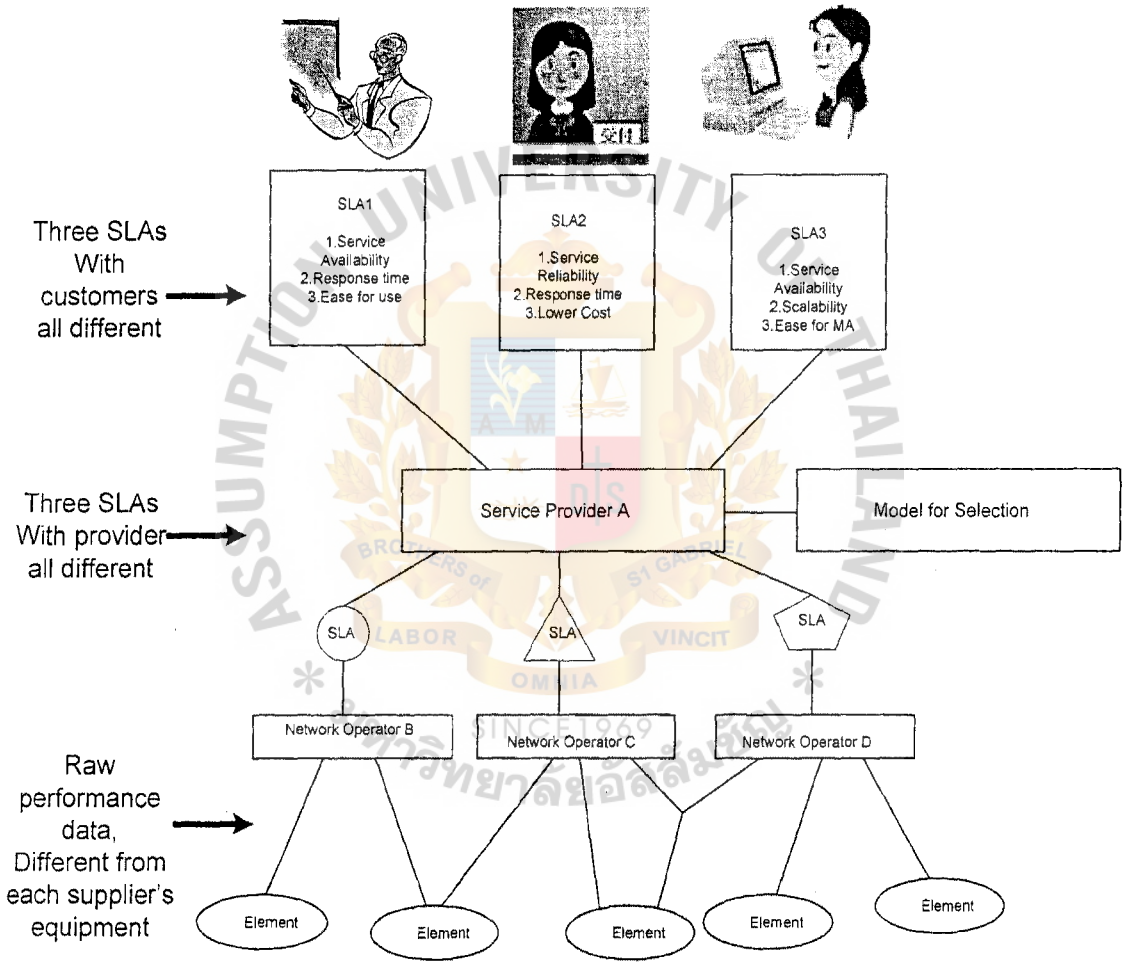


Figure 3.3 Mapping of QoS Parameter

According to the previous framework, Mapping QoS appropriate by the important part. These will perform to accurate model . Figure 3.2 SLA will represent user requirement Model for selection will be knowledge base information of (QoS Service Provider).Unless these model QoS Service Provider are used their expertise to consider

and select by themselves ,complexity and bias might appear with them.

3.3 Identify the relevant attributes in Common Requirements of Categories , Criteria and Considerations

The first part of model concern common organizational and technical criteria, the second part criteria integration. User must be very familiar with their system requirements and adjust them to the general requirements of this model:

1. Data link-layer QoS
2. Network-layer QoS
3. Transport-layer QoS
4. Queuing Technique
5. Traffic Shaping

Each general requirement has a set of common evaluation criteria ,including:

1. Quality of Service Level
2. Performance
3. Scalability
4. Ease of Use
5. Cost

Techniques, approaches or products which meet general requirements will be evaluated in term of their feature .In these evaluation questionnaire will apply to expertise people in QoS industry for accurate evaluation. (By explanation all of technique ,approaches to them)

Although the model gives a common set of requirement, criteria and considerations, they are flexible. Some items can be removed, if they are not of concern to an organization, others may be added according to need. The model comprises qualitative and quantitative criteria and aspects, ease of use being qualitative, cost quantitative. Its qualitative criteria and considerations are personal in that it is left for users to assign appropriate personal scores.

The concluding part of the model concern and approach to an evaluation of the overall score.

3.4.1 Data Link-Layer QoS

It is Layer 2 of OSI Layers. Which is important for reforming transmission to higher layer .Higher layer will consider and use in frame format .

And this level ,there is inspection for error checking that will display in CRC error checking. Product or Appoarch in this level has X.25, Frame Relay and ATM etc.

QoS will be applied to this level ,it depends on technique of each product or approach. The author will elaborately describe in chapter 5.

3.4.2 Network Layer QoS

It is Layer 3 of OSI Layers, which is important for reforming transmission to higher layer. Higher layer will consider and using in packet format .

And this level, there is inspection for error checking that will display in checksum error checking. Actually Product or Approach in this level will not have retransmission process, it will let the higher layer to do this process. Product or Appoarch in this level has Ipv4,Ipv6,MPLS and Constraint-Base Routing. QoS will be applied to this level, it depends on technique of each product or approach.The author will elaborately describe in chapter 5.

3.4.3 Transport Layer QoS

It is Layer 4 of OSI Layers. Which is important for reforming transmission to higher layer . And this level ,there are two inspection for error checking ,one for doing by itself and the other lets the higher layer do. Product or Appoarch in this level has InterServ and DiffServ. QoS will be applied to this level ,it depend on technique of each product or approach.The author will elaborately describe in chapter 5.

3.4.4 Queueing Technique QoS

It 's not OSI layer but it is technique for buffering the data during processing QoS. These techniques will improve efficient QoS in the system.Because the limitation of

memory or buffering these Queueing will elimiante the issues.

Product or Appoarch in this level has FIFO,PQ,CQ,WFQ and CBWFQ. QoS will be applied to this level ,it depends on technique of each product or approach.The author will elaborately describe in chapter 5.

3.4.5 Traffic Shaping QoS

It's not OSI layer but it is Product for collecting various technique in single box for doing QoS.These product will improve efficient QoS in the system.

Product or Appoarch in this level has Packeteer, Allot,Sitara and Toplayer. QoS will be applied to this level ,it depend on technique of each product or approach.The author will elaborately describe in chapter 5.

Criteria#1 Quality of Service Level

Consideration #1.1 Availability

It will inspect accordingly to using of QoS .How is product or approach?

Because each production has different purpose, it can support different purpose.

If anyone can appropriately support, it will be selected by the suitable selection.

Consideration #1.2 Level of Acceptance

It will verify QoS in each product or approach how it has a competency.

And how it has accepted in industries.

Criteria#2 Performance

Consideration #2.1Processing Time

It is time for CPU's process for sending the data with QoS.

Consideration #2.2 Throughput

This value will illustrate completency of transmission data. It will display actual efficiency of capability of sending data. If it is high value ,the capability will be consequently high .

Consideration #2.3 Transit Delay

Because of transmision, the data will be stored in the buffer for processing and wasting time for travel. So the delay will occur but the new technique will decrease the time for any process. Delay will reduce as technology growth.

Consideration #2.4 Error Rate

Consideration #2.4.1 Flase accept

It is methodology to verify the acceptable false of communication system.

Mostly it will depend on Production or Approach .The value should be less than 10 % between error and good packets.

Consideration #2.4.1 False Reject

If the system has error more than baseline value,that system should reject that value .

And that system will be recovery by retransmission.

Criteria #3 Scalability

Scalability is the means of expansion or growth of this system in the future.

Consideration #3.1 Expansion scale in the future.

This product or approach can expand in the future. It is a point of view for system growth in the future

Consideration #3.2 Flexible to integrate with other

This product or approach can integrate with the others. How is it good for integration?

Criteria#4 Ease of Use

Consideration #4.1Ease of Implementation

It is step for using QoS with organization .How easy or difficult for implemetation of QoS? This is holistic view for implementing.

Consideration #4.2 Ease for User

Consideration #4.2.1 User Acceptance

It is a point of view of user with this QoS .How is user when using?

It is possible for acceptance on user side.

Consideration #4.2.2 Ease to be Used

It is a point of view of user with this QoS .How easy when using?

It is an intuitive using.

Consideration #4.2.3 Ease of Administration

It is a point of view of admistrator or network administrator.

How comfortable for administration this system?

Consideration#4.2.4 Ease of maintenance

Besides using this sytem, the important thing is maintenace.

How about maintenace? It is easy or difficult for maintenace.

Criteria#5 Costs

It is very important criteria. Most person must think this criterion first.

It is will resonalble investment or not.

Consideration #5.1 Investment Cost

Consideration#5.1.1 Hardware Cost

It is one time cost that we will invest. This component will comprise of physical entity or material (Hardware).

Consideration#5.1.2 Software Cost

It is one time cost that we will invest. This component will comprise of logical entity (Software) and installation too.

Consideration#5.2 MA Cost

Beside one time cost we must pay annual fee cost for maintenance.

Normally we must pay per year.It will include both Hardware and Software fee.

3.4 Measurement of attributed(Rating Assigned)

The costs may be determined directly or estimated by price list. For other quantitative criteria the measurements are transformed using value functions.

The qualitative variables on the lowest level in model diagram are rated directly on an ordinal scale from 0 to 9.The author assigns score range in two types one for criteria and two for consideration by Model score Assigned .

Model Score Assigned

The judge will appraise the criteria or consideration and assign fitting scores by considering rate the mapping process in table should be occurred.

In this case, the judge only assign rating then the program will map to score at once.

Quality	Rating	Score Consideration (0-1)
Extremely High	9	1
Very High	8	0.88
High	7	0.77
Slightly High	6	0.66
Average	5	0.55
Slightly Low	4	0.44
Low	3	0.33
Very Low	2	0.22
Extremely Low	1	0.11
Not sufficient	0	0

Table 3.2 mapping value consideration rate

3.5 Weighting of Criteria

The author uses hierarchical weighting. Weights are defined for each hierarchical level separately .an then multiplied down to get the corresponding lower level weights.

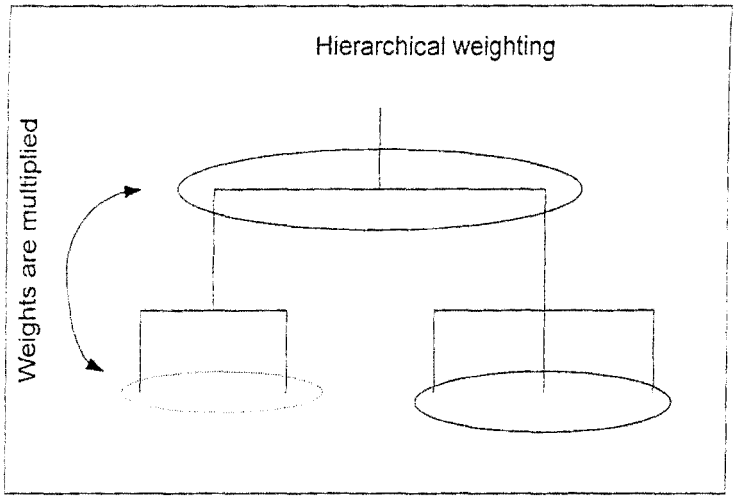


Figure 3.4: Hierarchical weighting

Weights are applied to the evaluation criteria so that decisions can be made based on the results of the component evaluations. The weights are subjective and dependent on the particular project emphases. The decision-maker must provide a set of weights that are believed to be appropriate for the situation.

In most case, the weights are normalized, in such a way that the sum of the weights equals to the highest value level Furthermore ,it is assumed that weights (w_n)are single value ranging from 0 to 1. $\sum_{n=1}^{N} w_n = 1.$

In this case the author will separate in weight in two methods, first for criteria (Rank Sum) and second for considerations(Directed Rank).

First: Rank Sum

The weight of and criteria reflect its relative importance for the decision makers.

The committee must rank the attributes and determine the weight by weighting factor

Position	Weighting factor	Level	Rank Sum/weight
1.	Very Important	Important 5	0.33
2.	Somewhat Important	Important 4	0.27
3.	Average Important	Important 3	0.20
4.	Somewhat Unimportant	Important 2	0.13
5.	Very Unimportant	Important 1	0.07
	Total	15	1

Table 3.3 mapping weight value

Weighting factor

1.Very Important = Level of Importance 5
2.Somewhat Important = Level of Importance 4
3.Average Important = Level of Importance 3
4.Somewhat Unimportant = Level of Importance 2
5.Very Unimportant = Level of Importance 1

Example

Total Level=15 = Total Rank sum =1

Rank Sum of each level =Level of that position/summation of Level

Position 1. Weight at Level = 5/15 =0.33
Position 2. Weight at Level = 4/15=0.27
Position 3. Weight at Level = 3/15=0.2
Position 4. Weight at Level = 2/15=0.13
Position 5. Weight at Level = 1/15=0.07

Weight at Level = Level/Total Level

Second: Directed Rank

Consideration level will use with Directed Rank.

1. Assign 100 points to the most important attribute(Rank=1)
2. Give points(<100) to reflect the importance of the attribute relative to the most important attribute.

Example

Data link Layer QoS

Criteria: Quality of Service

Rank	Considerations	Points	weight
1.	Availability	100	0.5
2.	Level of Acceptance	100	0.5
Total		200	1

Criteria: Performance

Rank	Considerations	Points	weight
1.	Throughput	100	0.6
2.	Transit Delay	42	0.25
3.	Error Rate	25	0.15
Total		167	1

Example of Calculation

Total Points=167 total weight =1

Points= 100 weight =100/167 = 0.6

Points= 42 weight =42/167 = 0.25

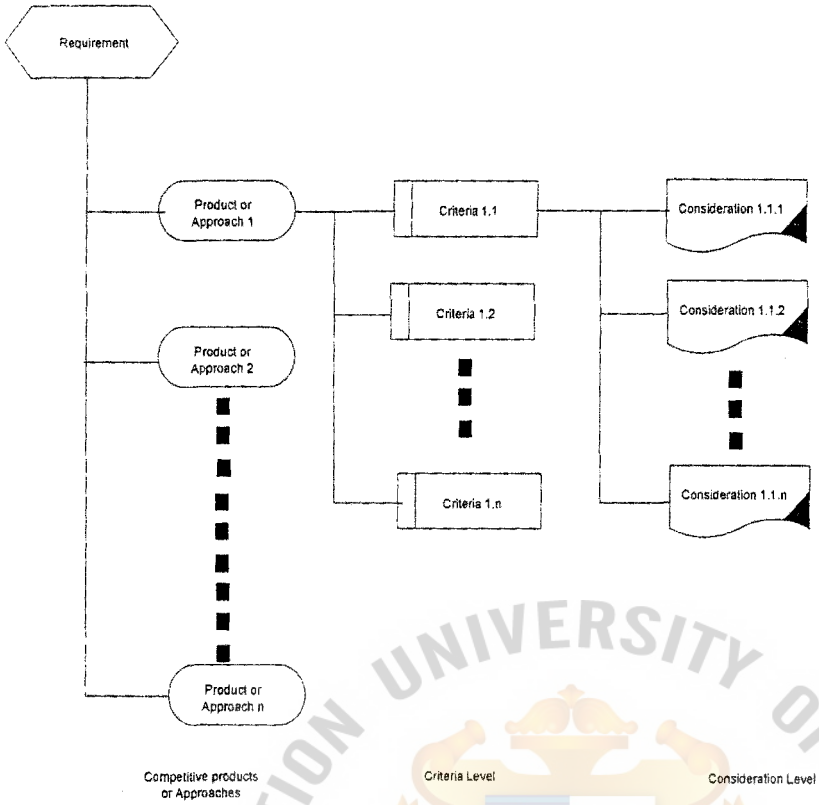
Points= 25 weight =25/167 = 0.15

Points= X weight =X/Total Point =

Note: Detail in appendix A page 79-81

3.6 Calculation of score by using the Criteria Evaluation Integration Model

In the model, every approach that satisfies the functional requirement is determined by means of a set of criteria, and consequently, each criterion may be concerned with a set of considerations.



An organization's officers collect approaches or products, which meet functional requirement, but different in Non-Functional requirements (NF-Requirements). They then apply the appropriate criteria and considerations to them, assign scores at the consideration or the criterion level and calculate total scores in order to determine the suitability of a product or approach.

Each organization has different QOS requirements. For example, the Internet Service Provider may require availability of data and response time , while a Bank may need ease of use, including reliability of data and availability . Moreover, during an evaluation of each requirement, organizations may lay different stress on criteria and considerations. For example, in the "Traffic shaping " requirement, Internet Service Provider may focus on "A quality of Service level" criteria, while Bank will focus on "Performance" Differences in emphasis also occur at the consideration level. The model faces a multi-criteria decision problem

In order to make an evaluation practical and flexible, the model adapts a solution

based on a Combined Utility Function (CUF)[39], which quantifies the user's preference patterns over the available components. Details of CUF are mentioned in the literature review. The model applies CUF in the following way.

- $A = A_1, A_2, .., A_M$, a set of products or approach which satisfy the functional requirement.
- $X_1, X_2, .. , X_N$, criteria which specify the quality of a product or approach. The model has the 5 criteria of Quality of Service level, Scalability, Performance, Ease of Use, and Cost.
- cv_n , critical value of criterion X_n. The model uses cv_n flexibly so that it is not represented by an equation.

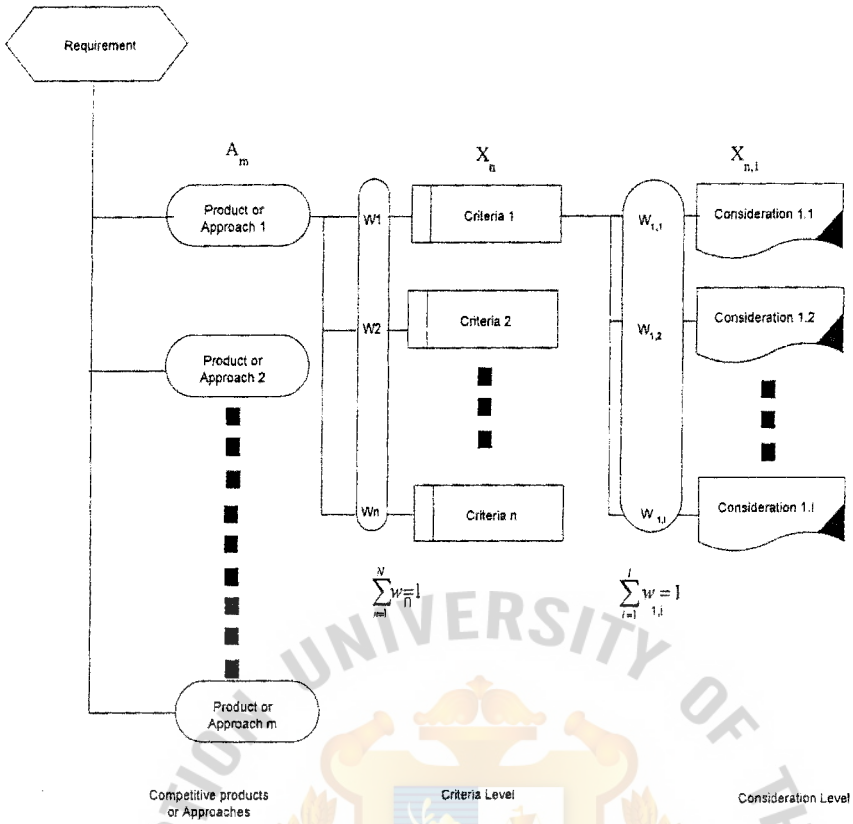
The summarized score of a product or approach Am can be calculated from :

$$U_m (X_1, X_2 , .. , X_n) = \sum_{n=1}^{N} w_n u_n (x_n).$$

- $w_1, w_2 .. , w_n$ are the weights of each criterion. They are come in place of scaling coefficients; $k_1 , k_2 .. k_n$. The summation of all weight is 1, or

$$\sum_{n=1}^{N} w_n = 1.$$

- An individual utility $u_n (x_n)$ is a utilization score of criterion X_n in the component Am, which $(1 \le m \le M)$ and $(1 \le n \le N)$. In the model, $U_n (x_n)$ is either assigned directly by the user or recursively by application of CUF at the consideration levels. In order words,
  - $u_n (x_n)$ = user defined constant.
  - $u_n (x_n) = \sum_{i=1}^{I} w_{n,i} \; u_{n,i} (x_{n,i})$. The $u_{n,i} (x_{n,i})$ can be further calculated recursively in the same way.



The reason for choosing CUF is that it is a simple and flexible model, which is commonly used in mathematics and statistics. At the present time, the software-engineering institute of Carnegie Mellon University uses CUF as solution concepts for the optimal selection of software components. The adapted CUF completely meets the flexibility of the model.

- Difference of requirements. Each organization, which has its own set of requirement, can choose to evaluate only its own requirements while the adapted CUF still preserves its property of independence between each requirement. In the model, Quality of Service Level , Scalability, Performance, Ease of Use and Cost are independent of each other.

- Weighting. An organization can select to put weight to the utility function according to their interest.

For the convenient usage the author will use Visual Basic 6.0 for a tool to write program input/output interface, and calculation score.

Program flow chart user interface

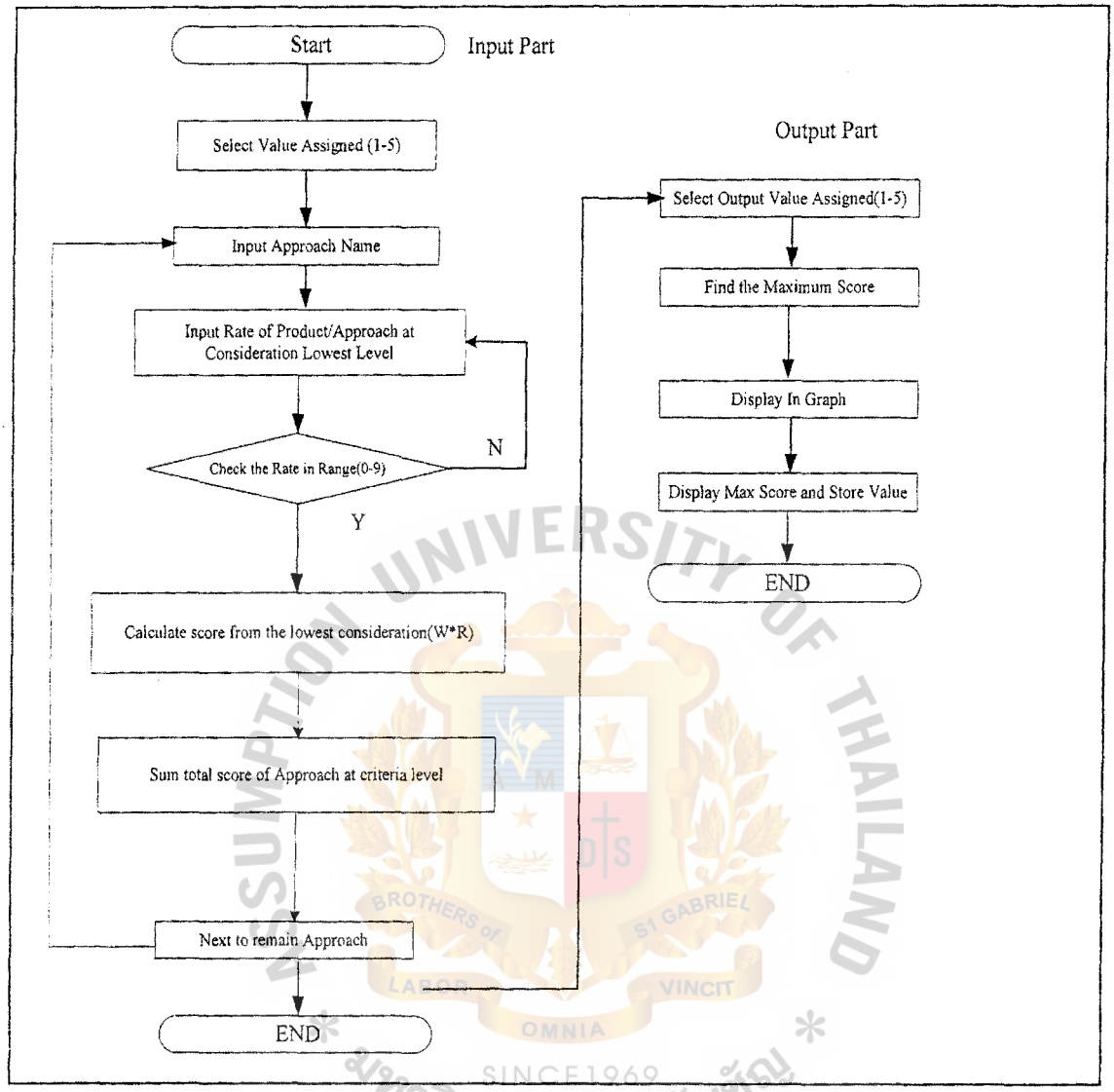


Figure 3.5 Program flow chart value assigned interface

VALUE ASSIGNED DIAGRAM #1

This diagram will be used with these approaches (X.25,Frame-Relay and ATM).

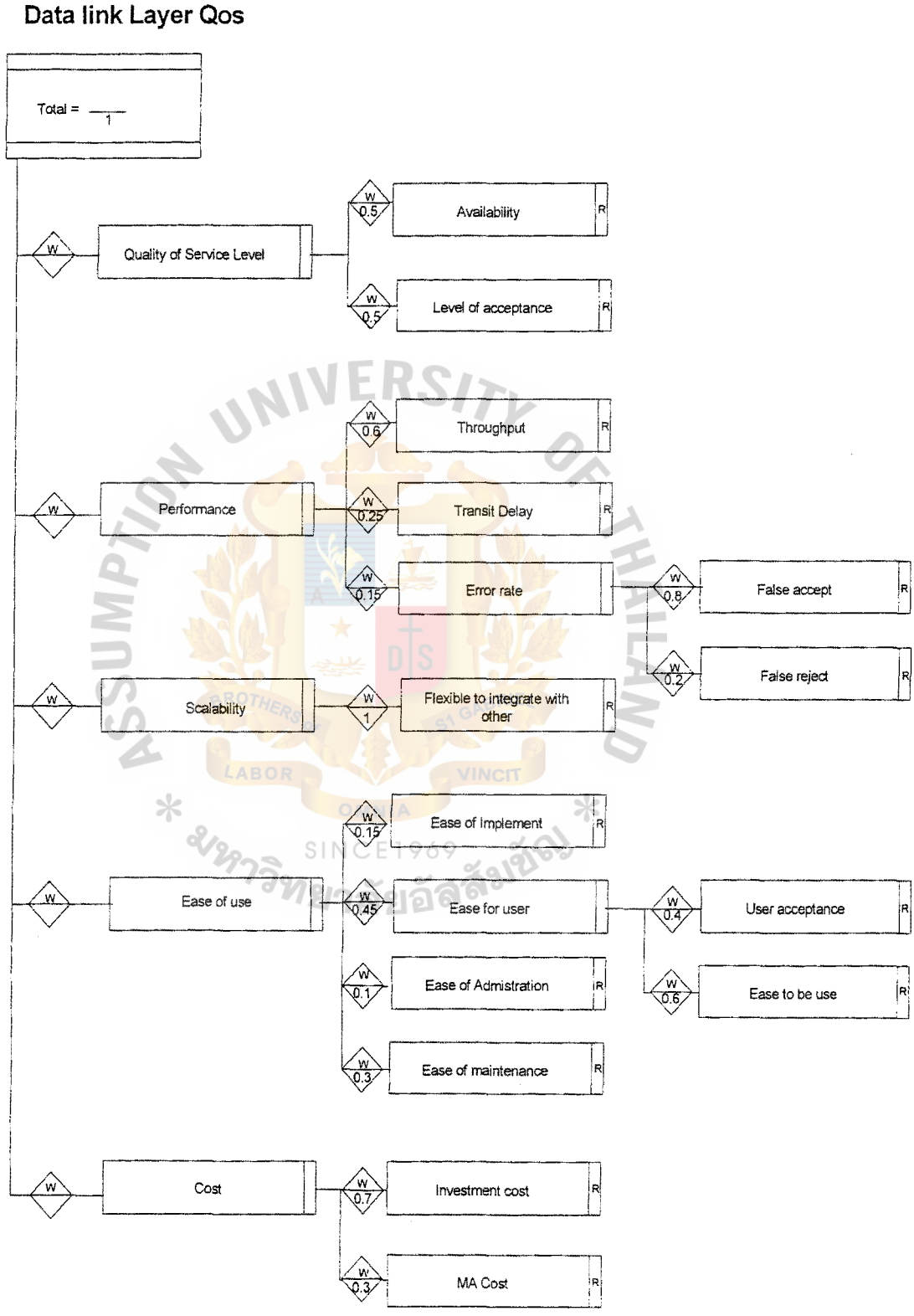


Figure 3.6 Value Assigned Diagram 1

R=Rate factor(0-9)
W=Weight factor

VALUE ASSIGNED DIAGRAM #2

This diagram will be used with these approaches (IPV4,IPV6 and MPLS).

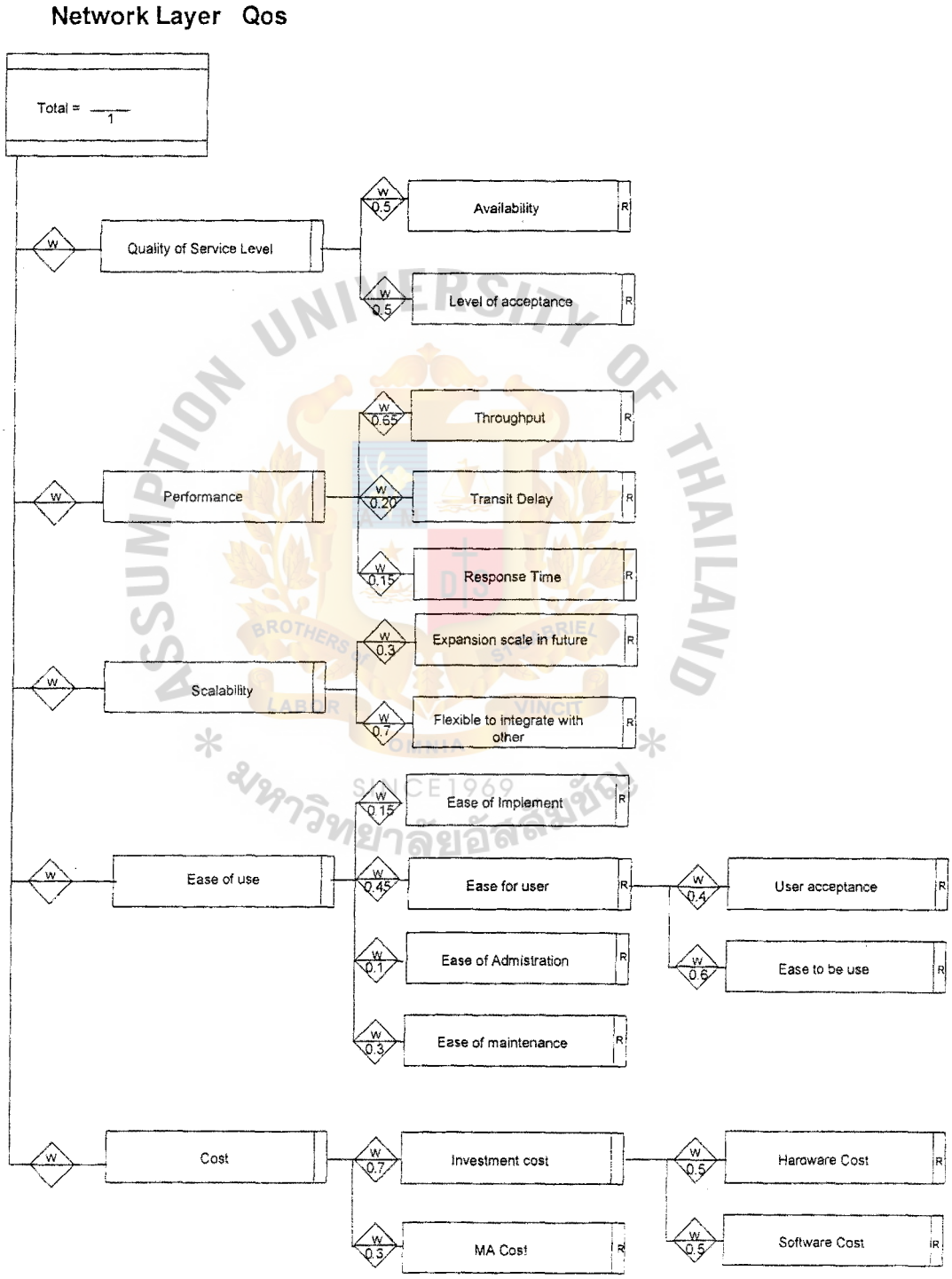


Figure 3.7 Value Assigned Diagram 2

R=Rate factor(0-9)
W=Weight factor

VALUE ASSIGNED DIAGRAM #3

This diagram will be used with these approaches (InterServ and DiffServ).

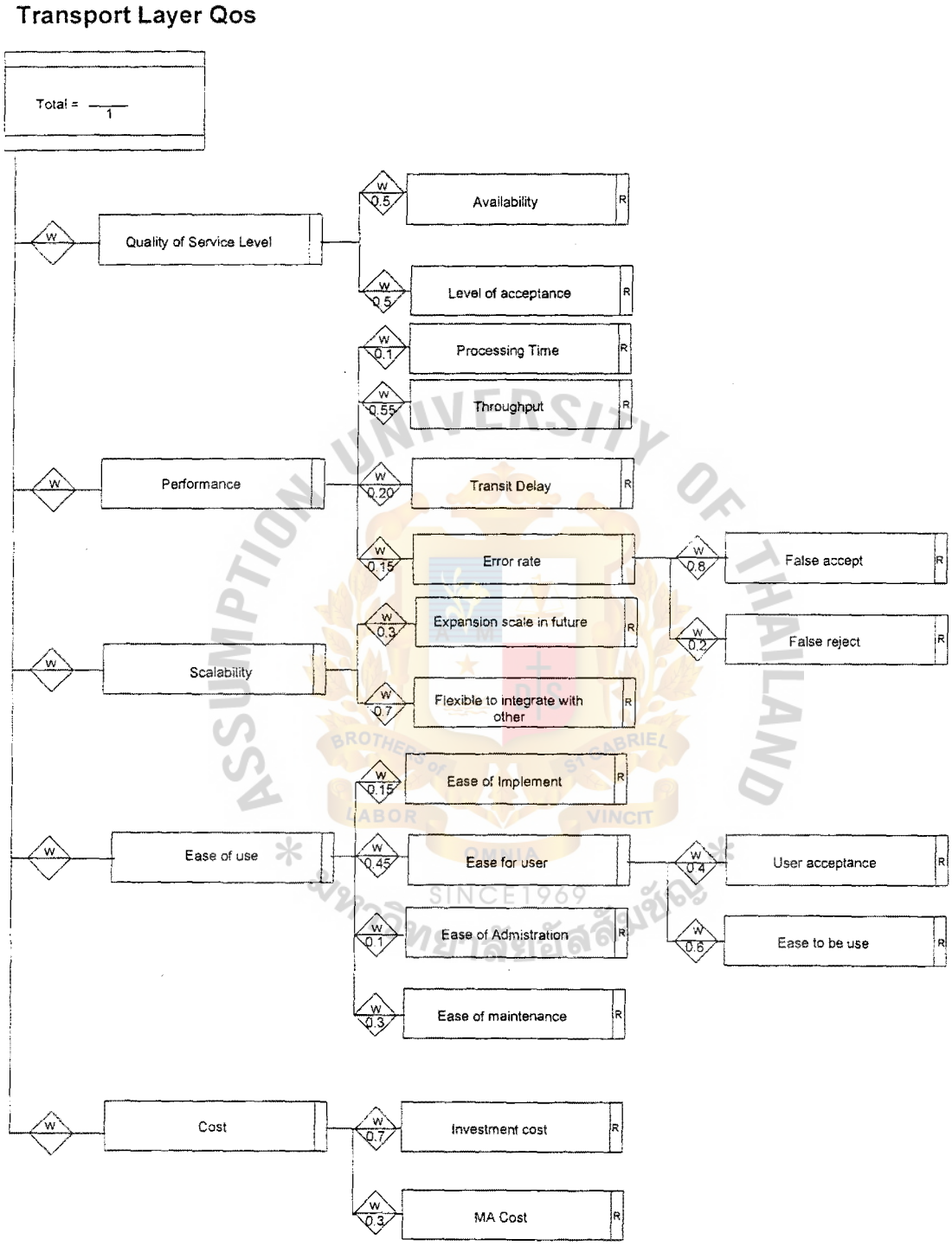


Figure 3.8 Value Assigned Diagram 3

R=Rate factor(0-9)
W=Weight factor

VALUE ASSIGNED DIAGRAM #4

This diagram will be used with these approaches (FIFO,PQ,CQ,WFQ and CBWFQ).

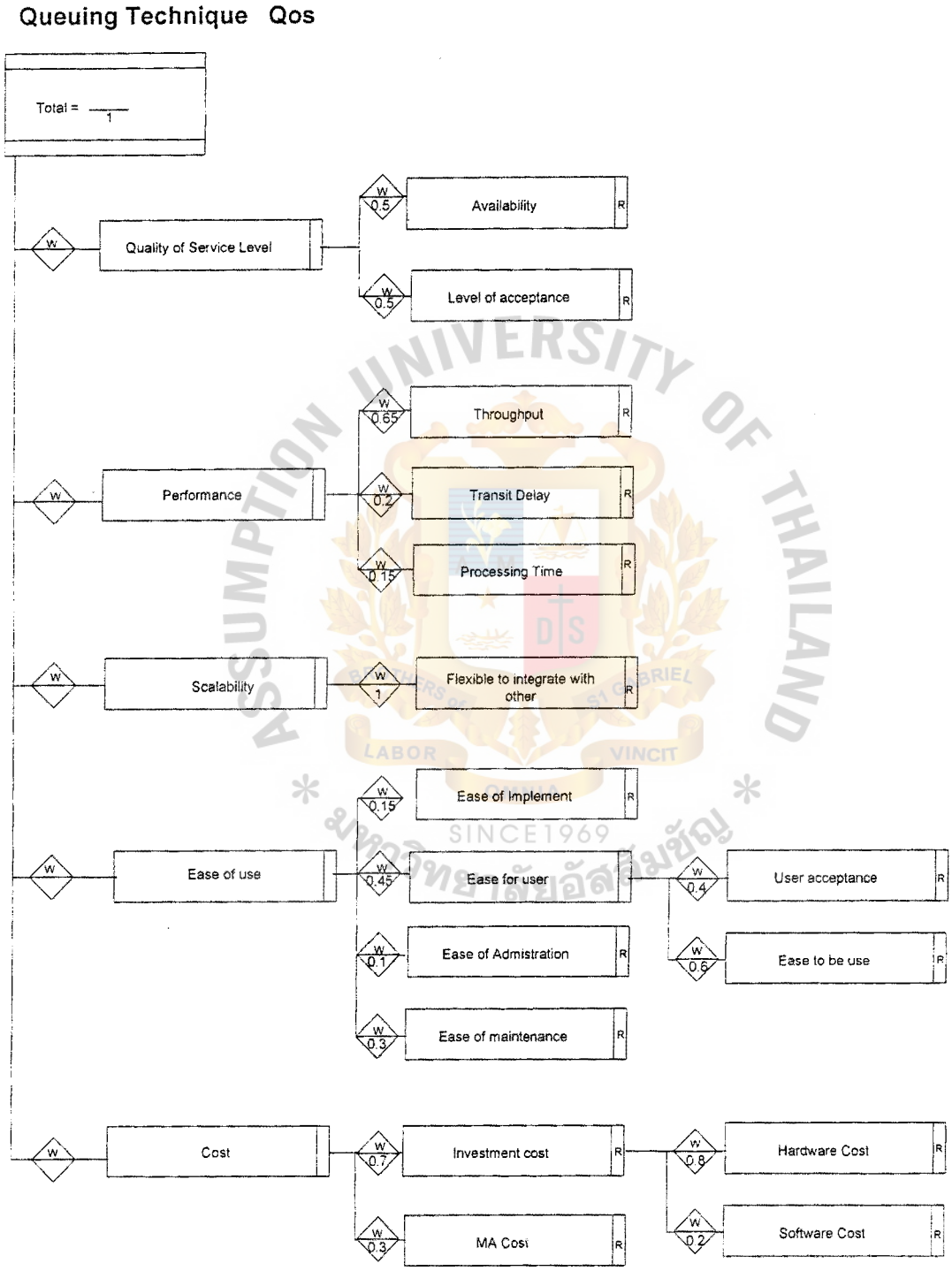


Figure 3. 9 Value Assigned Diagram 4

R=Rate factor(0-9)
W=Weight factor

VALUE ASSIGNED DIAGRAM #5

This diagram will be used with these approaches (Packeteer,Sitara and Flood-Gate).

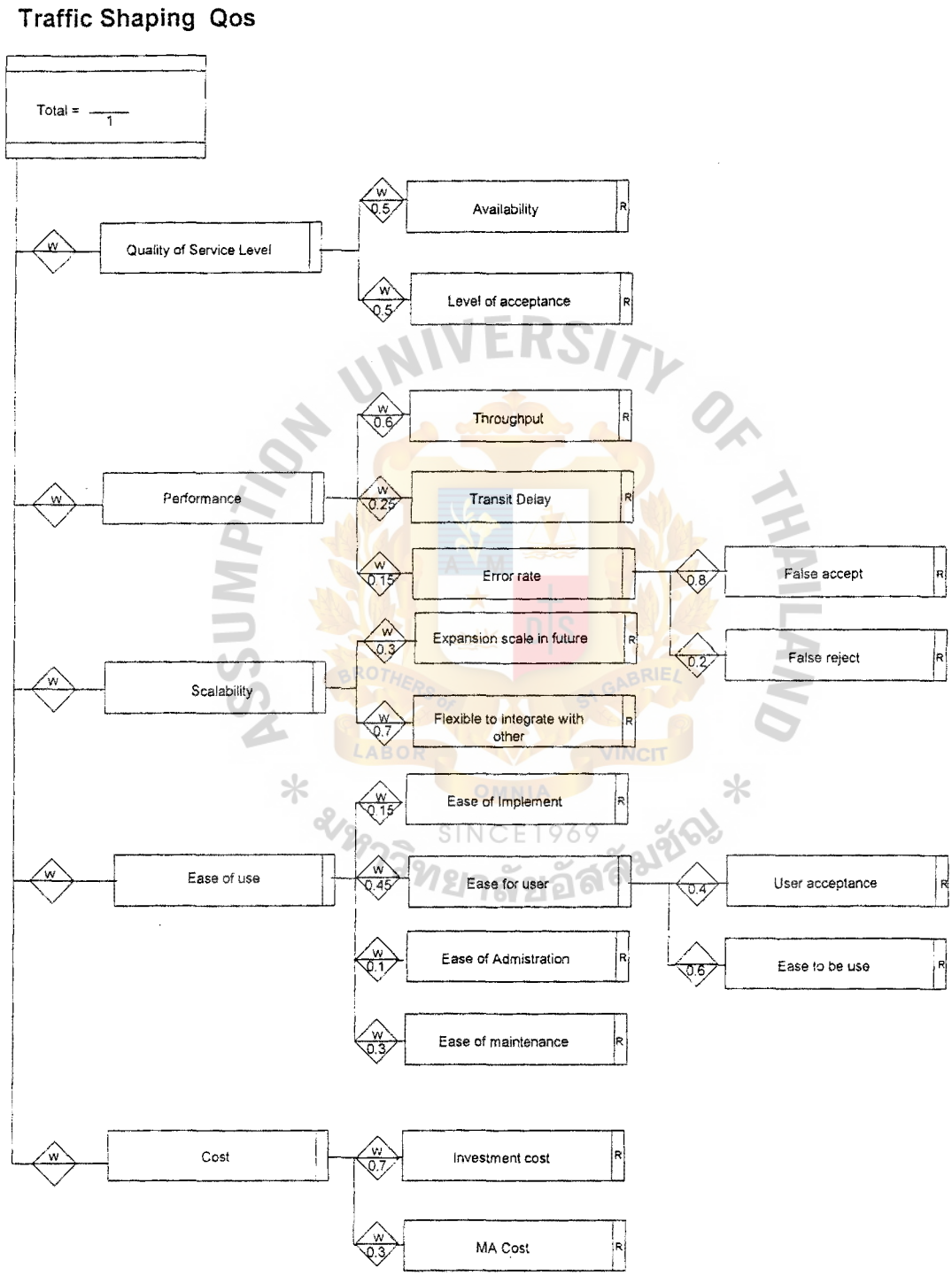


Figure 3.10 Value Assigned Diagram 5

R=Rate factor(0-9)
W=Weight factor

CHAPTER 4

Example of Quality Service Technique

4.1 Data Link Layer Quality of Service

4.11 X.25

X.25 is the packet Switching protocol. X.25 define the procedures for first data transmission between a DTE and DCE layer, the link access procedure , balanced(LAPB) layer and the packet level protocol(PLP) Layer the latter two layers perform both flow and error control.

At present X.25 is now decreasing as the industry migrate to the other such Frame relay, ATM or IP base.

4.1.2 Frame-Relay

Frame relay eliminate the extensive error checking necessary in X.25 protocol. Frame Relay operate in the physical and data link layers of OSI Model .In the data link layer Frame Relay use permanent virtual circuit(PVC) each PVC link is identified through DLCI .A switching Frame Relay perform error checking and routing . Error correction is left to the other protocol at the higher layer.

4.1.3 ATM

Asynchronous Transfer Mode(ATM) is the cell relay protocol designed by the ATM Forum and adopted by the ITU-T .ATM can be thought of as the " Highway" for the Information super highway.

Criteria#1 Quality of Service Level

Consideration#1: Availability

Approaches/Product	Quality of Service Level-> Availability
X.25	X.25 provide a few QoS in its characteristic by facilities for packet switched service .At Present X.25 is decrease using in industry. Until Now QoS of X.25 hardly use in the real world.
Frame Relay	Frame Relay provide extensive QoS by many parameter such discard eligibility(DE) reduce its QoS level to avoid congestion problem BECN ,FECN ,Bc,Be,delay, Throughput as well as the rules on emission and discard priority of custom traffic. Recently addition to Frame Relay include voice over Frame relay (VOFR).
ATM	ATM is very extensive and support a wide array of QoS feature. Such a Voice , Multimedia traffic both real time and non real time depend on service class of AAL CBR,VBR,UBR

Criteria#1 Quality of Service Level

Consideration#2: Level of Acceptance

Approaches/Product	Quality of Service Level-> Level of Acceptance
X.25	X.25 is first technique for standard data communication . It's not suitable for multimedia technology and high speed transmission communication .It's designed for the poor transmission, which is shows error on the cabling.
Frame Relay	Frame Relay is designed for the good transmission ,which's very clean on the cabling .Frame Relay eliminated redundancy of error detection on X.25 algorithm .At present Frame Relay is popular for transmission in many point of view in the industries including voice in some proportion task.
ATM	ATM is designed for high speed transmission .It's based on cell .ATM is popular for Real time Multimedia non real time And wan communication. At present in Lan communication and data transfer will use other technology

Criteria#2 Performance

Consideration#1: Throughput

Approaches/Product	Performance-> Throughput
X.25	X.25 was born in the first standard data communication .That will encounter with error transmission for older technology. Limitation of X.25 does not provide for high speed, because of technology for development and retransmission .At present we found a rate for transmission from 7.5-64 Kbps.
Frame Relay	Frame Relay was born for improvement with X.25 .That will work with new technology chipset and high speed than X.25 no retransmission in network layer because it work at data link layer. Currently, we find a rate for transmission from 2Kbps-2 Mbps.
ATM	ATM was for high speed data transmission .That will be used for backbone via fiber optic and cell base technology. It will support both real time and non real time. Currently .we find a rate from 45Mbps-10Gbps

Criteria#2 Performance

Consideration#2: Transit Delay

Approaches/Product	Performance-> Transit Delay
X.25	X.25 's transit delay will indicate facility permit a DTE to select a transit delay time through the packet network. It's established on a per call basis. Delay time is around 150 ms per 100 miles for 64 Kbps at transmission 64 byte.
Frame Relay	Frame Relay 's transit delay is the time taken to send a frame across a link between two machines. Transit delay can define a boundary between two DTE or between two international networks . Delay time is around 100 ms per 100 miles for 64 Kbps at transmission 64 byte.
ATM	ATM ' transit delay .Because of high speed and high

	technology .ATM will have lowest transit delay compared with the other technology. Delay time is around 10 ms per 100 miles for 64 Kbps at transmission 64 byte.

Criteria#2 Performance

Consideration#3: Error rate

Consideration#2.3.1 False accept and 2.3.2 False reject

Approaches/Product	Performance-> Error rate->False accept(or False reject)
X.25	X.25 will has network switch that will implement switch to switch error detection and transmission as well as preserve packet sequencing and integrity .The Receive Ready (RR) and Receive not Ready flow control will use and X.25 can retransmit if it found error by using packet sequence number for recovery at network layer.
Frame Relay	Frame Relay will use HDLC format and remove data link Layer error detection ,retransmission .Let to higher layer done. For this allow .the network switch to consider data link frame as being forwarded without waiting for positive acknowledgement from the next switch. we can use Residual Error rate (RER) for measured through the exchange of Frame relay service data unit(FSDU) during a specified period. And across a specified boundary. R=1-(Total correct –SDUs delivered)/(total offered SDUs) Users should use access for commit at that level otherwise it will generate higher error rate
ATM	ATM is similar process to Frame relay no retransmission and sequence number .Let the higher do .Flow control will be done at layer 2 operation. Performance parameter QoS characteristic. Cell Error Ration(CER) will be accuracy characteristic . Cell Los Ration(CLR) will be dependability characteristic. CER=(Error cell/Successfully transfer cell)+error cell CLR=(Lost cell)/(Total Transmitted Cell) Because of ATM is high technology high transmission. Normally ATM's error should be lower than in other.

Criteria# 3 Scalability

Consideration#3.1: Flexible to integrate with other

Approaches/Product	Scalability -> Flexible to integrate with other
X.25	Normally we can use router for gateway or use in X.25 pad equipment .It 's easy for integrate with other DTE equipment .Bit X.25 can't expand with high speed technology and inappropriate for multi protocol such IPX or more overhead protocol.
Frame Relay	Normally we can use router for gateway. It's simple to integrate with other DTE and Frame Relay can work well with ATM because of ATM interoperate with Frame Relay and expansion to ATM can take place in the future.
ATM	It will be appropriate with normal and edge user. Normally we can use router or other. It's difficult to integrate with other at present. It suits for high speed technology and backbone. ATM has a various form for interoperate with many multimedia product such VDO conference and Voice over ATM and multiplexer.

Criteria#4 Ease of Use

Consideration# 4.1 : Ease of Implement

Approaches/Product	Ease of Use-> Ease of Implement
X.25	X.25 is simple for implement with standard. No complexity with X.25 configuration.
Frame Relay	Frame Relay is easy to implement because of no consideration with error or retransmission part .
ATM	ATM is difficult for configuration including complexity with signaling and interoperate among vendor.

Consideration# 4.2 : Ease for user

Consideration #4.2.1 User acceptance

Approaches/Product	Ease of Use-> Ease for user a
X.25	X.25 is limit for using in some organization and it hardly increase growth in the market .In user point of view is normal acceptance for the oldest technology.
Frame Relay	Frame Relay is superior acceptance with flexible and user for usage. User can optimize bandwidth with this technology.
ATM	ATM is very superior acceptance with strong versatile usage both real time and non real time and very high speed low error.

Consideration #4.2.2 Ease to be use

Approaches/Product	Ease of Use-> Ease to be use
X.25	X.25 is simple for use in general
Frame Relay	Frame Relay is simple for user in general.
ATM	ATM is difficult for user in some part such as multi protocol , multi-type of application voice data and video.

Consideration #4.3 Ease of Administration

Consideration #4.4 Ease of Maintenance

Approaches/Product	Ease of Use-> Ease of Administration(or Maintenance)
X.25	X.25 is simple for configuration for admin so it 's simple for maintenance too.
Frame Relay	Frame Relay is simple for configuration for admin so it 's simple for maintenance too.
ATM	ATM is difficult for configuration both general data signaling and multi protocol and multi type of application voice video and data.

Criteria#5 Cost

Consideration# 5.1 : Investment cost

Consideration# 5.2 : MA cost

Approaches/Product	Cost -> Investment cost or (MA cost)
X.25	X.25 is cheap for investment cost about $3,000 per edge switch (Cisco 2610) and one time charge after 1 year MA is about 10% of total cost. It's about $300.
Frame Relay	Frame Relay is reasonable price same with X.25 hardware and implement cost $3,000 per edge switch (Cisco 2610)and one time charge after 1 year MA is about 10% of total cost. It's about $300.
ATM	ATM is expensive for investment cost about $7,500 per edge switch (Cisco 2610 plus ATM module) and one time charge after 1 year MA is about 10% of total cost. It's about $750.

4.2 Network Layer Quality of Service

4.2.1 IP version 4

In the global Internet, it is undeniable that the common bearer service is the TCP/IP protocol suit-therefore, IP is indeed the common denominator.(The TCP/IOP protocol suite usually is referred to simply as IP; this has become the networking vernacular use to describe IP, as well as ICMP,TCP an UDP.) This thought process has several supporting lines of reason. IPv4 has type of service(TOS) field for provision priority service.

IPv4 is the current IP employed in the industry. It is an old protocol conceived over twenty years ago .It is remarkable that it has performed so well for so long a time. But with the changing technology.IPv4 now exhibits a number of deficiencies.

First of course, is the limited IP address space .Various estimates have been made about when the 32-bit space will be exhausted.

4.2.2 IP version 6

IPv6 stipulates and address of 128 bits .It is designed to overcome the limitations of IPV4.As we mentioned earlier ,the major design philosophy behind IPV6 is to extend the IP address space and, at the same time, make the protocol simpler to use a data-specific protocol to a multiservice protocol. IPv6 provide more superior priority field for quality of service via internet .It has two field considerations 1. Priority field ,4 bits 2.Flow label field ,24 bits .IPv6 priority field can make different for quality of service 16 level.

The flow label field is also a new field in contrast to IPv4.Like the priority field .it is also designed to handle different types of traffic such .as voice ,video, or data.

4.2.3 MPLS (Multi-protocol Label Switching)

MPLS is a forwarding scheme .It evolved from Cisco's Tag Switching .In the OSI seven-

layer model, it is between Layer 2 and Layer 3.

Each MPLS packet has a header. The header contains a 20-bit label. A3-bit Class of Service field, and 1-bit label stack indicator and an 8-bit TTL field. The MPLS header is encapsulated between the link layer header and the network layer header. A MPLS capable router, termed Label Switched Router(LSR), examined only the label in forwarding the packet .The network protocol can be IP or others. This is why it is called Multi-Protocol Label Switching.

Criteria#1 Quality of Service Level

Consideration#1.1: Availability

Consideration#1.2 Level of acceptance

Approaches/Product	Quality of Service Level-> Availability or Level of acceptance
IPv4	IPv4 is wide spread for usage .It can support QoS by itself depend on TOS type of Service . TOS is 8-bits separate by 3 bit for Precedence,4 bit type of service 1 bit Unused Example by IP precedence 0-8 0= routing precedence 1=priority precedence 2=immediate precedence 3=flash precedence 4=flash override precedence 5=critical precedence 6= internetwork control precedence 7= network control precedence TOS characteristic 1000 Minimize delay 0100 Maximize throughput 0010 Maximize reliability 0001 Minimize monetary cost 0000 Normal service
IPv6	IPv6 is use for some place such backbone and during run test. There are some modify field in IPv6 from IPv4 for superior QoS

	support 1. Priority filed 4 bit 2. Flow label. IPv6 priority filed used to support different type of traffics from synchronous real time video to synchronous data 0= Uncharacterized traffic 1=Filler traffic news 2=Unattended data transfer(email) 3=Reserved 4=Bulk traffic(file transfer) 5reserved 6- Interactive traffic(telnet) 7=control traffic(OSPF,SNA) 8=High-fidelity video 9-14=Reserved 15 Low-fidelity video The flow label field is also a new filed in contrast to IPv4.Lkie the priority field ,it is also designed to handle different type of traffic such a voice ,video or data It is used to identify traffic in which multiple datagram are flowing from a specific source address to a specific destination address.
MPLS	Because of traditional software base routing is too slow .New idea to handle will occur based on label or code point switching. Each packet will be inserted with here before sending to switching fabric, Incoming port and Outgoing port will related each other like a lookup table for seeking the appropriate port out. This method will be a short cut for sending the packet and quick process for sending. but that equipment must support MPLS or Label Switching too. Cisco is Pioneer for MPLS Method Until now .There are some group for using MPLS Label=20 Bits Class of Service(COS)=3 Bits Bottom of Stack(S) 1 Bit Time to Live=8 Bits Label | Cos | S | TTL Figure 4.1 MPLS Header Multi-protocol label switching is much more than just QOS technique. It also providess network operator a way to offer

	different classes of Service, When packet enter an MPLS-aware network. They are tagged with a label ,that can contain a variety of information. MPLS-aware router ,know as .Label Switch Router LSR cam forward the packet through the network using the label instead of the traditional address field in the IP header. Different path through the network, Label Switch Path (LSP) can be configured for different label value.

Criteria#2 Performance

Consideration#2.1: Throughput

Approaches/Product	Performance-> Throughput
IPv4	IPv4 is popular at present .It will encapsulate all types of upper layer as well as decapsulate . IPv4 has a header and the data. When used for a variety type of media or machine throughput will be different in each type. In Lan will give higher throughput than wan .IPv4 can be adhere with PC , and router or host .it will consume lightly CPU process. Mostly IPv4 is traditional software-base routing. It will use router for processing. It requires much operation (marking, best match for processing. So it will be slow in that process.
IPv6	IPv6 is experiment test bed in core backbone or lab test .IPV6 has a header and the data .It will be different from IPv4 in 4 times header or data filed. Currently it mostly runs on Unix .And it is hardly finds on desktop pc .It will consume CPU process more than IPv4. IPV6 is same software base routing as IPv4.So it will be slow in that process.
MPLS	MPLS is a forwarding scheme .It evolved from Cisco's Tag Switching .In the OSI seven-layer model, it is between Layer 2 and Layer 3. Each MPLS packet has a header. The header contains a 20-bit label. A3-bit Class of Service field, and 1-bit label stack indicator and an 8-bit TTL field. The MPLS header is encapsulated between the link layer header and the network layer header. A MPLS capable router, termed Label Switched Router(LSR),

	examined only the label in forwarding the packet .The network protocol can be IP or others. This is why it is called Multi-Protocol Label Switching. It will be enhance with high speed label /tag switching because it will be label table instead of traditional software-base routing. But it requires specific machine .it must support MPLS function. And It doesn't have on PC base machine

Consideration#2 Transit Delay

Consideration#3 Response Time

Approaches/Product	Quality of Service Level-> Availability or Level of acceptance
IPv4	IPv4 is a lightly header. Delay, Response time is depending on method of usage. If we use in local area we will get low transit delay <10 ms and good response time. But If we use in wide area delay will increase varying on media type (satellite is highest delay about 600 ms lease line is about 50 ms in the same distance). IPv4 is moderate response time .Because it has the method for fragmentation, routing algorithm and timer idle.
IPv6	IPv6 is a big header and its extension header delay, response time depends on method of usage. But it will take more process if we compare between IPv4 and IPv6 .That means in the same method Lan , or wan will take more time than IPv4 caused by header size and routing processing.
MPLS	MPLS does not make a forwarding decision with each L3 data gram(routing method).That operation will remain with IPv4 ,IPv6 instead, a forwarding equivalency for the video conferencing traffic is determined and fixed-length label is negotiated(using the LDP) between neighboring router along label switch path(LSPs) from ingress to egress ,the route router A, and B Advantage of MPLS. 1. It provides faster packet classification for routing. 2. It provides ad efficient tunneling mechanism so it is the best for both transit and response time for minimization.

Criteria#3 scalability

Consideration#3.1: expansion scale in future

Consideraton#3.2: Flexible to integrate with other

Approaches/Product	Scalability-> Expansion scale in future
IPv4	IPv4 is the most popular in the world, it relies on various equipment such host pc, Unix ,Network Equipment.IPv4 is simple implementation so mostly equipment on the network both public or private has at least IPv4 for management over all. Normally layer 3 (Network Datagram) will cooperate between higher layer such RTP,RSVP etc. That will give high efficiency delivery sensitive time application.
IPv6	IPv6 is improved from IPv4 by resolution of lacking IP address. So it is good for scalability in the future both architecture and structure design. Nowadays it is used in somewhere of Internet backbone. It is on develop testing part. It can work well with higher layer, Now it hardly see those application. It has many enhance features such as security, multicasting, and flow label but is in its field.
MPLS	MPLS is a forwarding scheme .It evolved from Cisco's Tag Switching .In the OSI seven-layer model, it is between Layer 2 and Layer 3. Each MPLS packet has a header. The header contains a 20-bit label. A3-bit Class of Service field, and 1-bit label stack indicator and an 8-bit TTL field. The MPLS header is encapsulated between the link layer header and the network layer header. Which can be used to mark path and forwarding set of fixed-length values as opposed to the same number of variable-length value. It's computationally less intensive and thus take less time. MPLS label is inserted into various encapsulation type.

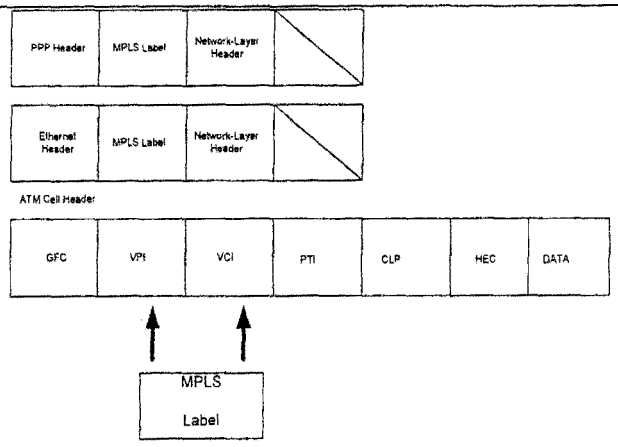


Figure 4.2 Inserting an MPLS label

Although MPLS can operate with various other technology such as Lan, Wan ATM it is specifically used in specific equipment feature. Limitation of specific usage will not expand usage of this technique.

Criteria#4 Ease of use

Consideration#4.1: Ease of Implement

Approaches/Product	Performance-> Throughput
IPv4	IPv4 is so simple for implementation including we can simplify assign a value at TOS field in the IP packet(4 bits level)
IPv6	IPv6 is rather difficult for implementation because it 's longer filed as human can recognize all of that so mostly system will be automatic by DHCP for assign. For QoS part priority field is 4 bits 16 level QoS and flow label= 24 bits .We have more difficulty to reassign and we only see IPV6 on backbone router or Laboratory.
MPLS	MPLS is moderate difficult configuration .We must assign label at router or switching for fast process beyond IP assignment. But it will increase for speed throughput and separate different class of data traffic from difference.

Criteria#4 Ease of use

Consideration#4.2: Ease for user

Consideration#4.2.1 User acceptance

Consiseration#4.2.2 Ease to be use

Approaches/Product	Ease of user->Ease for User->User acceptance or Ease to be use
IPv4	IPv4 is well known and simple for user. It's good enough for user acceptance. So it effects to QOS at IPv4 too .It is so simple for users and good for user acceptance.
IPv6	IPv6 is rather difficult for implementation for user. So it will effect to QoS at IPv6 too. Although it is not difficult so much. We can specify various style such as reality bulk application or data etc).
MPLS	Normally it will not effect with user interface. Because it hides on your IP pattern. User can't see the difference except speed user might find higher speed than the traditional.

Consideration#4.3: Ease of Administration

Approaches/Product	Ease of user->Ease of Administration
IPv4	IPv4 is simple configuration both user and administrator .It is traditional platform and used TOS 3 bit for doing 8 level of QoS.
IPv6	IPv6 is rather difficult for configuration its user priority filed 4 bit 16 level of QoS .Nowadays we hardly find this market.
MPLS	MPLS is moderate difficult for configuration. It will insert MPLS header in a frame such as ppp ,Ethernet or ATM frame before sending to destination of MPLS's router Inside of MPLS Label will consist of Label 20 bits, COS 3 bit Bottom of stack 1 bit TTL 8 bit. It gives network administrators the capability to define explicit path through an MPLS cloud base on any arbitrary criteria.

Consideration#4.4: Ease of Maintenance

Approaches/Product	Ease of user->Ease of Maintenance
IPv4	IPv4 often depend on implementation Normally it will be simplified for Maintenance.
IPv6	IPv6 is rather difficult for both configuration and MA.
MPLS	MPLS is moderate difficult both for configuration and MA.

Criteria#5: Cost

Consideration# 5.1 Investment Cost

Consideration #5.1.1 Hardware Cost

Approaches/Product	Cost->Investment Cost -> Hardware Cost
IPv4	IPv4 is a popular technique. Hardware is easy to buy .If we want to use QOS feature at IPv4 .We must pay additional cost for QoS around $ 3,000 per unit for medium router.
IPv6	IPv6 is not popular at end user .We might find in core backbone cost for QoS=$3,600 per unit for medium router.
MPLS	MPLS is used to specify task such as QoS .Normally in some proper hardware can have that feature. Cost of Hardware=$7,000 per unit for medium router.

Consideration #5.1.1 Software Cost

Approaches/Product	Cost->Investment Cost -> Software Cost
IPv4	IPv4's price is $300 per unit for medium router.

IPv6	IPv6 's price is $360 per unit for medium router.
MPLS	MPLS 's price is $700 per unit for medium router.

Consideration #5.2 Maintenance Cost

Approaches/Product	Cost->MA Cost
IPv4	Normally various vendor will calculate MA about 10% of total Cost both Hardware and Software so It is $330.
IPv6	Normally various vendor will calculate MA about 10% of total Cost both Hardware and Software so It is $393.
MPLS	Normally various vendor will calculate MA about 10% of total Cost both Hardware and Software so It is $770.

4.3 Transport Layer Quality of Service

4.3.1 InterServe of Integrated Serviced Architecture

The InterServe architecture was designed to provide a set of extensions to the best-effort traffic delivery model currently in place in the Internet.

The concept of the Integrated Service framework begins with the suggestion that the basic underlying internet architecture does not need to be modified to provide customized support for different applications.

Instead, it suggests that a set of extensions can be developed that provide service beyond the traditional best-effort service.

The Integrated Service architecture consists of five key components ; QoS requirement ,resource-sharing requirement allowance for packet dropping ,provision for

usage feedback and a resource reservation protocol (in this case RSVP)

4.3.2 Diffserv Architecture(Differentiated Service Architecture)

Diffserv provides a framework that enables service provider to offer each customer a range of service that are differentiated on the basis of performance. The customer and provider negotiate and SLA (Service Level Agreement) describing the customer's packet rate. If the customer submit traffic in excess of the SLA that traffic need not be given the service established in the SLA.

Differentiated Serviced (DS)Feature

-Service differentiated by performance and may be priced
-Service on a packet by packet basis
-Does not define a control plane
-Concerned with traffic classification and traffic conditioning
-Relies on IP header to contain a label(a Code point) to identify traffic type
-Traffic conditioning is the enforcement of rules for
Metering : measuring traffic rate
Marking :Setting /changing code point
Shaping :Controlled traffic emission
Policing :Traffic discarding
Rules are called :Traffic Conditioning agreement

Criteria#1 Quality of Service Level

Consideration#1: Availability

Approaches/Product	Quality of Service Level-> Availability
InterServ(IS)	It will use heavy weight signaling protocol .That will have more Quality of service than the other .It will guarantee delay and zero packet loss.
DiffServe(DS)	It will use premium service style .That will generate QoS by classification type of packet ,no signaling to control so QoS may be too soft than IS.

Consideration#2. Level of Acceptance

Approaches/Product	Quality of Service Level-> Level of Acceptance
InterServ(IS)	IS will give more efficiency task. IS will make higher quality work than DS.
DiffServe(DS)	DS will give a lower quality of service than IS.

Criteria#2 Performance

Consideration#1:Processing Time

Approaches/Product	Performance->Processing Time
InterServ(IS)	IS will give more signaling protocol so it will spend more time to create those signaling
DiffServe(DS)	DS will use soft technique .It considers those packet conformance or no conformance. It will spend less time to create QoS.

Consideration#2 :Throughput

Approaches/Product	Performance->Throughput
InterServ(IS)	IS will give high efficient throughput than DS .But IS will consume high resource when it works. If IS is lacked of resource it will be struggled for throughput and performance.
DiffServe(DS)	DS will consume low resource than IS. In various DS will consume low resource although it will stand on high work load.

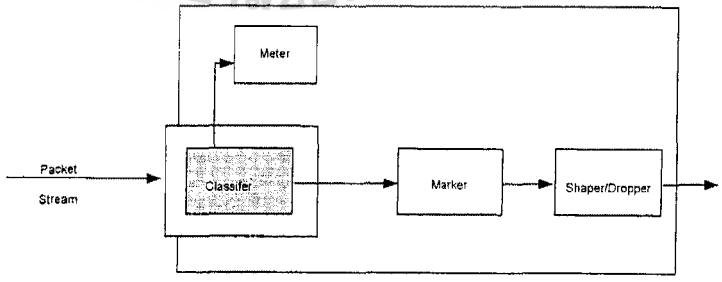
Consideration#3: Transit Delay

Approaches/Product	Performance->Throughput
InterServ(IS)	IS will give a good delay guarantee than DS .Because it will use signaling control dynamic delay guarantee.

DiffServe(DS)	DS wlll not concern about delay .Because it will let a delay value upon infrastructure .No responsibility of delay with DS

Consideration#4: Error rate

Consideration#4.1: False accept

Approaches/Product	Performance->Error rate->False accept
InterServ(IS)	IS architecture consists of 5 key components such QoS requirement, resource-sharing requirement the one for this consideration is allowance for packet dropping .One concept is that some packet switching gives a low preempt able, or subject to drop. This concept is based on situations in which the network is in danger on established service commitment .A router simply could discard traffic by acting on particular packets permeability option to avoid disrupting established commitments.
DiffServe(DS)	DS architecture consists of traffic conditioning .It 's the policing, traffic discarding. The dropping procedure, policies the packet stream into compliance with a particular traffic profile .The packet stream is stored in the shaper's buffer, and a packet maybe discarded. If there is not enough buffer space to hold a delayed packet. The dropping procedure policed the packet stream in order to bring it in to conformance with a particular traffic profile. It can drop packet to adhere to the profile. It states in TCB (Traffic conditioning Block)  Figure 4.3 The DS traffic classification and conditioning model

Consideration#4.2.Flase reject

Approaches/Product	Performance->Error rate->False reject
InterServ(IS)	IS provides false reject by provision usage feedback. It is necessary to prevent abuse of the network resource .It's signaling on IS.
DiffServe(DS)	DS don't provide False reject no feedback from network when failure occurred.

Criteria#3: Scalability

Consideration#3.1: Expansion scale in the future

Consideration#3.2: Flexible to integrate with other

Approaches/Product	Scalability->Expansion scale in the future or(Flexible to integrate with other)
InterServ(IS)	IS can work with ATM in some task such as RSVP over ATM PVC ,Multicast RSVP with ATM IS can work with Local area media If we use SBM (Subnet Bandwidth Manager) for cooperate .Currently we have new RSVP object called the TCLASS traffic Class that is used with IEEE802.1p for QoS .And RSVP can work with Constraint Base Routing.
DiffServe(DS)	DS will specify focus in DS style; it can work with a few the other technologies such as Constraint Base Routing. DS will use between the same technique more than cooperate with the other.

Criteria#4 Ease of use

Consideration#4.1 Ease of Implement

Approaches/Product	Ease of use-> Ease of Implement
InterServ(IS)	IS will has more complexity parameter configuration than DS. It provides more signaling and parameter for QoS. We must setup all of involved part core router and edge router until end node.

DiffServe(DS)	DS will be easier implement because of less parameter .It has no signaling for QoS.DS can implement at edge router without core router's configuration.

Consideration#4.2 Ease for User

Consideration#4.2.1 User Acceptance

Consideration#4.2.2 Ease to be use

Approaches/Product	Ease for User-> User Acceptance Or Ease to be use
InterServ(IS)	IS will give high complex signaling end to end .IS provide dynamic delay guarantee's IS will give high efficiency of QoS while kit has sufficient resource. In other word use will meet the high efficiency of QoS .But User might set configuration at the end node. too.
DiffServe(DS)	DS will give premium classification. DS will not guarantee delay but it will give you more than best effort service .DS will create low complexity at the end node before it will work properly.

Consideration#4.3 Ease of Administration

Approaches/Product	Ease of use-> Ease of Administration
InterServ(IS)	IS will have complexity configuration than DS.
DiffServe(DS)	DS will have less complexity configuration than IS.

Consideration#4.4 Ease of Maintenance

Approaches/Product	Ease of use-> Maintenance
InterServ(IS)	IS will be hard to maintain than DS because its complex configuration than DS.

DiffServe(DS)	DS will be easier for maintenance than IS because it is not complex configuration than IS.

Criteria#5 : Cost

Consideration#5.1 Investment Cost

Approaches/Product	Cost-> Investment Cost
InterServ(IS)	IS's hardware for edge router is around$ 3,600for medium router. IS's Software for edge router is around $ 3,600for medium router.
DiffServe(DS)	DS's hardware for edge router is around $3,600 for medium router. DS's Software for edge router is around $3,600for medium router.

Consideration#5.2 Maintenance Cost

Approaches/Product	Cost-> MA Cost
InterServ(IS)	MA for edge router is around $ 360 for medium router.
DiffServe(DS)	MA for edge router is around $360 for medium router.

4.4 Queuing Technique Quality of Service

4.4.1 FIFO (First In. First Out)queuing is considered to be the standard method for store-and forward handling of traffic from and incoming interface to outgoing interface. For the sake of this discussion however ,you can consider anything more elaborate than FIFO queuing to be exotic or "abnormal". This is not to say that no-FIFO queuing mechanisms are inappropriate-quite the contrary. No-FIFFO queuing techniques certainly have their merit and usefulness. It is not an issue of knowing what their limitation are. when they should be considered, and perhaps more important, understanding when should be avoided.

As Figure 4.4 shows as, packet enter the input interface queue, they are placed into the appropriate output interface queue in the order in which they are received-thus the name first in ,first out.

FIFO queuing usually is considered default behavior ,and many router vendors have highly optimized forwarding performances that make this standard behavior as fast as possible .In fact when coupled with topology-driven forwarding cache population, this particular combination of technologies quite possibly could be considered the fastest of technology implementation available today as far as packets-per-second forwarding is concerned. This is because ,over time developer have learned how to optimize the software to take advantage of simple queuing technologies .when more elaborate queuing strategies are implemented instead of FIFO, there is a strong possibility that there may very well be some negative impact on forwarding performance and an increase(sometimes dramatically) on the computational overhead of the system. This depends ,of course, on the queuing discipline and the quality of the vendor

implementation.

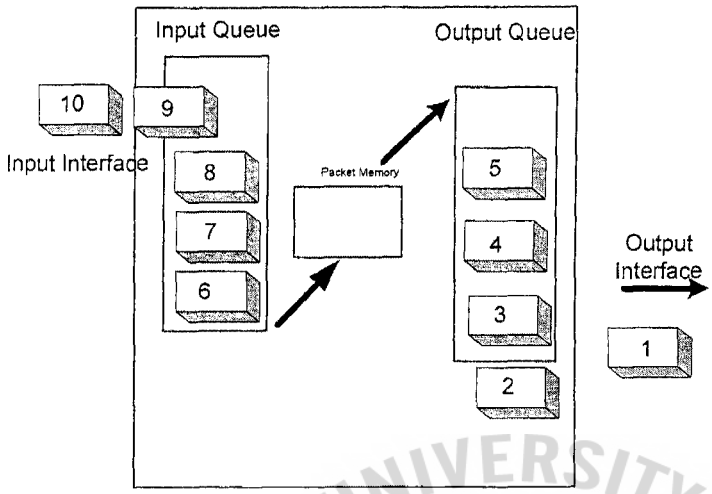


Figure 4.4 FIFO Queuing

4.4.2 Priority Queuing

One of the first queuing variation to be widely implemented was priority queuing .This is based on the concept that certain types of traffic can be identified and shuffled to the front of the output queue so that some traffic always is transmitted ahead of other types of traffic. Priority queuing certainly could be considered a primitive form of traffic differentiation, but this approach is less than optimal for certain reasons. Priority queuing may have an adverse effect on forwarding performance because of packet reordering (non-FIFO queuing) in the output queue. Also, because the router's processor may have to look at each packet in detail to determine how the packet must queue, priority queuing also may have and adverse impact on processor load. On slower links, a router has more time to closely examine and manipulate packets. However, as link speeds increase, the impact on the performance of the router becomes more noticeable.

As shown in Figure 4.5 below this, as packet are received on the input interface. They are reordered based on a user-defined criterion as to the order in which to place certain

packets in the output queue. In this example, high-priority packets are placed in the output queue before normal packets, which are held in packet memory until no further high-priority packets are awaiting transmission.

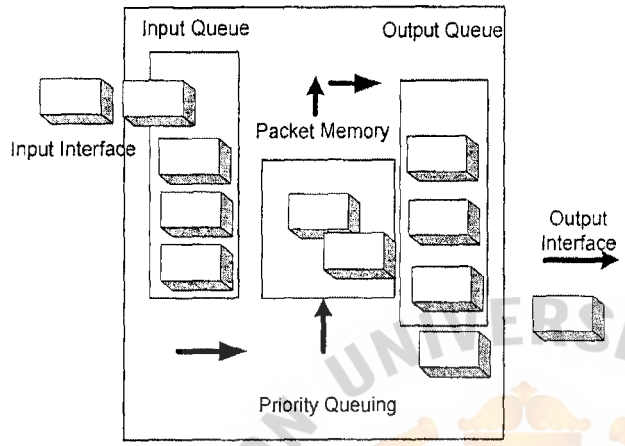


Figure 4.5 Priority Queuing

4.4.3 Custom Queuing (Class-Based Queuing)

Another queuing mechanism introduced a couple of year ago is called custom queuing. Again, this is a well-known mechanism used within operation system design intended to prevent complete resource denial to any particular class of service. CBQ is a variation of priority queuing, and several output queues can be defined. You also can define the preference by which each of the queues will be serviced and the amount of queued traffic, measured in bytes ,that should be drained form each queue on each pass in the servicing rotation. This servicing algorithm is an attempt to provide some semblance of fairness by prioritizing queuing services for certain types of traffic, while not allowing any one class of traffic to monopolize system resource and bandwidth.

The configuration in Figure 4.6 ,for example. has created three buffers: high, medium, an low .The router could be configured to service 200 bytes from the high-priority 150 bytes from the medium-priority queue, and then 1000 bytes form the low-

priority queue on each rotation. After traffic in each queue is processed ,packets continue to be serviced until the byte count exceeds the configured threshold or the current queue is empty. In this fashion. traffic that has been categorized and classified to be queued in to the various queues have a reasonable chance of being transmitted without inducing noticeable amounts of latency and allowing the system to avoid buffer starvation. Custom Queuing also was designed with the concept that certain classes of traffic ,or applications ,may need minimal queuing latency to function properly; Custom queue provides the mechanisms to configure how much traffic can be drained off each queue in a servicing rotation ,providing a method to ensure that a specific class does not sit in the outbound queue for too long. Of course, an administrator may have to fumble around with the various queue parameters to gauge whether the desired behavior is achieved. The implementation may be somewhat hit and miss.

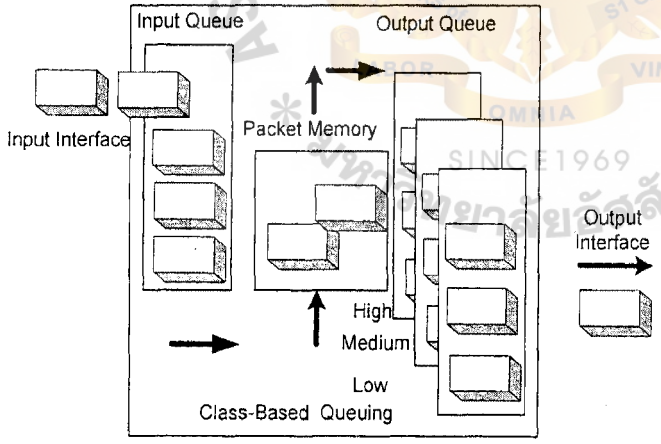


Figure 4.6 Custom Queuing

4.4.4 Weighted Fair Queuing

Weighted Fair Queuing(WFQ) is yet another poplar method of fancy queuing that

algorithmically attempts to deliver predictable behavior and to ensure that traffic flows do not encounter buffer starvation figure 4.7 gives low-volume traffic flows preferential treatment and allows higher-volume traffic flows to obtain equity in the remaining amount of queuing capacity. WFQ uses a servicing algorithm that attempts to provide predictable response times and negate inconsistent packet—transmission timing. WFQ does this by sorting and interleaving individual packets by flow and queuing each flow based on the volume of traffic in each flow. Using this approach. The WFQ algorithm prevents larger flows(those with greater byte quantify) from consuming network resource(bandwidth),which could subsequently starve smaller flows .This is the fairness aspect of WFQ-ensuring that larger traffic flows do not arbitrarily starve smaller flows.

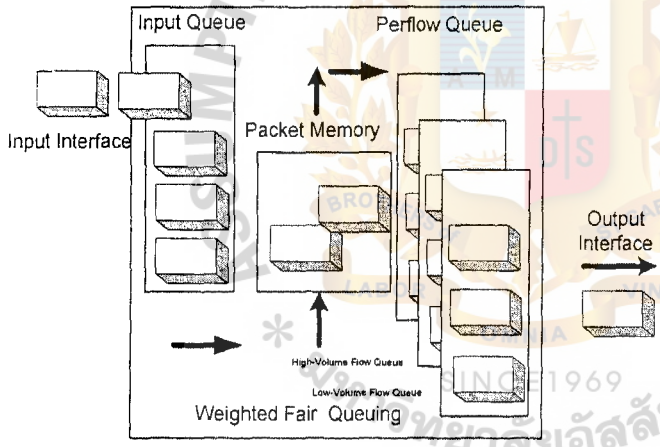


Figure 4.7 Weight Fair Queuing

4.4.5 Class Based weighted Fair queuing (CBWFQ)

Class based weighted fair queuing(CBWFQ) is a recent enhancement to the WFQ algorithm that includes user-defined traffic classes .Traffic classes can be defined based on protocol, port, access control, input queues, or DiffServ bits, Each traffic class gets its own queue. Traffic classes can have bandwidth and queue limits assigned to them. The

bandwidth is provided to the class during congestion. The queue limit is the maximum number of packets that are allowed in a class-based queue. If the queue fills up ,then packets are dropped.

CBWFQ may be used with a feature called low latency queuing(LLQ).LLQ offers delay sensitive data, like VoIP ,priority handling over other types of traffic. With LLQ ,VoIP traffic goes its own queue and as packets are queued to the LLQ ,the are dequeued and processed ahead of any other queues.

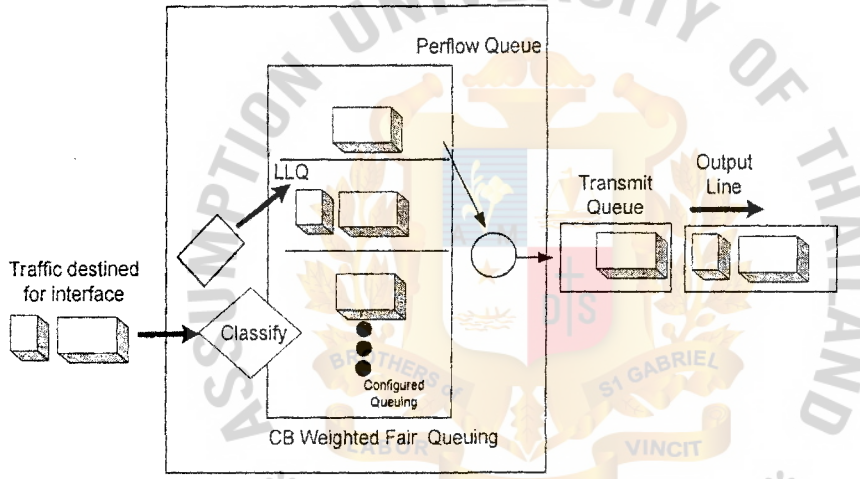


Figure 4.4 Class Based Weight Fair Queuing

Criteria#1 Quality of Service Level

Consideration#1.1: Availability

Consideration#1.2 Level of acceptance

Approaches/Product	Quality of Service Level-> Availability or Level of acceptance
FIFO	FIFO is implanted for default behavior regardless of QoS .If users need QoS FIFO will not be appropriate to do this function.
Priority Queue	PQ is implemented for advance servicing. Highest priority will be served first .It is good for some task, but it will generate proper

	problem starvation of low priority application because it uses single queue for doing Ossify it has no free queue low priority will be starvated when high priority application will be continuously coming .
Custom Queuing	CQ was born to resolve problem low priority starvation .It will have more queue space(No single Queue type).But the output queue of it use round robin fashion. It will be appropriate with same task not all task for quality of service.
Weighted Fair Queue	WFQ possess some of the same characteristic as priority queue and custom queuing .WFQ is a commonly used ,flow –base queuing algorithm .The Different traffic flow are queued to prevent bandwidth starvation-that is the fair port .A flow is composed of all packet with the same source address port and destination address port combination .A weight is assigned to flow . Those flow's priority queuing according to some scheme usually anther QoS mechanism. Different queue level are provided for the weighted flow .Slower data traffic stream. like VoIP are given priority over larger bandwidth consumers such a file transfer .Weighted Fair queue may use IP precedence or Diffserv bits to determine the weight of a particular flow. If all weights are equal. then available bandwidth is divided equally. It simply does not scale to provide the desired performance in some circumstance, primarily because of the computational over head and forwarding impact that packet reordering and queue management impose on networks with significantly large volumes of data and very high speed link. However if these method of queuing PQ,CBQ and WFQ could be moved complete into silicon instead of being done in software ,the impact on forewarning performance could be reduced greatly. The degree of reduction in computational overhead remains to be seen ,but if computational processing were not also implemented on the inter face card on a per interface basis ,the computational impact on central processor probably still would be significant.
Classed Base Weighted Fair queue	CBQ is a an enhancement to the "WFQ algorithm that includes user defined traffic classes .It gives the user the most control over queue parameter .The user has the option to guarantee a specified bandwidth. If the user bandwidth is over subscribed on multiple queue then WFQ algorithm is used to service the queue. The queue weighted normal and max burst threshold are also

	configurable .In addition the use has the option to drop traffic if the bandwidth guarantee is over subscribed. As an example ,consider a video stream that needs half the band width of T1 link .as additional flow are added , the video stream gets less of bandwidth of the fair nature of the EFQ algorithm Hence to provide the bandwidth the video needs CBWFQ can define a class specifying the desired bandwidth for the video stream. Video is not given the bandwidth that it needs.

Criteria#2 Performance

Consideration#2.1: Throughput

Consideration#2.2 Transit delay

Approaches/Product	Performance-> Throughput or Transit Delay
FIFO	When a network operates in a mode with a sufficient level of transmission capacity an adequate level of switching capability ,queuing is necessary only to ensure that short-term ,highly transient traffic bursts do not cause packet discard. In such an environment. FIFO queuing is highly efficient because ,as long as the queue depth remains sufficiently short, the average packet-queuing delay is an significant fraction of the end-to-end packet transmission time . When the load on the network increases, the transients burst cause significant queuing delay, and when the queue is fully populated , all subsequent packets are discard. When the network operate in this mode for extended periods, the offered service-level inevitably degenerates. Different queuing strategies can alter this service-level degradation, allowing some services to continue top operate without perceptible degradation while imposing more server degradation on other services .This is the fundamental principle of using queue management as the mechanism to provide QoS arbitrate differentiated services.
Priority Queue	Several levels of priority are possible, such as high ,medium, low and so on each of which designated the order of precedence in output queuing. Also the granularity in identifying to be classified into each queue is quite flexible. For example ,IPX could be queued before IP ,IP before SNA and SNA before AppleTalk. Also ,specific services within a protocol family can be classified in this manner; TCP traffic can be prioritized ahead of UDP

	traffic ,Telnet can be prioritized ahead of FTP, or IPX type-4 SAP{'s could be prioritized ahead of type 7 SAP's .Although the level of granularity is fairly robust, the more differentiation attempted ,the more impact on computational overhead and packet-forwarding performance. Another possible vulnerability in this queuing approach is that if the volume of high priority ,normal traffic waiting to be queued may be dropped because of buffer starvation- a situation that can occur for any number of reasons. Buffer starvation usually occurs because of overflow caused by too many packets waiting to be queued and not enough room in the queue to accommodate them. Another consideration is an extended period. It sometimes is hard to calculate how non-FIFO queuing may inject additional latency into the end-to-end round-trip time. In a worst-case scenario, some applications may not function correctly because of added latency or perhaps because some more time-sensitive routing protocols may time-out due to acknowledgements not being received within a predetermined period of time.
Custom Queuing	The CQ approach generally is perceived as a method of allocation dedicated portions of bandwidth to specific type of traffic .but in reality, CQ provides a more graceful mechanism of preemption ,in which the absolute model of service to the priority queue and resource starvation to other queues in the priority-queuing model are replaced to a more equitable model an increase level of resource allocation to the higher-precedence queues and a relative decrease to the lower precedence queues. The fundamental assumption here is that resource denial is for worse than resource reduction .Resource denial not only denies data byte also denies any form of signaling regarding the denial state. Resource reduction is perceived as a more effective form of resource allocation, because the resource level is reduced for low-precedence traffic and the end-system still can receive the signal of the changing state of the network and adapt theirs transmission rates accordingly. CQ also can be considered a primitive method of differentiating traffic into various classes of service ,and for several years ,it has been considered a reasonable method of implementing a technology that provides link sharing for Classes of Service(COS) and an efficient method for queue-resource management .However, CQ simply does not scale to provide the desired performance in some circumstances. primarily because of the computational overhead and forwarding impact packet reordering an intensive queue management imposes in networks with very high-speed links. Therefore ,although CQ does provide

	the basic mechanisms to provide differentiate COS ,it is appropriate only at lower-speed links which limits its usefulness.
Weighted Fair Queue	WFQ possess some of the same characteristic as priority queue and custom queuing. It simply does not scale to provide the desired performance in some circumstance, primarily because of the computational over head and forwarding impact that packet reordering and queue management impose on networks with significantly large volumes of data and very high speed link. However if these method of queuing PQ,CBQ and WFQ could be moved completely into silicon instead of being done in software ,the impact on forewarning performance could be reduced greatly. The degree of reduction in computational overhead remains to be seen ,but if computational processing were not also implemented on the inter face card on a per interface basis, the computational impact on central processor probably still would be significant. Another drawback of WFQ is in the granularity or lack or granularity –in the control of the mechanisms that WFQ uses to favor some traffic flow over others .Bu default .WFQ protects low-volume traffic flows from larger ones in an effort to provide equity for all data flows. The weighting aspect is attractive form an unfairness perspective; however ,no knobs are available to tune these parameters to alter the behavior of injecting a higher degree of unfairness into the queuing scheme-a t least not form the router configuration perspective .Of course ,you could assume that if the IP precedence values in each packet were set but corresponding hosts .for example, they would be treated accordingly, You could assume that higher-precedence packets could be treated with more priority. lesser precedence with lesser priority, and no precedence treated fairly in the scope of the traditional WFQ queue servicing .The method of preferring some slows over others is statically defined in the vendor specific implementation of the WFQ algorithm. And the degree of control over this mechanism may leave something to be desired.
Classed Base Weighted Fair queue	CBQ will give the user the most control over queue parameter. Users has the option to guarantee a specified bandwidth .If the user bandwidth is oversubscribed on multiple queuing the threshold are also configurable. In additional the users have the option to drop traffic ,if the bandwidth guarantee is oversubscribed. Throughput of CBWFQ will be better than WFQ in a few. But Transit Delay will be increased by additional overhead parameter.

Consideration#2.3 Processing Time

Approaches/Product	Performance-> Processing Time
FIFO	FIFO will give a straight forward algorithm. It consumes a lowest CPU time an processing time.
Priority Queue	PQ will consume moderate CPU time and processing time. Because it has to categorize of application according to user's requirements
Custom Queuing	CQ will consume moderate CPU time and processing time. Because it has to categorize of application according to users 's requirement .
Weighted Fair Queue	WFQ will consume a high CPU time and processing time. Because it will control each traffic flow.
Classed Base Weighted Fair queue	CBWFQ will consume a highest CPU time and processing time. Because it will control each traffic flow besides this it must control policy at user's side too.

Criteria#3 Scalability
Consideration#3.1 Flexible to integrate with other

Approaches/Product	Scalability->Flexible to integrate with other
FIFO	FIFO is lack of integrate with other technology. Because it's traditional from buffer and queuing.
Priority Queue	PQ is a little cooperate with some technique some vendor it can work with IP, or other protocol.
Custom Queuing	CQ is a little cooperate with some technique some vendor it can work with IP, or other protocol.

Weighted Fair Queue	WFQ is extensive scalability. It can work with IP precedence ,DifServ,RSVP and WRED.
Classed Base Weighted Fair queue	CBWFQ is extensive scalability. It can work with IP precedence ,DifServ,RSVP and WRED. Besides this with CBWFQ you can define group or classes of traffic and the control the QoS for each queuing and bandwidth allocation.

Criteria#4 Ease of Use
Consideration#4.1 Ease of implement

Approaches/Product	Ease of Use->Ease of implement
FIFO	FIFO is default and no additional configuration.
Priority Queue	PQ is a little additional configuration.
Custom Queuing	CQ is more additional configuration than PQ. Because it has more queue buffer than PQ.
Weighted Fair Queue	WFQ is complicate configuration than the other .We have to know the method and parameter more than the other.
Classed Base Weighted Fair queue	CBWFQ is most complicated because we have to concern both like WFQ' configuration and group of user view points.

Criteria#4 Ease of Use
Consideration#4.2. Ease for User
Consideration#4.2.1 User acceptance

Approaches/Product	Ease of Use->Ease for User->User acceptance
FIFO	FIFO will be normal if there is sufficient queue resource in case low users access. But not good enough for sensitive application.
Priority Queue	PQ will be normal if there is sufficient queue resource in case low users access. But not good enough in case of low priority application will be starvation .

Custom Queuing	CQ will be normal if there is sufficient bandwidth in case of low volume ,low priority of user access. But it 's not appropriate at high speed link. Because of the computational overhead and forwarding impact packet reordering and intensive queue management.
Weighted Fair Queue	WFQ will work will both any circumstance both high priority and low priority application .Because of predefined method in the weight for each application. But sometime it will take more processing time and delay for forwarding too.
Classed Base Weighted Fair queue	CBWFQ will work well in any circumstance like with WFQ .But user can cooperate with this as user can specify rule for themselves to classify each group for user queue.

Consideration#4.2. Ease for User

Consideration#4.2.2 Ease to be use

Approaches/Product	Ease of Use->Ease to be use
FIFO	FIFO is easiest to be used.
Priority Queue	PQ is easy to be used.
Custom Queuing	CQ is moderate to be used.
Weighted Fair Queue	WFQ is moderate to be used.
Classed Base Weighted Fair queue	CBWFQ is rather difficult to be used .Users have to involve for define policy rule more than normal method.

Consideration#4.3 Ease for Administration

Consideration#4.4 Ease of Maintenance

Approaches/Product	Ease of Use->Ease for Administration(Ease of Maintenance)
FIFO	FIFO can work without administration.
Priority Queue	PQ is simple for administration.
Custom Queuing	CQ is a little complicated for administration.
Weighted Fair Queue	WFQ is more complicated for administration.
Classed Base Weighted Fair queue	CBWFQ is most complicated for administration

Criteria #5 Cost

Consideration#5.1 Investment Cost

Consideration#5.1.1 Hardware Cost

Consideration#5.1.2 Software Cost

Approaches/Product	Ease of Use->Hardware Cost(or Software Cost)
FIFO	Hardware cost =$2,900 per medium router Software cost =$100 per medium router
Priority Queue	Hardware cost =$2,900 per medium router Software cost =$100 per medium router
Custom Queuing	Hardware cost =$2,900 per medium router Software cost =$100 per medium router
Weighted Fair Queue	Hardware cost =$2,900 per medium router

	Software cost =$1,000 per medium router
Classed Base Weighted Fair queue	Hardware cost =$2,900 per medium router Software cost =$1,000 per medium router.

Consideration#5.2 Maintenance Cost

Approaches/Product	Ease of Use->Hardware Cost(or Software Cost)
FIFO	MA cost =$300 per medium router
Priority Queue	MA cost =$300 per medium router
Custom Queuing	MA cost =$300 per medium router
Weighted Fair Queue	MA cost =$360 per medium router
Classed Base Weighted Fair queue	MA cost =$360 per medium router

4.5 Traffic Shaping Quality of Service

4.5.1 Packeteer Packetshaper classifies traffic from layers 2 to 7 of the OSI layer. Besides being able to identify all the above listed applications ,Packeteer can also analyses application content such as VoIP encoding type -8/14.4/28.8/64k speeds, Streaming media type Video/Audio, Oracle database names HTTP virtual host names and TN3270/TN5250 print traffic- jest to name a few.

Packeteer automatically classifies over 160 different types of applications, and new applications are released every quarter.

Packeteer supports this classification on all its products. And thus this solution can be

deployed across the entire enterprise. This solutions scales from 0-100 Mbps , and can classify at any speed or on any link.

4.5.2 Sitara Networks QoSWORKS is a dedicated QoS appliance with a platform that has been architected for extensibility and flexibility. In addition ,it is based on open hardware and software standards QoSWORKS is deployed behind the router and in front of the branch office Land an requires no changes to the existing router configurations. QoSWORKS is architected specifically to provide highly automated ,complete QoS solution at the edge of the network. QoSWORKS is architected specifically to provide a highly automated ,complete QoS solution at the edge of the network. This complete solution includes :Wire-speed classification, Policy setting ,Traffic management ,Web caching and GUI-based real-time monitoring and reporting.

4.5.4 FloodGate-1 Check Point Software Technologies

It will solve the network congestion problem, a policy-base QoS management solution. FloodGate-1 optimizes network performance by assigning priority to business-critical traffic . For example ERP ,database ,or e-commerce applications are easily prioritized over less time-critical email traffic.

Product Feature

-Flexible QoS polices with eights limits and guarantees
-VPN/firewall/QoS integrated on a single device
-Enterprise Policy Management Server
-Integrated DiffServ support

Product Benefits

-Optimize network performance for VPN and unencrypted traffic
-Eliminates requirement to deploy separate VPN,firewall, and QoS device
-Simply management by removing need to reconfirm each enforcement points.
-Provides end to end QoS support for IP networks.

Criteria#1 Quality of Service Level

Consideration#1.1: Availability

Consideration#1.2 Level of acceptance

Approaches/Product	Quality of Service Level-> Availability or Level of acceptance
Packeteer	Packeteer has many functions for QoS such as classification feature. Differentiation based on application ,protocol, subnet ,user IP precedence DiffServ ,ISL ,Vlan 802.1p/q MPLS tag,port,IP or MAC addresses. URL,Oracle database ,published Citix application. web browser ,mime type. QoSPolicy Features. Bandwidth settings: Min guaranteed; Max allowed, Bandwidth settings can apply to individual applications, users, groups, VLANs ,or combinations. Diffserv and 802.1p/q packet-marking for signaling QoS in network core,TCP Rate Control,UDP Rate Control Admissions rate Control, Burst priority and Dynamic Subscriber Bandwidth Provisioning(DSBP)
Sitara	Sitara Network provide wire-speed classification .It will automatically classify IP an non-IP traffic in real time. It 's intuitive Policy Management . It relies on AccuRate Traffic Management Technology. By this Class-based queuing ,TCP rate Shaping, Packet-size optimization and Algorithm for fair bandwidth allocating by connection . It can cooperate with Policy-Smart Web Caching. It is flexible Industry-Standard Open Platforms It will deploy end to end option. It supports for QoS in the Network Core in form TOS(IP Precedence)bit. And It will fail-Safe Operation (Automatic bypass switch)
Flood-Gate	Product Feature -Flexible QoS polices with eights limits and guarantees -VPN/firewall/QoS integrated on a single device -Enterprise Policy Management Server -Integrated DiffServ support Product Benefits -Optimize network performance for VPN and unencrypted traffic -Eliminates requirement to deploy separate VPN,firewall, and QoS device

	-Simply management by removing need to reconfirm each enforcement points. -Provides end to end QoS support for IP networks.

Criteria #2 Performance

Consideration#2.1 Throughput

Approaches/Product	Performance-> Throughput
Packeteer	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Packet Shaper has bandwidth 193 Kbps at Loss rate =0.5%
Sitara	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Sitara has bandwidth 196 Kbps at Loss rate =0.5%
Flood-Gate	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Flood-Gate has bandwidth 190 Kbps at Loss rate =0.5%

Consideration#2.1 Latency

Approaches/Product	Performance-> Latency
Packeteer	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 20, Fig 10b. Packet Shaper has 250 ms.
Sitara	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42]

	Test ,From Numerical results page 20, Fig 10b. Sitara has 100 ms.
Flood-Gate	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 20, Fig 10b. Flood-Gate has 1,700 ms.

Consideration#2.3 Error Rate

Consideration#2.3.1 False Accept

Consideration#2.3.2 False Reject

Standard for Error it should be less or equal to 10%.

Approaches/Product	Performance-> Error Rate-> False Accepted(or) False Reject
Packeteer	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Packet Shaper has bandwidth 193 Kbps at Loss rate =0.5%
Sitara	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Sitara has bandwidth 196 Kbps at Loss rate =0.5%
Flood-Gate	From literature "Survey an Performance evaluation of Bandwidth Enforcement Techniques over Edge Device [42] Test ,From Numerical results page 18, Fig 6. Flood-Gate has bandwidth 190 Kbps at Loss rate =0.5%

Criteria#3 Scalability

Consideration#3.1 Expansion scale in the future

Approaches/Product	Scalability-> Expansion scale in the future
Packeteer	Packeteer has many models for solution(ISP Model) Such= 4500/ISP Control Cap 45 Mbps Such= 6500/ISP Control Cap 100 Mbps Such= 8500/ISP Control Cap 200 Mbps
Sitara	Sitara has many model for solution QA-100 Control Cap 10 Mbps QA-1450 Control Cap T3/E3 Mbps QA-1000 Control Cap 100Mbps QA-2000 Control Cap 155Mbps
Flood-Gate	Only one Model (Software base) 100Mbps.

Consideration#3.2 Flexible to integrate with other

Approaches/Product	Scalability-> Flexible to integrate with other
Packeteer	Packeteer is very flexible when it does integrate with the other such DiffServ ,MPLS,HPopenveiw,Spectrum,LDAP ,XML PolicyXpert ,Micromuse NET COOL,InfoVista,Concord eHealth or Third party
Sitara	Sitara has limited flexibility when it does integrate with other such Policy-smart web Caching ,redirect and Class base queuing. Support external report by OSS ,CSV and other
Flood-Gate	Open platform ,it can run on Window-NT,2000 Server an XP Solaris 7,8 Red Hat Linux 6.2 and 7.0

Criteria#4 Ease of use

Consideration#4.1 Ease of Implement

Approaches/Product	Ease of Use-> Ease of Implement
Packeteer	Packeteer is difficult tree structure that scares potential and existing customers.
Sitara	Sitara has a hard to use GUI. To define policy the following steps must be taken to initiate policy definition. Define link Define class groups Define classes Define filters.
Flood-Gate	Flood-Gate is easy configuration. Because it uses GUI base and object intuitive view. Because of software base technology the hardware and operating system can easily to provide and install.

Consideration#4.2 Ease for User

Approaches/Product	Ease of Use-> Ease for User
Packeteer	Packeteer has done policy via TCP base rate control and it has be a great amount of application discrimination more than 500 list of predefined applications. .It can show deep packet analysis in stateful form.
Sitara	Sitara has done policy via TCP rate shaping and it has be application discrimination more than 25 list of predefined application
Flood-Gate	Flood-Gate is easy configuration. Because it uses GUI base and object intuitive view, it can be done via the Check Point Management console.

Consideration#4.3 Ease to be Use

Approaches/Product	Ease of Use-> Ease to be Use
Packeteer	Packeteer has monitoring features by spread sheet look to interface .It has good Top User report. But it is hard to configure QoS policy. Packeteer has difficult tree structure that scares potential and existing customer.
Sitara	Sitara has monitoring features by GUI .Sitara Monitor need refresh no dynamic.Sitara has a hard to use GUI to define policy.
Flood-Gate	Flood-Gate is easy configuration. Because it uses GUI base and object intuitive view. Flood-Gate has integrated real-time monitoring to view the impact of a QoS policy.

Consideration#4.3 Ease of Administration

Consideration#4.4 Ease of Maintenance

Approaches/Product	Ease of Use-> Ease of Administration or(Maintenance)
Packeteer	Packeteer is difficult tree structure that scares potential and existing customers.
Sitara	Sitara has a hard to use GUI to define policy the following steps must be taken to initiate policy definition. Define link Define class groups Define classes Define filters.
Flood-Gate	Flood-Gate is easy configuration, because it use GUI base and object intuitive view. Because of software base technology, it is independence from hardware. Administrators can upgrade hard ware or interface of the Flood-Gate by easily.

Criteria #5 Cost

Consideration#5.1 Investment Cost

Approaches/Product	Cost-> Investment Cost
Packeteer	One time Cost $ 33,000 Model PS-6500.
Sitara	One time Cost $ 29,000 Model QOS 10,000
Flood-Gate	One time Cost $ 26,250

Consideration#5.2 Maintenance Cost

Approaches/Product	Cost-> MA Cost
Packeteer	One year Cost $ 3,300 .
Sitara	One year Cost $ 2,900 .
Flood-Gate	One year Cost $ 2,650

CHAPTER 5

CASE STUDIES

The model was applied to two organizations. One is Sita (Thailand) and another is SCS Computer Systems(Thailand) Co., Ltd. By using the example set of Quality of Service Technique in the Chapter 4

Analysis process

Step 1. Analysis score of each Approach

Step 2. Comparison with Cost-Benefit analysis

Step 3. Selection each approach

Step 4. Comparison Selection with the Expert's result.

Step 5. Discussion and Conclusion

5.1 Sita (Thailand) Case studies

5.11 Detail and Background

Sita is a large organization around the world .This is non-profit organization, and it has core business by airline information provider for Airline Network. There are many service availability such X.25, Frame Relay and lease-line.

The judge who dedicated his time in my case study and filled in the value diagram is Assistant Engineer Manager of Sita's IT staff . He has graduated in Computer Engineering. His responsibility is monitoring the Sita's network and managing engineer teams. This committee starts with the beginning of framework process searching, evaluation criteria and consideration until the final value diagram.

The author explained to him the detail of every single technique in the Chapter 4 and let him fill in the questionnaires.

The summarized results are shown in the table below.

5.3.1 Detail after use weight to the questionnaire

Policy for Sita(Thailand)

1.	Cost	= Very Important	Level of Importance 5
2.	Performance	= Somewhat Important	Level of Importance 4
3.	Quality of Service	= Average Important	Level of Importance 3
4.	Scalability	= Somewhat Unimportant	Level of Importance 2
5.	Ease of Use	= Very Unimportant	Level of Importance 1

Cost-Benefit will be used in this case for elaborated decision.

In this case Benefit is summation of (quality of service score+ performance score +scalability score+ease of use score) will be shown in dollars unit.

Questionnnaire#1 Data link Layer QoS

	X.25	Frame Relay	ATM
Score	0.57	0.76	0.78
Benefit	0.35	0.54	0.64
Cost	$3,300	$3,300	$8,250
(Benefit/Cost)Ratio	$1.06*10^{-4}$	$1.64*10^{-4}$	$7.75*10^{-5}$

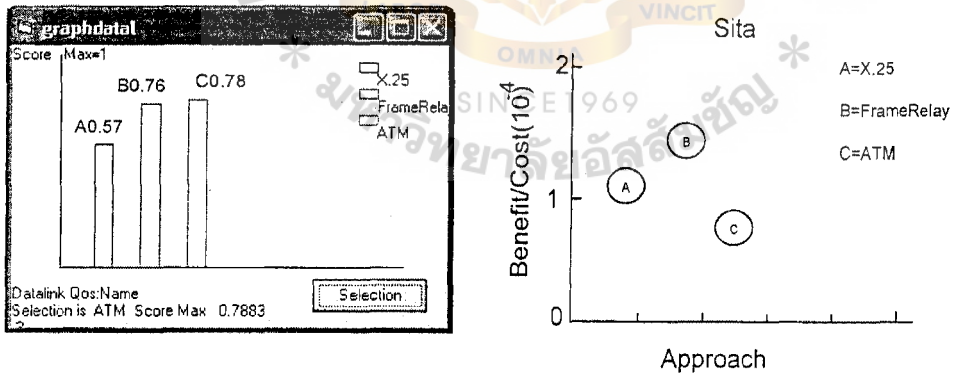


Figure 5.1 Result of Data link Layer Qos Score and Cost-Benefit analysis

Questionnnaire#2 Network Layer QoS

	IPv4	IPv6	MPLS
Score	0.72	0.78	0.78
Benefit	0.44	0.55	0.64
Cost	$3,300	$3,900	$7,700
(Benefit/Cost)Ratio	$1.33*10^{-4}$	$1.41*10^{-4}$	$8.31*10^{-5}$

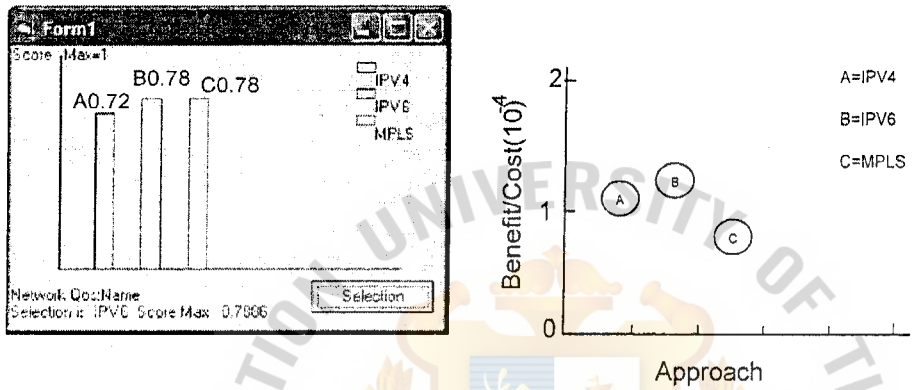


Figure 5.2 Result of Network Layer QoS and Cost-Benefit analysis

Questionnnaire#3Transport Layer QoS

	InterServ	DiffServ
Score	0.71	0.54
Benefit	0.49	0.43
Cost	$3,960	$3,960
(Benefit/Cost)Ratio	$1.24*10^{-4}$	$1.08*10^{-4}$

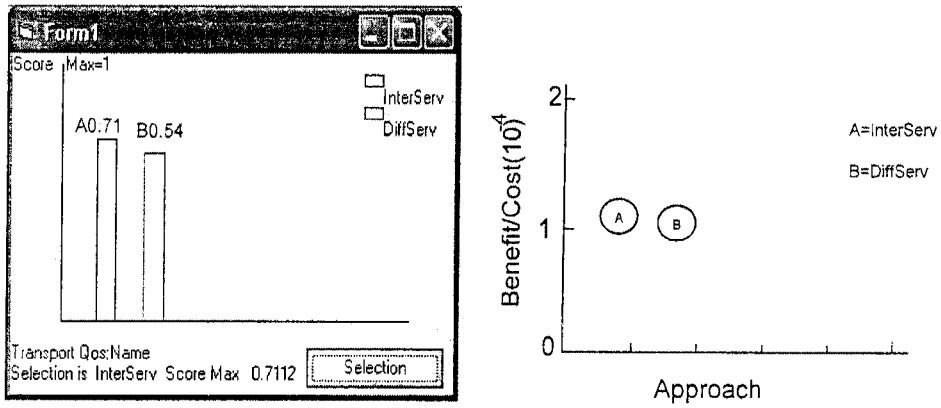


Figure 5.3 Result of Transport Layer QoS and Cost-Benefit analysis

Questionnnaire#4 Queuing Techinque QoS

	FIFO	PQ	CQ	WFQ	CBWFQ
Score	0.67	0.60	0.69	0.75	0.82
Benefit	0.45	0.38	0.47	0.53	0.6
Cost	$3,300	$3,300	$3,300	$3,300	$3,300
(Benefit/Cost)Ratio	$1.36*10^{-4}$	$1.15*10^{-4}$	$1.42*10^{-5}$	$1.60*10^{-4}$	$1.81*10^{-4}$

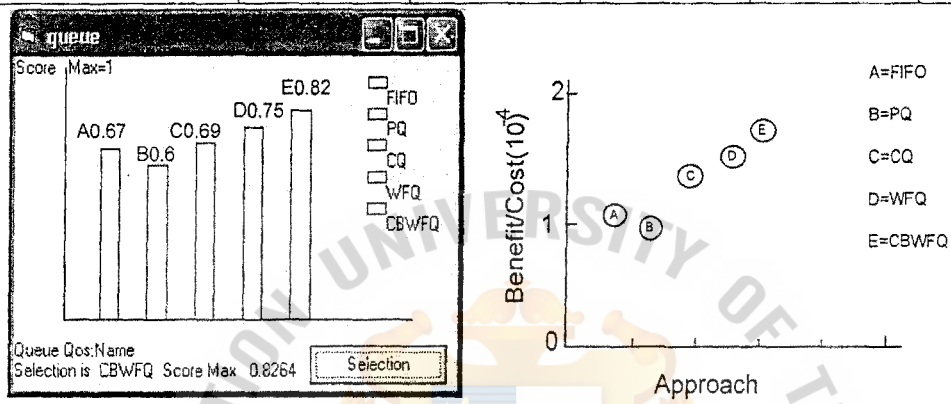


Figure 5.4 Result of Queuing Techinque QoS and Cost-Benefit analysis

Questionnnaire#5 Traffic Shaping QoS

	Packeteer	Sitara	FloodGate
Score	0.64	0.67	0.61
Benefit	0.49	0.48	0.39
Cost	36,300	31,900	26,500
(Benefit/Cost)Ratio	$1.34*10^{-5}$	$1.50*10^{-5}$	$1.47*10^{-5}$

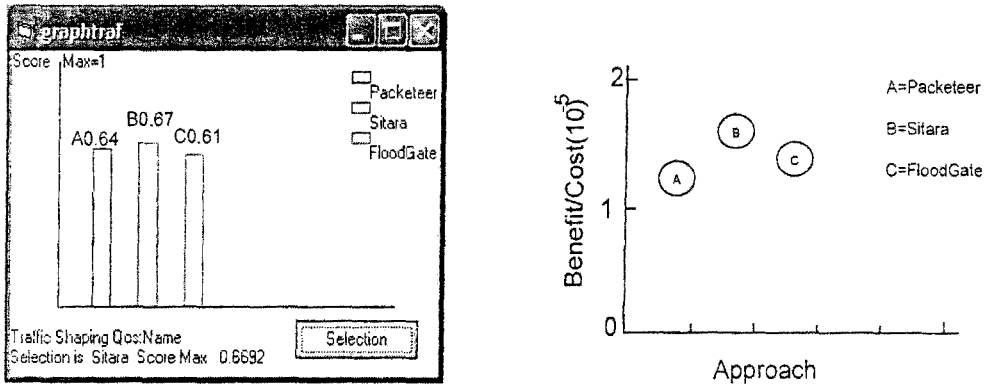


Figure 5.5 Result of Traffic Shaping QoS and Cost-Benefit analysis

5.3.2 Analysis of the result

The overall score is rather reasonable. We should select each approach by the highest score, but there are some interesting properly problematic points.

Problem at Datalink Layer : Even though the score of ATM is highest , we should select this approach.

But Sita's policy cost is the most criteria so cost benefit will be used in this case.

So Frame Relay was chosen instead of ATM because of the benefit difference between ATM and Frame Relay as less relevant than the cost difference. Significant considered from benefit/cost ratio.

Problem at Network Layer: Equally score level, the reason might be unclear in difference between each approach. It will effect with this score.

But Sita's policy cost is the most criteria so cost benefit will be used in this case.

So IPV6 was chosen by that reason. Significant considered from benefit/cost ratio.

But if we use cost benefit to help we will select approach by table 5.1 by below

No	Category	Selection
1	Datalink Layer QoS	FrameRelay
2	Network Layer QoS	IPV6
3	Transport Layer QoS	InterServ
4	Queuing Technique	CBWFQ
5	Traffic Shaping Approach	Sitara

Table 5.1 Selection with Cost-Benefit

5.4 SCS Computer Systems(Thailand) Case studies

Detail and Background

SCS provide solution for customer in various industries include Network ,Data communication an QoS is part of that system.

In this case we only adopt final value diagram for fill-in not start from beginning point. The judge who involved in this case study is consulting team of SCS. She has graduated in Electrical Engineering .

Policy for SCS (Thailand)

1. Scalability = Very Important Level of Important 5
2. Quality of Service = Somewhat Important Level of Important 4
3. Performance = Average Important Level of Important 3
4. Cost = Somewhat Unimportant Level of Important 2
5. Ease of Use = Very Unimportant Level of Important 1

Questionnnaire#1 Data link Layer QoS

	X.25	Frame Relay	ATM
Score	058	0.82	0.87
Benefit	0.50	0.68	0.81
Cost	$3,300	$3,300	$8,250
(Benefit/Cost)Ratio	$1.51*10^{-4}$	$2.06*10^{-4}$	$9.81*10^{-5}$

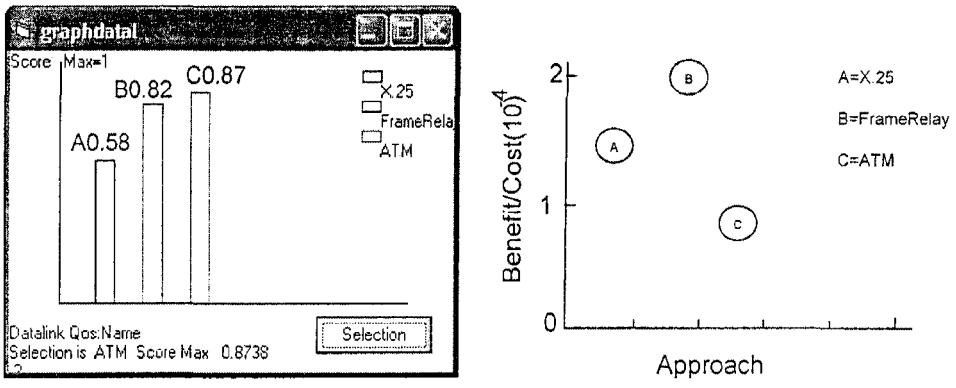


Figure 5.6 Result of Data link Layer Qos Score and Cost-Benefit analysis

Questionnnaire#2 Network Layer QoS

	IPv4	IPv6	MPLS
Score	0.63	0.74	0.8
Benefit	0.54	0.66	0.76
Cost	$3,300	$3,900	$7,700
(Benefit/Cost)Ratio	$1.63*10^{-4}$	$1.69*10^{-4}$	$9.8*10^{-5}$

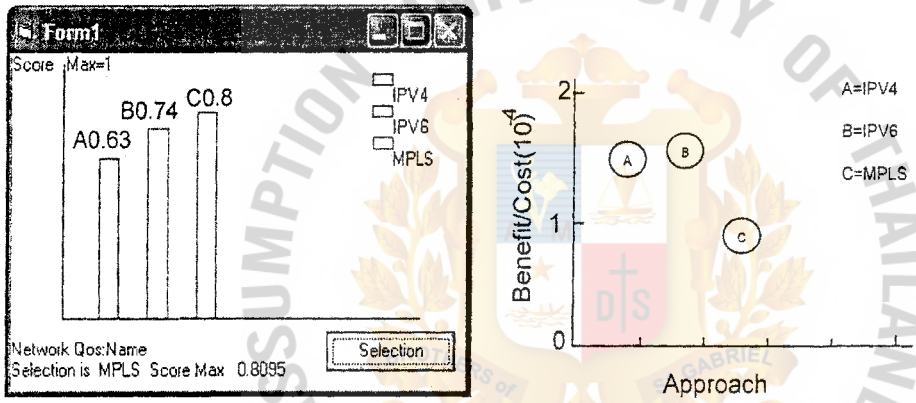


Figure 5.7 Result of Network Layer QoS and Cost-Benefit analysis

Questionnnaire#3Transport Layer QoS

	InterServ	DiffServ
Score	0.58	0.66
Benefit	0.49	0.56
Cost	$3,960	$3,960
(Benefit/Cost)Ratio	$1.23*10^{-4}$	$1.69*10^{-4}$

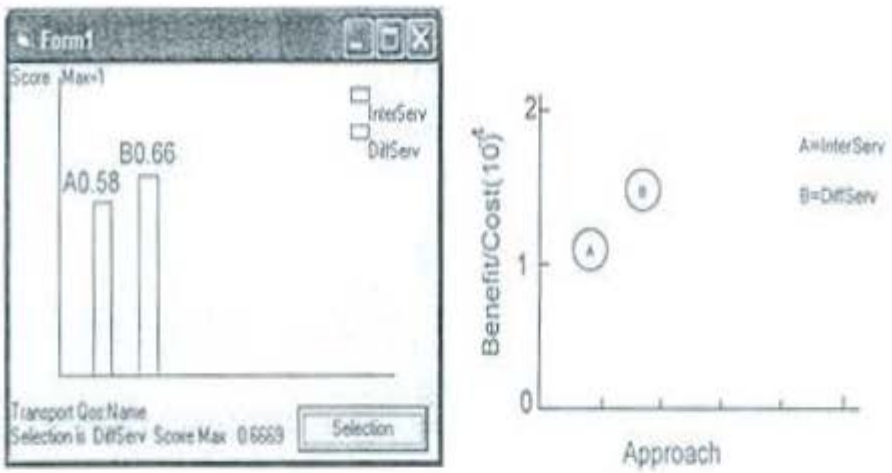


Figure 5.8 Result of Transport Layer QoS and Cost-Benefit analysis

Questionnnaire#4 Queuing Techinque QoS

	FIFO	PQ	CQ	WFQ	CBWFQ
Score	0.60	0.54	0.69	0.78	0.93
Benefit	0.50	0.44	0.59	0.68	0.82
Cost	$3,300	$3,300	$3,300	$3,300	$3,300
(Benefit/Cost)Ratio	$1.51*10^{-4}$	$1.33*10^{-4}$	$1.78*10^{-4}$	$2.06*10^{-4}$	$2.48*10^{-4}$

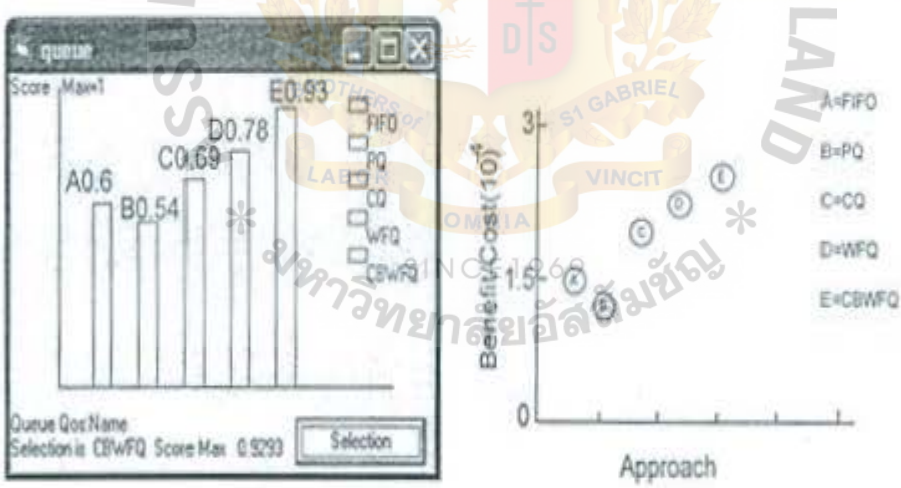


Figure 5.9 Result of Queuing Techinque QoS and Cost-Benefit analysis

Questionnnaire#5 Traffic Shaping QoS

	Packeteer	Sitara	FloodGate
Score	0.61	0.65	0.56
Benefit	0.52	0.55	0.43
Cost	36,300	31,900	26,500
(Benefit/Cost)Ratio	$1.43*10^{-5}$	$1.72*10^{-5}$	$1.62*10^{-5}$

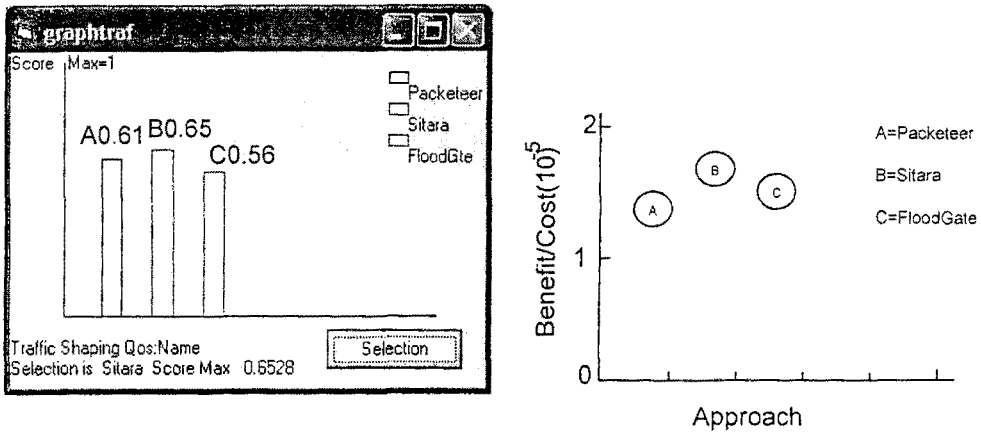


Figure 5.10 Result of Traffic Shaping QoS and Cost-Benefit analysis

5.4. Analysis of the result

The overall score is rather reasonable. We should select each approach by the highest score, but there are some interesting proper points.

SCS'policy scalability is the most criteria so cost benefit might not be used in this case.

Selection of each Category depends on the highest score.

No	Category	Selection
1	Datalink Layer QoS	ATM
2	Network Layer QoS	MPLS
3	Transport Layer QoS	DiffServ
4	Queuing Technique	CBWFQ
5	Traffic Shaping Approach	Sitara

Table 5.2 Selection without Cost-Benefit

But If we use cost benefit to help we will select approach by table 5.3 by below.

No	Category	Selection
1	Datalink Layer QoS	FrameRelay
2	Network Layer QoS	IPV6
3	Transport Layer QoS	DiffServ
4	Queuing Technique	CBWFQ
5	Traffic Shaping Approach	Sitara

Table 5.3 Selection with Cost-Benefit

Comparison Selection with the Expert's result.

Without baseline measurement the users might be reluctant for using this model.

In this case the author has to create baseline for standard measurement .The author will collect the information from two experts one is Cisco Certify Internetworking Engineer(CCIE) and 3Com Certify Network Expert, but they will use the same table 4.1-4.5 for reference

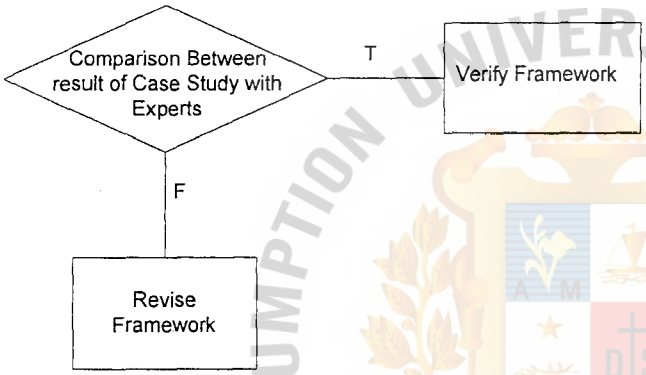


Figure 5.1 Revised Framework

Case study of SITA (Thailand) Company

No	Category	Selection from this Frame work	Selection from Expert1	Selection from Expert2
1	Datalink Layer QoS	FrameRelay	ATM	ATM
2	Network Layer QoS	IPV6	MPLS	MPLS
3	Transport Layer QoS	InterServ	SAME	SAME
4	Queuing Technique	CBWFQ	SAME	SAME
5	Traffic Shaping Approach	Sitara	SAME	SAME

Table 5.4 Comparison table of SITA

Analyst: There are some interesting properly different points at Data Link Layer QoS and Network Layer QoS. After the author has investigated with Expert1 and Expert2.From their opinions, they give me a value aspect .Both of experts consider accordingly by the performance for the best criteria. They use their own experience and their principle in this field. But in our experiment that we mention earlier, we found the appropriate decision by using multi-criteria decision and cost-benefit factor to solve that problem. In this case study of SITA, the most significant factor is cost not performance so the results are different in a point of view.

Case study of SCS (Thailand) Company

No	Category	Selection from this Frame work	Selection from Expert1	Selection from Expert2
1	Datalink Layer QoS	ATM	SAME	SAME
2	Network Layer QoS	MPLS	SAME	SAME
3	Transport Layer QoS	DiffServ	InterServ	InterServ
4	Queuing Technique	CBWFQ	SAME	SAME
5	Traffic Shaping Approach	Sitara	SAME	SAME

Table 5.5 Comparison table of SCS (Thailand)

Analyst: There are some interesting properly different points at Transport Layer QoS. After the author has investigated with Expert1 and Expert2.From their opinions, they give me a value aspect .Both of experts considers accordingly by the performance for the best criteria. They use their own experience and their principle in this field.

But in our experiment that we mention earlier, we found the appropriate decision by using multi-criteria decision (not use cost-benefit factor) to solve that problem. In this case study of SCS, the most significant factor is scalability not performance so the result is different in a point of view.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In the past Quality of Service Techniques for organization were chosen without any standard baseline. Any organization had to spent a lot of time and human resource for selection of the available technique. Each step has to use the expertise user. Although the users have a good technique guy the users have to decide the key person for jointing this event too.

Currently although the best method for resolving the multi-criteria problem, whereas technology is coming so fast. Therefore a searching for the optimal solution can be more difficult .Thus ,the major contribution of this thesis is to provide a general framework for the selection of appropriate Quality of Service Technique for an organization.

Decision making persons need not be a Quality of Service expert, but they should be any one who understands an organization's operation and objectives.

By conducting, the principle and utility function [36] are reasonable for resolving multi-criteria problem. That process becomes transparent and controllable.

This decision will meet accordingly by that purpose more than the existing principle(by only using expertise ,experience and principle of expert),because we will consider in multi-criteria for resolve the problem .And the author has consolidate case study in the previous chapter. There are some interesting proper different points, because of the different view between expert and the judge.

On the other hand there are some disadvantages:

1. The effort of judging involved is considerable.

2. The complexity of the approaches evaluated may obliterate the differences between the approaches.

3. The judge can be prejudiced in favor of the approaches and skill of the judge.

4. Fast emerging of approaches .It might be limited time to evaluate each approach otherwise the information will be obsolete.

6.2 Recommendations for Further Work.

The improvement of the present work demands further study of the following points.

Completeness of requirements, criteria and considerations: Although, the author had carefully selected all relevant Quality of Service requirements. Evaluation criteria and considerations of each criteria, it is still only an individual's preference. Even the two organization's staffs, who took part in the case studies, have stated that these sets cover mostly aspects, but that this still does not imply completeness .In the future ,some requirements ,criteria on considerations may be discovered and added to the framework . Include if there are changing of criteria or consideration how is effected with those decisions.

The advocate of group of decisions: This framework will be applied to use consensus-base decisions in the future. For more complex system or approach, one judge might not cover for whole completeness. If there are many judges, the result will have more reasonable decisions.

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APPENDIX A

TABLE MAPPING WEIGHT FOR VALUE ASSIGNED DIAGRAM

Table Mapping weight for Value Assigned Diagram #1

Criteria	Consideration 1	Level Point	Weight	Consideration 2	Level Point	Weight
Quality of Service Level	Availability	100	0.5			
	Level of acceptance	100	0.5			
Performance	Throughput	100	0.6			
	Transit Delay	42	0.25			
	Error Rate	25	0.15	False accept	100	0.8
				False reject	25	0.2
Scalability	Flexible to integrate with other	100	1			
Ease of use	Ease of Implement	33	0.15			
	Ease for user	100	0.45	User acceptance	66	0.4
	Ease of Administrator	22	0.1	Ease to be use	100	0.6
	Ease for Maintenance	67	0.3			
cost	Investment cost	100	0.7			
	MA Cost	42	0.3			

Table Mapping weight for Value Assigned Diagram #2

Criteria	Consideration 1	Level Point	Weight	Consideration 2	Level Point	Weight
Quality of Service Level	Availability	100	0.5			
	Level of acceptance	100	0.5			
Performance	Throughput	100	0.65			
	Transit Delay	31	0.2			
	Response Time	23	0.15			
Scalability	Expansion scale in the future	42	0.3			
	Flexible to integrate with other	100	0.7			

Ease of use	Ease of Implement	33	0.15			
	Ease for user	100	0.45	User acceptance	66	0.4
	Ease of Administrator	22	0.1	Ease to be use	100	0.6
	Ease for Maintenance	67	0.3			
cost	Investment cost	100	0.7	Hardware Cost	100	0.8
	MA Cost	42	0.3	Software Cost	25	0.2

Table Mapping weight for Value Assigned Diagram #3

Criteria	Consideration 1	Level Point	Weight	Consideration 2	Level Point	Weight
Quality of Service Level	Availability	100	0.5			
	Level of acceptance	100	0.5			
	Processing Time	18	0.1			
Performance	Throughput	100	0.55			
	Transit Delay	36	0.2			
	Error Rate	27	0.15	False accept	100	0.8
				False reject	25	0.2
	Expansion scale in the future	42	0.3			
Scalability	Flexible to integrate with other	100	0.7			
Ease of use	Ease of Implement	33	0.15			
	Ease for user	100	0.45	User acceptance	66	0.4
	Ease of Administrator	22	0.1	Ease to be use	100	0.6
	Ease for Maintenance	67	0.3			
cost	Investment cost	100	0.7			
	MA Cost	42	0.3			

Table Mapping weight for Value Assigned Diagram #4

Criteria	Consideration 1	Level Point	Weight	Consideration 2	Level Point	Weight
Quality of	Availability	100	0.5			

Service Level						
	Level of acceptance	100	0.5			
Performance	Throughput	100	0.65			
	Transit Delay	31	0.2			
	Response Time	23	0.15			
Scalability	Flexible to integrate with other	100	0.1			
Ease of use	Ease of Implement	33	0.15			
	Ease for user	100	0.45	User acceptance	66	0.4
	Ease of Administrator	22	0.1	Ease to be use	100	0.6
	Ease for Maintenance	67	0.3			
cost	Investment cost	100	0.7	Hardware Cost	100	0.8
	MA Cost	42	0.3	Software Cost	25	0.2

Table Mapping weight for Value Assigned Diagram #5

Criteria	Consideration 1	Level Point	Weight	Consideration 2	Level Point	Weight
Quality of Service Level	Availability	100	0.5			
	Level of acceptance	100	0.5			
Performance	Throughput	100	0.6			
	Transit Delay	42	0.25			
	Error Rate	25	0.15	False accept	100	0.8
				False reject	25	0.2
	Expansion scale in the future	42	0.3			
Scalability	Flexible to integrate with other	100	0.7			
Ease of use	Ease of Implement	33	0.15			
	Ease for user	100	0.45	User acceptance	66	0.4
	Ease of Administrator	22	0.1	Ease to be use	100	0.6
	Ease for Maintenance	67	0.3			
cost	Investment cost	100	0.7			
	MA Cost	42	0.3			

APPENDIX B

INFORMATION FROM CASE STUDIES

Value Assigned Diagram of Sita

We arrange consequently by each consideration.

1.Cost
2.Performance
3.Quality of Service
4.Scalability
5.Ease of Use

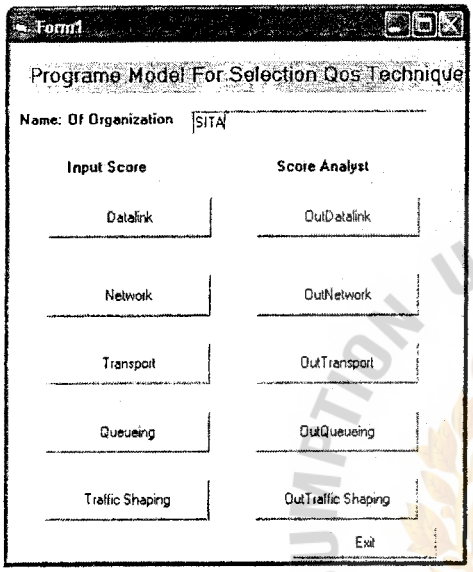


Figure 9.1 Questionnaire of Sita Company with weight

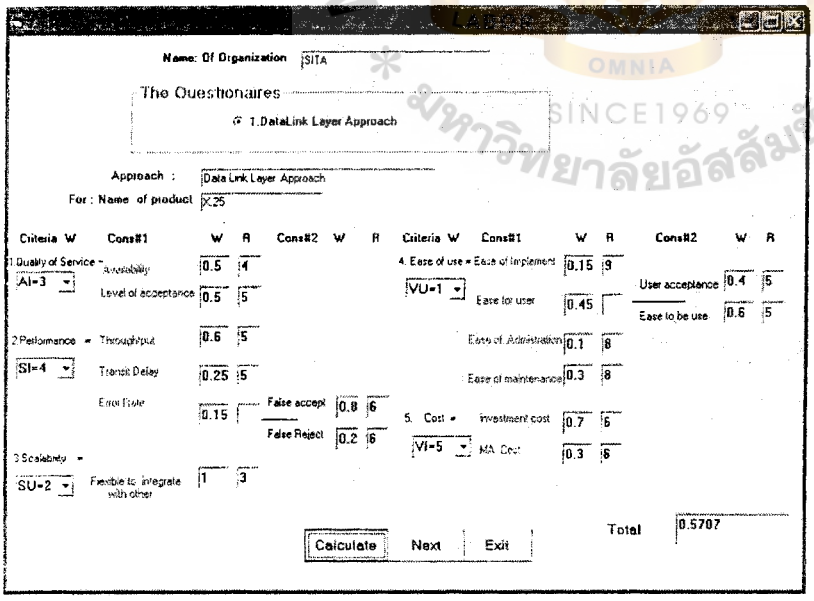


Figure 9.2 Sita's Datalink Layer QoS score for X.25

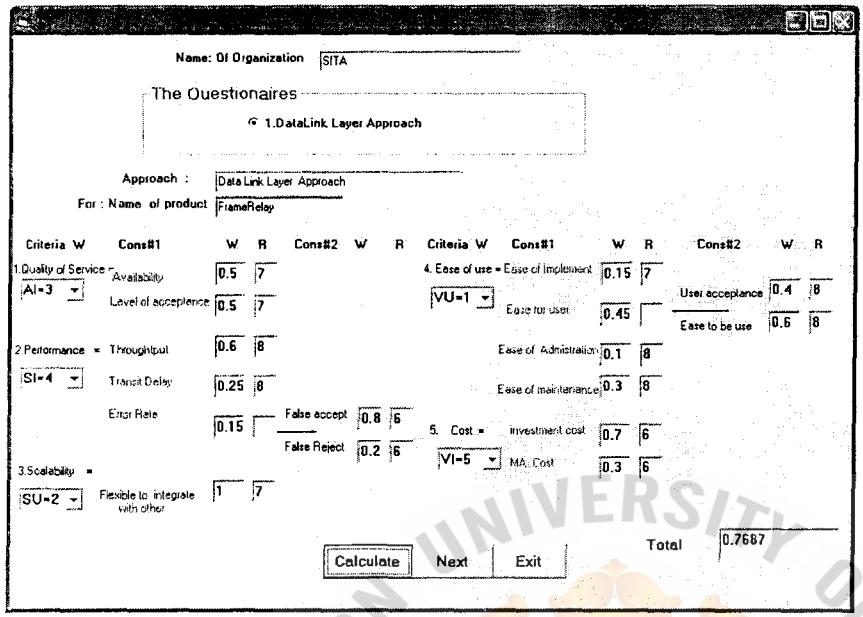


Figure 9.3 Sita's Datalink Layer QoS score for Frame Relay

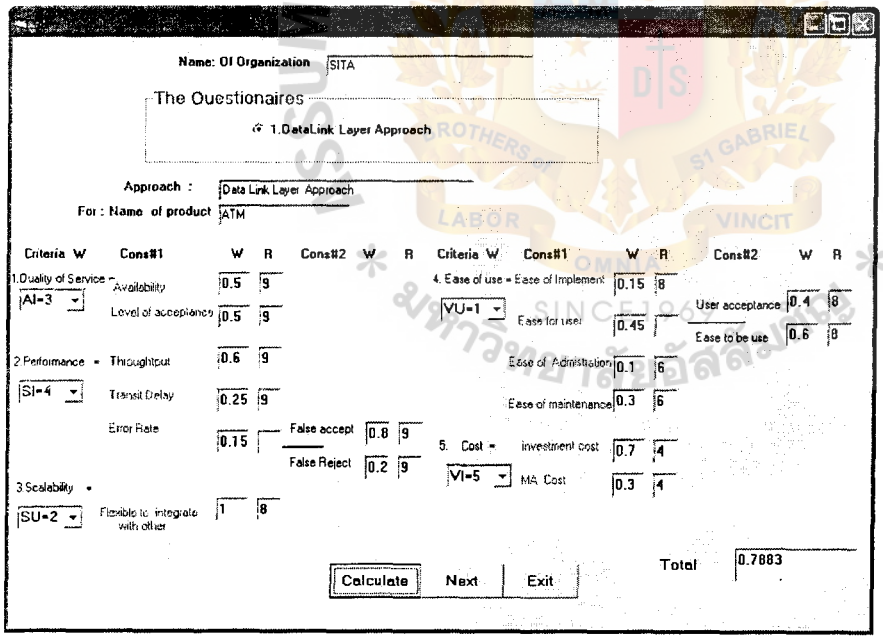


Figure 9.4 Sita's Datalink Layer QoS score for ATM

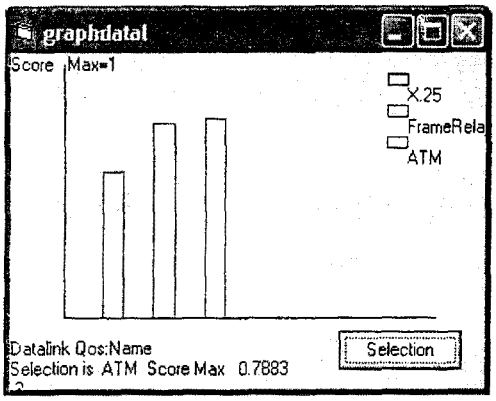


Figure 9.5 Result of selection Sita's Datalink QoS

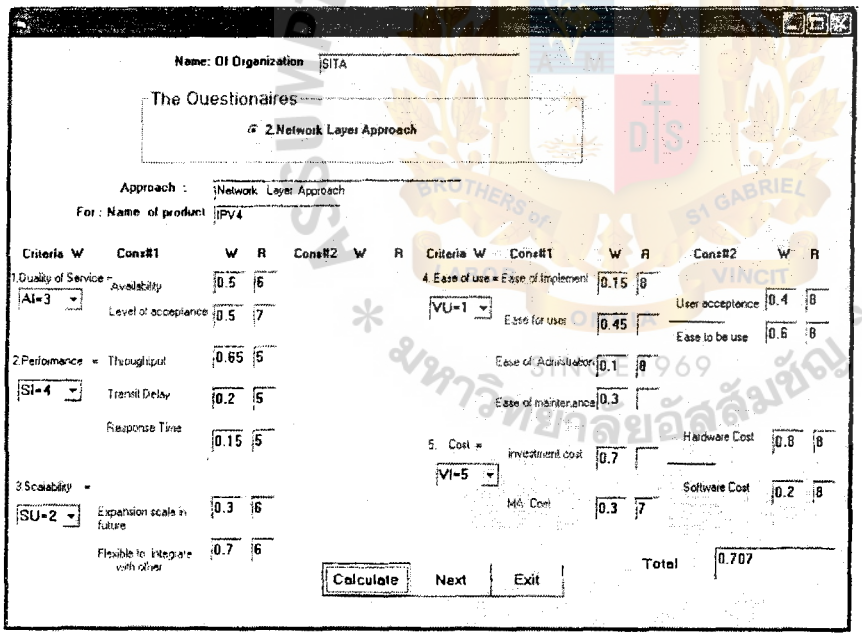


Figure 9.6 Sita's Network Layer QoS score for IPV4

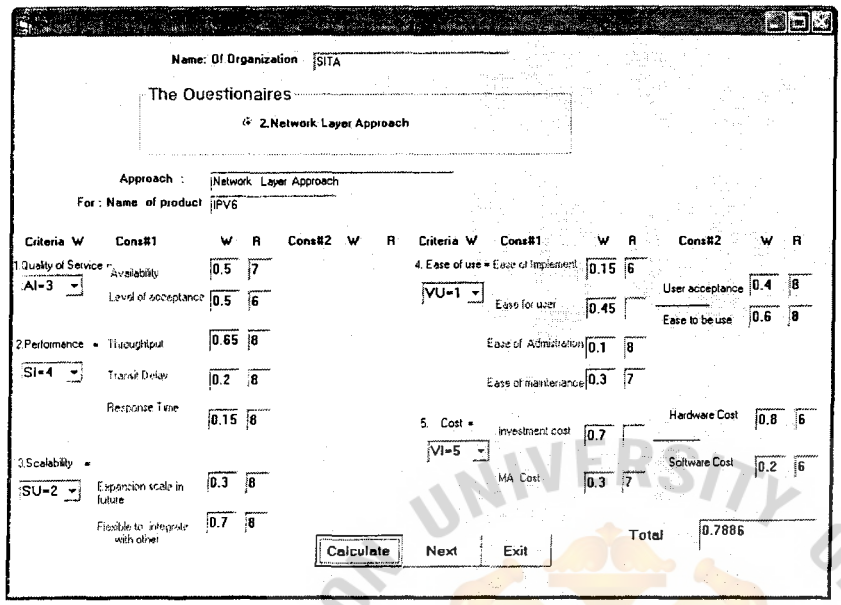


Figure 9.7 Sita's Network Layer QoS score for IPV6

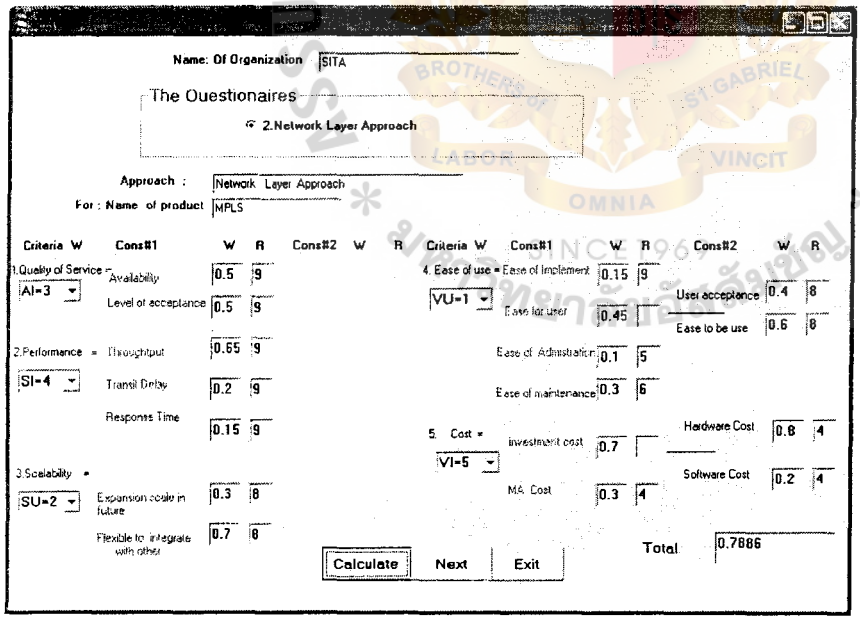


Figure 9.8 Sita's Network Layer QoS score for MPLS

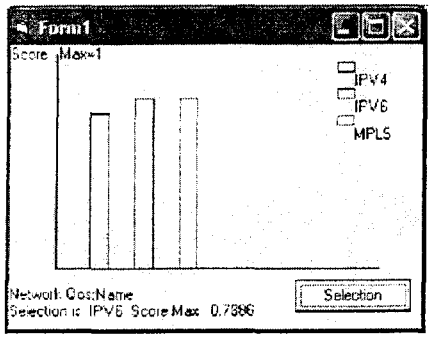


Figure 9.10 Result of selection Sita's Network Layer QoS

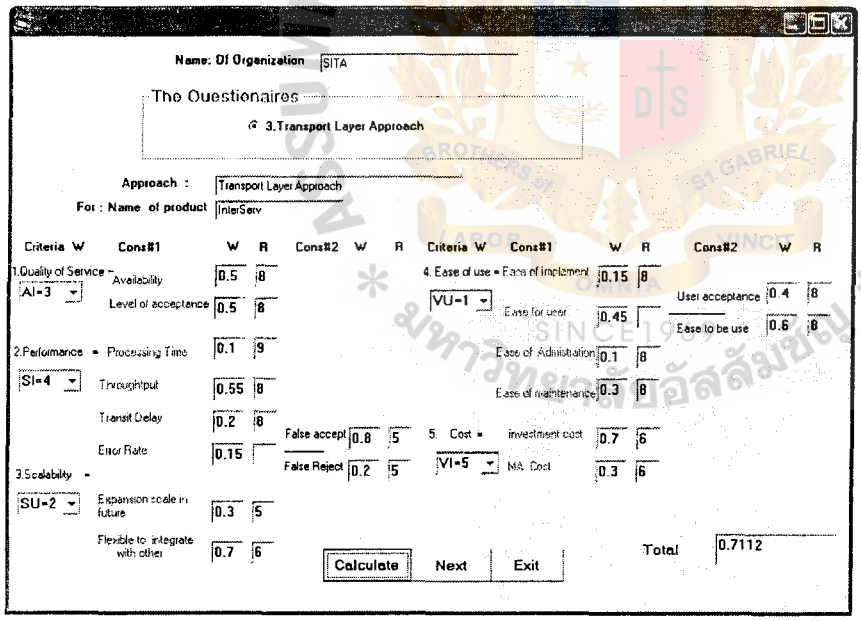


Figure 9.11 Sita's Transport Layer QoS score for InterServ

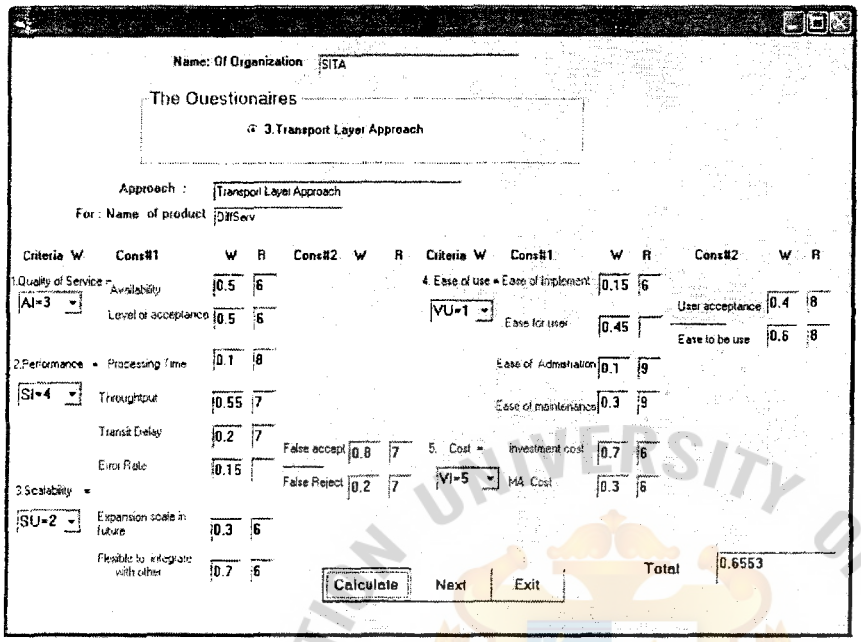


Figure 9.12 Sita's Transport Layer QoS score for DiffServ

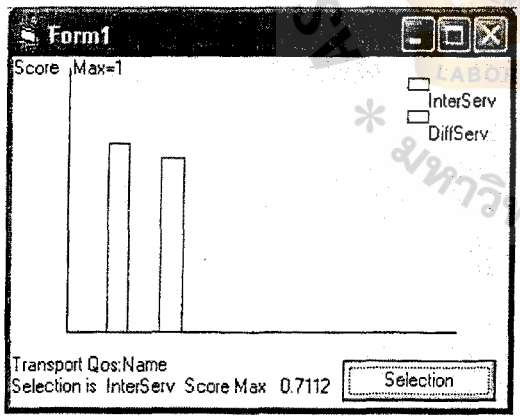


Figure 9.13 Result of selection Sita's Transport Layer QoS

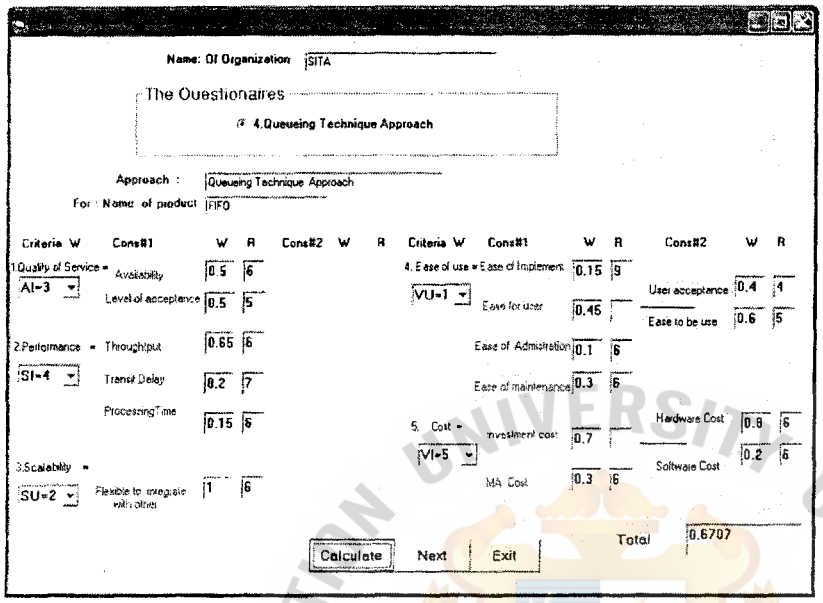


Figure 9.14 Sita's Queuing Technique QoS score for FIFO Queuing

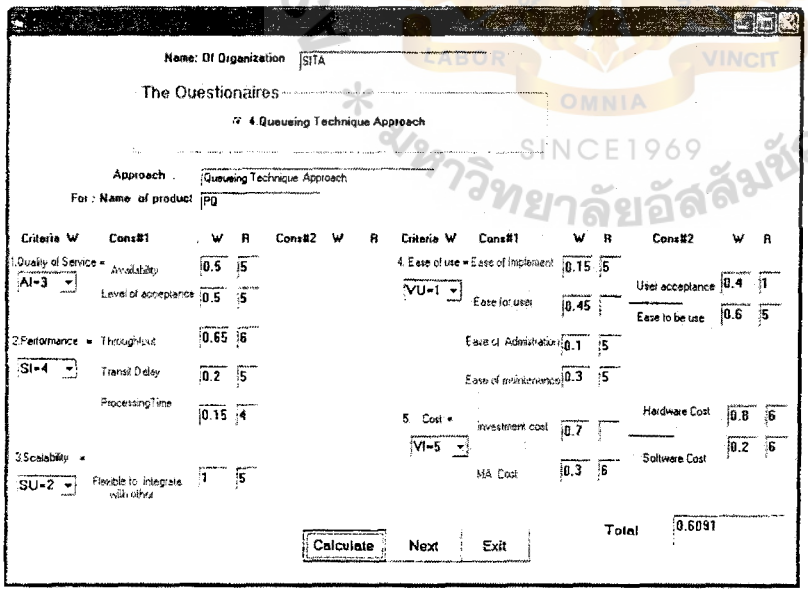


Figure 9.15 Sita's Queuing Technique QoS score for Priority Queuing

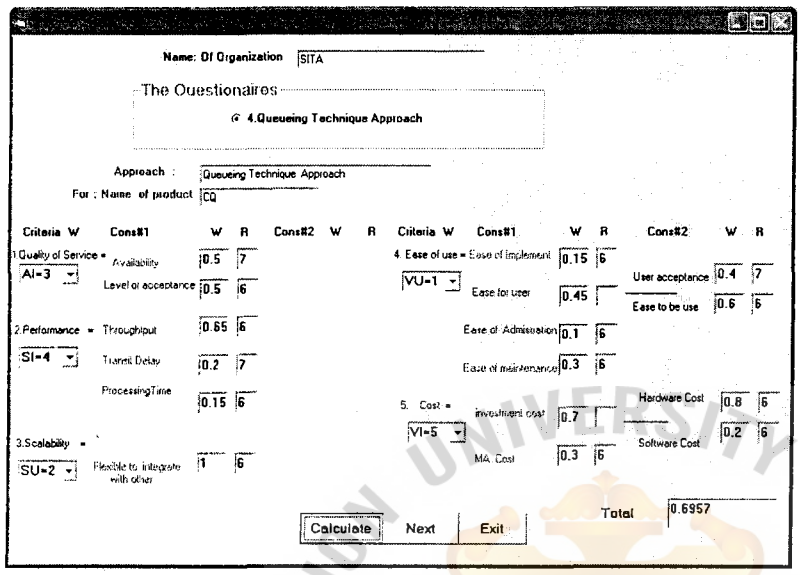


Figure 9.16 Sita's Queuing Technique QoS score for Custom Queuing

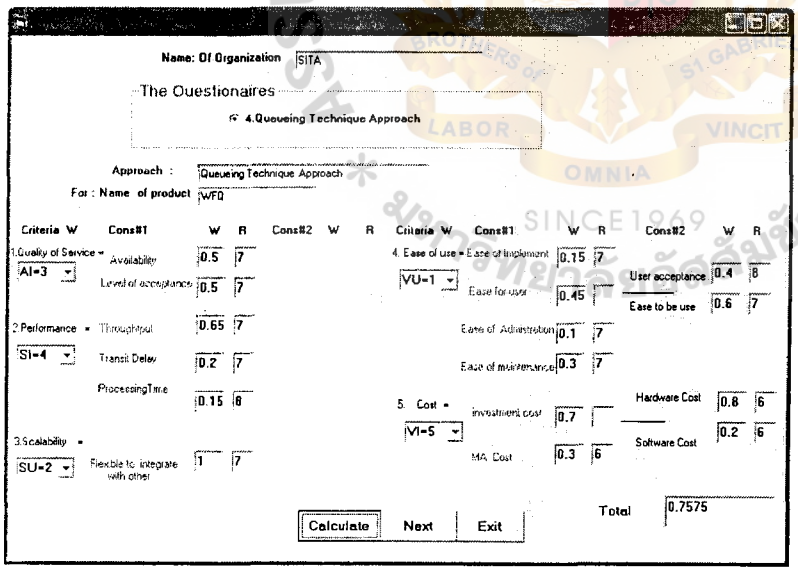


Figure 9.17 Sita's Queuing Technique QoS score for Weight Fair Queuing

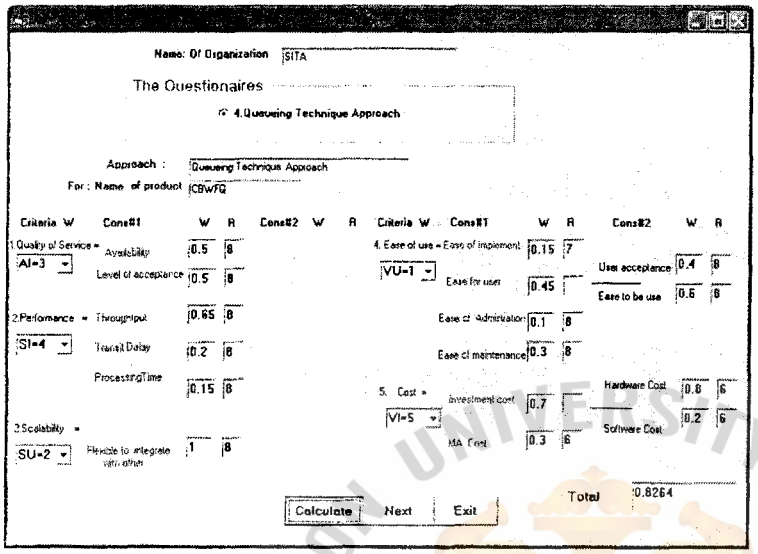


Figure 9.18 Sita's Queuing Technique QoS score for Class Based Weight Fair Queuing

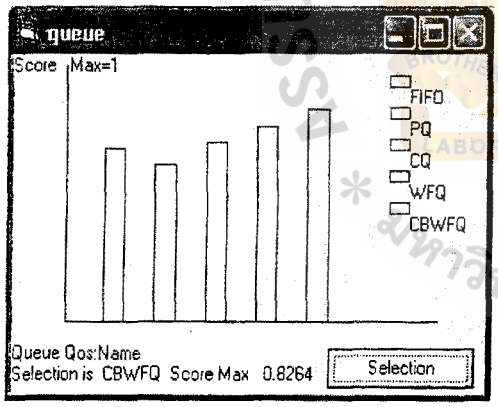


Figure 9.19 Result of selection Sita's Queuing Technique QoS

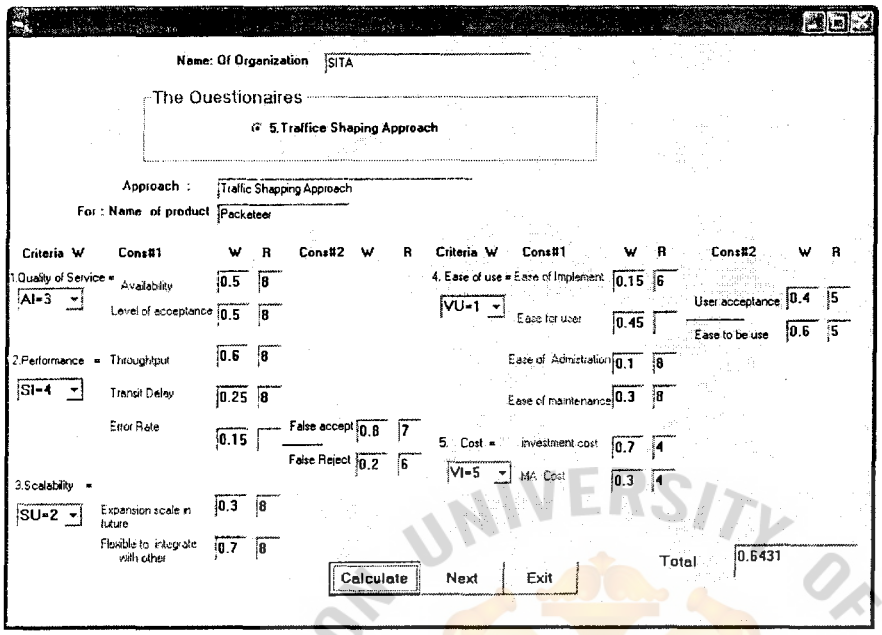


Figure 9.20 Sita's Traffic Shaping Technique QoS score for Packeteer

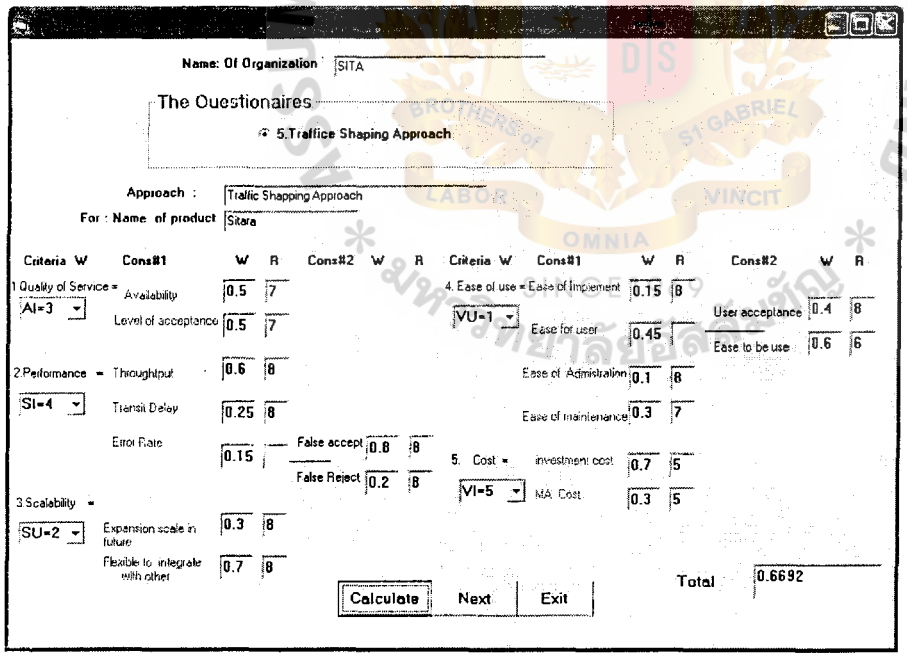


Figure 9.22 Sita's Traffic Shaping Technique QoS score for Sitara

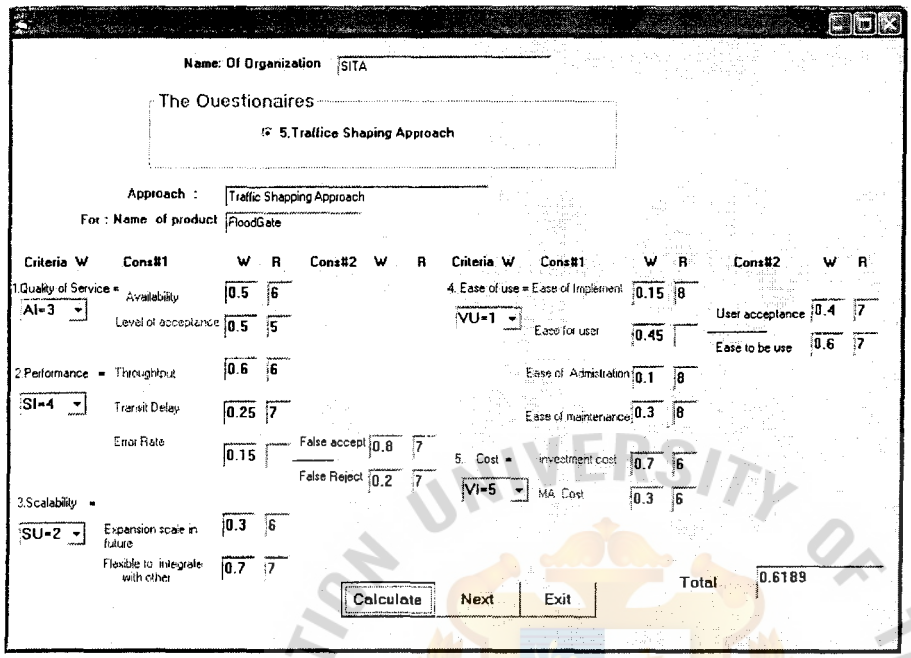


Figure 9.23 Sita's Traffic Shaping Technique QoS score for FloodGate

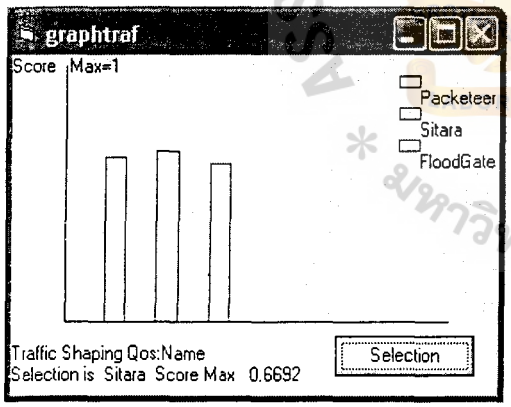


Figure 9.24 Result of selection Sita's Traffic Shaping Technique QoS

Value Assigned Diagram of SCS

We arrange consequently by each consideration.

1. Scalability
2. Quality of Service
3. Performance
4. Cost
5. Ease of Use

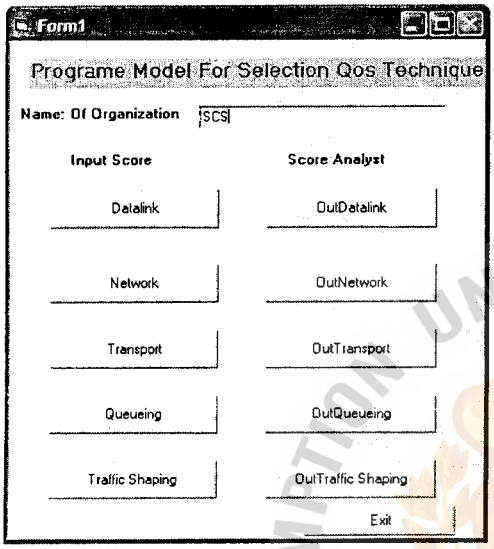


Figure 10.1 Questionnaire of Sita Company with weight

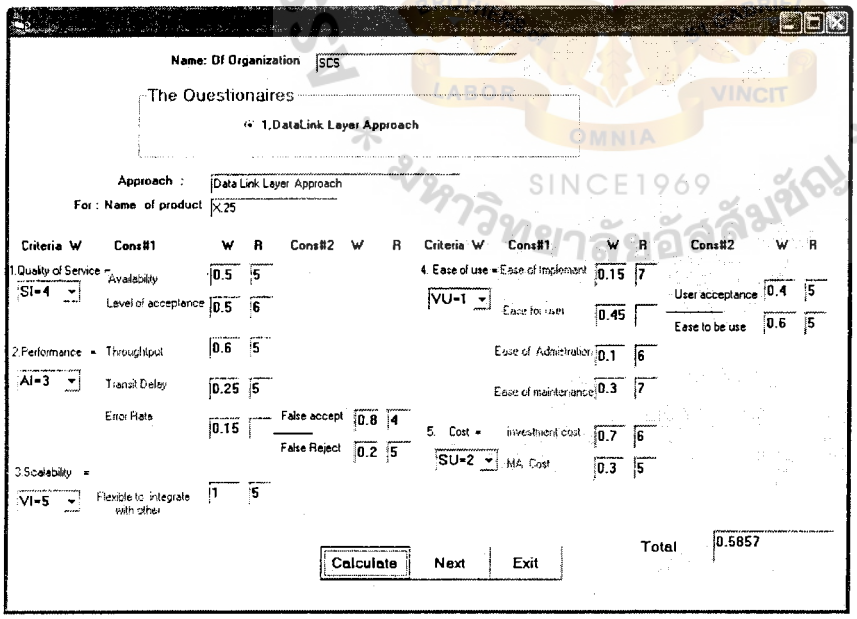


Figure 10.2 SCS's Datalink Layer QoS score for X.25

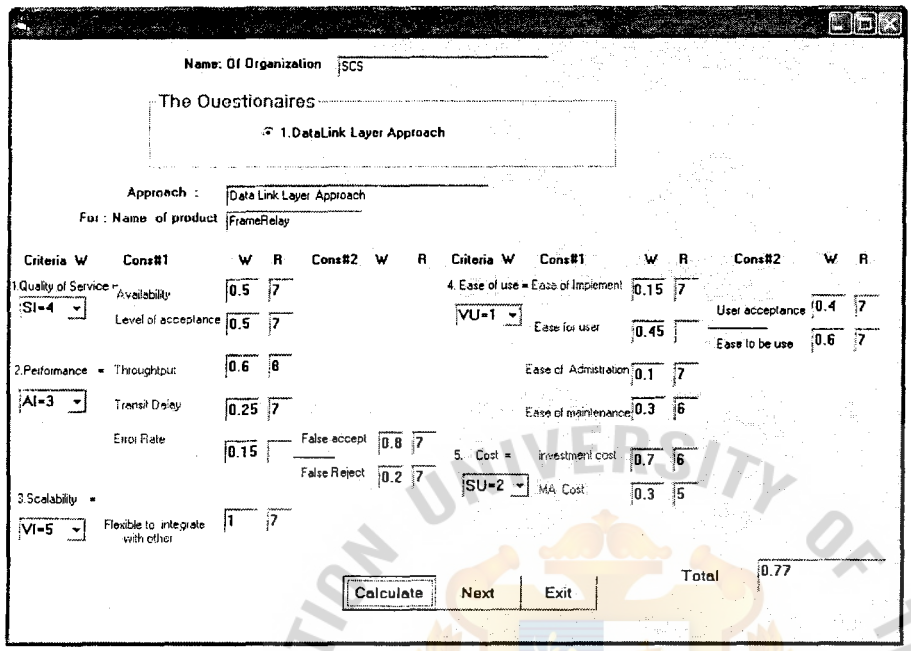


Figure 10.3 SCS's Datalink Layer QoS score for Frame Relay

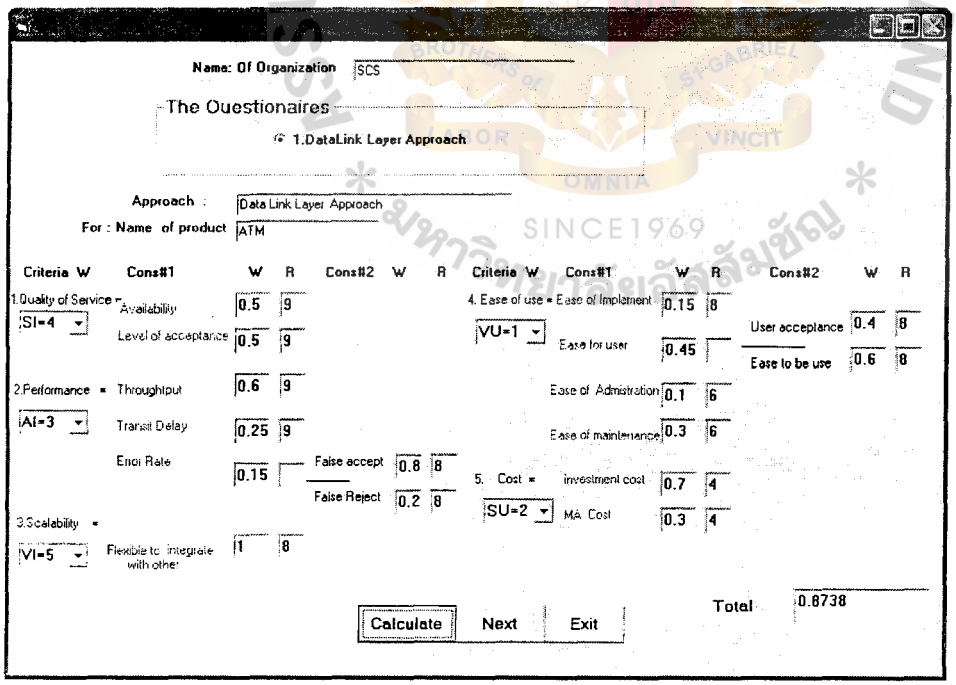


Figure 10.4 SCS's Datalink Layer QoS score for ATM

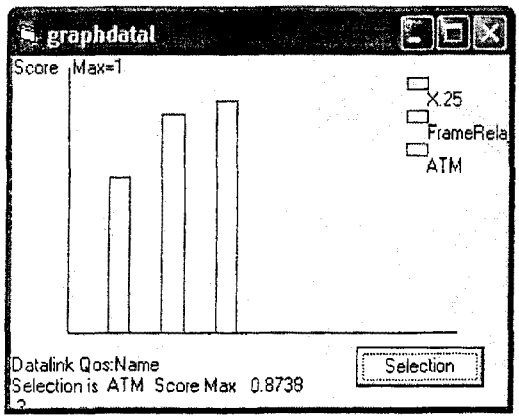


Figure 10.5 Result of selection SCS's Datalink QoS

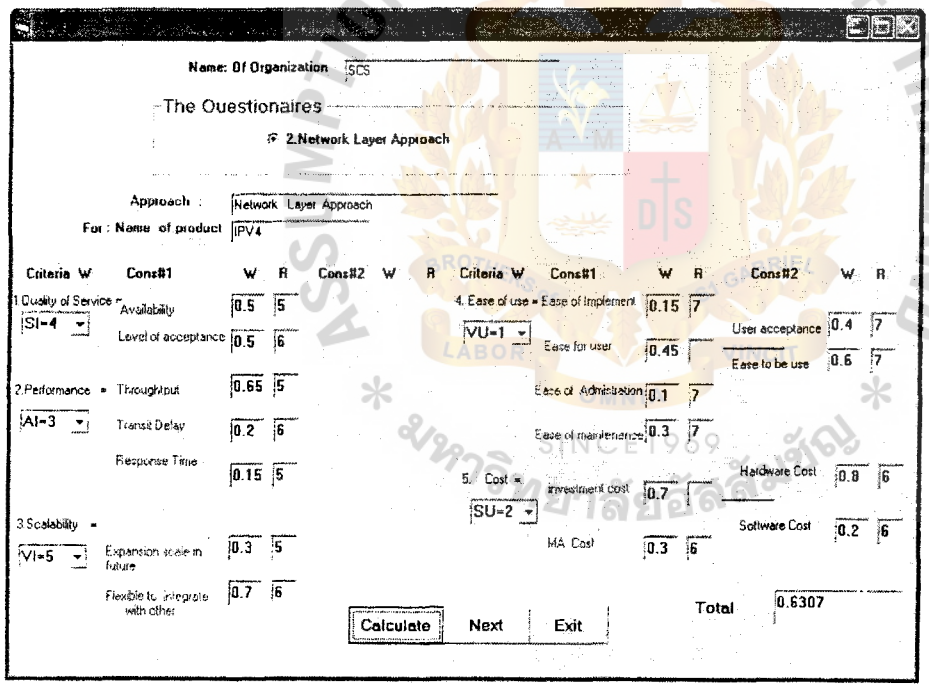


Figure 10.6 SCS's Network Layer QoS score for IPV4

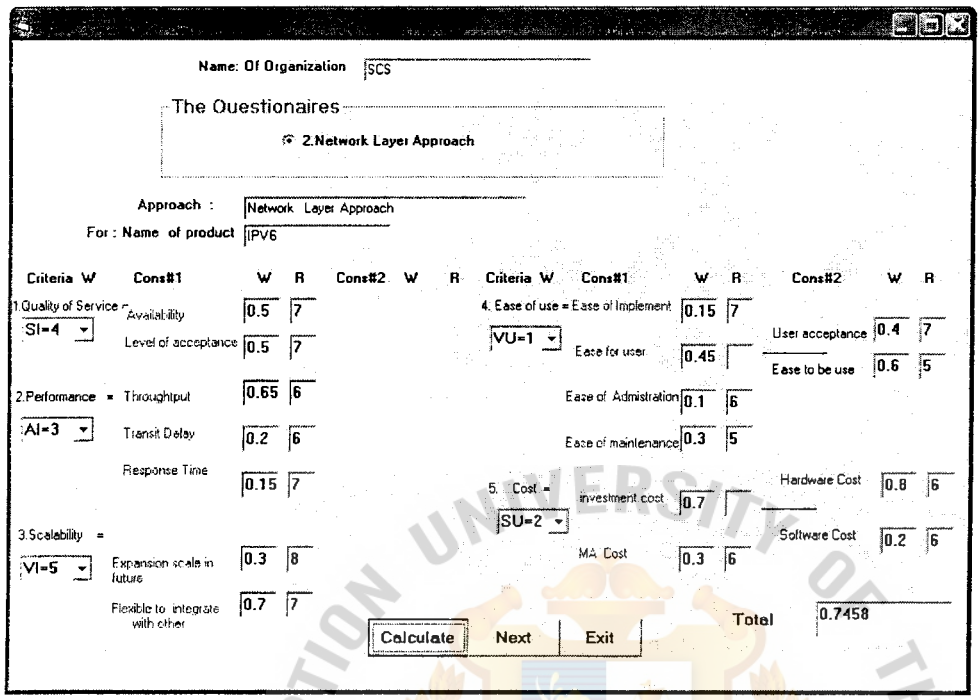


Figure 10.7 SCS's Network Layer QoS score for IPV6

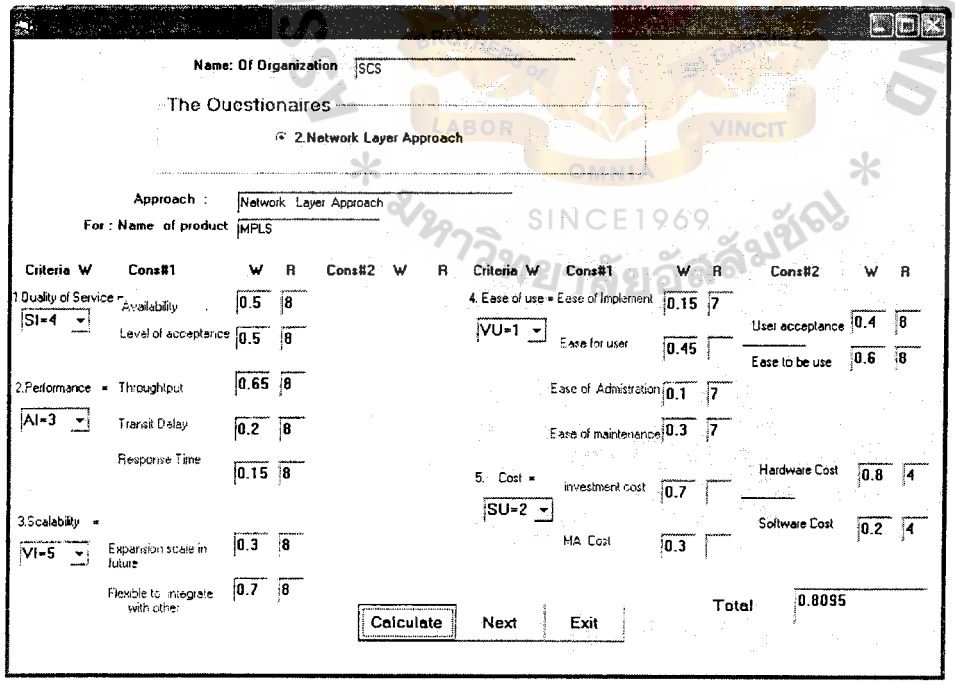


Figure 10.8 SCS's Network Layer QoS score for MPLS

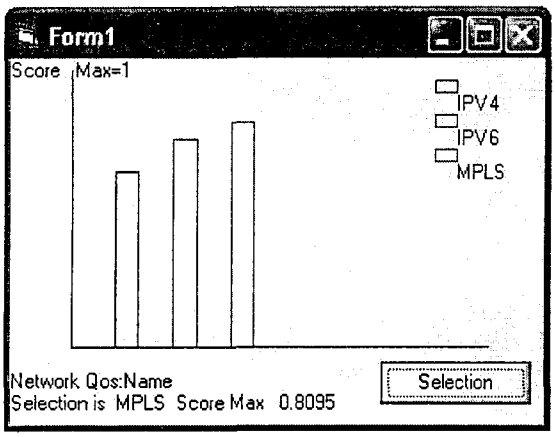


Figure 10.10 Result of selection SCS's Network Layer QoS

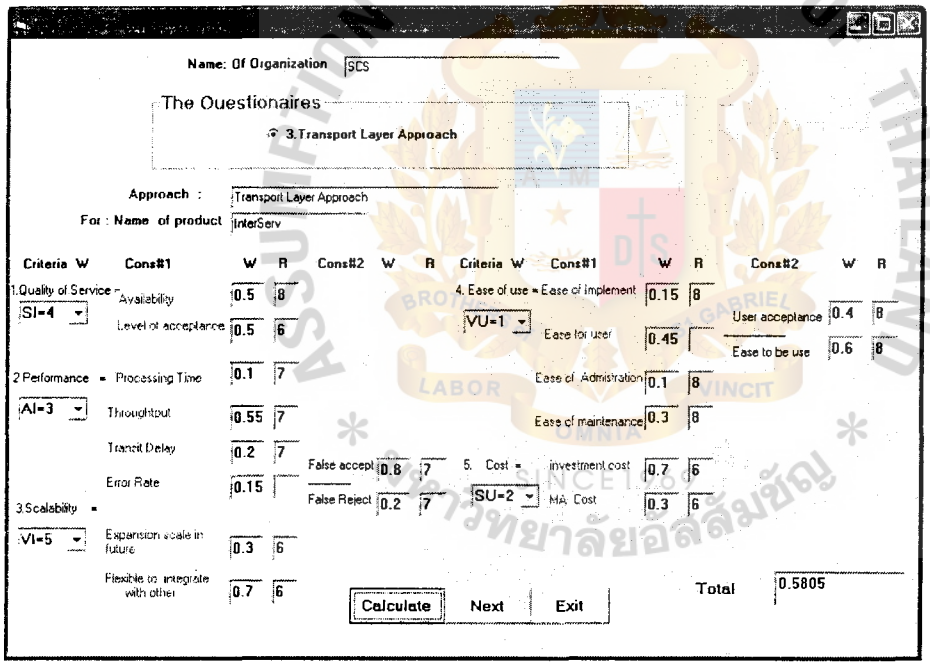


Figure 10.11 SCS's Transport Layer QoS score for InterServ

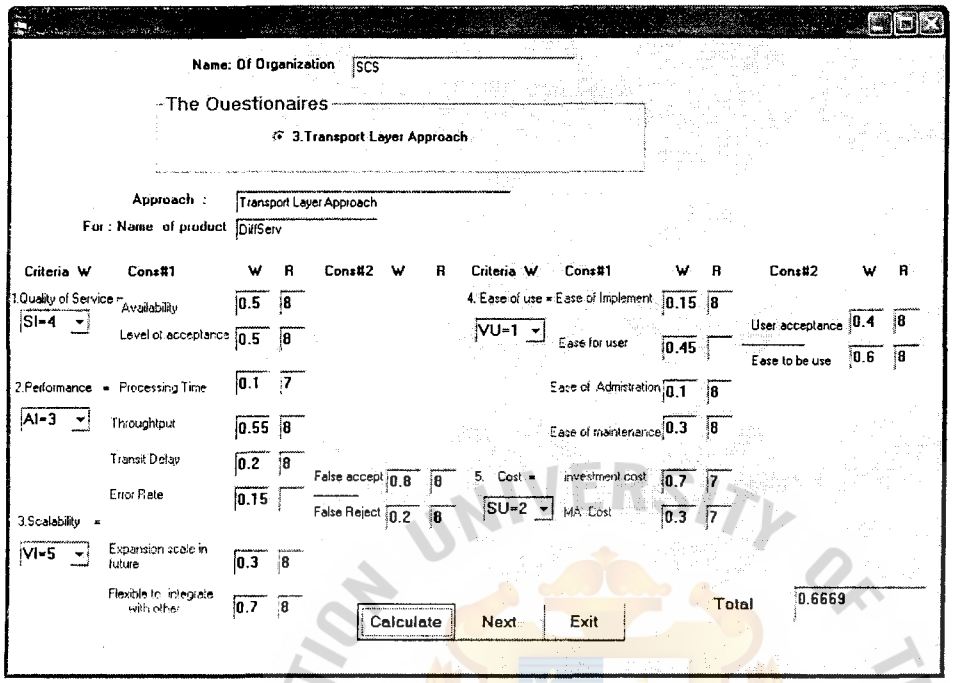


Figure 10.12 SCS's Transport Layer QoS score for DiffServ

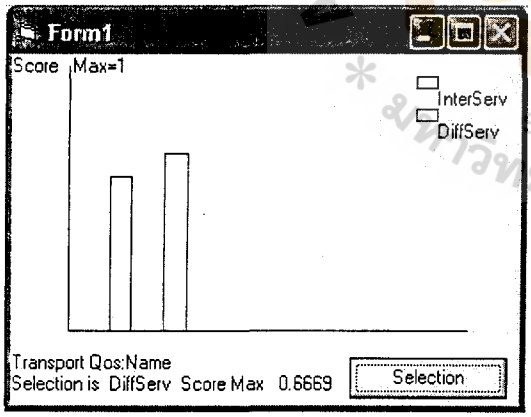


Figure 10.13 Result of selection SCS's Transport Layer QoS

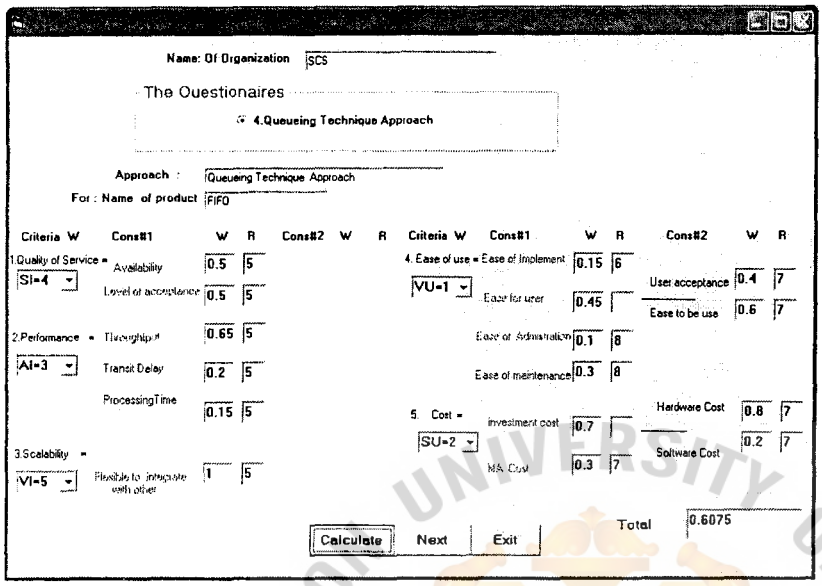


Figure 10.14 SCS's Queuing Technique QoS score for FIFO Queuing

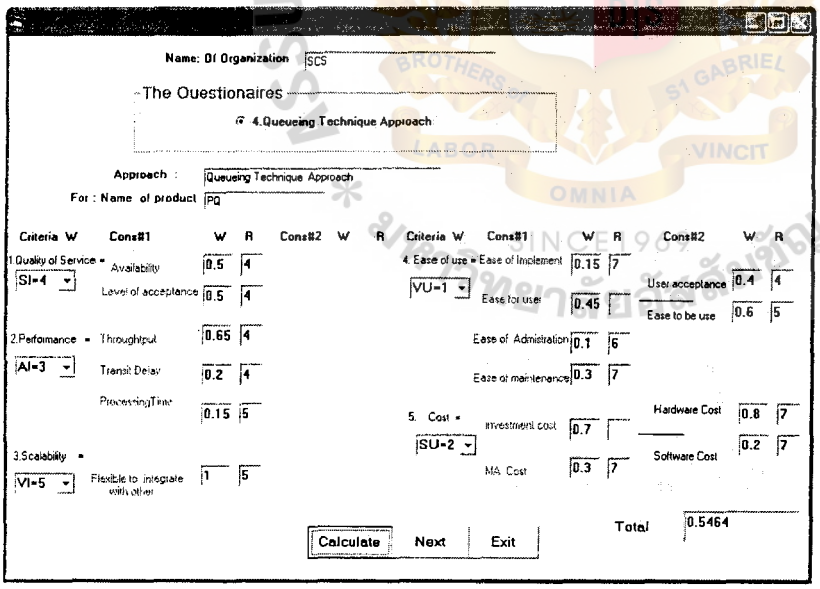


Figure 10.15 SCS's Queuing Technique QoS score for Priority Queuing

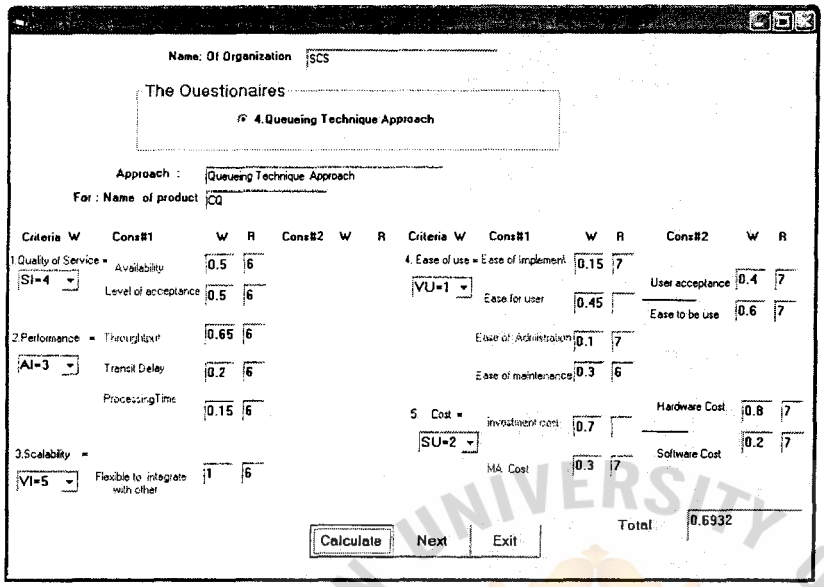


Figure 10.16 SCS's Queuing Technique QoS score for Custom Queuing

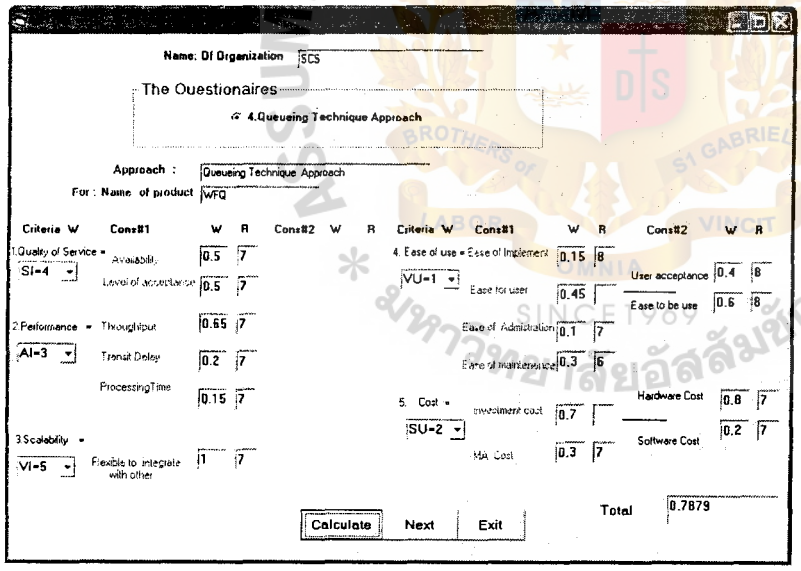


Figure 10.17 SCS's Queuing Technique QoS score for Weight Fair Queuing

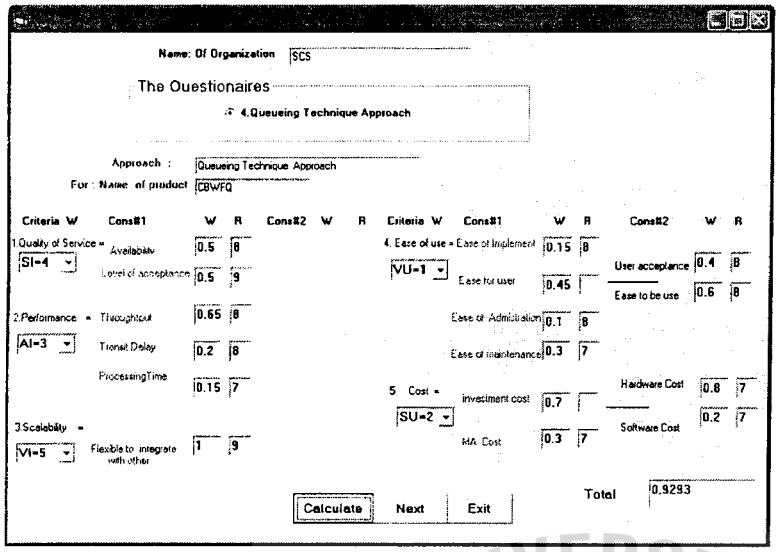


Figure 10.18 SCS's Queuing Technique QoS score for Class Based Weight Fair Queuing

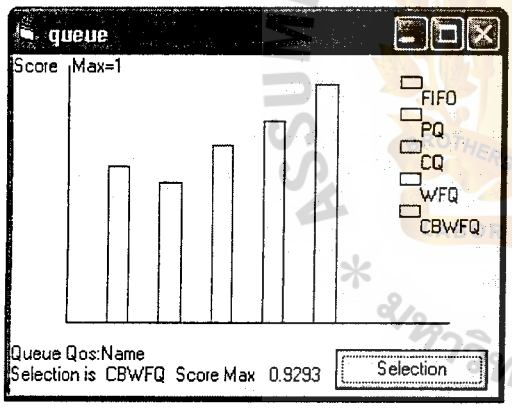


Figure 10.19 Result of selection SCS's Queuing Technique QoS

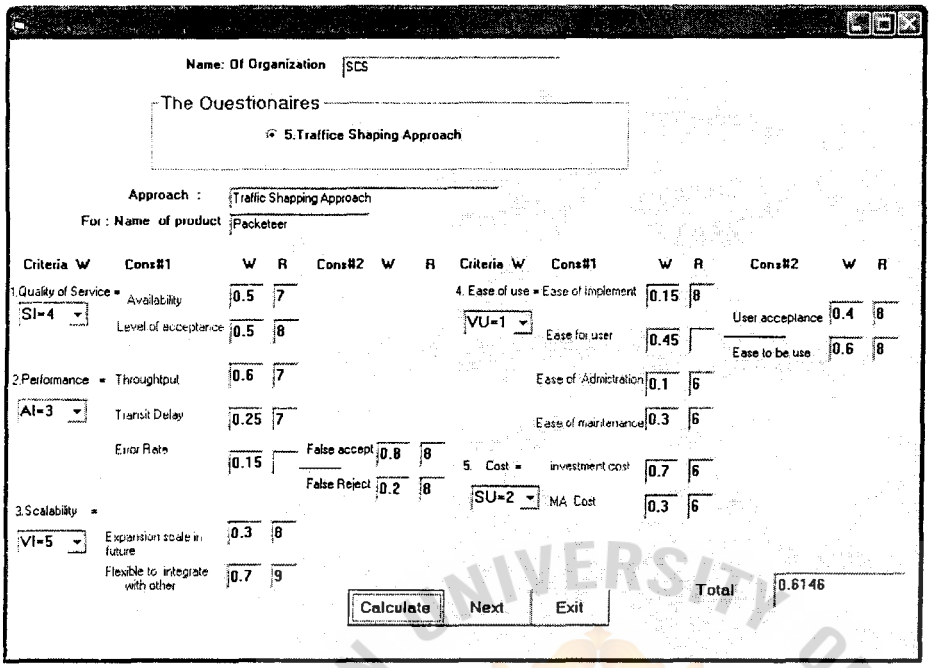
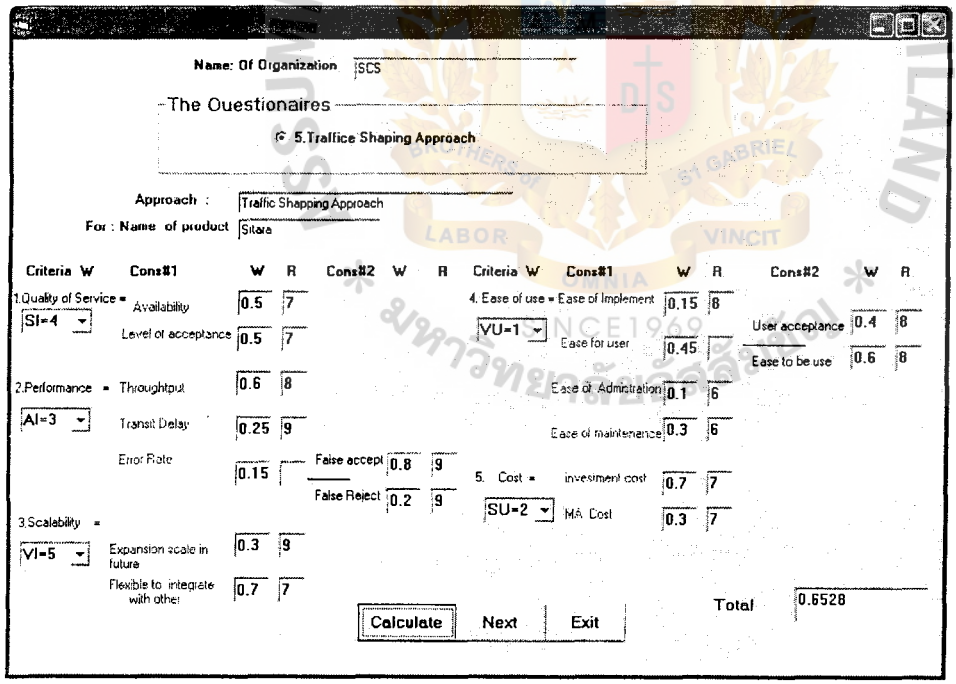


Figure 10.20 SCS's Traffic Shaping Technique QoS score for Packeteer



ure 10.22 SCS's Traffic Shaping Technique QoS score for Toplayer

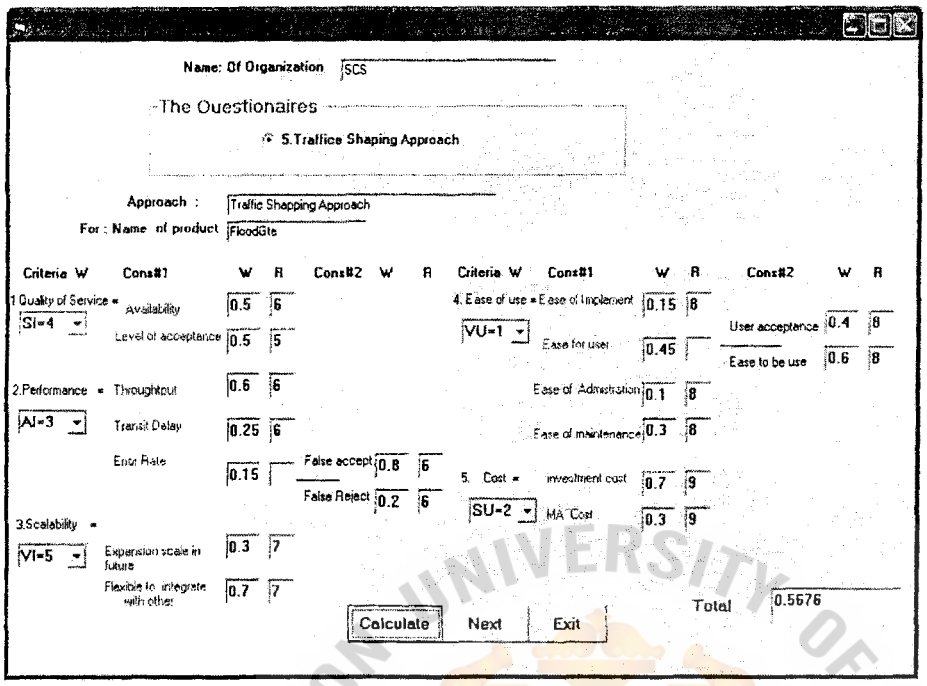


Figure 10.23 SCS's Traffic Shaping Technique QoS score for FloodGate

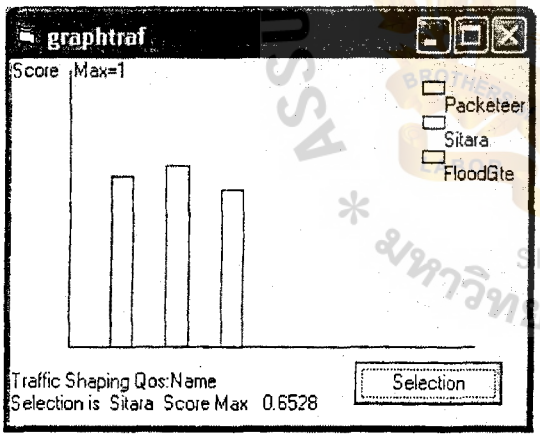


Figure 10.24 Result of selection SCS's Traffic Shaping Technique QoS

APPENDIX C

Reference: from Expert1 and Expert2

QOS Evaluation From Expert1 (CCIE)

1) Datalink Layer Technology in QOS environment

Performance + technology Major issue

1.1) ATM is the best technology that should be fit in the QOS environment both in the BACKBONE (ISP) point of view and Enterprise to access level point of view.

1.2) FRAME-RELAY is the second best in this QOS environment base on their nature of DLCI and NBMA (non broadcast multi access)

1.3) X.25 is the last one cause of some obligation and some mechanism to ensure their reliability at the datalink lavel so it may not be suitable for the real time QOS application.

Price + availability Minor issues

1.2) FRAME-REALY is the best for the cost effective and hardware + software support

1.4) ATM is hard to maintain in the complexity and the cost is very high,

1.5) X.25 is old fashion and not suitable for any regards in QOS applications

ATM→Frame Relay →X.25

2) NETWORK LAYER COMPARISON

1.1) MPLS is the best solution to fit the ISP and Backbone carrier who also using high speed network ATM.

1.2)IPV4 is the most popular one but the protocol itself has some limited features (ip precedence)that do not cover all new QOS applications.

1.3) IPV6 has more features than IPV4

MPLS →IPV6 →IPV4

3) TRANSPORT LAYER COMPARISON

Interserv has more advanced features than Diffserv with some critical applications.

4) Queuing Comparison

4.1) General Environment
CBWFQ → WFQ → CUSTOM → FIFO→ PRIORITY

4.2) Intense Environment
PRIORITY→ CBWFQ→ CUSTOM→ WFQ → FIFO

5) Traffic Shaping Technology comparison

Features /Performance

1) SITARA → PACKETTER → FLOODGATE

QOS Evaluation From Expert2 (3Com Expert Solution)

1.Datalink Layer Technology in QOS environment

1.1 ATM is high performance technology for QoS .It has variety of QoS level and it has best performance for transmission too(Mpbs-Gbps)
1.2 FRAME-RELAY can support with QOS environment base on DLCI specify. But it has limitation for transmission about 2Mbps.
1.3 X.25 is the older technology their reliability at the data link level so it may not be suitable for the real time QOS application. It has no QoS parameter for guarantee any service and it has limitation for transmission about less than 512 Kbps.

ATM→Frame Relay →X.25

2. NETWORK LAYER COMPARISON

1.1) MPLS is the fastest switching technology ,include it has provide parameter for QoS setting.

1.2)IPV4 is the popular technique but the QoS parameter has some limited features .

1.3) IPV6 has double parameter for QoS setting than IPV4 .

MPLS →IPV6 →IPV4

3. TRANSPORT LAYER COMPARISON

Interserv use hard signalling features so it can use the best QoS guarantee than Diffserv with real time application.

4. Queuing Comparison

4.1) General Environment
CBWFQ → WFQ → CUSTOM → FIFO→ PRIORITY

Class-Based WFQ has flexible and the most performance than the other..

5. Traffic Shaping Technology comparison

Features /Performance

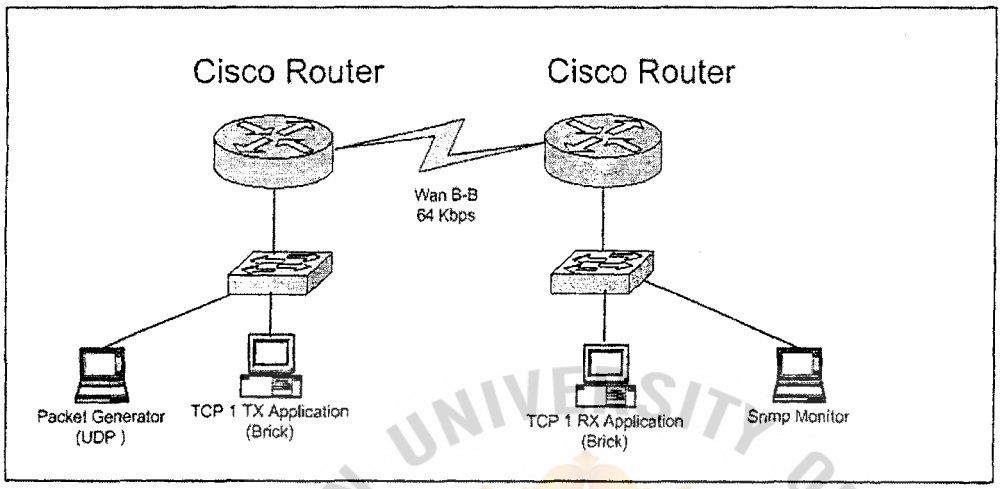
SITARA → PACKETTER → FLOODGATE

Comparison in same functionality SITARA has the fastest throughput than the other.

APPENDIX D

Reference: some part of Performance Evaluation

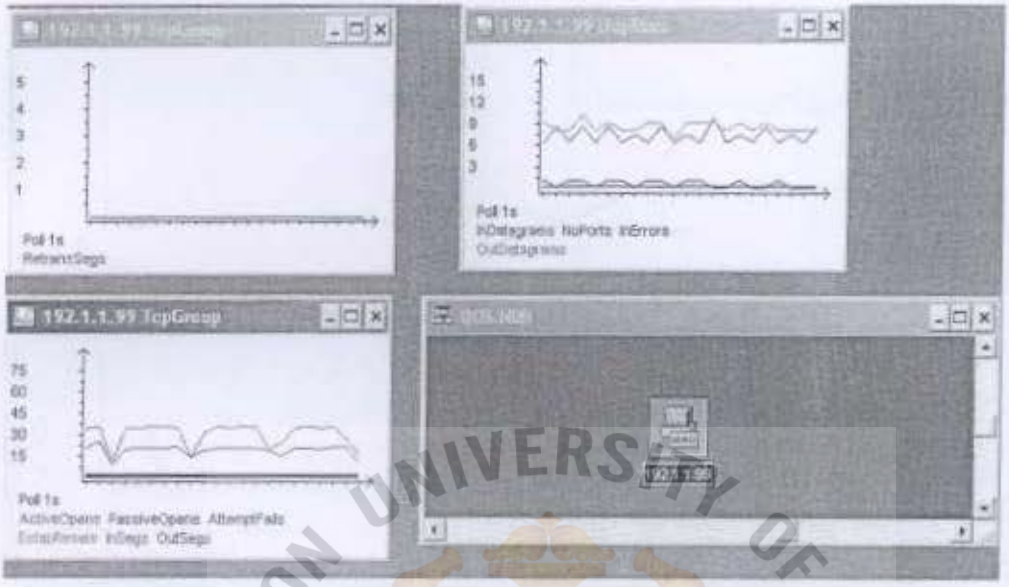
Evaluation behavior of QoS Data link Layer QoS Evaluation(X.25,Frame-Relay,and ATM)



1. Use Packet Generator (traffic generator UDP from Source to Destination router port) at load 100% of Wan speed.
   We will use wan speed at 64 Kbps for this evaluation.
2. Tcp 1 Application will use Brick program or other Tcp program
   (Note: Brick can show utilization menu or not.)
3. Run Brick at TCP 1 TX send TX to Tcp1 RX and observation behavior.
4. Start Service Snmp at both router and both TCP 1 TX Application ,Tcp1 Rx Application
5. Run Snmpc program for monitor utilization of TCP 1 Rx in each Queuing technique.

6. Record the Result of in format Axis Y is TCP utilization Axis x is Time for 5 Min.

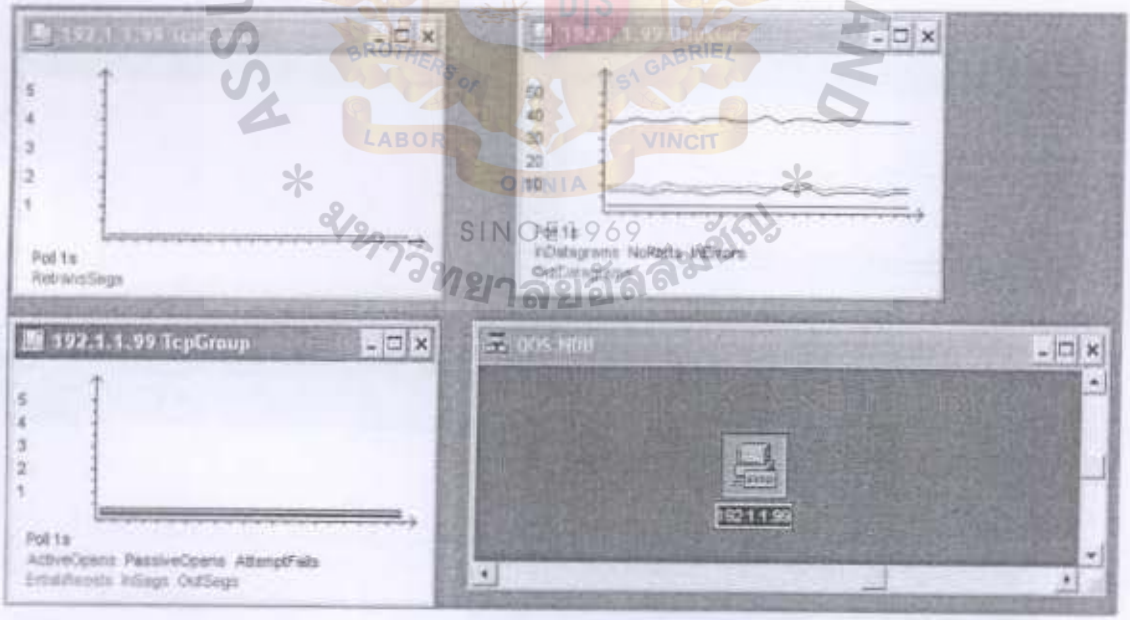
Result of X.25 (no Qos, no udp)



Result of X.25 (no Qos, with Udp)

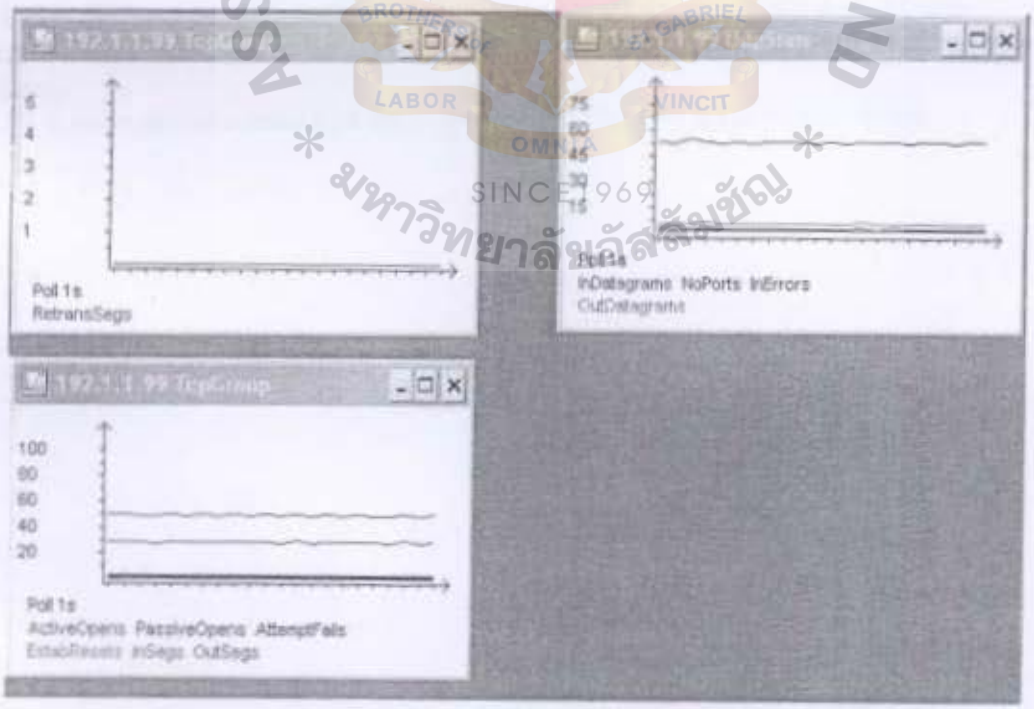
Result of X.25 (Qos, no Udp)

Result of X.25 (Qos, with Udp)

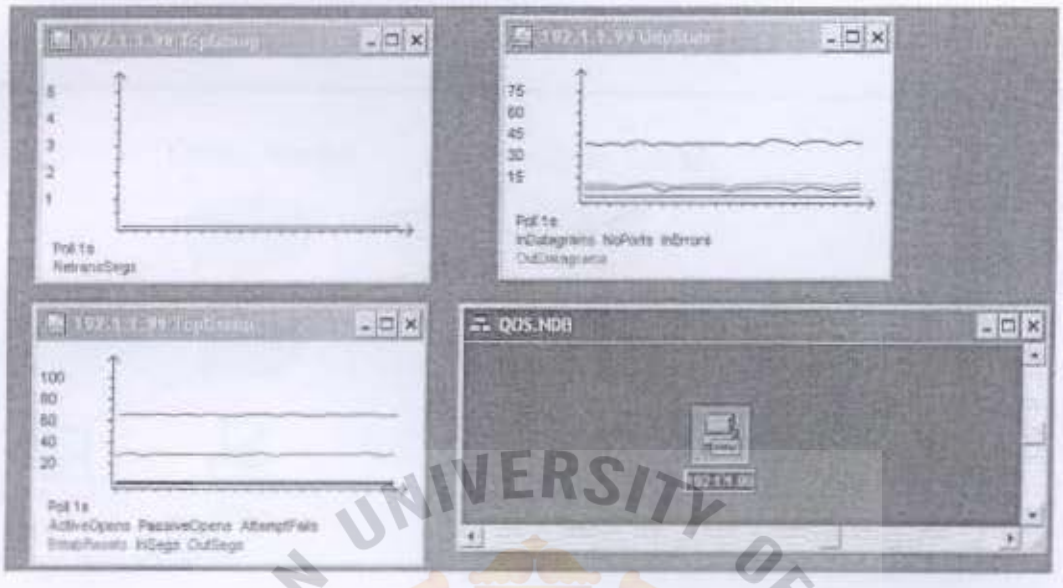


Result of Frame-Relay (no Qos, no Udp)

Result of Frame-Relay (no Qos,with Udp)

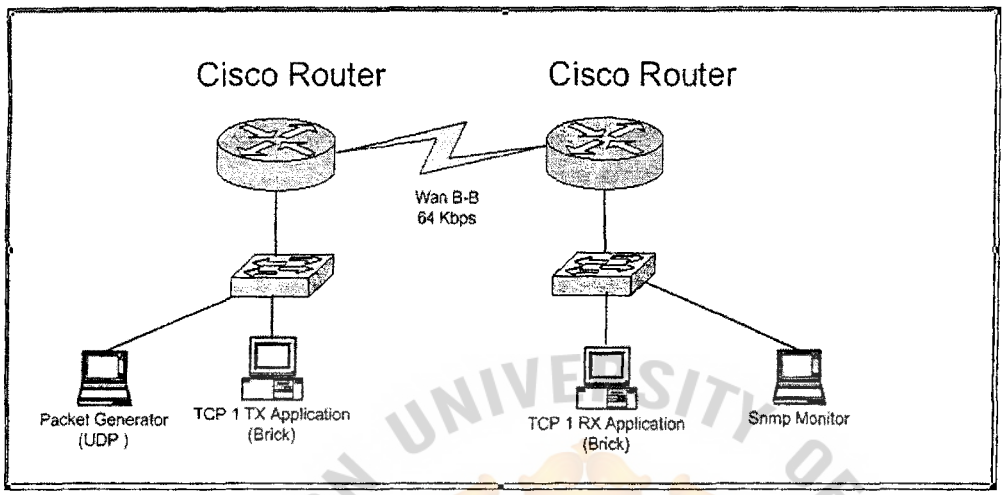


Result of Frame-Relay (Qos,with Udp)



ATM is the best performance and QoS ,speed start from 155 Mbps to 1 Gbps.
Frame-Relay is compromise performance and QoS ,speed start from 64 Kbps to 2 Mbpss.
X.25 is poor performance and QoS ,speed start from 40 Kbps to 512 Kbps.

Evaluation QoS Queuing Techniuqes Evaluation(FIFO,PQ,CQ,WFQ ,and CBWFQ)

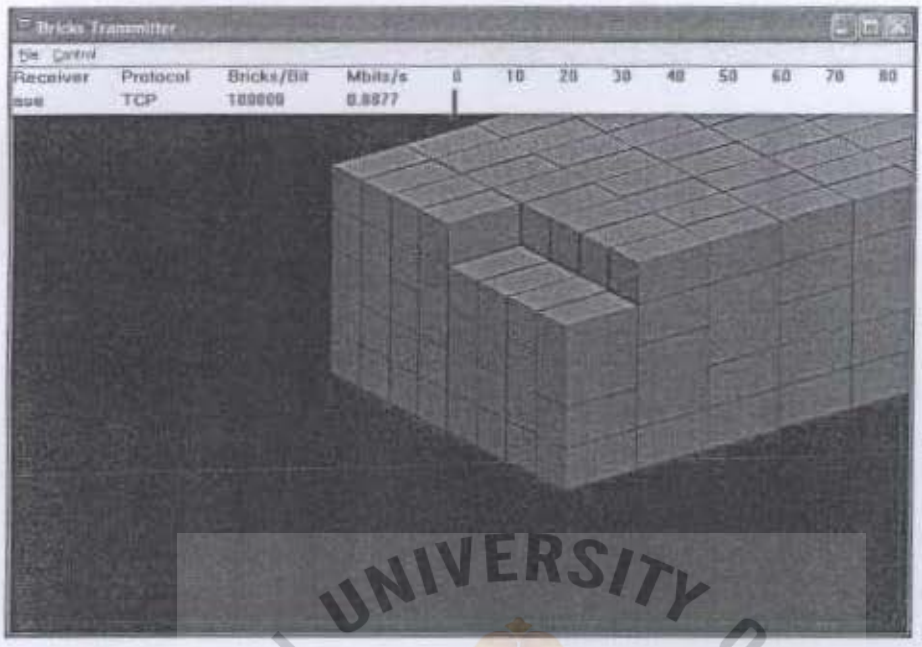


Let FIFO is baseline for all techniques. (Similar to without QoS baseline)

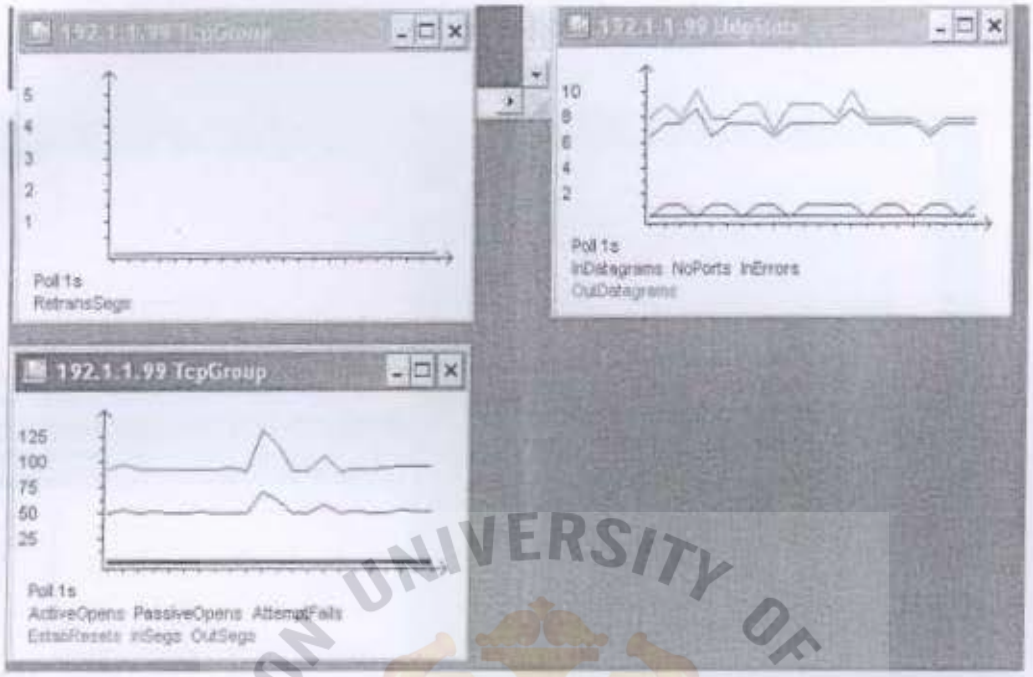
1. Use Packet Generator (traffic generator UDP from Source to Destination router port) at 100% of Wan speed.
   We will use wan speed at 64 Kbps for this evaluation.
2. Tcp 1 Application will use Brick program or other Tcp program
   (Note: Brick can show utilization menu or not.)
3. Run Brick at TCP 1 TX send TX to Tcp1 RX and observation behavior.
4. Start Service Snmp at both router and both TCP 1 TX Application ,Tcp1 Rx Application
5. Run Snmpc program for monitor utilization of TCP 1 Rx in each Queuing technique.

Record the Result of in format Axis Y is TCP utilization Axis x is Time for 5 Min.

(TCP transmit rate 0.887Mbit/s)(TCP receive rate 0.9Mbit/s)

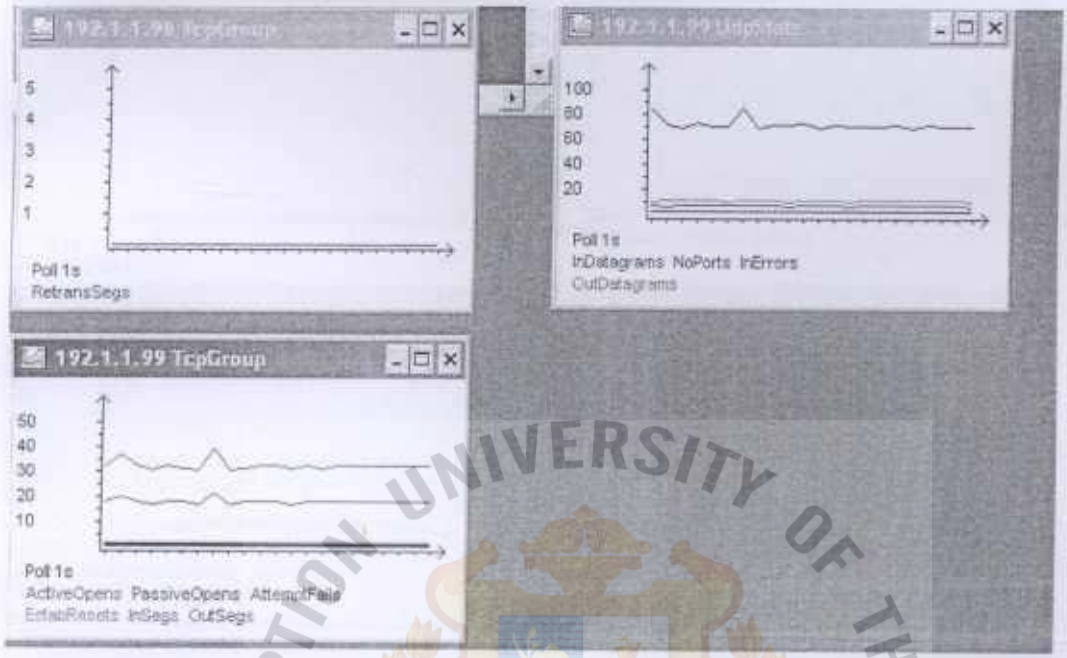


Result of FIFO Queueing(No udp)



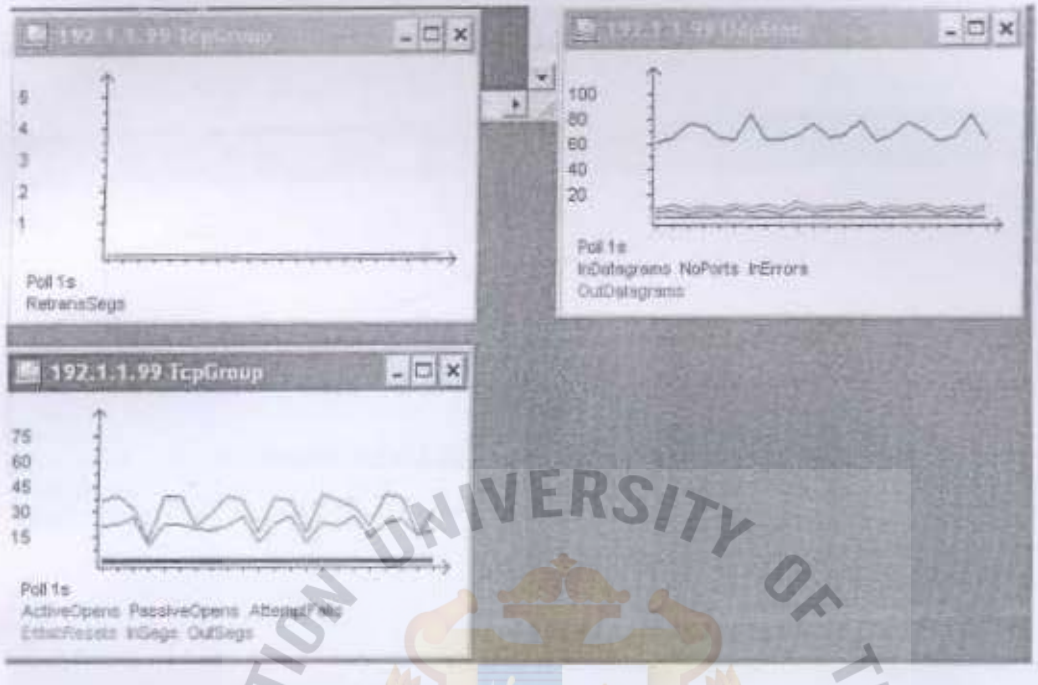
Additional UDP traffic to this system at 1Mbps

Result of FIFO Queueing(with udp 1 Mbps/s)



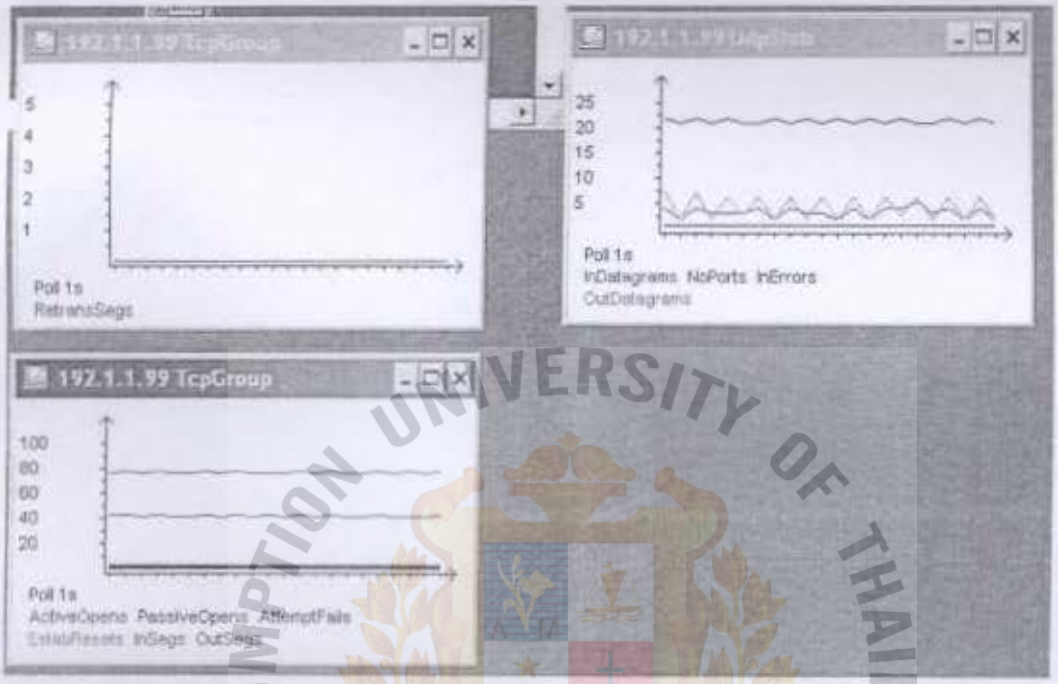
Result of PQ Queueing(High for TCP low for UDP)

Result of CQ Queueing(Low buffer for TCP High buffer for UDP)



Result of WFQ Queueing(TCP High , UDP Low)

Result of CBWFQ Queueing(TCP High , UDP Low)



CBWFQ and WFQ will give the best consistency and smooth to this evaluation. The other will give oscillates to this evaluation.