USER FRIENDLY CONGESTION PRICING IN 3G

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ABSTRACT

This study examines how methods proposed to price traffic in the fixed Internet can be accepted by customers of 3G mobile services. Most previously proposed congestion pricing models are complicated and therefore difficult to be accepted by customers. Simple data pricing methods are needed in today's 3G networks. A congestion pricing method is proposed only for customers willing to pay more during congestion. Other simple methods include usage pricing with cost constrains, event and content based pricing. Event and content based pricing have been successfully used in 2G and 2.5G (GPRS) mobile networks. They will also play an important role in pricing decisions in 3G, since the customer is interesetd for his delivered services and not for the number of bytes.

Keywords: 3G, content pricing, event pricing, subscription pricing, usage pricing.

1 INTRODUCTION

The development plans of mobile operators lay down towards 3G (3rd Generation) networks, designed to carry a wide variety of traffic types, from conventional voice, to interactive data, video and messaging. Since 2003, many countries in Europe went on commercial operation of 3G networks (Universal Mobile Telecommunications System- UMTS rel. 99). In the next releases 5 and 6, they will even use TCP/IP (Transmission Control Protocol/ Internet Protocol) for the wireless transport of the traffic. Many models have been proposed to price packet networks in the fixed Internet. This study examines how models proposed to price packet networks in the fixed Internet can be used to price packet switched services in 3G under certain constraints, which are induced by the customers, by the mobile operator and by the mobile technology. In almost all countries, there is an oligopoly, so the competition in 3G is expected to be fierce. Thus, the customer will play an influential role in pricing decisions. No company will risk implementing a pricing model that will not be accepted by the customer. We examine the previously proposed models under the customer's point of view. These models study how congestion can affect pricing decisions. The difficulties of congestion pricing to a commercial network will be pointed out.

Since, sophisticated congestion pricing is still not implemented in any network, simple pricing methods are the dominating pricing strategies for data in today's 3G networks. These simple methods include simple usage pricing with cost constrains, so that the mobile operator can make satisfactory earnings, event and content based pricing. Event and content based pricing have been successfully used in 2G and 2.5G (General Packet Radio Service- GPRS) mobile networks. They will also play an important role in pricing decisions in 3G. The reason for this is that the number of bytes, which are related to the network delivery cost, do not directly relate to value from an end user's perspective; but services do.

The next section 2 presents pricing models proposed for the Internet. Section 3 presents a simple alternative method for congestion pricing in wireless networks. Section 4 presents practical pricing strategies. Finally, section 5 concludes on the user friendly pricing in 3G.

2 INTERNET PRICING MODELS

In this section, we review the Internet pricing models under some fundamental factors that are important for a buyer to appreciate the charging scheme and for a seller to consider implementing it. Let present these fundamental factors (some of them are analyzed in [1]):

- Cost connection. Generally, the seller wants the revenues from a service to be connected to the costs of providing the service.
- Perceived value. The buyer wants to be charged according to his or her perceived value of the service. There might be a conflict between the seller's wish to cover

costs and the buyer’s wish to pay only for perceived value.
- Fairness. People usually expect everybody buying the same service to pay the same price, though some exceptions are widely accepted (e.g. discounts for retired people and students). Buyers do not wish to be charged for services that they cannot benefit from or do not want. Usage sensitive schemes tend to be seen as fairer.
- Predictability. The buyer wants to be able to know how much he will pay for the service before buying it. Also, the seller wants to know how much he will make from the service before providing it. Buyers and sellers also wish to be able to predict expenses or revenues over a time period, beforehand.
- Understand-ability. Buyers want to understand what they pay for and what their options are. An understandable scheme also improves the possibility to audit the bill. This means that the provider can, when requested, prove the validity of the charges he has made by tracing them to their origin.
- Simplicity. A complex scheme is often less robust than simpler charging schemes. It is also likely to require more intelligence from the application and/or user. More complexity probably means a higher cost for the billing system. Of course, this is unattractive for the seller, and indirectly also for the buyer as it affects the cost of the service. Complex charging schemes also tend to be less practical.
- Promotion/ Discouragement of usage. In some situations the seller may wish to promote usage. In other situations it may be favourable to discourage usage, e.g. due to congestion problems.

From the customer’s point of view, predictability, understand-ability, perceived value and simplicity are the key parameters. From the network provider’s point of view, the key issues are cost recovery and return on investment in order to have a financially sustainable business case. Fairness from an economic point of view helps the prices to be subsidy free. Some customers should not find themselves subsidizing the cost of providing services to other customers. If this happens, customers are likely to take their business to another provider with the same costs but with fair charging.

2.1 Congestion pricing in packet networks

Most research on network pricing is concerned with congestion control ignoring the return on investment. Congestion causes decline in service quality as the number of users increases. These pricing models try to control congestion and increase the value of services to users. The objective is to optimally share a scarce resource by inciting users to reveal their utility and attributing the resource to those who gain the most. The basic assumption of these models is that network resources are scarce. Prices are not determined by network costs, but just by the cost of inconvenience caused to other users who are denied the quality of service they demand. So, cost recovery has to rely on a parallel flat rate approach. We will show that a commercial network operator faces many difficulties.

The best-known example of congestion pricing is the “smart market” proposed by MacKie-Mason and Varian [2]. In the smart market, users include a bid in each packet. In case of congestion, the users offering the lowest bids are discarded first and accepted packets are priced at a rate determined by the highest bid among the rejected packets. Various other auction type models were proposed for resource reservation in the wireless access level [3]. These models require costly reforms of the network and also intelligent agents in the customer side to help him with the auctions. Since the customers’ bids are generally free with the exception may be of the starting point, auction, being a classical form of value-based pricing, determines prices that bear no relationship to the costs of service.

Another charging model is the responsive pricing. Similar to smart-market pricing, the charging mechanism only comes into operation during periods of congestion. In case of high network utilization, resources are stressed and the network increases the prices for the resources. Then, adaptive users, by definition, reduce the traffic offered to the network. Similarly, in case of low network utilization, the network decreases the price and the community of adaptive users increases their offered traffic. In this way, adaptive users do not just increase the network efficiency, but also economic efficiency. The network sets the prices using either a closed-loop or a smart-market approach. In the former scheme, the network measures its resource utilization, for example the buffer occupancy at the user-network interface, and then determines the price per packet.

Proportional fairness pricing is of significant interest for the allocation of telecommunication resources. It is appealing because it provides an economic foundation to the resulting allocation, when a utility function is used to describe user preferences in the place of the traditional (linear) cost minimization objective. Users declare their willingness to pay, e.g. per time unit. Correspondingly, an amount of resources is allocated to them in order to maximize revenues for the network and the benefit perceived by users themselves. Otherwise, users may declare their rates, and the network sets the price in order to maximize revenues for the network and the users' benefit. Several approaches for Code Division Multiple Access (CDMA) networks were proposed in [4] for resource control, resource reservation and pricing using economic modelling to maximize social welfare ($\max\{\sum_{r}(U_r(x)-C_r(x))\}$); all resulting to dynamic changing prices. Ur(x) is the utility function for user r consuming x network resources. Cr(x) is the cost for the consumer. The utility function, which is used to calculate prices, is changing with respect to the transmitted signal and that makes the calculated prices varying in per second basis.

Kelly [5] has proposed an alternative congestion pricing framework. His "self managed networking" scheme is based on a reactive congestion control like that of TCP where Explicit Congestion Notification (ECN) marks are issued to signal imminent congestion. Each mark received by the user implies a unit charge. In the event of congestion, users with high utility continue their transmissions. They receive more marks and pay a surcharge but successfully complete their transaction. Users with low utility will refrain from transmitting until the congestion ceases.

A simple pricing scheme to avoid congestion in packet networks proposed by Odlyzko is Paris Metro Pricing (PMP) [6]. In this case, the network is divided into a set of logical networks. The total bandwidth capacity is divided into several sub-networks. Each logical network operates on a best-effort basis and is priced differently. Users choose one of these logical networks for the transmission of their traffic, and this implicitly defines the service level. Network operators set the prices for each logical sub-network, for example through customer surveys or feedback forms. Users make a selection based on the expected network congestion and their budget. Assuming that prices are kept stable over significant periods of time and that users are price sensitive, higher priced networks will experience lower utilizations and hence be able to provide a higher service level. The pricing scheme is simple, understandable and predictable for the customer and easy to implement. However, if it is implemented in the wireless path the fixed capacity traffic classes inhibit effective multiplexing and the full utilization of the wireless path.

If pricing mechanisms at congestion points within the network do not scale, a price calculation at the network's edge approximates an efficient solution. Network operators might prefer this, since they would retain control over how they charge users, rather than leaving it up to a network-mandated mechanism. Instead of charging for the actual congestion caused by packets, the operators could charge for expected congestion, based on such metrics as the time of day, short term congestion history, and so on. Today's Internet backbone traffic has the form of Figure 1 (results from traffic measurement on Sprint's backbone network [7]). It is obvious that time of day pricing can be used as in the telephone network for congestion charging of congestion patterns that are predictable and apply to the backbone network.

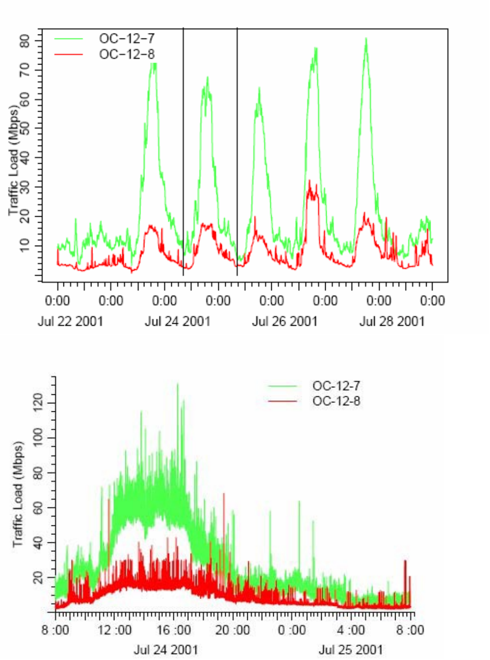


Figure 1: Weekly Internet traffic in a backbone link [7].

Table 1: Advantages and Disadvantages of Proposed Internet Charging Schemes.

	Expect Capac.	Responsive	Paris Metro	ECN Notific	Edge	Auction
Cost Connection	-	-	-	+	-	-
Perceived Value	+/-	+	+/-	+	-	+
Fairness	+/-	+/-	+/-	+/-	+	+/-
Predictability	+	-	+	-	+/-	-
Understandability	+	-	+/-	-	+	-
Simplicity	+	-	+	-	+	-

Table 1 summarizes some of the conclusions for the above mentioned pricing models. A thorough description and comparison of pricing models for both guaranteed and best effort services can be found in [8], and [9].

Despite the popularity of the above schemes in the networking research community, there are serious reservations on the use of congestion pricing by a commercial network operator. In the first place, network resources are generally not scarce. The provider can easily upgrade capacity and will do so before congestion occurs if return on investment is assured. Return on investment could be calculated by the opportunity cost of the lost traffic due to congestion and the cost of the lost subscribers due to the poor quality of service during congestion periods. Users may even interpret congestion as a sign of bad management. Congestion may happen even in the core network and not only in the wireless access level. The causes may be bad network design or networks failures or because it is not used the best technology to avoid congestion. Congestion avoidance can be managed through strictly technical means by managing packets queues in the network elements or even by compressing the data before delivering to the wireless path. Since other charges must already cover network cost, users might find it unreasonable to pay extra when bad planning or bad maintenance results in congestion. It is well known that congestion avoidance through overprovision may be reasonable in the backbone network, which consists of a fairly small number of links. However, it may not be reasonable in the metropolitan part and even less so in the access network that connects customers to the backbone. The largest cost of the network lies in the metropolitan and access part and it may be very costly to overprovision the entire network. In the case of 3G, the access network consists of base stations with a certain coverage area and there is a limit in the expansion till the area is covered by a picocell (which is typically a building). The connection of the base station to the Radio Network Controller is done via either a fixed wireless path in the rural and suburban areas or even high speed fiber optic paths in the urban areas. Obviously, the main congestion problem is more likely to appear at the access part.

From the customer's point of view, the congestion pricing fails to correspond to the basic requirements of understand-ability, simplicity and predictability. A proof of the wish for simple pricing schemes and risk avoidance are the results of the INDEX project [11], which was an experiment about the demand for Internet usage under different pricing schemes, and the work of Odlyzko [6].

From the network provider point of view, the complexity of theses pricing schemes increases significantly the operating costs in comparison to a simple volume based pricing scheme (already the charging and billing counts for a very large part of the costs). It maybe extremely costly to deploy a new control mechanism in an existing network, if the mechanism was not installed since the network was originally designed. Also, congestion prices are not determined by network costs, but just by the cost of inconvenience caused to other users who are denied the quality of service they demand. In this case the cost recovery has to rely on a parallel flat rate charge.

Another fact is that concerned with QoS (Quality of Service). Offered QoS is synonymous with the relatively static, uncongested QoS. Delivered QoS is the result of degrading static offered QoS with congestion. If the price goes down with congestion, there is a danger of congestion collapse. If pricing is to be used to encourage self-admission control, the price should rise as congestion approaches, preferably before it starts to have an impact on QoS. The idea is to push back demand in order to avoid congestion, but without having to charge more for poorer service. If congestion continues despite continuing price rises, QoS will eventually suffer. But the price must not be dropped (nor refunds increased) faster than the value of the service drops, because demand will then increase, leading to collapse. Of course, if session admission control [12] is used instead of price to protect against congestion, the QoS of successful sessions will not be degraded by congestion, and the price can stay constant as demand varies. So, the previous discussed models can apply only to best effort services with no strict QoS guarantees.

3 A SIMPLE ALTERNATIVE METHOD FOR CONGESTION PRICING OVER THE WIRELESS PATH

One alternative solution would be to use a congestion pricing scheme only for those willing to pay more to transmit during congestion periods. For example (Figure 2), if congestion is about to occur (if load reaches L_4 of capacity) a number of wireless channels could be reserved for users willing to pay more. These channels will be priced per Mbyte with an extra charge in addition to the normal price. For example, if the user pays a flat rate price A, then the price during congestion for these channels could be $P=A+B*V$, where V is the volume of data. If the user pays already a price per Mbyte $A*V$, then the new price would be $P= (A+B)*V$. People not willing to pay this extra price will suffer from congestion with higher probability since we suppose that customers are price sensitive and the majority will choose not to pay this extra charge. This means that they will suffer from lower QoS. This can be used in combination with time of day pricing. Time of day pricing can deal with predictable congestion patterns in the backbone and this PMP-like pricing can deal with unexpected congestion, which can be usual in populated places like at the end of a football game or a concert. This type of pricing can alleviate also non-predictable congestion like in the case of an earthquake. Since this pricing applies only on the wireless path, congestion due to failures in the backbone network would not affect it and this makes a lot of sense from the user's point of view. A user can understand that when many people try to access the same radio channel there is a chance that he will not be served. So, some users will find it normal to pay an extra charge. This type of pricing is also socially fair since it inhibits people with high willingness to pay (large income) to use all the capacity during congestion since only a fraction of the capacity is reserved for these people. Auction-based pricing could also apply for these reserved channels. When traffic load drops under a certain amount of capacity (L_3) these channels will be available for normal traffic. If the reserved channels also face congestion, the price will fall back to normal pricing since there is no difference in QoS from normal served channels. During time periods of very low load (L_1) demand, stimulation can be done in the same way by lowering the price (that can be done by returning minutes of calls or bytes of data in a three part tariff) so elastic applications can contribute more traffic till traffic load reaches (L_2).

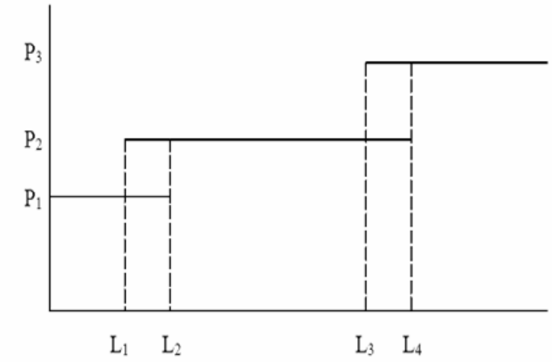


Figure 2: Pricing with concern of traffic load.

A technical disadvantage of this pricing model is the potential for instability. During periods of congestion, price-insensitive users may choose a higher-priced network expecting to receive better service. This may lead to congestion in the higher priced networks and thus cause instability. The price must be high enough to avoid this instability and the fall back to normal price in case of congestion must be done for fairness reasons. Also, because the price directly depends on the traffic load, this means that the traffic load must be included in the Charging Data Records (CDRs) in order to be transparent to the customer. The customer should always know what he is paying for.

To alleviate pricing in the backbone network simple usage based pricing scheme may be a sufficient control mechanism, since it lowers significantly the demand of elastic applications. In the mobile telephony, congestion is also more frequent in the urban densely populated areas where the density of the cells (picocells: coverage less than 100m, and microcells: coverage less than 250m) is high. We assume that congestion will be limited to access level and it can be avoided by over-provisioning in the metropolitan and backbone level, since the technologies used in the fixed links (wireless microwave links, wireless optical links, fiber optics) can help so that the congestion to be negligible.

Our conclusions on the congestion pricing are as follows:

a) The various models, which include an auction mechanism to avoid congestion, are too complicated for the customers and too costly for the service providers to deploy and they are alien to the majority of customers.

b) Congestion pricing forces the consumers to spend extra time to monitor the congestion of the network.

c) Charging according to expected congestion time periods (time of day pricing) is simple to implement, understandable and predictable for the customer and it is the one still being used. This pricing scheme can alleviate congestion in backbone network.

d) Congestion in mobile networks can appear in many different places (e.g. the Radio Base Stations). It is very complicated and costly to implement a model of dynamic pricing to avoid congestion. A simple congestion pricing scheme for a reserved channel capacity can deal with congestion in the wireless access.

e) Session admission control works better than congestion pricing and leads to stable prices for services with QoS guarantees.

f) Revenue is not a simple function of bytes. Different services have different price elasticity and the computation of the price must be made per service. Every byte has a different value and it depends on the application used.

4 PRACTICAL PRICING STRATEGIES

In practice, cost recovery and return on investment are key costing issues for mobile operators, so they can be used to determine prices [9], [10]. Cost information provides a useful starting point for the determination of a profit-maximizing charging structure. A simple approach to pricing would take into consideration the various types of services (Table 2).

Table 2: Service with predictable and unpredictable traffic volumes per session

Services with predictable traffic per session	Services with unpredictable traffic per session
	Conversational person-to person real time (voice & video telephony)
Person-to-person non real time text messaging (sms)	Person-to-person non real time (multimedia messaging-mms, email)
Content to subscriber – downloading (ringtone, game, mp3, videoclip)	Content to subscriber – browsing mobile portal
Content to subscriber – Person-to-person streaming (Vod-Video on Demand)	Content to subscriber – person-to-person live streaming (mobile TV)
	Mobile Internet Access

Such an approach is illustrated in Figure 3. Services with predictable traffic per session incur predictable cost to the network provider, whereas services with unpredictable traffic incur unpredictable costs. For services "content to subscriber", an additional content price must be added.

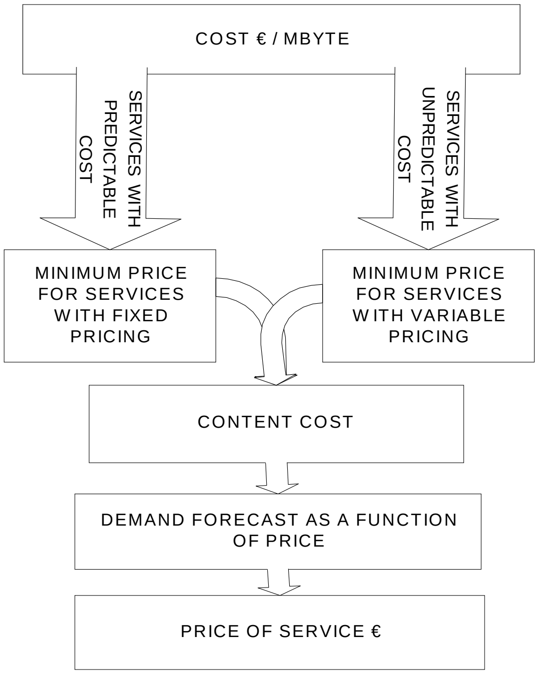


Figure 3: A simple approach on price calculation.

4.1 Volume-based and time-based pricing for unpredictable traffic volumes

In wireless networks, fixed costs constitute the major costs making the Marginal Cost (MC) approximately zero. To overcome these obstacles, the concept of Incremental Costs (IC) has been developed. Instead of measuring the cost of a single output, the incremental costs express the cost of providing an additional increment of output (e.g. one million minutes or one million transferred Mega Byte of data). When costs are measured over the long run (LR) time horizon, all equipment vary in response to a change in demand, resulting in Long Run Incremental Cost (LRIC). Then, the Long Run Average Incremental Costs (LRAIC) is the LRIC divided by the number of units in the increment ([9]).

Apart from LRIC, other cost models include the SAC (stand alone cost), and FAC (fully allocated cost). SAC is the total cost of providing a service in a separate production process. FAC allocates the total network operator's costs to the different services it produces. The rules of cost based pricing are:

i) The price of any product will be no *lower* than the *incremental* cost of providing an extra unit of the product; nor than the *average incremental cost* of all units of that product.

ii) The price of any product will be no higher than the average stand-alone cost of producing that product.

In practice, these rules do not determine exactly what the right price should be for every service but they give a lower and upper limit on the price (Figure 4).

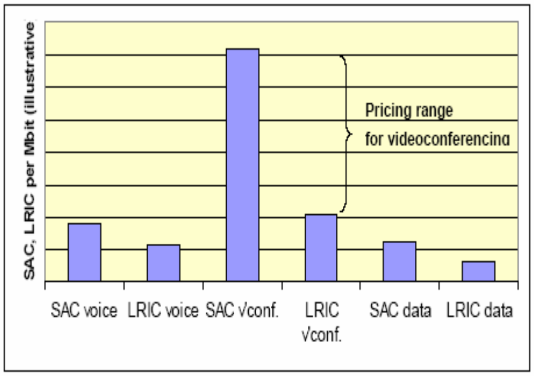


Figure 4: Price floors and ceilings based on incremental and stand-alone costs [10].

The basic idea behind the cost approach is illustrated in Figure 5 which shows a Required Revenue (RR) curve for an individual service. RR has been obtained by summing the cost function for the service plus a target rate of return. By adding the required profit or return on capital to the cost function shows the sum of operating costs and depreciation incurred, by level of output. The shape of the curve reflects economies of scale and scope in the delivery of the service. Whilst the RR function is initially determined at an aggregate level, it can be converted into a revenue requirement per user by dividing across the expected number of users.

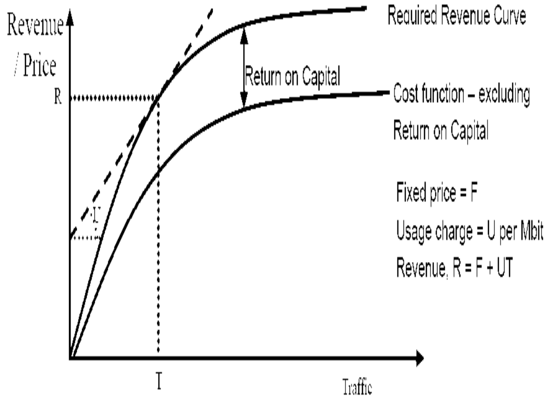


Figure 5: Defining tariff options for an individual service [10].

Figure 5 shows a variant on this sort of price package, where the customer is charged a flat fee (R) for traffic volumes up to a specified maximum (T), with usage charges being applied if the maximum is exceeded. Different prices can be designed for an individual service by differing R and T. These prices are designated to different user profiles. This pricing scheme is used today for pricing voice services in 2G and 3G, and pricing mobile Internet in 3G. One benefit of such pricing options is that they give users an incentive to reveal accurate information to the service provider about their expected traffic volumes, because by choosing the right tariff option they will minimize their expenditure. This gives important information to network providers to design and manage the capacity of the network. This sort of information will be especially useful during periods of great uncertainty over future traffic volumes, as is currently the case, for example, with 3G data services.

Also this pricing scheme can introduce a crude method to deal with congestion in the backbone network, such as applying higher usage related charges for traffic above the expected levels. This is a desirable requirement for services with unpredictable traffic in order to inhibit users who tend to overuse the network to do so. In terms of Figure 6, this would be equivalent to increasing the slope of the line SU (which is a tangent to the RR curve), and charging instead on the basis of line SV. This method is used today in charging mobile data in most countries around the world. Prices of the mobile Internet in UK are illustrated in Figure 7. ([13]-[17])

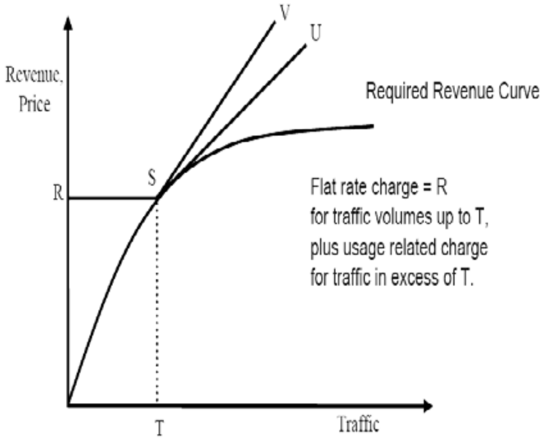
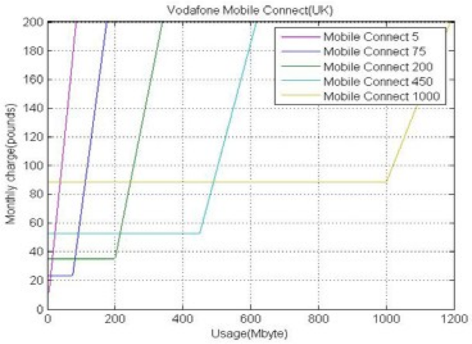
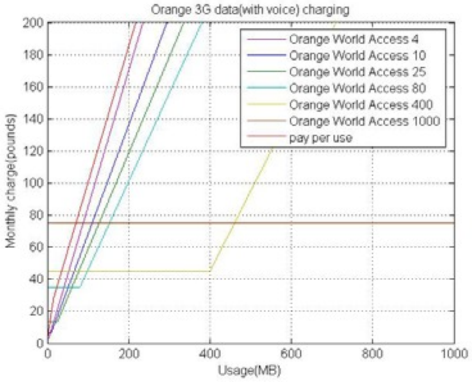


Figure 6: Flat fee for a specified traffic volume [10].





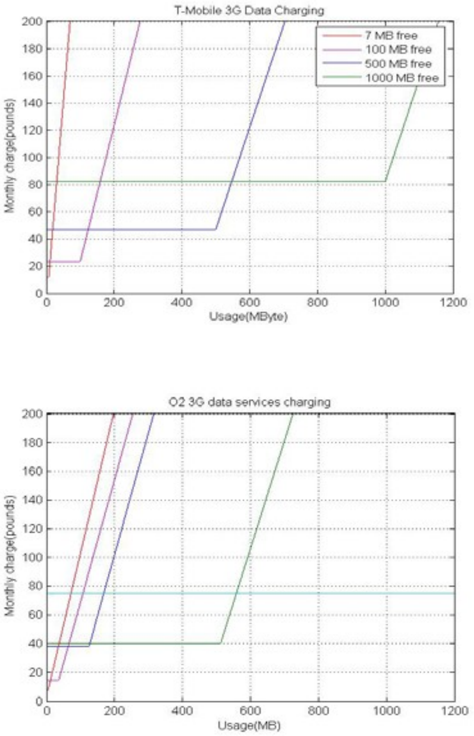


Figure 7: Prices for mobile Internet in U.K.

4.2 Pricing for predictable traffic volumes

A wireless Internet pricing model must encourage usage while maximizing per-service profitability. Fixed pricing per event is well suited for services with predictable traffic (i.e. the number of bytes required to deliver the service). Examples of predictable traffic include mp3 downloading, sms, mms, and e-mails with a restriction in the volume of the attachments. Enhanced optional services that build on this core service can be charged based on perceived value. This provides end users with what they typically prefer, that is simple flat rates, while opening to the wireless service provider the opportunities to increase revenue and manage costs. The final price (Vp) can be calculated by summing the content price (Cp) and the cost of transmission of data (Tp), i.e. Vp=Cp+Tp. The content price is split between the content provider and the network provider [18].

A subscription-based model can be used for pricing the transmission of data. In this case, for a fixed monthly subscription a specific amount of products can be sold (for example 20 mp3 songs for 10€). The pricing model of Figure 6 can be implemented. However, since the traffic is a discrete function of bytes, a pricing structure like this on Figure 8 is implemented. For every additional mp3 song or video clip consumed after the limit, an extra charge is induced. Once again the slope of line SV discourages users to use the service too much. This Figure 8 shows the pricing of products with almost fixed traffic volume per session. To the above price the content price must be added.

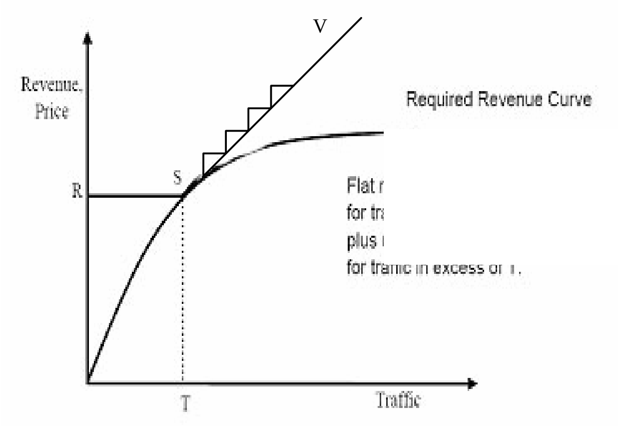


Figure 8: Subscription Pricing for services with almost fixed traffic volume per session

Concluding, the event based pricing (presented in the generic pricing schemes) has all the advantages (predictability, understand-ability, simplicity etc.) from the customer's point of view. So, a customer would prefer such a pricing model.

Mobile network providers hope that Mobile TV to be the killer application that will take up there revenues. Mobile TV is a service that has both unpredictable and predictable traffic. Its traffic is unpredictable when the customer watches a broadcast or unicast TV channel. It is predictable when the customer requests a specific video on demand which has a known time length. TV programs on demand can be charged in an event basis (pay per view) or with a subscription based charging scheme like that of Figure 8. On the other hand, a live TV channel can be charged on a subscription basis with limited minutes using a model like that on Figure 6. Let calculate the cost of a mobile TV programme. For 60 minutes of average quality (128kbps) with cost 0.4 €/Mbyte, it costs about 25€. This is a high price for the customer. So, for 3G a unicast TV service is profitable for prices that a user can accept only if it is used for short video clips on demand with premium content (football game highlights, popular TV programmes). Of course using multicasting techniques these costs may be reduced. A number of subscribers will watch a TV programme simultaneously and this will cause lower traffic in the backbone and backhaul network in comparison to a unicast service which will deliver the service to each subscriber separately. So, it is expected that the cost per Mbyte will be further decrease using the Multimedia Broadcast Multicast Service (MBMS) which will be available in Universal Mobile Telecommunications System (UMTS) rel.6.

5 CONCLUSIONS

In the 3G networks of the future, one of the key network management issues will be how to deal with congestion. Broadly, the three available options are: i) to block the excess traffic, ii) to deliver it with a lower QoS (e.g. slower transmission speeds, or higher packet loss), or iii) to charge a higher price for carrying it. At some stage, dynamic charging structures may well adjust tariffs on a second by second basis in order to choke off congestion-causing traffic. If we assume that the applications which require guaranteed bandwidth (conversational and streaming applications) are either served or blocked in case of congestion, then the various congestion pricing models can be used in best-effort and interactive applications like Mobile Internet. However, the strong requirement of customers for predictable, understandable and simple pricing schemes makes unlikely such schemes to be employed in the high competitive 3G mobile markets. The competition with fixed Internet, Wi-Fi and WLAN (Wireless Local Area Network) technologies which use flat-rate and simple usage based charges will be another obstacle for the operators to employ congestion pricing with on a second-by-second basis adjusted tariffs.

Simple usage charges, time of day pricing, and a simple PMP-like pricing with linear and not flat-rate tariff for congested cells can be used to deal with congestion in the wireless path. Usage based charging helps to deal with congestion in the backbone for both services with predictable and unpredictable traffic per session as shown in Figures 6 and 8. In this paper, we have proposed a simple congestion pricing method only for those willing to pay more to transmit their data during congestion periods.

The biggest growth area is likely to be per-event charging, because it enables the suppliers to set prices which for many services are: i) more easily understood by customers than a charge per Mbit, and ii) more closely aligned to the market value of the service being provided. Per event charging for text messaging has proved very lucrative for the mobile operators, who are now looking to repeat the experience with picture messaging over their 3G networks. Per event charging is also well suited to the downloading or streaming of data, music or video, where most of the value resides in the content of the deliverable rather than the manner in which in it is delivered.

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