# Edge Pricing

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## Abstract

Pricing of the network and content services are key issues in the development of the Mobile Internet. This paper discusses the use and applicability of edge pricing in the mobile packet core. It explains why roaming and prepaid have to be considered when defining the edge of the mobile packet core. It shows that for Internet access over GPRS most reasonable items to charge can be charged at the edge and that operators indeed use these. The identified limitations of edge pricing are only partly of technical nature but relate more to the role of the network operator. Vendors are actively improving the service awareness of the mobile packet core. So it is likely that the role of edge pricing will remain very strong also in the future.

## 1 Introduction

Edge pricing as defined in [1] has been frequently discussed as a basis for pragmatic usage constraining Internet pricing schemes [1], [2], [3]. The architectural approach has been applied to broadband access and to QoS capable environments.

This paper discusses the practical applicability of the concept in the mobile networks. The focus is on the packet switched (PS) core of 3GPP compliant networks. Wireline networks are used as reference as many of the mobile Internet concepts are derived for the wireline environment. Also the implementation of the circuit switched (CS) core in the mobile networks is important as the CS and PS domains still share a wide range of functionality.

In section two a simple definition for edge pricing is given. Section three tries to locate the edge - a non-trivial question in the mobile networks. In section four the relationship between charging and pricing in the mobile packet core as well possibilities and limitations of edge pricing is discussed. Using actual GPRS pricing schemes the applicability of edge pricing in the current mobile environment is analysed. Recent approaches to enhance the edge of the mobile Internet are described in section five. Finally section six lists the conclusions.

## 2 Edge Pricing

The fundamental idea of edge pricing in [1] is, that the price is based on the expected congestion along the expected path appropriate for the packet's source and destination. All information on the usage of services and network resources needed for billing has to be available at the edge, or made available to the edge.

Edge pricing is radically different from most of the research work done on Internet. Traditionally the focus has been on the actual congestion cost along the route that the packet really traverses [4], [5]. These proposals include instant auctioning of bandwidth, variable congestion charges and other fair but hard-to-understand pricing schemes.

Edge pricing is more than a pricing scheme. When applied it defines the technical constraints for the price setting, i.e. [6] selecting the pricing objective, determining demand, estimating costs, analyzing competitor's prices and offers, selecting a pricing method and selecting the final price. In the process the possibility to charge for the service at the edge of the network has to be considered.

Note that the original definition of the price being based on the expected congestion along the expected path is quite sufficient for the wireline networks where much of the value of the ISP service is in the high bandwidth low latency access to content in the Internet. In the mobile networks it is more accurate to define edge pricing being based on the expected value (or cost) of the packet. Pricing in the Mobile Internet is more focused on services than plain bandwidth. One reason for this is that the network operator controls the service systems and has been able to charge for the services. This is in sharp contrast to the Internet where most of the content has traditionally been free of charge.

## 3 Where is the edge

In this section we look for the edge, i.e. those network elements that are essential for collecting the charging information. Here the focus is on packets and calls. Extending the charging to more complex services is discussed later.

### 3.1 Wireline networks

In an ISP environment the edge is easy to define. In a traditional dial-up service or circuit switched data service provided by mobile networks the user data enters the ISP network in a remote access server (RAS). These devices terminate the modem or ISDN connection and

the PPP session to the user device. In the RAS authentication, authorization and accounting (AAA) also takes place, although in most cases a separate AAA server is used as database. For broadband services (e.g. DSL) and direct IP access essentially the same services are implemented in a broadband access node.

The ISP view of the network [13] is shown in Fig. 1. Note that in many cases there may be a large network between the subscriber and the "edge". These networks are not aware of the user IP packets as the traffic is tunneled across these networks using PPP, ATM, Frame Relay or some other transport.

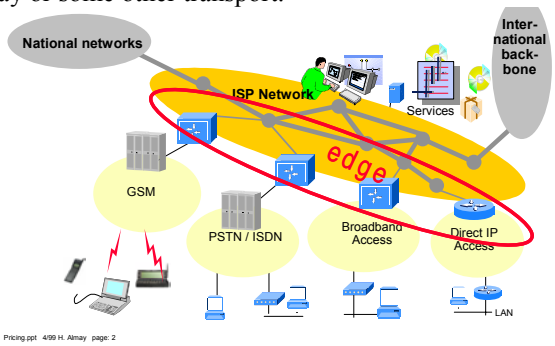



**Figure 1: Network structure from ISP perspective**

Especially in the broadband environment the initial access nodes have evolved to advanced service management systems that support service selection and a variety of charging options.

## 3.2 Mobile networks

3GPP defines CS and PS core network (CN) domains of the mobile system. Additionally Services and IP Multimedia Subsystems have been defined. These all use the GSM EDGE Radio Access Network (GERAN) or WCDMA Radio Access (UTRAN).

A rough outline of the 3GPP domains and subsystems and how the edge maps to these is given in the figure below.

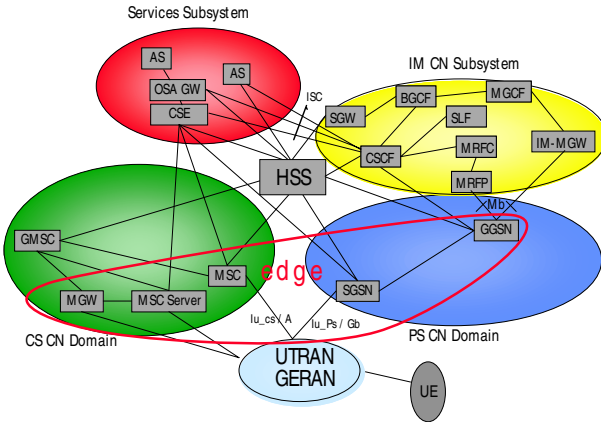



Figure 2: The edge in the 3GPP architecture (based on [10])

Traditionally in the CS core the serving MSC has been the edge device. The MSC invokes user authentication, it switches and supervises the calls and generates charging information much like the RAS in the ISP environment or the local exchange in the PSTN. In the MSC server concept the functionality has been split to the MSC server and the media gateway (MGW). It is worth to note that in the CS core the edge will move along with the subscriber. A roaming subscriber is served by the visited network.

A lot of work has been done during the GSM evolution to ensure that services travel along with the subscriber. Using the Customised Applications for Mobile network Enhanced Logic (CAMEL) it is even possible to provide prepaid services for roaming subscribers.

In the packet switched core the definition of the edge is more complex than in the CS environment. The most obvious approach is to say that the GGSN is the edge. It provides the connection to the service network (Gi). It generates charging records. It is easy to implement deep packet lookup to allow even content charging. So why does Fig. 2 suggest that the SGSN should be included in the edge?

The obvious reason is that a visited network needs the SGSN for charging a roaming subscriber in the case that the GPRS access point used is in the home network of the subscriber. Only if the user is attached to the default Internet access point both SGSN and GGSN are in the visited network. This option is not widely used today.

IN based prepaid services also need the SGSN. CAMEL based prepaid covers also GPRS access. When a prepaid GPRS user initiates a connection the SGSN communicates with the IN in the subscriber's home network and checks if credits are available.

CAMEL and SGSN charging capabilities provide a solution to the charging of roaming GPRS subscribers. Knowing that in countries like Italy most of the mobile users have prepaid accounts, the issue has also commercial impacts for the network operators.

So looking at the roaming cases both the SGSN and GGSN have to be considered as edge. The SGSN is the edge to the home networks of all the visiting subscribers and the GGSN is the edge to the services networks.

In this document the focus is on the GGSN and the services although also the applicability of edge pricing to the roaming charges will be briefly discussed.

# 4 Charging and pricing in the Mobile Internet

In this section a brief discussion of actual mobile network charging mechanisms provides a background for the assessment of the possibilities and limits of edge pricing. With real pricing examples the possibilities to achieve differentiated pricing schemes with edge pricing is analysed. Additionally some thoughts about edge pricing and roaming connections are presented.

## 4.1 Charging in the mobile packet core

The figure below shows an example 3GPP release 5 mobile network with PS core and IM Subsystem and Services Subsystem. It highlights the elements that generate charging records (CDR). Charging information is collected by the SGSN and GGSN and potentially all of the service systems used (WAP gateways, messaging platforms, download servers etc.).

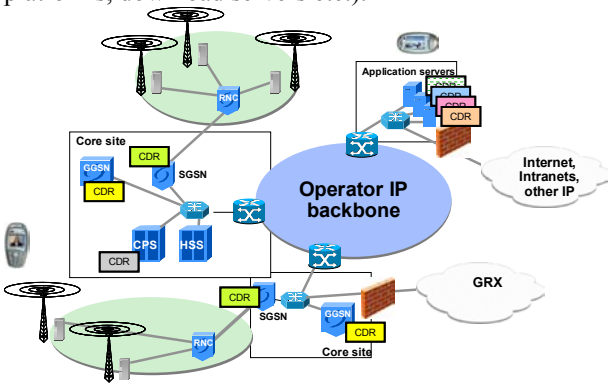



**Figure 3: Charging in the PS core and IM Subsystem**

The different CDR colours of Figure 3 indicate different formats. In the PS core edge (SGSN and GGSN) two record types with almost identical content are produced. Generally in each of the server systems charging is done in a different way.

In most cases the different charging records generated for a particular session have to be correlated, analysed and rated according to the used pricing scheme. A large number of charging record formats and charging interfaces leads inevitably to much work in the mediation devices and the actual billing systems.
Changes in a charging record (e.g. a new chargeable event) mean changes to the billing system. These changes take time and cost money especially as the quality and stability requirements for charging and billing are extremely high.

From the above discussion it can be concluded that edge pricing looks attractive as it helps to keep the number of sources for charging information at a minimum.

## 4.2 What can be priced at the edge

When looking at the charging record of a standard GGSN (or SGSN) the most important parameters that charging can be based on are data volume upstream and downstream, access point name, connection time (start, stop, duration). Additionally charging for QoS (UMTS traffic class) is possible, provided the network supports QoS differentiation.

Additional service components may include e.g. provisioned access capacity both upstream and downstream, equipment rental, IP addresses, authentication services and private access points. None of the listed items requires additional dynamic information from the network. So they conform to the edge pricing scheme.

Already at this stage it can be mentioned that extending the GGSN charging capabilities with a deeper lookup into the relayed packets allows charging based on source and destinations IP addresses, used protocols and to some extent even transactions.

## 4.3 Limitations of edge pricing

While edge pricing provides a solid and potentially cost saving architecture for pricing network services the challenges are in the area of content. In case mobile payment [8] and wallet applications in mobile devices become popular, there is no added value in network based charging, pricing and billing for content. End-user self service is more flexible and cost efficient provided that generally accepted reliable, secure and user-friendly wallet applications are available.

Flexibility is a second potential weak point of edge pricing. In the 1990's many PSTN operators struggled with the charging of premium rate services. Providing billing services for all types of service providers was initially an easy business for the network operators, but when service usage and competition increased the service providers complained about inflexible [edge] pricing schemes imposed by the telcos. Those in turn were busy with the huge amount of moves adds and changes in their numbering and billing caused by rapidly changing services. Avoiding credit fraud became also an issue.

The same challenges as with the PSTN service numbers are also present when edge pricing [and the network operator billing services] is used for pricing services of independent IP service providers.

Encryption is a potential limitation to the use of edge pricing. If the traffic is end-to-end encrypted, no intelligent traffic analysis at the edge is possible. When thinking about downloading valuable content, banking, e-commerce or corporate connectivity it seems quite

likely that much of the traffic across the mobile edge will be encrypted.

Literature [1] lists services with highly variable delivery cost as a challenge to edge pricing. The example service is a multicast tree, where the number of users shares the actual cost of the used bandwidth. While this may be an issue in a broadband access environment, it is likely that in the mobile networks the most valuable and scarcest resource will be the radio access.

From the discussion in the previous section we know, that prepaid causes some considerations, not just for roaming, but also for charging new services available over the mobile packet core. As prepaid charging is typically done by the SGSN, it is challenging to do service differentiation, e.g. offer free of charge data transfer to service systems (MMS Center).

The above is a symptom of a bigger issue. For new services used over the packet core the operators want to offer clear and easy to understand pricing schemes (e.g. fixed price per MMS). This might be possible using by charging in the service system. If however most other services are charged at the edge, the price for the end user may be a complicated mix of access and service charges. Post-processing the charging information in the billing system could help, but this option is not available for prepaid subscribers.

## 4.4 GPRS pricing schemes

Keeping in mind the charging capabilities listed in 4.2 it is now possible to analyse to what extent actual edge pricing is used for actual GPRS services.

A look at the GPRS pricing on the German market (Table 1) reveals that monthly rates and volume charges are the most frequently used price components. While some pricing schemes include installation charges or time based (hourly, daily) rates, these are in most use cases not essential.

**Table 1: GPRS Pricing in Germany [9]**

| Tarif | Installation charge (€) | Monthly rate (€) | Volume included (Mbytes) | Hourly rate (€) | Daily rate (€) | Volume charge WAP/Internet (€/ 10 kbyte) |
|---|---|---|---|---|---|---|
| **T-Mobile** | | | | | | |
| GPRS Basic | - | - | - | - | 0,29 | 0,29 |
| GPRS Profi | - | 9,95 | 1 | - | - | 0,29 (100 kbyte) |
| GPRS Office | - | 39,95 | 20 | - | - | 0,19 (100 kbyte) |
| **Vodafone D2** | | | | | | |
| GPRS By Call* | - | - | | 0,016 | - | 0,20/0,29 |
| GPRS L | 4.95 | 9,95 | 5 | - | - | 0,09/0,029 |
| GPRS XL | 4.95 | 19,95 | 20 | - | - | 0,05/0,025 |
| GPRS XXL | 4.95 | 39,95 | | - | - | 0,05/0,019 |
| **E-Plus** | | | | | | |
| GPRS Tarif | | - | - | - | - | 0,25/0,06 |
| GPRS Premium | - | 10 | 1 | - | - | 0,1/0,1 |
| GPRS Data S | - | 10 | 2,5 | - | - | 0,25/0,04 |
| GPRS Data M | 5 | 20 | 7 | - | - | 0,25/0,03 |
| GPRS Data L | 5 | 30 | 15 | - | - | 0,25/0,03 |
| GPRS Data XL | 5 | 40 | 20 | - | - | 0,25/0,03 |
| **O2** | | | | | | |
| GPRS L** | 5 | 9,95 | 1 | - | - | 0.025 |
| GPRS XL** | 5 | 19,95 | 5 | - | - | 0.022 |
| GPRS XXL** | 5 | 39,95 | 20 | - | - | 0.019 |

It is worth to note that the volume charges are for 10kbyte or 100 kbyte blocks of Internet traffic or in case of WAP individual pages or 1kbyte blocks of WAP traffic. While all the other price components can be charged at the packet core edge, information about consumed WAP pages has to be collected at the WAP gateway.

Basically Table 1 contains pricing both for the service *Internet access over GPRS* and *WAP surfing*. Edge pricing is applied to the Internet access service in all of the sixteen pricing models. This is hardly a surprise as the mobile operator has no control over the content or type of content transferred.

In case of WAP a closer look at the listed tariffs [11] indicates that also the WAP traffic is charged based on volume. Technically the price differentiation between the WAP traffic and Internet traffic is today implemented using different access points for the services. So also the WAP surfing service conforms to edge pricing.

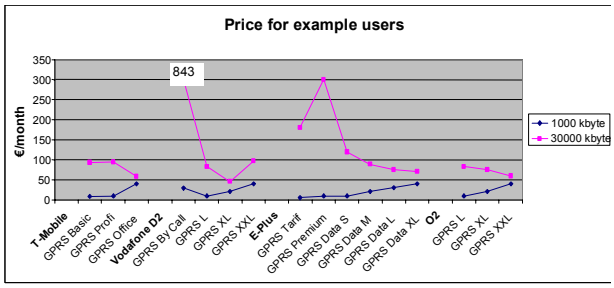
The prices listed in Table 1 apply for postpaid subscribers. For prepaid T-Mobile offers XtraData and XtraMMS with volume based pricing [15]. No instantaneous credit check is implemented so the user can overdraw his prepaid account. Prepaid GPRS is also available in the O2 network.

## 4.5 Edge pricing and price differentiation

Now that we know that [at least in Germany] all operators base their *Internet access over GPRS* service pricing on the edge pricing model it is time to analyse to what extent the limited charging counters available for supporting edge pricing do restrict the operator price setting. Are the pricing schemes all the same or is there a real choice?

Looking at the German GPRS pricing schemes it is quite obvious that basic volume and time-based models are attractive only for occasional very low volume users.
Most of the German GPRS pricing models use block pricing with the block included in the monthly rate ranging from one to twenty Mbytes. Currently the block size is the key difference between the individual schemes.

Figure 4 shows the monthly cost of GPRS based Internet access for two example users. One of them is a PDA or smart phone user reading e-mail and surfing occasionally. His monthly traffic is one Mbyte. The other user is a mobile professional with GPRS connectivity to his laptop. Using e-mail and mostly web-based corporate applications he generates 30 Mbyte traffic per month.




| User 1: *PDA surfer* | User 2: *mobile professional* |
|---|---|
| uses GPRS on 20 days | uses GPRS on 20 days |
| 2 times a day (during 2h) | 6h / day, long times connected |
| Monthly usage: 1000 kbytes | Monthly usage: 30000 kbytes |

24 months usage assumed

**Figure 4: Price of GPRS for example users**

The case of the example users shows that the sixteen pricing models provide some differentiation. While the lightweight user could select between seven pricing schemes and four operators with a monthly cost of 10€ or below the heavy user has two viable alternatives (45/59€). There is also a clear difference in which pricing model appeals to the mobile professional and which to the low end user.

It can be concluded that price differentiation between the models are possible even though edge pricing is used across the board. However considering that all of the German operators essentially use similar pricing schemes which are built on the standard charging capabilities of the GPRS network, sustainable price differentiation in the Internet access service is hardly to be expected.

## 4.6 Edge pricing and roaming charges

The traveling GPRS user is charged both by the visited network and the home network. Generally the tariff models used in the home network do not apply today for a roaming user.

Of the example operators used in this section Vodafone D2 bills the charges of the visited network plus a handling charge, an hourly rate and per kbyte rate. A simpler scheme is used when roaming to other Vodafone networks. T-Mobile charges per 250 kbytes of data and daily usage charge. No information is available what a network operator will charge for the visiting subscriber.

The listed pricing schemes all fit into the edge pricing model.

# 5 Enhancing the edge

Charging of the new services available over the mobile packet core has become a hot topic. Network operators want to implement simple and easy to understand pricing schemes. The current combination of edge and service pricing is too complex to achieve the goal.

Several equipment vendors have identified the issue and are working on improving the edge pricing capabilities of the packet core.

Nokia has launched the Intelligent Edge concept [12], which improves the service awareness of the packet core. The key charging options of the concept are outlined in the figure below. In practice the charging is based on a deep packet lookup at the Gi interface. The differentiated charging also supports the prepaid real-time charging of packet traffic as there is a connection to the IN.

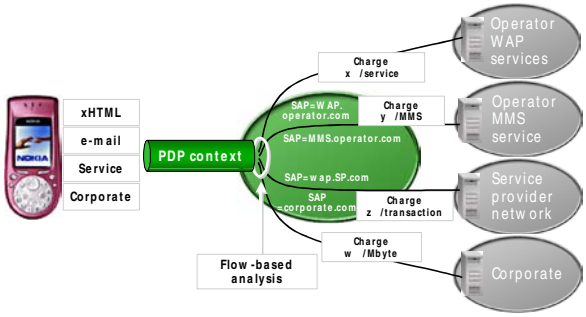



**Figure 5: Charging options of the ingelligent edge [13]**

A second approach to provide an intelligent edge is the Cisco Mobile Exchange, which provides postpaid and prepaid billing for time, volume, service or content level charging. The system components are shown in Figure 6.

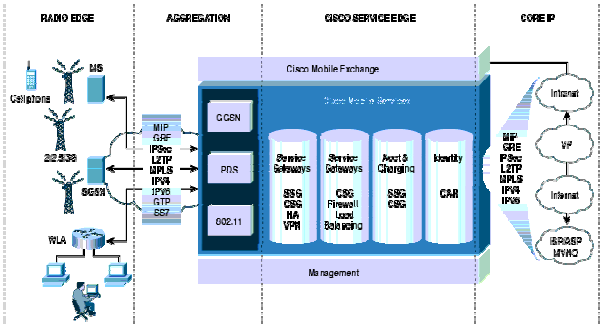



**Figure 6: Cisco Mobile Exchange Components [14]**

Note that this approach is derived from the broadband environment.

The two example systems show that enhancing the edge pricing capabilities of the mobile packet core are very high on the agenda and the role of edge pricing will stay dominant also in the future.

# 6 Conclusion

The edge pricing concept can be applied in the mobile networks, but the complexity of the mobile network has to be considered. The current pricing of the Mobile Internet services is to a very large extent based on edge pricing.

There are technical limitations in the current charging capabilities of the mobile packet core edge. These issues are addressed in the emerging intelligent edge products.

The big limitations and challenges to the role of edge pricing are not of technical nature. The big question is, will services be priced and charged together with network services, or is service pricing and charging only and issue between the service system and the mobile device.

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