CHARGING AN ATM NETWORK

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ABSTRACT
New services are emerging rapidly within the world of telecommunications. Charging strategies that were appropriate for individual transfer capabilities are no longer appropriate for an integrated broadband communications network. There is currently a range of technologies for the different services in use and a limited number of charging schemes are applicable for each of the underlying technologies irrespective of the services used over it. Difficulties arise when a wide range of services has to be supported on the same integrated technology such as asynchronous transfer mode (ATM); in such cases type of service in use and the impact it has on the network becomes much more important. This paper therefore proposed a new approach to charging in an asynchronous transfer mode network. It employed the use of bandwidth to determine the charges on the network. It was demonstrated that the proposed charging scheme met all the requirements of customers and of network operators. The result of comparison with an existing scheme showed that the performance of the new scheme was better in terms of meeting the expectations of both the customers and the network operators.

KEYWORDS*: Charging, ATM, Bandwidth, Pricing, Resources*

1. INTRODUCTION

Many advances have already been made in technology. The difficulty for the operators is to convince the users and the providers of the services that asynchronous transfer mode network is what they need. In the real world, this essentially means convincing them that it makes good economic sense; this raises the question, what will it cost? [6]. In order to answer this question, the operators must deduce the cost and produce a charging strategy that will suit the requirements of all the parties involved. Finding this strategy is, however, a challenge. For example, if POTS and Internet protocol (IP) are provided over a single link, should the charge be based on the rates for POTS and IP? [7][12] If so, there is little incentive for replacing current infrastructure and converting to ATM. On the other hand, charging on a single basis regardless of the service in use will not be adequate as this will make some services more expensive while making others far too cheap compared to their impact on the network as a whole.

In order to improve on the weaknesses of the existing charging schemes, some charging requirements are needed to develop a suitable scheme that will be more reliable and not be full of surprises to the customer. The new scheme is user friendly, easy to implement and at the same time, it can accommodate the flexibility of the ATM technology in terms of the way a customer may vary his bandwidth requirements while call is in progress, which is a great challenge for creating the charging scheme.

In this paper, a new charging scheme that offers users choices of varying bandwidth by performing data services with either the new charging scheme or holding on to the conventional scheme with acceptable degradation in performance. However by offering users discount in the bandwidth charging, they would be more satisfied than in a case of traditional scheme. The remainder of the paper is organized as follows. Section 2 describes a review of some related methods on charging. In Section 3, the proposed model is presented and the parameters involved are defined. Section 4 shows performance analysis of the charging model. In Section 5, the conclusion of the work is presented.

2. LITERATURE REVIEW

Several charging schemes that have been proposed can be grouped based on statistical bandwidth, effective bandwidth and dynamic methods.

Karlsson [14] charging is an interesting technique which initially gives the impression that it could make the ATM concepts and UPC redundant. Each connection feeds into a common ATM cell buffer. A charge is levied on each connection based on the instantaneous fill level of the buffer – the higher the fill level, the higher the charge. Kelly's [5] approach was based on the use of probability theory and requires knowledge of the statistics of the ATM cell traffic generated by the user's source. A version of Kelly's algorithm assumes the user has an on-off source for which he knows the peak bit rate as well as the probability distribution for the mean bit rate. Griffiths and Culbert [8] offered no surprises to user or operators, while at the same time allowing for some burstiness in the user's ATM cell stream. Murphy *et al* [13] proposed a distributed pricing scheme for embedded ATM networks. Parris et al [2] gave a framework for the study of pricing inn integrated networks. Anania and Solomon [10] examined how the allocation of costs in telephone distribution plant could change as new infrastructure models such as fibre optic technology and broadband ISDN control mechanisms are introduced. They suggested that as the variable costs associated with a B-ISDN network approach zero, the only practical way of pricing may be to levy a flat rate for access on each network user. Low and Varaiya [11] used resources like bandwidth and buffers to design and ensure that services are provided to customers in an ATM network in an optimal way. Lindberger [9] used cell loss ratio to develop a charging scheme for the small buffer cases. Botvich *et al* [4] used the notion of effective bandwidth developed by Kelly to further simplify the basis for charging. In Viero's scheme, at every particular second the number of cells that passes through the network was monitored thus generate an estimate of the average bandwidth from which calculations could be drawn.

3. PROPOSED SCHEME

In conventional circuit-switched networks, such as PSTN, when a call is setup, a constant bandwidth is allocated to the call which is at the disposal of user throughout the holding time. It has been extensively quoted that a voice user really utilizes the system resources only about 40% of the time [2]. However, if the line is used for 100% of the time, the user doesn't have to pay more but only pay for the used bandwidth at that particular time.

The scheme lays emphasis on **pricing bandwidth** to reflect network utilization, with users competing for resources. This method can be applied to general ATM networks and to full range of user and service types such as voice, video and data. Charging is mainly based on unused bandwidth. It is done to have a charging scheme that can allow discounted amount on the use of assigned bandwidth within a period of time. Charges over ATM networks include service and customer type related charge, subscription charge

3.1. Pricing Bandwidth

The system, made up of the users together with the network, has various resources that can be used to meet services demand. However in all realistic systems these resources are limited and some method of allocating them is needed when total demand is greater than the resource limit. In this paper, the resources are the capacities of the ATM connections. The bandwidth allocated to a user is considered to be a commodity which is sold by the network to the user. That the users are placing a benefit, or willingness to pay; on the bandwidth they are allocated. Given a price per unit of bandwidth, a user's benefit function completely determines that user's traffic input. Users are assumed to act in their own best interests to be capable of responding to changes in the price for bandwidth.

In the formulation, network constraints such as virtual path capabilities are translated into cost functions on the bandwidth demands. This is because one user's consumption of bandwidth gives rise to a social 'cost' which is borne by all users. The network operator sets the prices so that the marginal benefit the users place on their bandwidths is equal to the marginal cost of handling that traffic in the network. The network operator dynamically adjusts the prices based on monitored network conditions. It is assumed that when the price of bandwidth increases, users reduce their demands. There is no need for enforcement of call parameters in the new scheme because users do not declare anything about their traffic. The new approach is intended to be applicable to general ATM networks and to the full range data. However, a special case that is particularly suitable is that of a virtual private network (VPN) where operator controls the network and all applications running on it. The relative importance of various applications could then be varied over time and from node to node. For example, the operator may place a high priority on operational data transfer and low priority on other data transfers or interactive video and voice might get higher priority than other traffic types.

However, assigning dynamic priorities is difficult. If the real-time applications such as voice and video are given priority to ensure timely delivery, then data traffic may suffer higher loss though it may not be able to tolerate cell loss as well as voice. On the other hand, if priority is given to data and large buffering is employed, then real-time applications may suffer large variable delays.

3.2. Assumptions

The parameters used throughout the analysis are typical in the common practice of ATM networks. Assume that:

- a user function for each assigned bandwidth that has not been used
- Charge per unit bandwidth is close to 1
- Deployment charge and access charge should be minimal
- Difference between the lower and upper bandwidth limits should not be too much
- Packets used will be based on used bandwidth and packet loss will be based on lost packets
- The user stays on the network over a period, t, when a packet is sent.

3.3. Mathematical Model

Bandwidth allowed for the customer in any network is limited by the capacity of the link. Then the cost of using bandwidth, which may be fixed however, depends on the policy of the network operator. Moreover, every customer connected to that network pays a fixed access charge and deployment charge. Therefore, an **aggregate cost (C_A)** is calculated as:

$$C_A = C_{AC} + C_D + C_{BA} \qquad (1)$$

where

C_{AC} is the access charge, C_D the Deployment charge and the cost of using bandwidth C_{BA}.

But C_{BA} determines the total amount in monetary terms of the consumption of bandwidth. This is calculated as:

$$C_{BA} = k * B_A \qquad (2)$$

where

k is the cost of a unit of bandwidth and B_A is the assigned bandwidth otherwise known as the upper limit assigned to customer.

Equation (1) can therefore be written as:

$$C_A = C_{AC} + C_D + (k * B_A) \qquad (3)$$

UNUSED BANDWIDTH

To calculate the number of unused units of bandwidth, we subtract Used Bandwidth (B_W) from the Assigned Bandwidth (B_A) which yields

$$B_U = B_A - B_W \qquad (4)$$

Then the bandwidth not used is thus the B_U, from which the discount is evaluated, in form of a user discount function. Converting this to monetary values, a constant k (cost of a unit of bandwidth) is used to multiply the unused bandwidth; which gives

$$D_i = k * (B_A - B_W) \qquad (5)$$

where D_i is the discount function.

$$\text{If } \begin{cases} B_A > B_W & D_i \\ B_A = B_W & 0 \\ \text{Otherwise Di is undefined} \end{cases}$$

TOTAL COST

To calculate the total cost at the end of a session with emphasis on discount deducted, using equations (3) and (5), we have

$$C_T = C_A - D_i \qquad (6)$$

C_T represents total cost which comprises of Aggregate charge and the discount. Thus,

$$C_T = [C_{AC} + C_D + (k * B_A)] - [k * (B_A - B_W)]$$
$$C_T = [C_{AC} + C_D + (k * B_A)] - [(k * B_{A)} - (k * B_W)]$$
$$C_T = [C_{AC} + C_D + (k * B_A) - (k * B_A) + (k * B_W)]$$
$$C_T = [C_{AC} + C_D + (k * B_W)] \qquad (7)$$

4. PERFORMANCE ANALYSIS

In this section the performance of the proposed charging scheme was evaluated.

It was observed that the proposed charging model significantly reduce the total amount paid by a customer over the units of bandwidths used for the services without degradation in the quality of service. The result of the analysis is shown in figure 4.1. Moreover, reduction in the total cost over the bandwidth used is as a result of the discount deducted from the total cost. This is explained in figure 4.2.

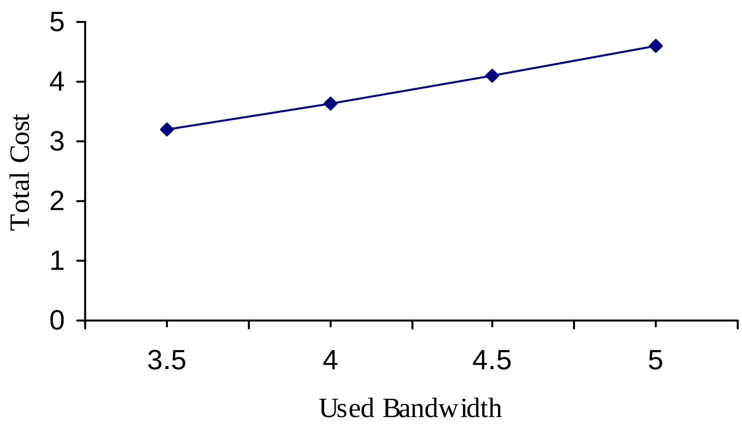

Figure 4.1: Total cost versus used bandwidth

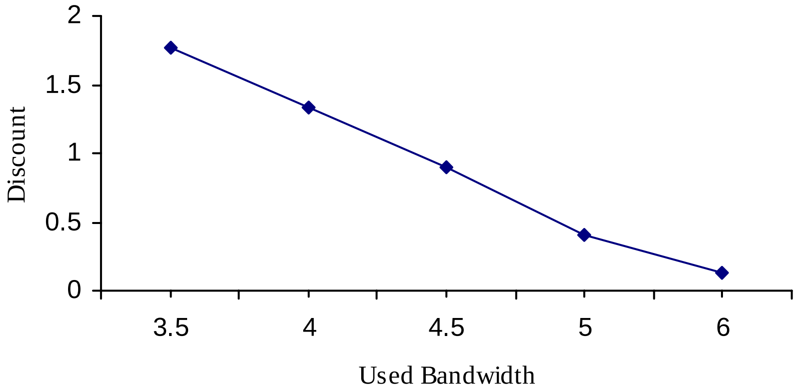

Figure 4.2: Discount against Used bandwidth

Figure 4.3 presents the total cost paid over the unused bandwidth. It shows that the decrease in total cost is due to the increase in the number of unused bandwidth. The reason can be found from figure 4.4. By increasing the number of unused bandwidth, discount given invariably increases thus reduces the total cost.

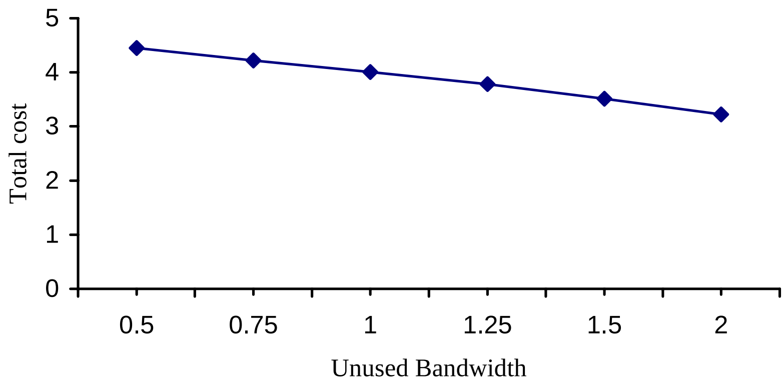

Figure 4.3: Total cost versus unused bandwidth

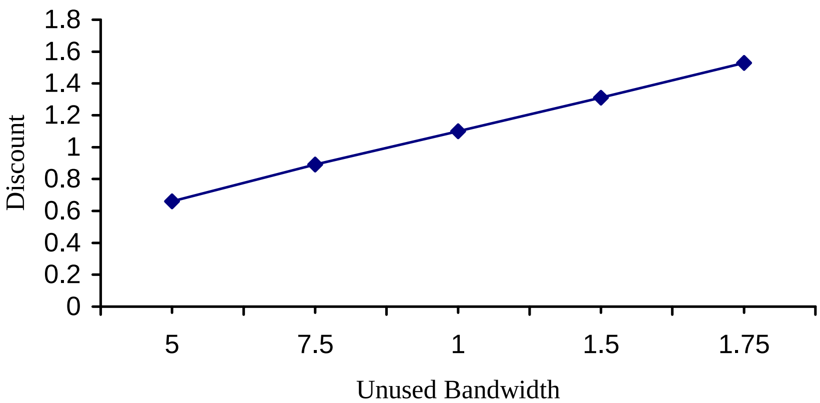

Figure 4.4: Discount against Unused bandwidth

As shown in figure 4.5 below, It can be deduced that both schemes have the same result, in that the higher the fixed cost (comprising the deployment charge and access charge) the higher the total charge. Moreover, that of the existing scheme increases at a faster rate thereby not favouring the customers because a little rise in fixed charge leads to a great rise in the total charge whereas a lot of measures were taken by the new scheme to avoid such rise so that when there is a little rise in fixed charge the affect is not much on the total charge and the operator still maintains maximum profit.

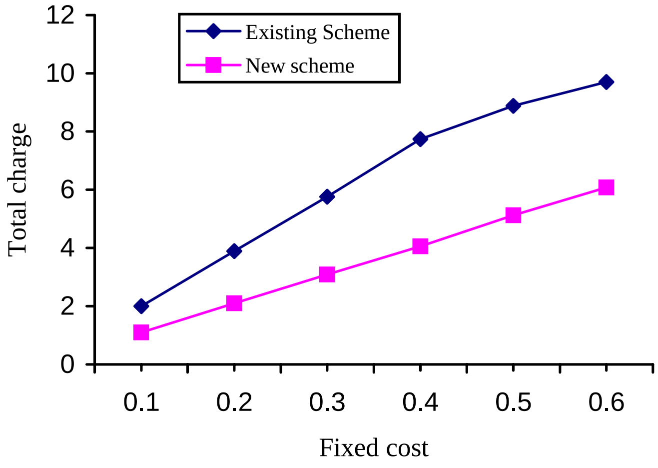

Figure 4.5: Total charge against fixed cost

Figure 4.6 illustrates the comparison of the two schemes under different conditions in terms of the total charge against the cost of a unit of bandwidth. One can clearly see from the graph that the total charge is considerably reduced by using the new scheme.

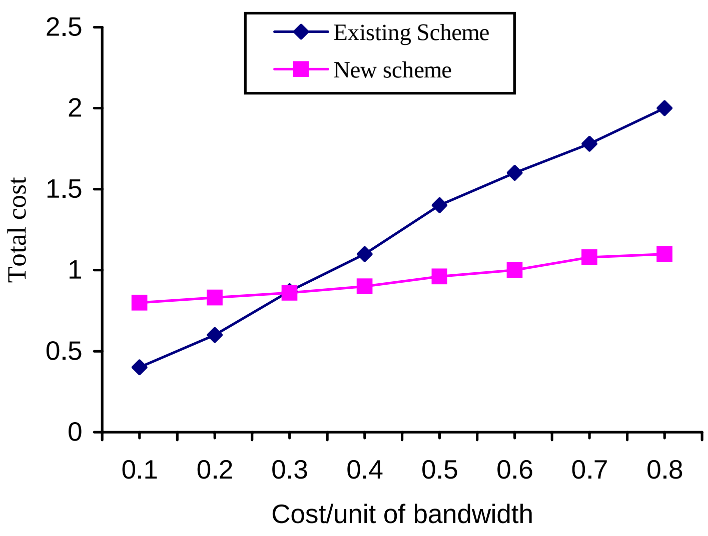

Figure 4.6: Total cost against Cost per unit of bandwidth

5. CONCLUSION

Charging for ATM network is an important step towards making the technology of ATM available to customers and service providers. Through the introduction of the charging mechanism can the bridge between the technology and business be made, leading to rapid deployment of ATM.

The charging scheme provides the incentive for users to utilize the network resource more efficiently. More importantly, due to this charging scheme, more user satisfaction and revenue could be gained. Users are potentially more satisfied with the fact that they can predict the total cost after using the resources with no quality of service (QoS) degradation.

The proposed scheme is designed to meet the necessary criteria to achieve a general acceptability. The techniques used to design and implement the key features of the scheme were evaluated theoretically. In particular, the proposed scheme was tested and compared with a number of other existing charging schemes. The result from the performance model shows that, the new scheme can significantly improve network performance.

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