

# Internet Pricing

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## Abstract

Internet pricing can be seen from two points of view - between service providers and end-users and between service providers. These two cases require a very different set of tools for price setting. Pricing schemes between providers and end-users should be simple because end-users may be willing to pay more for simple pricing schemes. But pricing schemes between providers are not as simple as in the end-user case. Service providers interconnect among themselves in order to provide good services to their end-users. Interconnection mechanisms among service providers have an impact on pricing. In this paper we concentrate on how pricing can be done for two cases - between provider and customer, between provider and provider.

**KEYWORDS:** Pricing, Internet, Interconnection, flat-rate, usage-based, auction

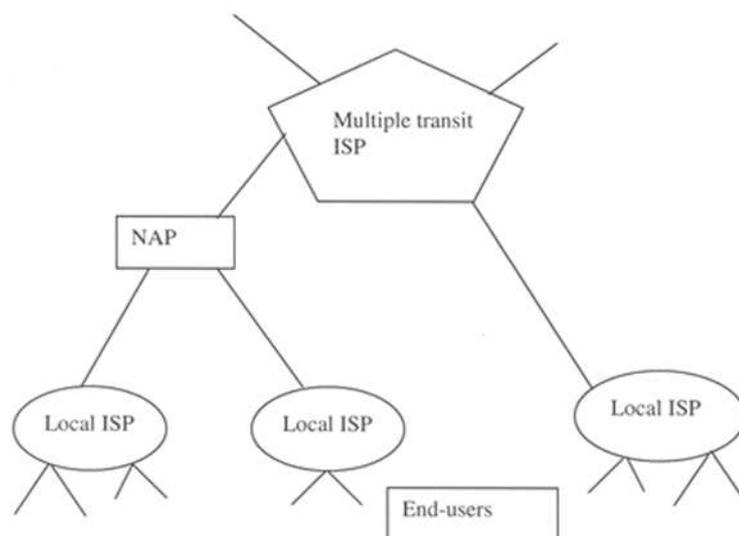


Figure 1: The structure of the internet

## 1 Introduction

To find an efficient and usable pricing scheme for the Internet has attracted a lot of research effort over the last decade. Many pricing models have been proposed so far, such as Flat-Rate, Usage-Based, Smart Market [1], Paris-Metro [2] pricing etc. These pricing schemes try to provide different levels of services to different end-users with different needs. These schemes are designed to charge end-users only for their perceived quality of service (QoS)[1] and consumed resources and also help Internet service providers (ISPs) develop profitable business models.

Pricing can be considered as an effective means to recover costs. In order to attract users, some ISPs are offering the lowest price for Internet access. The primary pricing scheme currently offered by Internet service providers in the USA is flat-rate pricing scheme that allows end-users to access the Internet for a flat monthly rate [3]. In Europe, although flat-rate pricing scheme exists, ISPs mainly offer usage-based pricing schemes [3]. Several facts need to be considered in choosing a pricing scheme. Pricing schemes should be such that end-users are allowed to select among different set of services in a controlled manner. For example, users might like the options of purchasing either more or less capacity of the bandwidth during the congestion periods. End-users connect to the Internet in different ways, such as modem with telephone line, Asynchronous Digital Subscriber Line (ADSL) etc. There are also a growing number of mobile users of the Internet. Each of the above mentioned mechanisms require a different set of pricing schemes. In this pa-

per, we categorize Internet pricing schemes into two classes - end-users and providers. There is a strong relationship between end-users and providers in Internet pricing. End-users always want the best services at low cost whereas providers want to maximize their profit. Internet pricing schemes aimed for the service providers are critical because they have different mechanisms for provider to provider case and for provider to end-users case. Network service providers need to interconnect with other service providers in order to provide truly global services. They need to negotiate with others about interconnection agreements and tariffs so that they can provide the best services to their end-users.

This paper is organized as follows. Section 2 begins with describing the current Internet structure, how traffic is exchanged among network providers. Then in section 3 we describe some of the existing pricing schemes. In section 4 we discuss the pricing schemes suitable for customer and service providers.

## 2 Interconnection

Users who are connected to different networks will be able to communicate with each other if there is an interconnection of the networks. Interconnection is important if networks are to offer truly global services. In this section, we discuss interconnection mechanism, exchange of traffic among the networks and impact of these issues on pricing.

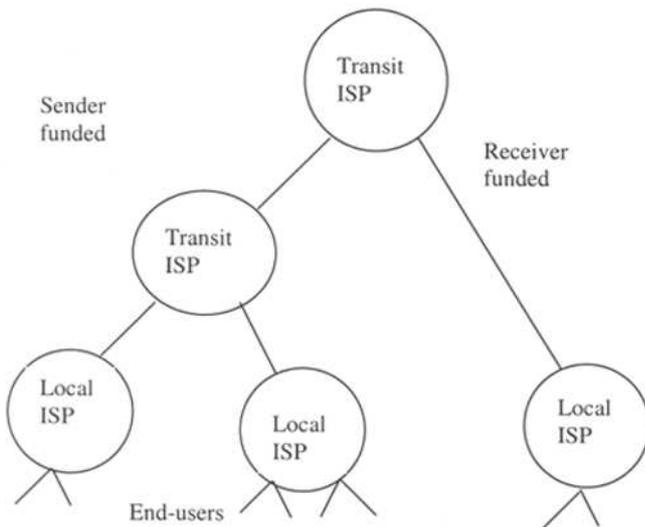


Figure 2: Hierarchy of providers

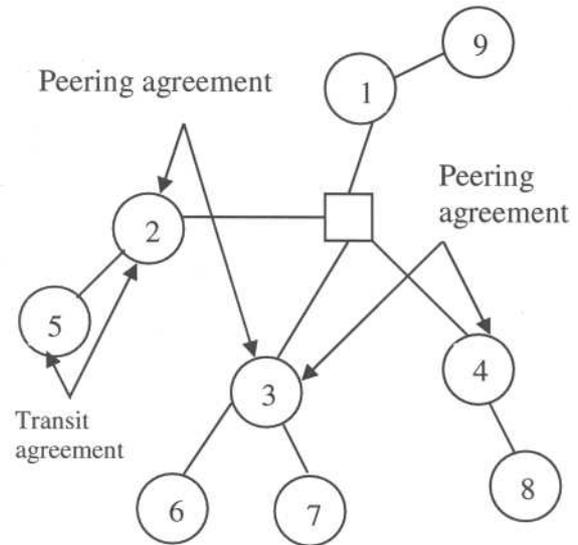


Figure 3: Interconnection agreement

Internet is a collection of different networks [4]. We can divide the networks into two groups: a group of local networks connected to each other providing end-users with connection points to the network and networks providing connectivity between local networks. Figure 1 shows the structure of the Internet with three main levels of participants: end-users, ISPs, transit ISPs. Local Internet Service Providers (ISPs) provide services in small regions and transit ISPs transfer data between local groups. The groups exchange data with each other at Network Access Points (NAPs).

In the Internet, there is a hierarchy of providers. The sender does not pay for the end-to-end transport of traffic, but only a part of the path. Once the traffic passes beyond the sending ISP's service domain, the receiver implicitly assumes responsibility to pay for the traffic and the second part of the complete transport path is paid by the receiver. Figure 2 illustrates the hierarchical model of interaction. It is seen that higher level ISPs charge regardless of traffic direction. The higher level ISP is said to provide a transit service to the lower levels. However, the hierarchy is not rigid. Traffic could be exchanged within local groups within a region. Therefore, traffic need not traverse the whole of the hierarchy.

Once interconnection is in place, a network service provider can use the infrastructures of a number of other networks to provide services to any of his customers. In present Internet practice traffic is exchanged between network providers in two ways - peering and transit traffic [4]. In peering, traffic is exchanged between two data network providers without payment but in transit traffic both parties have to pay interconnection charge depending on the agreement between them.

Let us consider the example of Figure 3. Networks 1, 2, 3 and 4 are the transit networks. They provide transit services to networks 9, 8, 7, 6 and 5. Suppose networks 2 and 3 agreed on peering agreement. Network 2 advertises network 5 to network 3, and network 3 advertises networks 6 and 7 to network 2. Similarly, when networks 3 and 4 peer, network 4

advertises network 8 to network 3, and network 3 advertises networks 6 and 7 to network 4. We can see from the example that network 3 does not advertise to network 4 the information it obtained from network 2 concerning the reachability of network 5. However, since the network 3 charges networks 6 and 7 for transit service, it does advertise networks 6 and 7 to its peers.

Peering agreements have some distinct characteristics. Peering partners exchange traffic on bilateral basis, the traffic originates from a customer of one partner and terminates at a customer of the other partner. This allows customers of the two networks to exchange information. Network service providers consider several factors when negotiating peering agreements [4]. These include the customer base of their prospective peer and the capacity and span of the peer's network. Clearly, some providers have greater bargaining power than others. It may be of no advantage for a provider with a large customer base to peer on an equal terms with a provider with a small customer base.

Transit agreement has important differences with peering. Now a partner pays another partner for interconnection and the partner selling transit services will route traffic from the transit customer to its own peering partners as well as to other customers. Transit agreement gives an ISP customer access to the entire Internet, not just the customers of its peering partners.

### 3 Pricing Schemes

There has been an explosive growth in the number of ISP networks recently. This has placed considerable pressure on ISPs to come up with new, more attractive pricing schemes. The options available to ISPs for charging their customers allow a full range of pricing models based on the relationship between quality and cost.

A different variety of pricing schemes exists for the Internet, such as hourly charges, flat-rate charges, volume based

charges and many other forms of charging schemes. In this section we discuss several proposed pricing schemes.

### 3.1 Free Internet Access

In order to attract more customers several ISPs offer free Internet access for certain period of time and additional hours are billed to the customer. The only cost involved in this scheme is the cost of a modem and telephone call charge or other form of connection costs. It is possible that in this model users may not get the preferred level of QoS guarantee. This model is not a long-term feasible model and currently, most of the ISPs offering free access service have gone out of business.

### 3.2 Flat-Rate Access Pricing Model

Flat-rate pricing scheme is the most widely used pricing scheme for the Internet access in USA [3]. This model involves a fixed monthly fee that allows the end-users an unlimited access to the Internet. Additionally there is a limited flat-rate pricing that is either based on time or on the volume delivered to the customer.

Some ISPs offer flat-rate access pricing contracts for unlimited access. These offers generally attract a large number of high bandwidth consuming users and places considerable pressure on network facilities. The main advantage of this scheme is low administrative and billing costs for the ISP. In addition invoicing and payments may take place in advance of service delivery. From the customer perspective the main advantages are the flexibility in accessing the Internet and the absence of marginal costs.

However, with flat-rate access pricing lower volume customers may increase their traffic without generating corresponding increase in the revenues of the ISPs. In order to overcome this problem the ISP can raise the flat fee to reflect the average usage levels. But this solution may produce negative impact on the number of customers, as customers can move between ISPs in order to optimize costs within a strongly competitive price-based market.

Limited access flat-rate pricing is another variation of flat-rate pricing scheme. In this pricing scheme an end-user can access the Internet for a fixed number of hours per month and download a fixed number of megabytes per month. A typical offer may be 100 hours of access and 250 MB of download. This scheme has a clear benefit to the ISP. Users who produced increased levels of cost by downloading greater volumes of traffic pay a greater amount.

### 3.3 Usage-Based Pricing

Usage-based pricing scheme is popular scheme in Europe and Asia [3]. This scheme is also known as metered pricing. Usage-based pricing is mainly volume or time based. In volume based pricing scheme user is charged based on the size of the data delivered to the user. In time based charging ISP mainly offer per-minute pricing. Rates may vary depending on the time of day to encourage smooth utilization of the available bandwidth resources. This pricing schemes gives end-users to monitor their usage of the various applications

available to them. The disadvantage of usage-based charging scheme is that they do not motivate the user to use and spend more time on the Internet.

### 3.4 Smart Market Pricing

Jeffrey MacKie-Mason and Hal Varian [1] proposed a model called smart market to charge the end-users when the network is congested. The charge in this scheme is determined through an auction [1]. In this scheme each packet contains a bid field where the user expresses his willingness to pay for the transmission of a packet. The network collects all the bids and makes a decision on which packets to be transmitted. The network determines a threshold value depending on the capacity of the network. This threshold value is called marginal cost. It then transmits all the packets whose bid exceeds the threshold value. Instead of charging the actual bid, each transmitted packet is then charged this marginal congestion cost.

There are some disadvantages of smart market pricing model. This model is not compatible with existing technologies. It requires a lot of technical changes to networking protocols and hardware. Providers need to keep record of all the packets transmitted from a user and for each transmitted packet the user's billing records need to be updated. The scheme only ensures that the packets are transmitted according to their relative priority, determined by the bid. So there is no service guarantees or even a guarantee of transmission in this scheme. There is also a problem of social distribution in this scheme. Poor users may not be able to use the service in this scheme, hence creating a problem of social distribution.

On the other hand, smart market pricing encourages both network and economic efficiency. If the users have unlimited access to the Internet, they will create congestion that results in delays and dropped packets for other users. Using an auctioning mechanism some users are denied or delayed to transmit the traffic during congestion. In this scheme bid represents the benefit to the user of having the packet transmitted. If a packet is valuable to a user, he set the bid in such a way that represents the social value of the packet. Bandwidth is allocated according to the bids, and is given to those users whose traffic is socially most valuable. Another important thing is that bids carried in each packet could also be used to decide how routing of the packet will be performed. Packets with high bids could be routed over shorter paths to minimize the transmission delay, whereas packets with low bids may be routed through longer paths.

### 3.5 Paris-Metro Pricing

A.M. Odlyzko [2] proposes a scheme based on the pricing of the Paris Metro, called Paris-Metro Pricing (PMP). In this scheme, the total bandwidth capacity of the network is divided into several logical subnetworks. Network operators set the prices for each logical subnetwork. Each logical network is priced differently to provide different levels of services to the different end-users. Users choose one of these logical subnetworks for the transmission of their traffic. Users make a selection of the logical subnetworks based

on their budget and preferred level of service. In this scheme higher priced subnetworks will experience lower utilizations and will be able to provide a higher service level.

Paris Metro Pricing has some advantages. It is one of the simple schemes that have been proposed so far and also compliant with existing technologies. In this scheme pricing affects the generation of traffic. Users choose network depending on their budget and therefore select their own service level.

There are some disadvantages of this scheme. Since there are different levels of services available in this scheme, providers now need to keep track of each user's choice of network for billing and accounting. Though PMP provides different level of services, it does not support QoS guarantees within logical subnetworks. Because of the price differential, utilization levels of higher priced networks are low and lower priced networks are high. There is also a problem of instability in this scheme. During congestion periods, some users may choose a higher priced network to get better service. This may create congestion in the higher priced networks and cause instability.

## 4 Discussions

By charging users, the Internet service providers attempt to cover the costs. Mackie-Masion and Varian [1] identify five types of costs. First is a fixed cost of providing the networking infrastructure. Second is an incremental cost of connecting to the network. Each new connection to the Internet involves cost for access lines and switching equipment. Third is the cost of expanding the network's capacity. This cost should only be beared by the users who wish to use the network when it is congested. Users who are willing to defer their transmission during congestion times should not pay for the expansion of the network's capacity. Fourth is an incremental cost of sending an extra packet. This cost should be very zero when the network is not congested. Finally, the social cost of delaying other users packets when the network is congested.

Many different Internet pricing schemes have been proposed so far. Several facts need to be considered when choosing a pricing model. Falkner, Devetsikiotis and Lambaris [5] list several points to consider in choosing the pricing model. Pricing schemes should be compatible with existing technology. Pricing schemes that are compatible with existing technologies are easier to adapt than those requiring significant changes in the existing technology. The amount of measurements required for billing is an important criterion. It indicates the implementation complexity of the pricing schemes. If a pricing scheme requires extensive measurements, that pricing scheme provides complexity in billing process. Support for congestion control or traffic management is another criterion in choosing the pricing scheme. Sometimes user's connection may be refused, hence forcing the user to delay the transmission. Support for individual quality of service is also important in choosing pricing scheme. Resource utilization is important when choosing pricing schemes. Low utilization levels is important for users because low utilization means availability of service. A highly utilized network, on the other hand, may have to deny

service to some users. Pricing scheme should be such that it does not prevent some users from accessing the Internet during congestion periods because of their inability to pay. This criterion is referred as social fairness.

To choose pricing scheme for users, perhaps the most important consideration is user perception. Users want flexibility in choosing QoS for Internet access and do not want a constantly meter calculating usage-based charging to access the Internet. Many users are reluctant to accept complex pricing mechanisms. They prefer a simpler, more predictable mechanism. There are strong arguments for flat-rate pricing in the end-user case. Odlyzko [6] cited some arguments in favour of flat-rate pricing scheme. A frequently cited one is that of reduced costs for service providers and simplified life for consumers by providing a single bill and a single point of contact. The value users place on network performance depends on the task at hand. For file transfer, a user might be interested only in how long it takes to deliver the last byte. On the other hand, in a video conferencing or such type of applications, a user might want to maximize bandwidth or minimize delay. So pricing scheme for the end-users could be a combination of flat-rate and usage-based pricing [3], where users choose a flat-rate basic service, which provides access to the Internet at a certain basic rate. In addition to this end-users will be able to request higher bandwidth on demand, which will be charged based on usage. From user's perspective this kind of pricing scheme gives the user flexibility. From ISP's perspective this kind of pricing scheme deals with the issue of over usage under a flat-rate service and also enables the ISPs to get additional revenues beside the revenues they would get from a purely flat-rate pricing scheme.

Pricing schemes among the service providers depend on the agreements among them. They have to decide whether to use peering and transit agreements. Consider the example in Figure 4. In the case that network A offers a transit service to network G, network A advertises to G all the destinations it can reach. Such information can be used by G and advertise to any other neighboring network that it can reach also the above destinations through network A. In this case network A charges network G a fee, since all the destinations reachable through A are also reachable through G from any network connected to G. This charge may be based on measuring the volume of data. But in the case of peering between network A and G, G uses the information about the destination reachable through A only for the benefit of its own customers and will not further advertise the destination to other neighboring networks. Assume that network J uses network B and network K uses network C for transit service. Suppose networks J and K observe that they have substantial traffic between one another. If network J and K peer they can save transit charges that they have to pay to networks B and C. They should decide to peer if the cost of doing so is less than savings they can make because their local traffic no longer needs to flow through the transit providers B and C. After establishing a new peering relationship, the transit contract can continue to act as a backup, to carry traffic between peers whenever the direct peering connection is out of order.

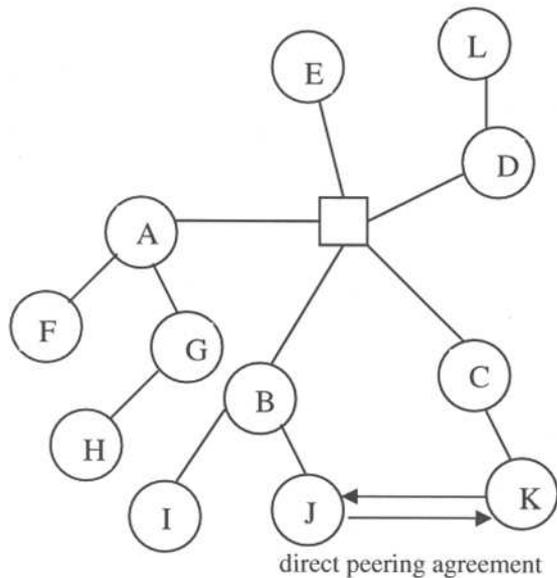


Figure 4: Interconnection agreement

## 5 Conclusion

In this paper we describe pricing schemes that could be used for end-users and providers. It is difficult to define exact pricing schemes for the Internet usage, because pricing schemes depend on many factors. Pricing schemes for end-users mostly depend on the behavior of the user. Users always want increasing QoS and at the same time simplicity and predictability of prices for a service. Flat-rate or usage-based pricing schemes could be preferable for end-users case. Other pricing schemes, such as paris-metro and auctions models are not suitable for end-users case as these models are complex models. Pricing schemes between providers also depend on many things, such as traffic crossing between providers, total number of end-users, whether traffic crossing between providers is generated during peak period or not. So simple peering and transit pricing schemes are too restrictive now-a-days. ISPs could use route based pricing schemes, where different rates are charged for delivery of traffic to different destinations. ISPs could also adopt more sophisticated pricing schemes based on usage of network resources. Auction model pricing scheme may be used between providers. But this model has a problem when there are multiple network providers between source and destination. In multiple providers case it is possible that auction might fail in one of the providers in the path and thus stop the transmission of traffic. If this problem could be overcome auction model would be the suitable pricing scheme for the providers.

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