IEEE MELECON 2002, May 7-9, 2002, Cairo, EGYPT.

Billing System For Internet Service Provider (ISP)

Hamdy A. Ibrahim, Bahnasy M. Nossier, and Mohamed G. Darwish
Faculty of Engineering "Menoufiya University", NTI, Faculty of Computers & Information "Cairo University"

ABSTRACT

The main objective of this paper is proposing and developing a billing system used by Internet Service Providers (ISPs) to charge Internet users according to their network usage (e.g. their traffic). This means that, depending on the volume of traffic created by users they will be charged. The main idea of the proposed billing system is when a user attempts to establish a connection with the outside world, the connection establishment will be postponed while the user is authenticated and verifying that he is ready to pay for this connection. Generally, if the user is ready to pay, the connection will be established and his traffic (which reflects his usage) will be metered. An invoice is generated according to the metered traffic. The proposed billing system consists of two main components, which are the meter module and invoice generation module. We measure several key statistics as connection setup time, active connection count, response time and complexity of searching the connection tables without the billing system and with it to determine if it is feasible to implement the proposed billing system or not.

Keywords: Internet accounting, usage-based pricing, Internet economics

1. INTRODUCTION

The Internet is an enormous computer network for the transmission of digitized data. It has become the primary means of communication for most of its users. It is no wonder that individuals who have access to it get more information through Internet than any other source. The Internet currently provides individuals access to e-mail, news groups, free software, data transferring capability, real-time conferencing, and many other services. Researchers can also use The Internet facilities such as telnet, ftp, gopher, and World Wide Web (WWW) to obtain research articles, software tools, or to conduct a survey.

Initially, the Internet appeared to be "free" to its users. Government grants and academic research budgets funded it. Local costs were often buried in corporate and organizational facilities budgets. But in recent years the Internet has grown too large and diverse to be supported by hidden subsidies. The U.S. National Science Foundation no longer underwrites backbone costs. In order to maintain growth and performance, service provision had to be transferred to for-profit Internet service providers (ISPs). The Internet has become a business.

Today, ISPs levy charges for Internet use. Full-time connections are charged a flat monthly rate according to the speed of the access line. Part-time users are charged a fixed monthly fee or by the minute, or a combination of both. These cost recovery schemes are easy to implement, but they fail to reflect the actual cost of providing Internet service, thus producing discrepancies between revenues and costs that put ISPs at risk [1].

Historical factors explain why in the early 1990s Internet users faced only fixed charges. Until 1990, the Internet was heavily subsidized, and most users belonged to universities and research institutions. The Internet was rarely congested and when congestion did occur, hosts automatically exercised flow control. Thus fixed charges were adequate. Internet traffic grew because commercial network access providers extended the user group beyond the academic and research communities and because of the popularity of Internet applications such as WWW. This growth has made the Internet vulnerable and exposed difficulty in serving applications that need guaranteed service quality. According to the previous discussion, we can say that the billing system used to charge Internet users must reflect the actual usage. This means that, the billing system must be a usage-sensitive system.

The economics of networks have been previously discussed in [2], [3]. Some concepts and the role of pricing policies in multiple service class networks have been studied in [4]. Some issues about Internet economics, the economics of digital networks, and Internet Resource allocation and Pricing models have been presented in [5], [6] and [7]. Economics, Internet Interconnection agreements, and competition among ISPs have been discussed in [8], [9], and [10]. Internet accounting and the status of related work within the IETF and IRTF have been discussed in [11]. Benefits of using the usage-based pricing in a subnetwork have been studied in [12]. A number of network billing systems have been proposed [13], [14], and [15]; in addition, one billing system has been implemented [16]. In 1990, Estrin et al. Suggest some research topics toward usage billing and feedback [17].

In this paper, we propose and develop a billing system used by an ISP to charge its users according to their traffic volume. The proposed billing system will be a traffic-based system. Section 2 introduces the economic principles underlying network charges. These principles apply to all networks including Internet. Section 3 discusses features, which are essential to any Internet billing system. Section 4 shows how the Internet is priced at present and discusses advantages and disadvantages of non-traffic-based billing systems. In Section 5, we give a detailed description for the proposed billing system. We explain how it works and its components. Section

6 discusses some several key statistics about connections to determine whether the proposed billing system is feasible to implement or not. We draw some conclusions from our study in section 7.

2. NETWORK CHARGES: THEORY AND PRACTICE

At first, Internet is fully subsidized by the United States government. Internet subsidy has diminished over time, disappearing altogether in 1995. Internet is now run by commercial carriers and network access providers, who recover costs and profits through charges. In the following section, the terms *charging* (or charge) and *pricing* (or price) are interchangeably used, although a useful distinction can be made. A ***price*** is normally associated with one unit of service: if you buy ***n*** units of service, you pay ***n*** times the unit price. A ***charge*** is a more general form of price. For example, a charge may consist of a fixed component plus a unit price. Although there are many kinds of charges, it is important to distinguish between four types, which are:

- *Fixed Charge*

It is a monthly subscription fee for access to the network. The access may be limited to a certain period of time each day, or it may be unlimited. The fee is paid independently of how many connections the subscriber actually makes, or how much data is transferred.

- *Usage Charge*

It depends on the amount of network use. It is, therefore, based on each connection or call the subscriber makes. *The usage charge* can be calculated in many ways. It may be a function of duration of the connection, the amount of data transferred, or the end-to-end distance. Telephone usage charges, for example, depend on the call duration and the distance between the calling parties.

- *Congestion Charge*

It depends on the amount of traffic or load that the network is carrying at the time of the subscriber's connection. *The congestion charges* are responsive to the state of the network. This means that, the charge is higher when the network is congested, and there is no congestion charge when it is uncongested.

- *Service Quality charge*

As we know, a network may provide different qualities of service, some of which require more network resources than others. *The quality charge* reflects this difference in resource use. Telephone networks and data networks typically provide only one service quality, so quality charges are uncommon. However, with the growth of high bandwidth applications that require guaranteed service quality (e.g., guaranteed delay bounds), services will be differentiated by quality, and quality charges will become commonplace [18].

3. BILLING SYSTEMS FOR INTERNET

The specification of a billing system developed for Internet connections depends on charge type. A billing system for usage charges must able to meter the traffic and collect appropriate data for each connection. If there is a congestion charge that depends on real time changes in the network state, the billing system must monitor the network state and provide real time price feedback to users. Generally, a number of features are essential to any billing system:

- ***No changes to existing Internet protocols and applications***

Because of the huge number of installed end systems, bridges and routers, it is important that an Internet billing system work with the existing Internet protocol. It means that the billing system should not require the use of any special option fields by end systems (for example, IP options or TCP options).

Many applications such as *ftp, email, Gopher, and mosaic* are in widespread use today and collectively contribute to most of the traffic on the Internet. A billing system should be able to meter traffic for these and other existing applications without any change to it.

- ***User involvement***

In order to bill or charge individual users for their traffic, the billing system must first determine the identity of the user. It should also obtain approval from the user or an authorized agent that they will pay for resources consumed in a secure manner. And finally, the billing system should provide accurate and credible on-line feedback to the user as they consume resources. This implies that the metering of traffic should be exact and not based on traffic sampling.

- ***Provide On-line reporting of network usage***

In order to institute a congestion charge, the billing system must collect and report in real time aggregate network usage data so that the appropriate congestion charge can be calculated. The congestion-based billing system controls the network congestion. This control may be implemented using priorities or by a time varying pricing policy.

- ***Allow Sharing of information and resources***

The growth of the Internet can be attributed to applications that encourage the sharing of information and resources between remote sites. It would be advantageous if billing systems could cooperate to identify the user and bill them for their traffic [19].

4. HOW THE INTERNET IS PRICED AT PRESENT?

Today's Internet faces different types of pricing schemes, most of which is non-traffic based. Traffic-sensitive pricing has been around since the involvement of the private market, but it has not had a good acceptance by the public and has not been largely used either. Yet, none of these pricing schemes are optimal. Pricing models on the Internet can be implemented on end-users, including institutions (businesses, universities, organizations, etc.), and on ISP's interconnection.

The dominant pricing scheme for end-users on today's Internet is a non-traffic sensitive scheme. This is a direct result from the structure of Internet interconnection agreements (ISP peering) and the difficulty of introducing the more sophisticated routers as the Internet standard, which would allow a system to implement more efficient pricing schemes. Currently, there is a number of pricing mechanisms, which are (for example):

- ***Capacity-Based Pricing scheme***

MacKie-Mason and Varian (1995) suggest that the most common non-traffic based charging mechanism used by ISPs on is probably a fixed monthly fee based on the capacity of the connection (capacity-based pricing). This is the typical scheme paid by universities, government agencies, and large corporations, where end-users themselves pay nothing.

- ***Committed information rate (CIR) pricing scheme***

It is another alternative, where a user faces a two-part fee for traffic: the first part is based on the maximum feasible bandwidth of the connection and the other part is based on the maximum guaranteed actual bandwidth. Thus, for most traffic, the marginal packet placed on the Internet is priced at zero.

- ***Per-unit-of-time pricing scheme***

It is another non-traffic sensitive pricing scheme, which is based on the duration of the connection. In this scheme, users are allowed a certain number of hours per month (e.g., 20) at a flat rate. Extra hours are priced at a higher price.

- ***Time-of day pricing schemes***

There are some ISPs that have even implemented *a time-of day pricing schemes, where pricing varies depending on the hour of the day*. However, these mechanisms do not confront congestion directly. That is, they merely attempt to reduce the number of users at peak times, but do not consider the fact that any user, at any time, may overload the network—making the pricing scheme inefficient. This scheme is largely applied to end-users using a dial-up connection.

4.1. Advantages and Disadvantages of Non-Traffic Sensitive Pricing Schemes

<u>The advantages are:</u>

- ❑ Desirability by user as they do not feel constraint on strict usage quotas.
- ❑ Technical easiness to implement it, as there is no need for complicated measuring and billing mechanisms.
- ❑ Provides predictable costs for users, as they know exactly how much they need to pay.

<u>The disadvantages include:</u>

- ❑ By ignoring congestion, these schemes do not provide any incentives to flatten peak demands. So, they prevent some users from accessing the network during congestion times.
- ❑ They do not rank the value of different service requests (e.g., e-mail versus video), so it does not provide a mechanism for efficiently allocating resources.
- ❑ Small users (below average users) are subsidizing large users—as all costs are recovered through a flat connection fee (the average connection fee), which keeps some users off the Internet [20].

5. BILLING SYSTEM DESCRIPTION

This section presents a general detailed description of the proposed usage-based billing system, which will be used to account Internet users according to their network usage. Figure 5.1 shows the basic idea of the proposed billing system used by an ISP. The basic idea of the proposed system is When a user attempts to establish a TCP connection with the outside world, the connection establishment will be postponed while: The user is authenticated and verifying that he is prepared to pay for it. If the user is ready to pay, the connection will be established and his traffic (which reflects his usage) will be metered.

A bill or an invoice will be generated according the metered traffic.

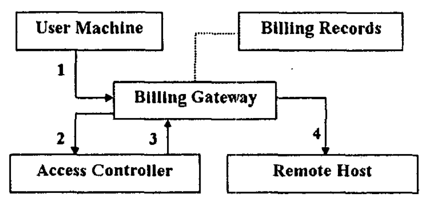

Figure 5.1: A Simple Billing System Diagram

Using the above figure, we can say that the proposed billing system has two main components:

- ***Access Controller***

This category is responsible for deciding whether to allow the connection to be established. In other word, the access controller determines whether the user is authorized to access the billed link and is ready to pay for this connection or not.

- ***Traffic Measurement and Invoice Generation***

This category contains two components:

❑ <u>The Billing Gateway</u>

It is a specialized router that maintains a table of established connections for metering the associated traffic, in addition to perform the usual IP routing functions. This table may be called traffic flow table. The BGW must able to understand connections so that it can determine which connection record to update. Also, the BGW must able to determine when connections have close so that the entry in the connection table can be freed. Connections may close in a number of different ways including receiving the TCP FIN message or the BGW times out connections that are inactive for a long period.

❑ *The Billing Records*
The billing records are responsible for maintaining records of metered connections. The billing records are used for generating the final invoice, which will be sent to the user. This invoice will reflect the actual usage of user for the network resources.

To simplify the development process, we assume that all users are authorized to establish connections at any time. This means that, the user is not involved in the connection acceptance and is ready to pay for his network usage. The development of the described model includes three stages, which are discussed in the following sections.

5.1. Developing an Administrative Domain or ISP Model

The process of developing a network model, which represents an ISP network, is the most important and difficult step. We used a Waterloo TCP model, which is available (including full source code) as public domain software, to develop the ISP model. This ready-made model is modified to allow processing of incoming packets for the purpose of traffic measurement. Figure 5.2 shows the basic ISP model. This model consists of servers (including mail server, WEB server, Access server, etc.) running software that provide various services. It also includes routers that provide connectivity to the Internet and dial-in access for remote users.

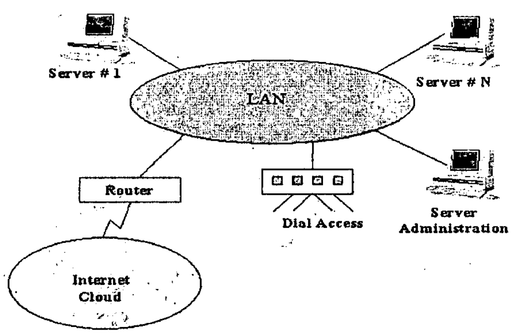

Figure 5.2 :Administrative Domain Model

5.2. Implementing the Traffic Flow Measurement Capability

Generally, a traffic flow measurement system is used to aid in managing and developing a network. It provides a tool for measuring and understanding the network's traffic flows. *Metered* or *usage data* is a generic term for the data obtained using the traffic measurement system. We developed the traffic flow measurement capability according to the RTFM architecture [21], which is shown in Figure 5.3. This model consists of four entities, which are:

- ***Meter***: it's the component which has the task of accounting packets according to some attributes such as their source and destination addresses. The meter follows a set of rules, which specify the attributes of the traffic flows to be observed; a packet is counted if all its attributes values match.

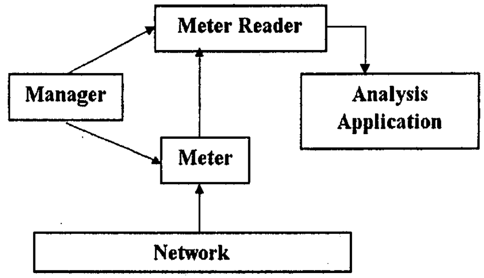

Figure 5.3 :RTFM Architecture

- ***Meter Reader***: it collects and transfers the registered data in a reliable way between the other three applications.
- ***Manager***: it's an application that configures and controls the activity of one or more meters and meter readers; it works according to the requirements of the applications that make use of accounting data.
- ***Analysis application***: it's an application that handles usage data so as to provide information and reports, which are useful for network engineering and management purposes.

5.2.1. Implementing the Meter Module

The traffic flow meter module is a program used for collecting data about traffic flows at the metering point within a network. The header of every packet passing through the network metering point is offered to the traffic meter program. The meter program could be implemented in the router (packet-forwarding device). The following section describes the operation of the meter program, meter components, and the algorithm used by the meter program. Consider Figure 5.4, which depicts the structure of the meter program.

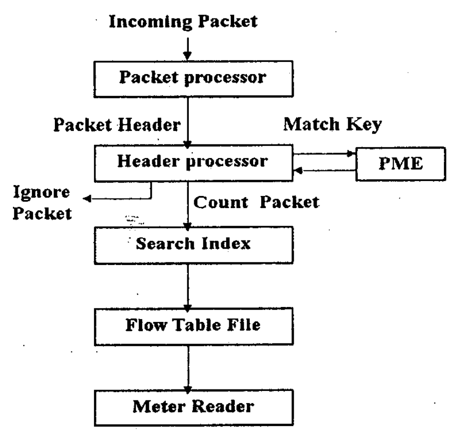

Figure 5.4 :Meter Program Structure

The meter program operates as following:

- Incoming packets reached to the router, which runs the meter program.
- *The Packet Processor routine* (PKT_PROCESS) processes the incoming packets to exclude their headers.
- Incoming packet headers are passed to *the header processor* (HEADER_POROCESS).
- The *header processor routine* excludes the match key (e.g., source-destination addresses) and passes it to the *packet-matching engine (PME)* where they are classified according to the match key.
- The *PME routine* (PKT_MATCH) checks the match key and returns instructions on what to do with the packet. Some packets are classified as to be ignored. Other packets are matched by the PME (i.e. These packets belongs to flows which will be counted.
- The *PME* returns a flow index, which is used to locate the flow's entry in the flow table file. If the flow is first seen, a new entry will be created and byte counters will be updated.
- Finally, the meter reader routine will download the flow table file for later processing.

Figure 5.5 describes the algorithm used by the traffic meter program to process each packet. The objective of the meter program is to measure traffic sent and received by administrative domain's users. Note that, *S* indicates the flow source address (i.e. its set of source address attribute values) from the packet header, and D indicates its destination address. The algorithm assumes that there are some packets, which will be ignored and others, which will be measured. Actually, the implemented meter program will count all packets, which passed through the router. This means that, the algorithm reprresents the general case.

```
START
- Initialize the meter parameter.
- WHILE ( Meter received packets or simulation not completed) DO
- PKT_HDR     = PKT_PROCESS (Incoming packet).
-- MATCH_KEY = HEADER_POROCESS (PKT_HDR).
- PKT_MATCH (S → D) if 'IGNORE' then ignore packet.
- PKT_MATCH (S → D) if 'NOMATCH' then
{
- PKT_MATCH (D → S) if 'IGNORE' then ignore packet.
- PKT_MATCH (D → S) if 'MATCH' then
{
- FLOW_EXIST (D → S) if success then count (D → S, r) else
- CREATE_FLOW (d → S, r), count (D → S, r);}}
- PKT_MATCH (S → D) if MATCH then
{
- FLOW_EXIST (S → D) if success then count (S → D, f) else
- CREATE_FLOW (S → D), count (S → D, f)
}
END WHILE
- Calling the meter reader routine to download the flow table file.
END
```

Figure 5.5 :Meter Program Algorithm

Figures 5.6,5.7 show the received and sent traffic patterns for user1.

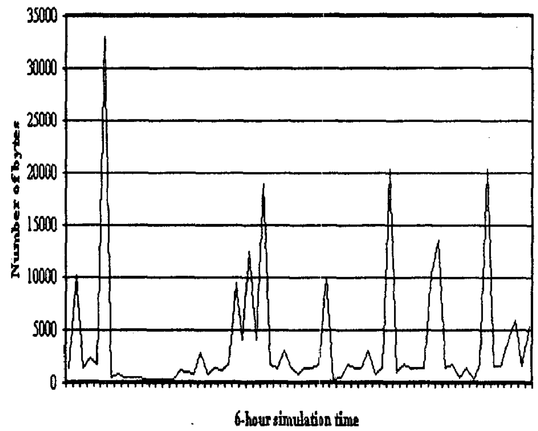

Figure 5.6 :Received Pattern by User1

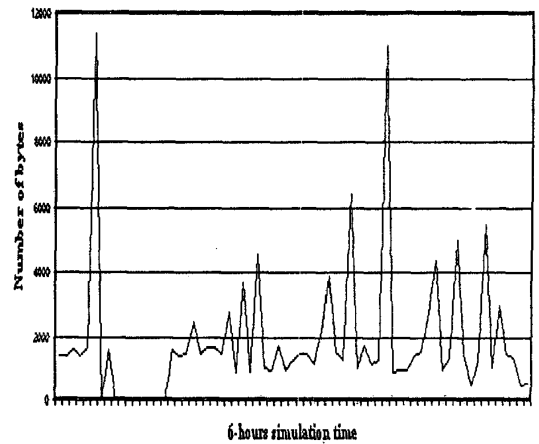

Figure 5.7 :Sent Pattern by User1

5.3. Developing the Invoice Generation Program

An invoice generation program is a program, which processes the usage data collected by the meter program and stored in the flow table file to generate invoices. Invoices will reflect the actual network usage for all users. Firstly, it is necessary to discuss the pricing scheme used for generating invoices then, explaining the algorithm used by the invoice generation program.

The pricing scheme used by the invoice generation module should be a multi-part tariff, which consists of:

- *A flat fee(Fixed portion)*: it should be ***directed to cover costs*** such as Monthly customer support, Equipment maintenance, and Billing and accounting.

The charging price for the flat-fee portion of a tariff should vary depending on factors such as, The maximum bandwidth (capacity) of the connection and The air mileage from user's home to the ISP's network

- ***A varying fee***: it should be ***directed to recover usage costs of the network*** and should vary depending on Current Network Load, Rate of Transfer requested, and the volume of the transfer session (i.e. number of packets/bytes sent or received).

It is clear that, the proposed pricing scheme should be traffic sensitive, have rate-of-transfer adaptability, and be network load sensitive. Figure 5.8 shows the layout of the *proposed pricing scheme*.

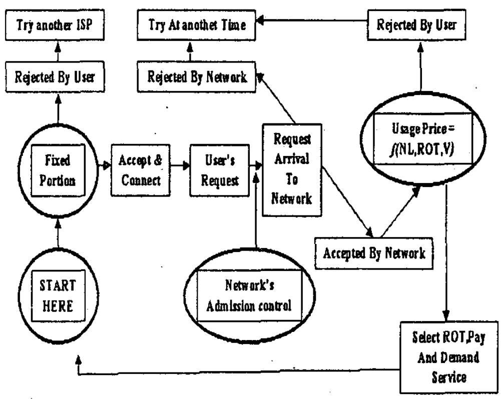

Figure 5.8: The Layout of the Proposed Pricing Scheme

5.3.1. Pricing Program Algorithm

Using the above discussion, we can conclude that:

1- Total of User's Charge = Fixed Fee + Usage Fee

2- The usage charge will vary proportionally with traffic volume, transfer rate, and network load. The simplest way to compute the usage charge is as following:

- *Usage Charge = C1 * V* *(5.1)*
- *Usage Charge = C2 * NL* *(5.2)*
- *Usage Charge = C3 * ROT* *(5.3)*

Where:

C1, C2, and C3: Constants V: Volume of Traffic

NL : Network Load

ROT : Rate-Of-Transfer

Adding the above equations

Usage Charge 3 = (C1*V) + (C2*NL) + (C3*ROT)*

Dividing two sides by 3

*Usage Charge = [(C1*V)+(C2* NL)+(C3 * ROT)] / 3*

We can use this equation to compute the usage charge. Figure 5.9 shows the algorithm used to process the usage data file to generate invoices sent to users.

```
START
- Sort records according user ID or user name.
- WHILE (!EOF) DO
{
- FOR user = FIRST_USER TO LAST_USER DO
  {
- Compute traffic volume.
- Compute usage charge.
- Create the invoice for the current user.
  }
}
END
```

Figure 5.9: Invoice Generation Program Algorithm

6. RESULTS DISCUSSION

After presenting the proposed billing system and discussing its components in details, we present results produced by running the simulation model. Firstly, most of our billing system's complexity is connection related. Therefore, we measure several key statistics about TCP connections. These statistics are *connection setup time, active connection count, and complexity of searching the connection table.* It is also necessary to measure the effect of such billing system on the response time. The billing gateway maintains a table of active connections; therefore, we measured the evolution of connection count to determine the required size of the connection table. The connection table is frequently searched; therefore, we measure the performance of different search methods to determine the complexity of connection table lookup.

6.1. Additional Connection Setup Latency

Under the proposed billing system, connection establishment is delayed while locating the user and then verifying that they will pay. Therefore, we measured connection setup latency without the billing system and measured the additional connection setup latency introduced by the billing system. Clearly, it is expected that there is an additional communications because of the existence of the billing system. These additional communications increase connection setup time, which is the required time to establish a connection. The measurement of this delay caused by the proposed billing system helps us to determine if this delay is practically acceptable or not. During the simulation model running, we measured the time from sending the connection establishment signal sent by any initiating user till the acknowledge signal is received. We consider two cases, the first one is without billing system and the other is with billing system. We record the connection identifier number

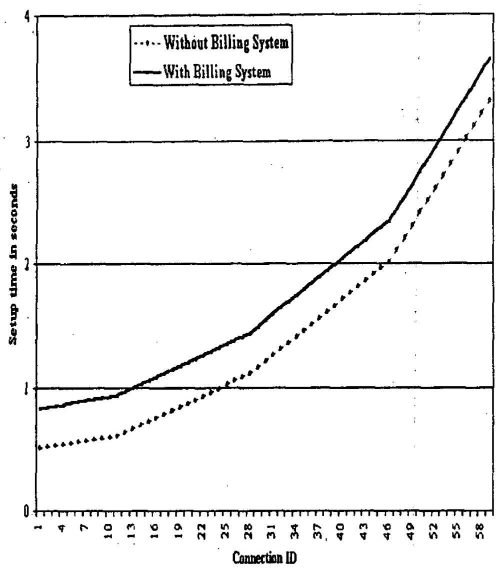

Figure 6.1: Connection Setup Time

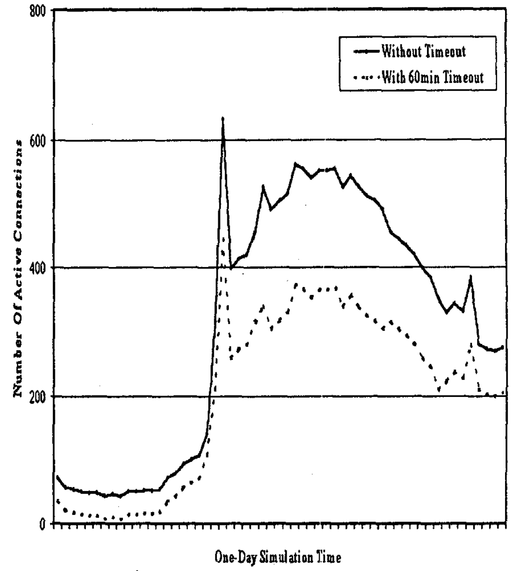

Figure 6.2: Number Of Active Connections

and the corresponding connection setup time and then draw the collected data for about 60 connections.

Figure 6.1 illustrates the two cases. By comparing the two curves, we found that the average additional delay caused by the billing system is about 332ms.

6.2. Size of Connection Table

As we described above, While a connection is active, an entry must be handled or maintained in the billing gateway connection table. To determine whether the proposed billing system is feasible to implement or not, it is necessary that this table must not be too large. So, it is useful to determine the maximum number of active connections. We have used two approaches to reconstruct the connection count. The first one removes connection from the table only when the connection is normally closed. Figure 6.2 shows this reconstruction method. From this figure the maximum number of active connections is 630. Some of hosts fail to properly close down connections. From this, we conclude that the billing gateway can not reliably detect closing of all connections. So, it is expected that an upward drift in the connection count. Hence, it is expected the maximum number of active connections will increase. This means that the size of connection table will be large. So, it will be difficult to implement the proposed billing system.

The second method applies an inactivity time-out concept. This means that, if any connection is inactive for a specific time the connection will be automatically closed. Figure 6.2 shows the evolution of connection count if connections are timed-out after 60min. With this method, the maximum connection count is 444. It is clear that, the maximum number of active connections is decreased and also, with this technique, there will no be any significant upward drift.

6.3. Complexity of Connection Table Lookup

The billing gateway meters every TCP message that it routes or forwards. It is therefore necessary that connection table entries are located quickly. These entries are keyed by a 96-bit connection identifier. Using this key to directly index a 2^{96} entry table in RAM or using a 96 bit wide CAM (Contents Addressable Memory, sometimes called Associative Memory) is impractical. We have found effective hashing functions for hardware and software implementations using CAM based connection table. The hashing function is a mathematical technique used to convert a key into an array index. We emulate the behavior of each hashing function with the simulation model, measuring the average number of lookups that are needed to find the correct table entry. We considered three widths that are commonly available and used in commercial IP routers. These widths are 48b, 32b, and 16b wide. A hashing function is applied to the 96b key to reduce it to a 48b, 32b, or 16b index. This index will be used to find the first match in the CAM. Associated with each CAM entry is a shadow entry at the same offset in RAM. The shadow entry contains an orthogonal portion of the key that when combined with the index can be used to recover the full 96b key. The orthogonal portions of the key are compared to verify that the entries match. If they do not, then search is repeated looking for the next match in the CAM [19].

Figures 6.3, 6.4, and 6.5 plot the average number of comparisons per table lookup over One-day simulation time.

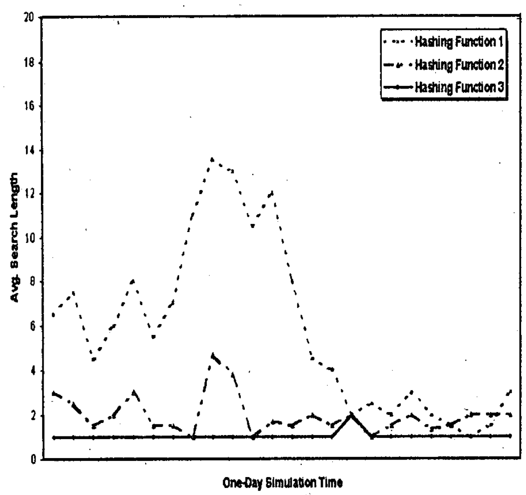

Figure 6.3: Avg. # of look-ups for each connection in 48b CAM based

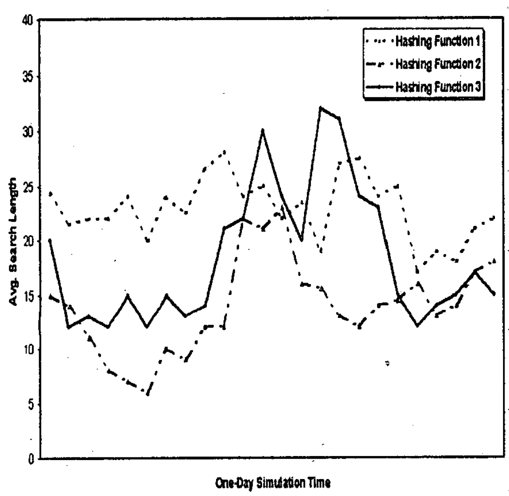

Figure 6.5: Avg. # of look-ups for each connection in 16b CAM based

By using these figures, we can say that:

1. Generally, Using 48b-key to address the CAM-based table is more efficient than using 32b-key or 16b-key CAM-based table.
2. For 48b-key and 32b-key, the performance of f_{CAM3} is very high than f_{CAM2} and the performance of f_{CAM2} is very high than f_{CAM1}. This means that the hashing function f_{CAM1} is much less effective than others.
3. The performance of these hashing functions is significantly degraded for a CAM width of just 16b.

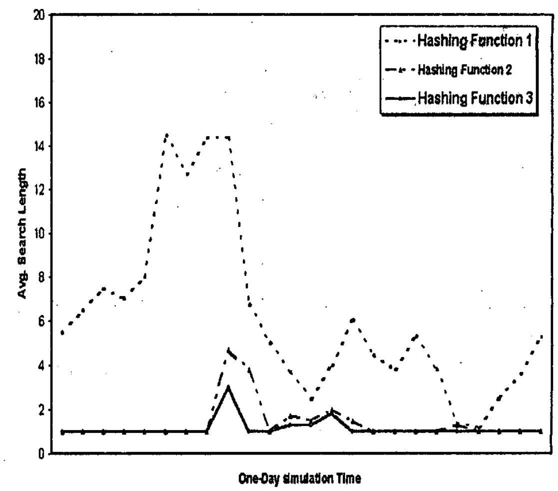

Figure 6.4: Avg. # of look-ups for each connection in 32b CAM based

The proper selection of the hashing function is very important. As we say, the connection table will contain an entry for each connection. This entry contains traffic counter field. When a connection is established, the connection table is searched to index or point to the entry corresponding to this connection. If there is not any entry for it, an entry will be added into the connection table. When packets that belong to any connection passes through the billing gateway, the connection table is also searched to find the corresponding entry to update its traffic counter field before forwarding it to the proper destination.

It is clear that the searching technique may affect the average response time. The efficient searching technique is used, the less latency of searching the connection table. Figure 6.6 illustrates the relation between the average response time and network load without billing system. It is clear that when the network load increased, the average response time increased. Figure 6.7 shows the same relation with the existence of billing system, which uses 48b-key CAM based connection table and with different searching techniques. Figure 6.7 illustrates that the minimum response time latency is offered by the third hashing function f_{CAM3} applied to the 48b-key CAM-based connection table.

7. CONCLUSION

In this paper, we proposed a billing or pricing system used by Internet service providers (ISPs) to account Internet users according to their actual network usage (e.g. their traffic). We also developed a model that simulates a small ISP's network and implemented the proposed billing system within this model. We studied the effect of adding the billing system on some statistics parameters to determine whether it is feasible to implement this system or not.

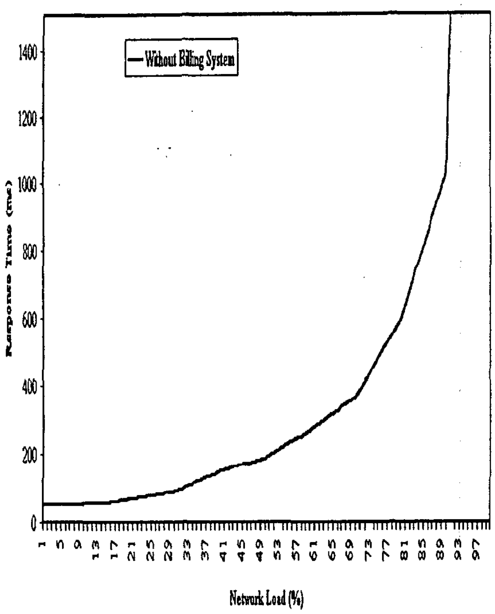

Figure 6.6: Response Time vs. Network Load

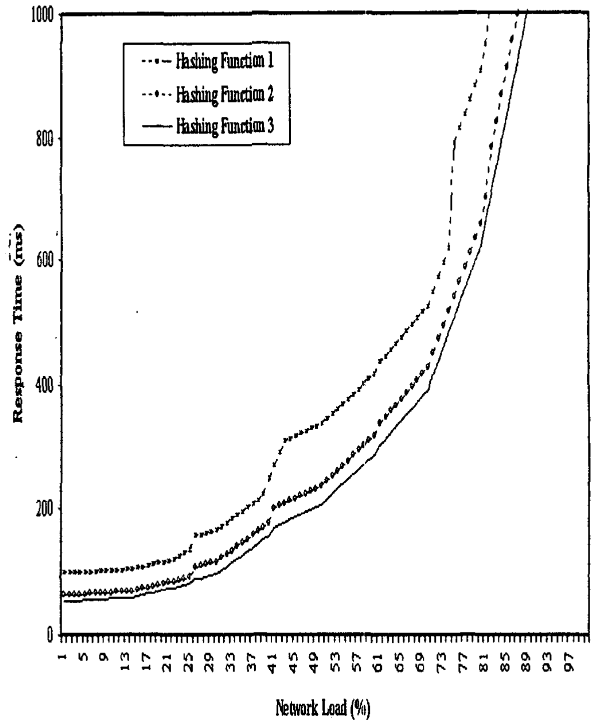

Figure 6.7: Response Time vs. Network Load with Billing System

The proposed billing system can be used to allocate ISP's network resources fairly and efficiently. It can be also used to overcome the network congestion problem.

The proposed billing system includes two main components:

- The traffic flow meter routine, which is a routine used for collecting data about traffic flows at the metering point within a network. This routine processes every incoming packet to determine whether the packet is ignored or counted and to which flow it belongs. The meter routine is implemented in the router (packet-forwarding device). The collected data is stored in the traffic flow file for later processing required for invoice generation.

- The invoice generation routine is a routine, which processes the usage data stored in the traffic flow file to generate invoices that reflects users'network usage. The billing or accounting process of users will depend upon the pricing scheme used within the proposed billing system. This pricing scheme will be a multi-part tariff, which consists of two types of charges (fixed and variable charges).

The variable fee or usage charge will vary proportionally with traffic volume, transfer rate, and network load. So, we concluded a simple form used to compute this portion of charge. This form is:

- ***Usage Charge=[(C1*V)+(C2*NL)+(C3* ROT)]/3***
- ***Total Charge = Usage Charge + Fixed charge***

- Under the proposed billing system, connection establishment is delayed while authenticating the user and verifying that they will pay. Therefore, we measured the connection setup time without the billing system and with it to determine the additional connection setup latency (delay). We found that the average additional delay is 0.332 Sec (332 ms).
- We also measured the number of active connections with 60min timeout and without timeout to determine the size of the connection table. With 60min timeout, the maximum number of active connections is decreased and also there will no be any significant upward drift.
- We also study the effect of searching methods on the average response time. We found that the most efficient technique is to use f_{CAM3} with 48b CAM-based connection table.

References

[1] Gregory R. Ruth, "Usage Accounting for the Internet", In public access to Internet, May 1997.

[2] Nicholas Economides, " The Economics of Networks", International journal of industrial organization, vol. 14, no. 2, March 1996.
[3] Jong Gong and Padmanabhan Srinagesh, " The Economics of Layered Networks", Presented at MIT workshop on Internet economics, March 1995.
[4] Cocchi-R, Shenker-, Estrin-D, and Lixia-Zhang, " Pricing in Computer Networks: motivation, formulation, and example", IEEE/ACM Transactions on networking, vol. 1, no. 6, Dec. 1993.
[5] Lee W. Mcknight and Joseph P Bailey, " An Introduction to Internet Economics", Presented at MIT workshop on Internet economics, March 1995.
[6] Joseph P. Bailey, " Internet Economics: What happens when constituencies collide", In public access to Internet, April 1995.
[7] Lee W. Mcknight and Joseph P. Bailey, "Global Internet Economics", Brazilian Electronic Journal of economics, Dec. 1997.
[8] Joseph P. Bailey, " Economics and Internet Interconnection Agreements", Presented at MIT workshop on Internet economics, March 1995.
[9] Oystein Foros and Bjorn Hansen, " Competition and Compatibility among ISPs", In Public access to Internet, Aug. 1999.
[10] Geoff Huston, " ISP Survival Guide Strategies for Running a Competitive ISP", In Public access to Internet, Oct. 1998.
[11] Pras-A, Van-Beijnum-B-J, Sprenkels-R, and Parhonyi-R, " Internet Accounting", IEEE communications Magazine, vol. 39, no. 5, May 2001, pp108-113.
[12] Gupta-A, Linden-LL, Stahl-Do, and Whinston-AB, " Benefits and Costs of Adapting Usage-based Pricing in a Subnetwork", Information Technology & Management Journal, vol. 2, no. 2, 2001, pp175-191.
[13] C. Mills, D. Hirsch, and G. Ruth, " Internet accounting: Background", IETF, RFC 1272, 1991.
[14] H. W. Braun, K. C. Claffy, and G. C. Polyzos, "A Framework for Flow-based Accounting on the Internet", Proc. Singapore Int. Conf. Networks, 1993.
[15] Borella-MS, Upadhyay-V, and Sidhu-I, " Pricing Framework for a Differential Service Internet", European-Transactions on Telecommunications, vol. 10, no. 3, May-June 1999, pp275-288.
[16] N. Brownlee, " New Zealand Experiences with Network Traffic Charging", ConneXions, vol. 8, no. 11, Nov. 1994.
[17] D. Estrin and L. Zhang, " Design Considerations for Usage Accounting and Feedback in Internetworks ", ACM Comput. Commun. Rev., vol. 20, no. 5, Oct. 1990, pp56-66.
[18] Richard J. Edell, Nick Mckeown, and Pravin P. Varaiya, "Billing Users and Pricing for TCP", IEEE Journal on Selected Areas in Communications, vol. 13, no. 7, Sep. 1995, pp1162-1175.
[19] Santiago J. Villasis, " An Optimal Pricing Mechanism for Internet End-User ", In Public access to Internet, May 1996.
[20] N. Brownlee, " Traffic Flow Measurement: Architecture", IETF, RFC 2722, Oct. 1999.