A Proposal for Billing Internet Services

Based on User Throughput and Services Categorization

Marcos Paredes Farrera; Gilberto Flores Lucio, Mohammed Ghanbari
Audio-Video Networking Research Group
Department of Electronics Systems Engineering, University of ESSEX
Wivenhoe Park, Colchester CO43SQ/United Kingdom
E- mail: mpared@essex.ac.uk, gflore@essex.ac.uk, ghan@essex.ac.uk

Abstract

This paper presents a scheme for billing services provided by the Internet Service Providers (ISPs). We present a brief review of the role of the ISP and how it may evolve to provide new services. We divide the services into three different categories: "Internet Connection", "Proxy services and local services", and "Fixed services". We introduce the concept of "effective throughput" (which is the data consumed by the subscriber) and we show how to measure and bill this parameter. The first service category includes the Internet connection, and the billing is based on the effective throughput. The "proxy and local services" are services provided directly from the ISP, and they are billed with a reduced price based on the effective throughput. The "Fixed Services" category is the services transmitted over the Internet, which require certain level of QoS (Video, voice and multimedia); the billing is based on the cost of the service provided by a third party and the use of the network. Finally we present the advantages of this model compared with other schemes like INDEX and CASHMAN.

Key words: Billing internet services, billing effective throughput, categorization of internet services, Internet connection, fixed services, proxy services.

INTRODUCTION

Billing Internet services is one of the key factors in the development of the Internet. This will give an incentive to the ISP and telecommunications companies to increase link capacity and the QoS.

The function of the ISP has evolved in a similar way to the telephone companies. Their initial role was to offer interconnection services to calls between the subscribers. However with the developments in technology, new services like voice mail, roaming, voice conference, automatic operator, call forwarding, call tracing, call return and "Internet", are also part of their scheme. In this way the telephone operator became a service provider that offered services through the telephone system [i]. In a similar way the ISP has evolved from giving basic services like Internet connection to more advanced services like proxy servers, e-mail and web hosting. Initially, the network was aimed at providing the connection between the users and the Internet Backbone. Later other common services were developed like web hosting, e-mail and information services [ii]. When an ISP has a high network capacity, it may offer services like connectivity and access to the Internet backbone to other ISPs. Consequently the network has become a multi service network; and we therefore can claim that the ISPs are bound to assume a new role.

The scheme of billing the Internet, at present, is based on flat rent. The flat rent model present the following shortfalls [iii]:

- Encourages waste of bandwidth and increases cost.
- Forces light users (users with lower use of resources) to subsidize heavy users.
- Can introduce differentiated service quality only by inefficient segmentation in quality tiers.

One of the main concerns for the ISP is how to cope with the increase of the traffic, as well as how to prevent users from behaving inadequately with the use of the bandwidth. A policy of good use of the network call "Acceptable Use Policy" (AUP) was created, the first AUP [iv] was used in the NSFNET Backbone, which prohibited Backbone usage for purposes "not in support of Research and Education". The policies are guidelines to restrict the use of bandwidth, and the amount of data that a user can download.

In order to avoid congestion in the network, the ISP provides proxy services such as: the web cache, video cache, and ftp (store popular software). However, these services are presented as an option, and most of the time not was by the subscribers. The ISP occasionally makes it mandatory to use these services. Other restrictions that the ISP introduces are:

- CAP the users connections.
- Introduction of the AUP
- Block ports of well known peer-to-peer sharing applications.
- Ban or cancel the accounts of heavy data traffic customers.

It is ironic that the ISPs offer a faster connection to the Internet, when they do not want the users to make full use of the offered bandwidth capacity offered. On the other hand, they are blocking and limiting a wide range of services on the Internet.

The connection type limits the amount of data that subscribers can download [v]. This is shown in Table 1.

Speed	**Connection Type**	**Transfer Time**
28.8 kbps	Analog modem	2 hours
33.6	Analog modem	1.5 hours

kbps		
56 kbps	Analog modem	1 hour
128 kbps	ISDN dual channel	20 minutes
1.5 mbps	T1, xDSL, or cable modem	1 minute
4 mbps	xDSL or cable modem	30 seconds
10 mbps	XDSL	10 seconds

Table 1. - Comparison of different types of connections downloading a 10 Mbytes file.

Table 1 shows the different types of connections that are offered by an ISP. It can be seen that the analog modem restricts the amount of data that a user can download. The maximum speed for a modem is 28800kbps ≈ 3.5kbytes/s and in the case of xDSL, it is 10Mbps ≈ 1.2 Mbytes/s. It can be observed that the user reduces the time of download with better technologies but increases the traffic in the network. If the subscribers are offered faster connections (i.e. cable modem, xDSL, XDSL) they will be able to download larger files in shorter times. Table 2 shows the normal activity of a typical subscriber [vi].

Application	**Data downloaded (Mbytes /hour)**
Internet Relay Chat	0.5
General web surfing	5-10
Games (like Quake)	15-30
Streaming media (64 kbps)	30
Streaming media (128 kbps)	60
Streaming media (256 kbps)	120

Table 2. - Relationship between the data downloaded per hour and the application.

It is shown that an ordinary subscriber does not produce very high traffic. Web browsing is the most common activity and it adds from 5 to 10 Mbyte/hour onto the network traffic. Though, Killer application like, peer to peer sharing or downloading files, could exist and take all the available bandwidth. These applications can flood the network easily, and most of the times, they appear like a trend. A network can be working in good levels of operation and in the following week, with the release of new peer-to-peer software, the network can be congested. For example Napster showed an increase of 50% in traffic in only two months on the AMES Internet Exchange [vii].

Due to these motives, it is necessary to find a new model for billing the Internet. This model should give an incentive to the users to constrain and establish the traffic priorities, giving a better use of the ISP private network and encouraging new developments. The model should focus on billing different services that an ISP is providing, or will provide.

There are different proposals for charging in the Internet, based on:

- The effective bandwidth (based leaky bucket regulators, duration and volume)[viii,ix], this model is based on ATM.
- Expected capacity (based on a traffic meter at the source)[x], based on ATM.
- Price control, congestion avoidance pricing, routing, interoperation [xi], a more general model based on the communication system and the Internet services.

2. MULTISERVICE NETWORK AND SERVICE CATEGORIZATION

An ISP usually has a robust infrastructure, including a network with high switching capabilities. Nevertheless, the links from the users to the ISP are slow, and the connection between the ISP and the Internet Backbone is also slow. In the near future, we expect that ISP will provide Access and End-user Services, changing the way that the users get connected to the Internet. Some of the broadband technologies keep the user online all time, even if the computer is turn off [vi]. This means that the user will have access to a large bandwidth permanently. On the other hand, when the bandwidth increases, the ISP can offer novel Internet services.

2.1 Service Categories

Based on [ii] an ISP can provided services, in the Internet Service Layer, to the end user like:

- *Connectivity Service Provider.* It provides all the resources necessary service to forward packets in its own network. It works at the network level.
- *Information Service Provider.* This service process and supply information to users, and it works at the application level.

We propose a three-service categorization model, where every category embraces a group of services with common necessities:

- *Internet Connection*. – Provides access and connection to the Internet. This is a small part of the connectivity service.
- *Internet local services and Proxy Connection*. - This category was intended to lighten the traffic in the ISP network. It provides a faster access to redundant data that is frequently accessed by subscribers. For example: Popular Web pages, downloads, upgrades, video proxies, local ftp servers, local news servers, local

game servers. These services are a mixture of the connectivity and information services.

- *Internet Fixed Services.* - This category holds the services that need a constant bit rate, such as: IP telephony, IP TV Broadcast, IP videoconference, IP radiobroadcast and web hosting. These services are mainly related with the Information service provider, and may also be provided by a third party.

ISPs are already using the services in the first and second categories. The third category will require a better allocation of the resources, QoS, and mainly a large available bandwidth between the ISP and the users. If these conditions are fulfilled, the ISPs could give services like telephony and TV broadcast.

2.2 Billing the Services.

The next step is billing the services. Every category provides a different service to the user and is one set of requirements for the network and the information services.
We divide the cost of the network in two parts: Static and dynamics costs [ix]:

Static = Infrastructure + OAM[1] *+ License* …(1)

Dynamic = Internet Connection + proxy services + Fixed Services … (2)

The total cost is calculate as:

Total cost = Dynamic cost + static costs. … (3)

The next step is to calculate the billing for each category.

Internet Connection. - The billing scheme for this category has two components. The first one uses the same scheme used today by the ISPs, where the user has to pay a flat rate rent every month and has and allowance of downloading stream of 200 to 500 Mbytes per day [vi]. Nevertheless if a user crosses this limit, they will be billed per every Mbyte downloaded. The same method is used for the upload stream. The second approach is based on a unique payment for the Internet installation and it is not a flat rate. The ISP will bill the effective throughput that the subscriber uses. In section three a technique used to measure the effective throughput is explained (upload and download streams).

Internet local services and proxy services. - This category uses the same approach as the previous. The difference is that the ISP can give more allowance to this type of service (Mbytes), and the cost per Mbyte is reduced because the ISP is using local services (i.e. if the ISP has a web cache proxy server, the web pages are stored in the server and are downloaded only once from the internet). Therefore the next subscribers will access the web page stored in the server.

[1] Operation Administration and Management.

In the same way the ftp servers can store software commonly used like software CD images, with the CD being downloaded only once from the Internet. All the subscribers can in the future download this software without flooding the ISP Internet connection, something similar happens with video proxy servers and the game servers. This price reduction will give an incentive to use these services instead of a direct connection to the Internet, providing a priority in the traffic and a better use of the resources.

Internet Fixed services. - The cost of services will rely on the price of the service provided by a third party, regulations and most of the time the market politics. It must be remembered that in this part all the services that require a guaranteed level of QoS are accommodated. The ISP provides the quality, and the services deployed will depend on the network speed and reliability. Services like voice over IP can be offered. The interconnection of phone calls can be done by the ISP in its own area but in the case to connect the call to other areas, the connection and the cost will depend on others ISP and telephone companies. Another example is the TV broadcast and high quality video on demand to the users. The ISP must take care that the cost of implementing these technologies will not surpass the cost of services that are being offered by other companies (i.e. cable TV, telephone).

This research paper have analysed the billing scheme for the first two categories and, the third one is for future work.

3.- BILLING THE EFFECTIVE THROUGHPUT

The definition of Effective Throughput is the amount of data transmitted or received by the subscriber. This data is measured at the top of the TCP/IP suite. This means that a user will not pay for the transmission of headers in the IP layer and lower layers, but only for the useful data transmitted through the network. Making an analogy with a telephone system a subscriber does not directly pay for the technology used to transmit voice. A subscriber doesn’t decide if they prefer to send the voice over ATM or over Fibre optic, or compress the voice. They just expect a certain level of performance. In the same way an ISP subscriber just expects to download the data that is needed in an expected time. This billing method can be used for most network technologies; frame relay, ATM, Ethernet, Switching, xDSL, ISDN, T1. The user will measure the performance from the IP layer.

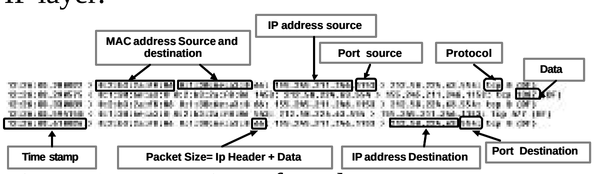

Figure 1. – Fraction of tcpdump output.

In this method, we have implemented a billing system based on a Linux router that works as a Gateway. The router connects the ISP with the ISP subscriber, as the billing data is collected at the Router. Tcpdump was used to monitor every packet forwarded by the Linux router, and another program Tcpflw was used to filter and analyse the collected data.

For this analysis packets were categorized intro flows. Every packet that is sent and received has, in the header, an IP source address, IP destination address, and in the case that the packet use UDP or TCP, it has the port source and destination numbers. The term flow is used in our analysis to represent the pair combination: "IP-address source and IP address destination", this combination is used to represent the existence of a flow of packets between the source and destination host. For instance, if we use tcpdump to monitor an Internet application, form Figure 1, we can obtain a combination of IP address host source and destination:

155.245.211.246 /1153 → 212.58.224.63/554

From the second line of Figure 1 we observe the following combination:

212.58.224.63/554 155.245.211.246/1153

Our host is 155.245.211.246, the ports are not important at the moment. What will be used is the position of the host address in the left, which represent the packets that are being delivered, and in the right the packets received. Every packet is labelled as flow one for the delivered packets and flow two for the arriving packets. We can analyse only one host or we can analyse a subnet with just taking the first 3 octets.

Classification of the packets is an important step in billing. However we have to decide what is the data that we need to classify. We can classify the packet, just into delivered and received packets; or we can classify them based on the combination of the ports. However, if we increase the filtering complexity the data that we collect is large.
For this model we recommend to classify the packets according to:

- Flow 1. - Incoming packets from the Internet.
- Flow 2. - Arriving packets to the Internet.
- Flow 3. - Incoming packets from the proxy and local services.
- Flow 4. - Arriving packets to the proxy and local services.

This filtering scheme can be used to mark the packets that are being forwarded by the gateway.

The following task is to measure the effective throughput of the flows analysing the size of the packets. We define the Effective Throughput as "The amount of data transmitted or received over the network in a fixed amount of time". Based on this definition we can determine the amount of data by the total bytes transmitted Te, and the time used for the transmission P.

We then calculate the Throughput used by a host that generates packets in a time t. Therefore, the calculus is only the summation of the size of all the packets generated between t=0 and t=P, Te can be expressed as: $Te = \frac{\sum_{t=0}^{P} Ps(t)}{P}$
(4)

Equation 4 expresses only the effective throughput used during all the processes. If we wish to know the determinate range of time that the application used less or more bandwidth; we can divide the range between t=0 to P in n steps of size *P/n*. So if we wish to know the bandwidth use in an *i* range the equation 4 change to:

$$Te_i = \frac{\sum_{t=\frac{P}{n}i}^{\frac{P}{n}(i+1)} Ps(t)}{\frac{P}{N}}$$

$\therefore$ i =1,2,3 …n (5)

We can define the n ranges so we can monitor the subscriber activity every, hour, day, week, and month.

We have in some cases; measured the reception of video over Internet and the following statistics were measured by Tcpflw program:

Flow	**No Packets**	**Data +header**	**Effective Throughput**
1	563	25899	2253
2	10679	1953077	1504544

Table 3. Statistics that show the amount of data transmitted during a video session on Internet.

We can observe the difference between the data transmitted in the IP layer and the data compared with effective throughput. In flow one, the Effective Throughput just represents 8.6% of the total data transmitted. This is because of the acknowledgement packets. In flow two we can see that the data represent the 77% of the data received which has a much better rate of transmission.

Therefore, in the case of the second flow the subscriber will be charged with 1.46 Mbytes of downstream and 2.2 Kbytes of Upstream.

This scheme of billing will precisely measure the exact amount of data that the subscriber downloads and uploads to the network. Since the monitoring billing system is based on the TCP/IP protocol suite, we can extend this monitoring to any transmission technology. The use of Tcpdump is not mandatory to sniff the packets, however the software that performs this task should give us the time and the size of every packet in the router.

4. COMPARISON OF THIS MODEL WITH THE CA$HMAN AND INDEX PROJECT.

The Ca$hman project [viii] was aimed to create charging schemes for ATM Networks. The charging scheme is based on the effective bandwidth and the different QoS required for the users.

The INDEX project [xii] is aimed to analyse the behaviour of the users. The billing system is based on time connection and the speed of the network. Every user is charged per minute of use and the tariff increase if the user selects a faster connection.

Our scheme of billing is based on charging schemes for TCP/IP networks and is divided in three categories of services and billing. The first two service categories are based in the effective throughput; the only difference is the cost per Mbyte. The user can take the decision to change the connection to a proxy server just setting up his applications. The third category is the fixed services, this category is optional for the user, and will be used for applications that require a guarantee level of QoS like video, voice or any CBR application.

We can establish that our scheme is more "fair" because the real amount of data that the subscribers use through the network is what they are being billed for, and from an ISP perspective, this will help them to "educate" the subscribers to prioritise their traffic and therefore use the network resources more efficiently.

5. CONCLUSIONS

The categorization of the services and the scheme of billing based on the throughput will provided an incentive for the users to prioritise their traffic and avoid the misuse of the network.
A basic model based on static and dynamic parameters was presented to define the total network cost. From this model, the three categories were described

The first two categories ("internet connection" and "proxy and local services") provide an option to the user to use a direct connection to the Internet or a connection trough the local proxy caches. This will educate the users on how to prioritise the traffic and how to use the resources in a smart way.

Finally we have provided a methodology to realize the billing in the gateway side. This methodology can be used regardless of the platform employed.

Future work includes a more detailed dissemination of the costs to maintain the network in operation and prepare for future services. Also, define the means to bill the third category (Fixed services) based on present costs. Finally, the development of an "agent" that collects the information in the gateway side and upgrades the databases for a billing server.

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