On Charging for Internet Services provided over an ATM network

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Abstract: This paper explores the charging aspects of Internet services delivered over ATM. The process of charging scheme design in this paper is motivated by the fact that both market and technological considerations influence charging. This service-driven process has been developed and applied with success in an ATM environment by the CANCAN project. The scenario considered in this paper involves three layers of the service provision value chain. The actors involved are a network operator (NO), a value-added service provider (VASP), and internet users. The NO provides a wholesale transport service to the VASP and the VASP provides a specific retail internet service to end users. This approach was used in real trials conducted in CANCAN. The retail service trialled was access to an internet magazine. A few charging schemes are selected for both the wholesale and retail services, and sample bills are produced. These charging schemes are evaluated on the basis of user criteria. Conclusions are drawn on the basis of a comparison of charges from the viewpoint of the VASP. Technical issues relating to internet charging are also discussed.

1. Introduction

The demand for Internet and Intranets are growing both in terms of the number of connections and the volume of information per connection. Value-added service providers (VASPs) on the internet, such as internet service providers (ISPs) are moving to use ATM in their backbone networks, replacing the use of leased lines. While the VASPs used leased lines, the business costs were stable and predictable and hence fixed rate charging is the norm for internet connections. However, as ATM moves to some form of usage based charging [1][2][3], VASPs may need to pass on those usage costs to their customers. The work described in this paper investigates the issues of charging for Internet services provided over an ATM network.

IP/ATM interworking, while presenting significant challenges at a technical level, also requires consideration at a commercial level. This paper explores the charging aspects of Internet services delivered over ATM, in the context of the FIONN[1] trial [4], which was conducted in 1996 by the CANCAN[2] project. The scenario considered in this paper, and on which the trial was based, involves three layers of the service provision value chain. The actors involved are a network operator (NO), a value-added service provider, and internet users. The network operator provides wholesale ATM bearer services to a VASP, who resells this service as part of a larger retail package that includes content components. Figure 1 shows a simple representation of this service provisioning chain.

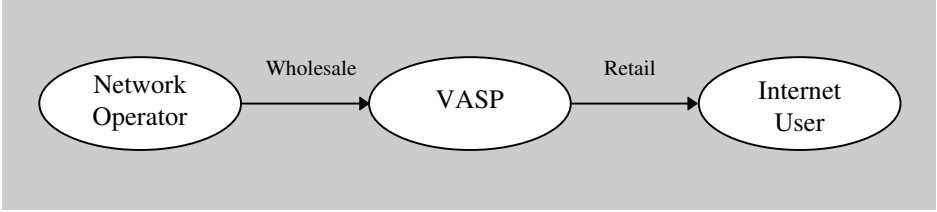

Figure 1: Wholesale and retail service provision in our trial

[1] In common with other CANCAN trials, *FIONN* is named after an Irish mythological figure.
[2] AC014: *Contract Negotiation and Charging in ATM Networks*, part of the European Union *ACTS* programme.

As well as investigating Internet charging in a live environment, this paper examines the basis for such charging. How are network operator tariffs for ATM bearer services passed on to internet customers by VASPs, or are the two charging schemes completely independent?

A new charging scheme design process [4] developed by the CANCAN project, and which has produced results that have had broad acceptance, is used in this paper. This process is very much service-driven, and the idea is to design contract and charging schemes that relate to a particular service scenario with a particular category of customer in mind. The design of ATM charging schemes involves both market and technological considerations. Thus, as well as looking at network resource use, the design of charging schemes should take into account the perceived value of the service, the business environment, competition, user requirements, and, where appropriate, the requirements of value-added service providers or other re-sellers. A model was developed to facilitate charging scheme design while taking into account business and technical issues, and a design process was built from this model. The service considered in the FIONN trial was used to test this process; in fact the structure of this paper largely reflects this process.

The remainder of this paper is structured as follows. Section 2 details the retail Internet service delivered (a Chinese language magazine), and proposes a charging scheme and price plan. Section 3 examines the wholesale ATM services required for delivery of this online magazine and proposes a suitable charging scheme at this level. Technical detail on the operation of the trial and measurement of the relevant parameters is given in Section 4. Results are summarised in Section 5 and conclusions are drawn in Section 6.

2. Charging for a Retail Internet Service

The scenario considered in this paper is based on access to a Chinese web-based magazine, *Multiworld* [5]. This magazine is produced bi-monthly and is aimed at the global Chinese community. The FIONN trial, described in detail in Section 4, involved routing traffic to and from one of the *Multiworld* mirror servers over ATM. Two services are of interest, as follows:

- Wholesale ATM transport service provided by the NO to the VASP.
- Retail online magazine service provided by the VASP to internet users.

The retail service includes both the magazine content and the delivery of that content to the users, as is described in more detail below. The wholesale service is detailed in Section 3.

2.1 Retail Service Description

(Provider: VASP, Customers: Regular internet users)

At the retail level, the service provided is an online Chinese-language magazine. It is assumed in the service definition that the users already have Internet access. A distinction is made below between service set-up and service usage.

Service set-up

In a commercial environment, the contract between the supplier and the customer would be set up formally, probably on-line by means of a suitable electronic forms interface. Users would then be given some means of authenticating themselves for future transactions. In this trial, however, the means of identifying a user for later transactions is his/her IP address.

Service usage

Charging for service usage is of most interest to us in this paper. For any telecoms service, a crucial contract component is the definition of the *session,* i.e. the basis on which service usage is charged [6]. A clear mutual understanding of what constitutes usage is necessary for charging, and a session should represent what would appear as a line on an itemised bill. The term session can be considered equivalent to *call* in the context of voice telephony.

For the retail service here, we take a session[3] to be:

[3] This session definition is chosen for ease of implementation. Several alternatives could have been chosen, such as the following:

a single file transfer from the server to the user's IP address, resulting in an entry in the server's log file.

Charging for content (rather than just volume or time related to network usage) is achieved in a fair way for this service by distinguishing different kinds of files, as in Section 2.2 below.

2.2 Retail Charging

Generally speaking, charging schemes involve two levels. The first level presents the set-up level and the second one corresponds to the session level. The set-up level reflects the subscription charge and the session level reflects the usage charge. In the experiments it is assumed that each session consists of transmission of one file only.

Service set-up

Normally charging for telecoms services contains parts relating to service set-up (i.e. when the contract is initiated). We do not apply such a charge in our experiments, as this was not our main concern.

Service usage

For analysis purposes, a number of different charging schemes were used in the experiments at the session level. They are based on connection time, transmitted volume, file information indicator, or combination of these parameters depending on the scenario considered . The file information indicator reflects the cost of file content. The file content charge is calculated in very simple way as a fixed charge which depends only on the type of file. This charge is known for users in advance. The following types of the file information indicator are used in the experiments:

0 - index files
1 - articles
2 - large images

For the sake of convenience each of the used charging schemes can be considered as an instance of the three-term charging scheme [1]. So the charge was calculated as:

$$UsageCharge = FixedCharge + E * Time + F * Volume$$

where *UsageCharge,* is composed of:

1. a constant term, *FixedCharge,* representing a charge for a file content (or file information indicator).
2. a duration dependent term, $E * Time$, where coefficient E is the charge per unit time and *Time* is the session duration during which the file is transmitted, and,
3. a volume dependent term, $F * Volume$, where coefficient F is the charge per cell, and *Volume* is the file volume (in cells).

All eight possible variations of the three-term charging scheme are considered in the work for the purposes of analysis. With one of these scenarios, terms E and F go to zero and we just have fixed charging. Other scenarios have charging by volume only, duration only, and a combination of fixed and volume-based charging.

Price plan

Table 1 shows four alternative price plans based on the charging schemes above. These different price plans are obtained by setting some of the terms (*FixedCharge, E, F*) to zero. The price are based on existing communication (e.g. telephone) tariffs, with currency units in US$.

- an issue of the magazine
- a section of the magazine
- a day's use of the service
- a month's use of the service

Pricing Schemes	Duration *E*	Volume *F*	File Information Indicator *FixedCharge*	Remarks
A			Index files: free Articles: 0.15 US$ Big Images: 0.015 US$	Estimation of value of magazine.
B		0.015 US$ per 10,000 bytes		PSTN, international rate, US$0.75 per minute
C	0.015 US$ per second			
D		0.015 US$ per 10,000 bytes	Index files: free Articles: 0.15 US$ Big Images: 0.015 US$	Charge is produced using I times size charge. Methods for size charge see above

Table 1: Tariffing for the FIONN trial

Note that our investigations focus on usage (as distinct from set-up) charges.

3. Charging for a Wholesale ATM Service

3.1 Wholesale Service Description

(Provider: NO, Customer: VASP)

ATM is currently being deployed by network providers as a backbone technology. They are using ATM as a technological base to provide services to customers. An example is the frame relay service, delivered by MFS in London where the customer interface, both commercial and technical, is frame relay but ATM is used in the network to deliver this service.

The ATM Forum [7] has service categories whose descriptions are technically detailed and are unlikely to be sufficient for buyers other then wholesale or some technically sophisticated buyers (e.g. some large corporate users or universities). Small to medium sized enterprises or the residential market may wish to gain benefits from the ATM opportunity yet are unlikely to devote the energy necessary to purchase the service categories of the ATM Forum. This, in itself, is a reasonable argument for introducing a commercial layer between the provider of ATM services and the end user. Organisations operating in this commercial layer would purchase ATM as a wholesale connection service and resell it, with appropriate packaging, to its target market. This reselling concept is described in work on service provisioning in a multiprovider environment [8].

Walker suggests [2] that ATM forms the natural building blocks of a wholesale network and further suggests that: 'the role of the network wholesaler can be envisaged as supplying basic, service independent communications capacity to the various category of user i.e. direct customers, value added service providers, resellers, ISPs, application developers, systems integrators, content owners and any retail arm of the underlying ATM transmission network infrastructure owner'.

In this paper we consider ATM to be sold on a wholesale basis to a value-added service provider.

3.2 Charging for a wholesale ATM service

Commercial ATM services are currently based on permanent virtual circuits and are priced, in the main, based on the lease line model with long term contracts. As such the charges for these services are not strongly coupled to usage. ACTS projects such as CANCAN and CA$HMAN are exploring possibilities for usage based charging. A question then arises: what is the primary unit of the charge for the wholesale ATM service?

From the unit point of view, we could look at the spectrum of possibilities of increasing value to the end user, from photons or electrons to number of emails sent. In between we could consider a volume component such as cells sent or delivered, a rate component such as peak cell rate (PCR) or sustainable cell rate (SCR) [7] or even

some statistical measure like effective bandwidth or Poisson envelopes [1]. We consider here a unit of ATM charging, described by Walker [2], where the unit of charge is the Megabit. Indicative tariffs proposed by Walker are given in Table 2. The price is differentiated based on the ATM service category [7]. It should be noted that ATM market is currently characterised by a high degree of confidentiality concerning details of prices and as such the price values given in the paper are not intended to reflect the plans of any commercial organisation, yet are a useful discussion point.

These volume-based costs would form a fundamental cost of 'production' for value-added service providers and other telecommunications service retailers who purchase ATM services from the owners of transmission infrastructure.

ATM Service Category	Price Range (US$/Mbit)
VBR	0.2
CBR	0.1
ABR	0.005
UBR	0.0002

Table 2: Wholesale Volume based ATM Charging Structure proposed by Walker. Note that Walker's scheme is independent of duration and distance.

4. Trial set-up

The FIONN trial examines charging of services carried over an ATM network. The system consists of an Internet World Wide Web server supporting a Chinese language magazine, and an ATM network. About 20 users were organised to access this magazine. Figure 2 shows this configuration.

The ATM network consists of two Sun workstations, one working as an ATM router, the other as host of the WWW page, and a Passport ATM switch connected by optical links. The gateway machine is a Sun Ultra running Solaris 5 using static routing with an Efficient ATM card, while the WWW server machine is a Sun Sparc station running SunOS 4.1.3, with FORE card. The switch used is a Nortel Passport switch, working as a feed-through (no switching functionality implemented). The switch can detect network traffic, by examining the cell count of the traffic flow. As long as there is an increase in the cell count, then the system determines that the NMS is working properly. This implies that there must be a mechanism to increase network traffic even when there is no user using the network. This as will be shown in billing, plays a very significant role in network traffic figures.

The considered trial object, the WWW server is connected to the Internet via the PASSPORT switch, the Internet gateway and the Telia Research internal data network TRABnet. Some notable remarks of the system:

- The WWW server and the NMS are hosted by the same computer.
- The ATM traffic between the Internet gateway and the WWW server is connected via the PASSPORT just as loop-backs in each port, i.e. not connected through the switch.
- All traffic to/from the WWW server is routed to be ATM connections. The traffic from PASSPORT to NMS, e.g. charging raw data, is routed via the TRABnet.
- Charging raw data recorded by the PASSPORT may contain accesses other than just to the home page of the WWW server, due to the fact that all Telia external access are routed via the ATM connections.

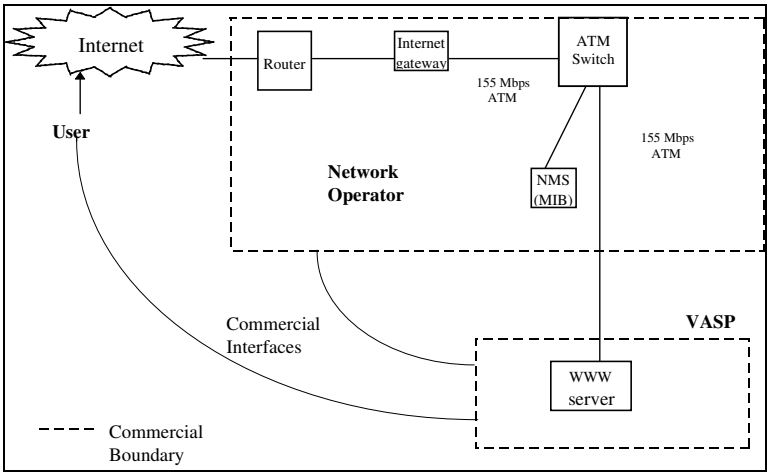

Figure 2: Overview of FIONN trial architecture

The WWW server is a modified NCSA 1.4.2 WWW server, with the source code compiled under SunOS system. The contents provided by the server is a Chinese-English multiple-language magazine. Internet with IP over ATM is assumed readily available, so is WWW browsing software, with terminal cache capability. The trial shows that cache plays a very interesting part.

If a session set-up fee is included, the charging and billing system will have to be able to distinguish a real file transaction from a mere user request such as occurs when Netscape is used to call a page already held in cache. For the purpose of FIONN trial, and due to the nature of the service engine, only two sets of data are available.

The first set of data is directly from the server's log file:

- Duration of transaction
- Amount of information transferred
- Information identifier (file name)

IP address is also recorded in the server log file, but if not sufficient to distinguish individual users. Authentication technology will be implemented at a later stage of the trial, and new ID will be recorded to provide identification methods for users, instead of IP addresses. For this trial, IP numbers are used as user identification.

The second set of data is from the ATM switch measurement, and this should provide us with information from VCs and individual cells with time stamps. The data is recorded in two sets of log files. One set of log file only record:

- Time stamp, accurate to 1/100 of a second
- Number of cells received at the time stamp

The other set of log files contains more ATM network related information such as the VCI and VPI.

5. Results

5.1 Bills

Bills were produced for both the retail value-added service and the wholesale transport service, for several pricing scenarios.

Bills for retail value-added service

Table 3 shows a sample bill using each of the four pricing schemes shown in Table 1 above. This bill is just intended for illustration and represents a short duration. The bill is related to one click on the browser which

causes a download from the server to the user of sixteen GIF files, which comprise the relevant article of the Mutliworld magazine. The GIF file size range is between 107 and 24576 bytes.

Duration (Sec.)	Volume (Bytes)	Inf. ID	Bill A (cents)	Bill B (cents)	Bill C (cents)	Bill D (cents)
0.065	3600	1	15	0.54	0.098	15.54
0.017	248	0	0	0.038	0.026	0.038
0.054	23456	0	0	3.51	0.081	3.53
0.03	107	0	0	0.017	0.05	0.017
0.023	6652	0	0	1.01	0.035	1.01
0.047	24576	0	0	3.69	0.071	3.69
0.023	289	0	0	0.044	0.035	0.044
0.05	24706	0	0	3.76	0.08	3.76
0.056	17624	0	0	2.64	0.084	2.64
0.023	282	0	0	0.042	0.035	0.042
0.027	14046	0	0	2.10	0.041	2.10
0.414	44398	0	0	6.66	0.62	6.66
0.041	19327	0	0	2.90	0.062	2.90
0.019	266	0	0	0.041	0.029	0.041
0.023	395	0	0	0.060	0.035	0.060
0.021	18313	0	0	2.75	0.032	2.75
Total	**198285 (4141 cells)**		**15**	**30**	**1.5**	**45**

Table 3: Four sample bills produced by VASP for retail service

Bills for wholesale transport service

A sample wholesale bill has been prepared as shown in Table 1. This provides an indication of the charge which the VASP will pay to the supplier of the wholesale service.

Walkers scheme in Table 2 shows a significant divergence in price between the lowest and highest priced service category- a factor of 1000. This divergence gives significant reason to look at the lowest priced categories UBR and ABR when considering the current service model of the internet, (i.e. with no transfer time guarantees).

Wholesale Connection Service	Charging Scheme [$/Mbit]	Volume of Cells [Cells]	Volume of bits [Bits]	Wholesale Charge [cents]
ABR	0.005	4849	1862016	0.9310
UBR	0.0002	4849	1862016	0.0372

Table 4: Wholesale charges based on UBR and ABR wholesale services.

5.2 "Ghost" Traffic and its effects

If VASPs selling internet-based services are to be charged by NOs on the basis of a cell count, a major concern is the incidence of "ghost" cell traffic. This is because it may be quite difficult to recover charges from end users that do not directly relate to the volume or content transferred. Any cell traffic that does not involve the transfer of content to the user can be considered as ghost traffic. Such traffic exists to support protocols, and may include "pinging" and other periodic communication that is required to maintain a connection over a period of time. The relative significance of ghost traffic of course depends on the total amount of traffic carried; in times of heavy traffic it may be negligible, but if a service is lightly used, it may constitute a significant overhead. Internet

servers are normally online all the time, even though traffic may be very light at certain times, so ways of reducing ghost traffic are required.

Over the duration of the FIONN trial, we have the following statistics (Table 5):

	Duration of activity	Volume(cells)
Total activity on WWW Server	~2900 seconds	~550,000
Total activity on Switch	16 days	~3,600,000

Table 5: Total cell counts measured at the WWW server and at the switch

The reason for such a huge amount of difference shown in the two log files, is due to the unexplained ghost traffic. The reason for the ghost traffic was never fully recovered, but from the way the switch fetches data to NMS, our guess is that there is a ping going at a constant rate. The switch knows and only knows it is functioning when it sees a constant increase in the amount of cell count in its log files. This could imply that there is a mechanism to increase the network traffic after a certain amount of time. Calculation shows that if all the extra cells are due to the ghost traffic, the it amounts to about 2 cells per second, which is very small if examined in a short time period. But notice that the total amount of time user browser used to communicate with the server is less than 50 minutes, compared to the 16 day trail duration, during which there was always a constant traffic flow. Figure 3 shows graphically how the cell counts could be so different:

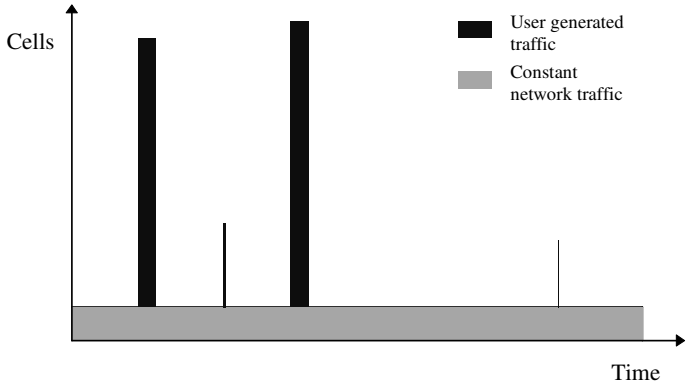

Figure 3: Typical traffic profile for FIONN trial

Even though the increase is very small, the result is still quite significant after such a large amount of time.

5.3 Comparison of wholesale and retail charges

Table 6 provides a indication of the gross margins[4] which the VASP may obtain depending on which of the retail charging schemes are applied. For the UBR case, irrespective of the retail charging scheme, the margins intuitively seem quite high and unsustainable in a competitive market. For the ABR case the margins still seem high except for Charge C.

Retail Charging Scheme	**Session Revenue**	**Production Cost[5] Wholesale Service = ABR**	**Gross Margin**	**Production Cost Wholesale Service = UBR**	**Gross Margin**

[4] The Gross Margin is calculated according to differential of the production cost and the session revenue expressed as a percentage of the session revenue.

[5] The cost of content for the VASP is assumed to be zero for the purposes of this paper. As such in our calculations production cost and wholesale charge are equivalent. Content could be included in a more complete treatment of an VASP business model.

Charge A	15	0.9310	93.8%	0.0372	99.8%
Charge B	30	0.9310	96.9%	0.0372	99.9%
Charge C	1.5	0.9310	37.9%	0.0372	97.5%
Charge D	45	0.9310	97.9%	0.0372	99.9%

Table 6: Gross Margins based on wholesale charges and proposed retail charges.

It remains to be seen what is the advantage of ABR over UBR for the customer when the price differential is a factor of 25 in favour of UBR. Considering 'reasonable' gross margins for the VASP an appropriate retail charge for this transaction might be the Charge C result scaled by a factor of 25 and calculated based on delivered payload rather the transaction duration.

Internet Service Providers in North America are losing money [10] which, according to *The Economist,* 'most firms lay at the feet of the flat fees'. From a customer point of view there has been a degradation of service. Value-added service providers may wish to change their business model from flat fees to a usage based scheme and compete on service rather then price. The charging model for ATM proposed in this paper allows them to do so, providing the UBR service is dimensioned appropriately by the NO.

Table 7 proposes a charging scheme closely coupled to the underlying transport cost and identifies margins which might be seen as more realistic in a competitive market. The scheme is characterised according to the formula:

Retail Charge = (1-Gross Margin) * Wholesale Charge

Gross Margin	**Transaction Volume** [Cells]	**Wholesale Charge 0.0002$/Mbit** [Cents]	**Profit Contribution** [Cents]	**Retail Charge** [Cents]
10%	4849	0.0372	0.0041	0.0414
20%	4849	0.0372	0.0093	0.0466
30%	4849	0.0372	0.0160	0.0532
40%	4849	0.0372	0.0248	0.0621

Table 7: Gross Margins based on wholesale charges and proposed retail charges.

5.4 Evaluation

The CANCAN project has proposed a number of evaluation criteria [1]. The charging schemes used in the trials were analysed using the following four criteria, considered by a sample of members of the CANCAN User Forum[6] to be the most important:

- Auditability; the ability to check the content of the bill.
- Practicality; the basis of billing should be understandable and meaningful.
- Usage sensitivity; the charge should be related to the use of the service.
- Predictability; it should be possible to predict the charge from experience and knowledge of the use of the service.

We have evaluated the wholesale and retail charging scheme according to these criteria.

Wholesale

Auditability: It seems reasonable, initially at least, that systems can be put in place for an audit trail between the network provider and the VASP. Information from a cell counter may be as reliable as information from a timer as implemented in a PSTN network today. An audit trail correlating retail charge with the network charge may be more difficult.

[6] A User Forum on ATM Charging was set up among members of the Telecommunications Managers Association, as part of the CANCAN project.

Practicality: This scheme was implemented in field trial and a call detail record with volume information was produced whose type has been evaluated successfully in a prototype billing system. The trial was carried out with one traffic scheme so further evaluation is required in terms of scale-ability

Usage Sensitivity: This scheme is usage sensitive and allows the value-added service provider to fulfil a standard business objective of shifting costs from a fixed nature to a variable nature. It does not, however, take burstiness into account.

Predictability: The wholesale charges are static in Walker's [2] paper and as such are predictable. Simple calculations can determine, theoretically at least, the volume to be transferred for any application type during a session. A method of budgeting usage at the application level within the billing period will allow for a degree of predictability. The extent of ghost traffic needs to be clarified and financial responsibility identified.

Retail

Auditability: Auditability for retail charging scheme essentially depends on charging parameters used in the scheme. In the charging scheme based on volume only the situation is similar to the wholesale. In the case of retail each user should have access to his/her *individual* Call Detail Record. Full implementation on Internet of an audit trail for duration based charging looks more problematic. Extra equipment may be needed at the VASP to support this. A high level of auditability of content based charging scheme is simple enough to implement. The billing system should be flexible enough to charge a user in a different way for repeated attempts to access the same file content not to charge for files which have no content charge.

Practicality: The practicality of the schemes will depend on the development of suitable internet tools. For example, duration based charging systems are widely used at the moment on Internet, particularly for users connecting to ISPs such as CompuServe. Volume based charging and content based charging have been shown to be practical in the FIONN trial, as reported in Section 4 above.

Usage Sensitivity: All the described retail charging schemes are usage sensitive. The charging schemes allow the value-added service provider to control the level of the service usage which gives a possibility to tune tariffs depending on service demand and the wholesale charge. Extra flexibility can be achieved using the combined charging approach (for example, the charging scheme D).

Predictability: In principle, all of the described retail charging schemes have a high level of predictability. The charging schemes based only on one of the charging parameters (duration, volume or content) are more predictable because much more simple to control only one parameter. A method of budgeting usage at the application level within the billing period would allow for a degree of predictability.

6. Conclusion

The work in this paper has investigated charging for Internet services provided over an ATM network in the context of a user trial. Wholesale and retail charging schemes have been applied, the relevant parameters have been measured and bills have been produced. A comparative evaluation of these schemes has been performed. We conclude with the following observations:

- At a technical level, we have demonstrated the ease of metering traffic from a World Wide Web server (by modifying the server code). We have also exposed a limitation in the range of charging parameters that can be measured at the IP level, restricting flexibility in devising Internet charging schemes.
- The financial responsibility for the volume of ghost traffic needs to be determined, unless this traffic can be substantially reduced.
- Using PSTN-based tariffs for internet related value added services, leads to gross margins which seem excessive for a competitive market, when the underlying production costs are as low as some of the proposed ATM tariffs. More realistic gross margins are observed when designing charges for internet-related services, if they are related to the ATM tariffs.
- One proposed set of ATM tariffs for VBR and UBR differ in price by a large factor. This would suggest that services will migrate to this lower priced service (UBR).

- Wholesale volume based charging for ATM, with the tariffs shown in Table 2, leads to gross margins which seem acceptable, while offering an end user price, which intuitively would seem acceptable.
- Use of an additional commercial layer between the end user and the provider of ATM services may be necessary to assist the end user to obtain the full value of ATM.
- Proposed usage based ATM tariffs allow value-added service providers to move their business model from underlying fixed leased line costs to more variable costs.

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