Data Traffic Costs and Mobile Browsing User Experience

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ABSTRACT

Cost of mobile data traffic is seriously restraining mobile browsing from becoming commonplace. Our user studies with 35 international interviewees show that cost is a major influencer in mobile browsing user experience, and it is hard to understand, follow, and control mobile data traffic costs. In this paper, we discuss different billing models for mobile data traffic, how users perceive these billing models, and how they try to control costs. We discuss the different solutions for improving mobile browsing user experience on client, gateway, and carrier sides.

Keywords

Cost control, Wireless data traffic, Mobile browsing, User experience.

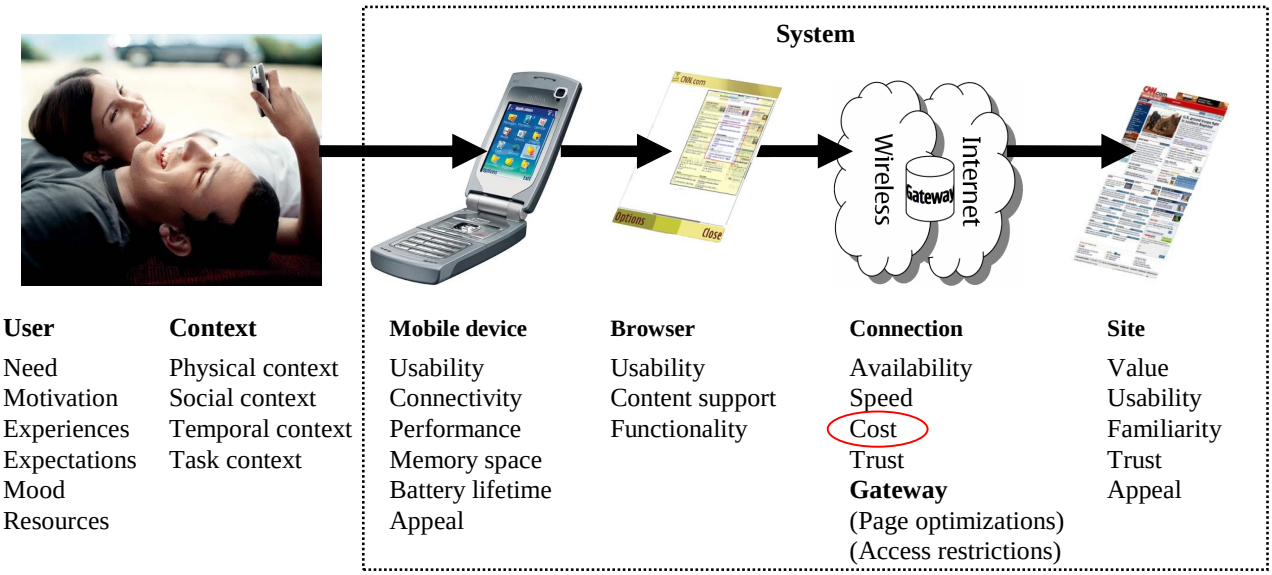
1. INTRODUCTION

Mobile phones are used mainly for phone calls and text messaging today, but an increasing number of carrier revenues is coming from mobile data traffic. As an example, end of 2005 Vodafone Japan saw 31%, O2 in the UK saw 28%, and China Mobile in Hong Kong saw 21% of their revenues coming from mobile data traffic [5]. Although our focus is in Internet browsing on mobile devices, mobile data traffic includes also downloading files from online sources, streaming, online games, email, and other data traffic generated by various kinds of mobile applications and services. Short Message Service (SMS), Multimedia Messaging Service (MMS), and subscriptions to paid services are outside the scope in this paper, because they are charged separately from the data traffic.

If you would ask somebody on the street why he does not access online information and services more on his mobile device, one of the top reasons will be the cost of using such services. Even if a layman uses mobile services actively, it is likely that he cannot show you any other way to control the costs of data traffic than use it less often and in shorter sessions. Only few advanced users are able to explain you how to control the costs when, for example, browsing the Web on a mobile device.

In the first part of this paper, we investigate the effect of mobile data traffic cost on end-user experience. Surprisingly, the current definitions of user experience [2],[4] do not mention the effect of pricing to user experience, although pricing is a key influencer on whether the user found a system worth the value, which directly affects user experience. Below, we illustrate a set of components that affect end user experience when accessing online information on a mobile device. The illustration is based on our earlier work [9] that the World Wide Web Consortium adopted [14]. We have now added components that affect user experience, not only usability. For example, connection cost does not affect usability, but we will show that it is an important influencer in user experience.

In the latter part of this paper, we propose possible solutions to improve user experience when it comes to mobile data traffic expenses. Note that we are not investigating the different technologies to minimize the amount of data. Instead, our research question is: Given a certain site or service, how to allow the *end user* to understand, follow, and control the expenses?



User	Context	Mobile device	Browser	Connection	Site
Need	Physical context	Usability	Usability	Availability	Value
Motivation	Social context	Connectivity	Content support	Speed	Usability
Experiences	Temporal context	Performance	Functionality	Cost	Familiarity
Expectations	Task context	Memory space		Trust	Trust
Mood		Battery lifetime		**Gateway**	Appeal
Resources		Appeal		(Page optimizations)	
				(Access restrictions)	

2. BILLING MODELS FOR MOBILE DATA TRAFFIC

Most current billing models for mobile data are designed for WAP (Wireless Application Protocol) services where the amounts of transferred data are low. However, the amount of data traffic is expanding among those who dare to access online sources with their mobile devices. There are several mobile devices today with a Web browser that allows users to access the very same Web pages as on a PC, and the number of users connecting their laptops to cellular networks is increasing. As data traffic in mobile networks will quickly increase, the cost per byte must come down dramatically.

Mobile phone billing models are fairly complex and vary from carrier to carrier. Typically, wireless data traffic (e.g. browsing) is separated from wireless voice (phone calls over the cellular network). The criteria for data traffic billing may be the duration of connection, amount of data downloaded and uploaded, connection speed, number of downloads, or a combination of these. Typically, billing is based either on time that the connection is open or bytes transferred (Table 1). We can roughly say that user experience of cost is the worst on the top left part of the table, and the best on the bottom right, so billing models tend to develop to that direction. As long as the fees are too high at bottom right, customers will prefer to stay at the earlier phases.

Time \ Bytes	By byte	Data block (+ by byte)	Unlimited
By second	Pay by time*bytes	N/A	2G
Time block	Monthly pay-per-byte	Monthly fixed data block	Monthly flat rate / Charged WiFi time
Unlimited	Prepaid	Prepaid	No fee / 1-time subscription fee

Table 1. Examples of data billing models by time and bytes. User experience is best at bottom right.

In the traditional 2G (second generation) telecommunications network, data connection was billed by the connection time. Although time-based billing is relatively easy to understand for users, they need to optimize their actions and concentrate to response as quickly as possible in order to minimize the connection time. Users have also to pay for waiting time and for correcting mistakes. Time based billing does not suit well into the mobile context, because users cannot dedicate their full attention to the application as in front of a stationary computer [8]. Still, almost 30**%** of the mobile subscribers globally were using 2G at the end of 2005 [12].

Packet switched 2.5G technologies, such as GPRS and EDGE, followed by 3G, enable charging by transferred data instead of connection time. This allows users to have the connection always on without extra cost. In late 2005, more than 60**%** of the mobile subscribers were using 2.5G connections, and roughly 5% 3G, with Western Europe (9%), South Korea (33%) and Japan (50%) having the greatest ratio of 3G subscribers [12].

In real life, data based billing is more complex than described above. Connection providers may separately decide that certain pieces of data are sent without a data traffic fee, e.g. its own portal pages, or a game file the user just purchased for a separate fee. It is very hard to find out the data billing rules of each carrier.

To improve user experience, many carriers have tried to provide a monthly flat rate: the customers pay a fixed fee no matter how much online data they use during a given period, e.g. a month. The monthly cost may vary according to the connection speed, so that 3G connections would be more expensive than 2.5G. This billing model is widely used for wired broadband browsing, perhaps because of its simplicity for both the customer and the provider. The downside is that occasional users have to subsidize the traffic generated by the heavy users [1]. The downside for network carriers is the fact that traffic increases a lot [10] Although in developed countries people are surprisingly willing to pay extra for a flat fee [7], we suspect in developing countries people with the lowest income cannot afford paying an average fee.

Many mobile carriers are skeptical about the monthly flat rate for mobile data traffic, and have had to cancel flat fee offers because the network quickly becomes congested. The threats are that consumers transfer their mobile voice calls to the data traffic side using VoIP (Voice over Internet Protocol) technology, and download large files such as music collections or movies in the background over hours or days. Widespread use of such applications could seriously congest wireless networks and reduce the available capacity for subscribers.

To solve the above threats for a monthly flat rate, many carriers today have restricted the flat rate traffic to WAP services only, or set an upper limit for the amount of data that users can download during the billing period with the flat rate. The fixed data block model gives end-users the opportunity to have a fixed data amount per month included in the plan, and only data exceeding this amount needs to be paid per byte. The model makes data usage more attractive as small data blocks can be offered for a low price, and the user has better chances to estimate monthly costs. There are several downsides in this model, however. First, users find it hard to estimate how much data they will consume. Second, users are often not informed about exceeding the data limit, and the bytes above the monthly data limit are typically very expensive. Third, even if the user was warned about reaching the limit, there is no simple way today to purchase an extra data block with a reasonable price. In the worst case, users are as surprised to receive a huge bill as without the fixed data block.

Today, a vast majority of mobile data users do not have any simple way to estimate the data traffic sums on the forthcoming phone bill, so it is a tempting opportunity to pay a sum in advance. A prepaid system is increasingly popular for mobile phones: in 2005, 62% of mobile phone users globally paid their phone costs in advance, and the number is expected to grow [12]. The convenience of purchasing a prepaid card is one important reason for the popularity, but we believe the ability to keep the phone costs within a budget is also an important motivator. Paying in advance does not make it any easier, however, to estimate how much one consumes for data traffic. Instead of the huge bill surprise, users are surprised by how quickly the prepaid sum is spent.

If you are lucky, you are one of the 26% mobile phone users who have the phone bill paid by a company [12]. You are of course less reluctant to data traffic costs if it does not affect your own

financial situation. Still, the smaller the company, the more the business users do care about how much their browsing costs for their company.

Future technologies for mobile communication include also non-cellular connections such as WLAN and WiMAX. Today, few mobile phones support WiFi (Wireless Fidelity, IEEE 802.11), but market analysts predict that there will be more than 47 million WiFi enabled mobile phones sold during 2008 [13]. WiFi is currently either free of charge or paid by connection time, and there are signs that envision free WiFi to be broadly available [6][11].

If there is a reasonably priced flat fee or free connections available for everyone, this paper would be obsolete and we would be gratified. However, based on the facts we described in this section, we believe a monthly flat rate billing or free connections will not become commonplace for all mobile phone users within the next five years, and there remains a significant number of users who need to follow cost accumulation for mobile data traffic.

3. BILLING MODEL PERCEPTIONS

Earlier research shows that the connection billing model has a dramatic effect on how people consume online data and how satisfied they are with the connection and online services [1][3][10]. There are various billing models for mobile data today, and most carriers do not clearly communicate how data traffic is billed. This leads to an interesting phenomenon, not been investigated earlier: users make assumptions on how their data traffic costs cumulate based on prior knowledge, system feedback, and the information on the phone bill. This *perceived billing model* affects usage patterns of online data, no matter if the perception is right or wrong. If the perceived billing model is different from the actual billing model provided by the carrier, it is an unfortunate situation for all parties.

The phenomenon of the misunderstood billing model has come up in our studies about mobile online access. We have run altogether 35 in-depth interviewees in five user studies in different parts of the world (Table 2). 6 interviewees were female and 29 male, ages varied between 17 and 63 years (mean 32 years). In studies 1 and 4, participants used a mobile phone or Nokia Communicator for browsing. In the WLAN study in the US, we interviewed 7 laptop and 2 PDA users, and in study 3 in Finland, all participants used a Nokia 9500 Communicator. Users had different service providers, having different pricing models for mobile data. We used a contextual inquiry method, although not every interview could be conducted in real use context. The cost of browsing was not originally of primary interest in these studies, but it came up in every study as an important factor in user experience.

	Location	Interviewees	Time	Scope
1.	Helsinki, Finland	6	2/2004	Phone browser
2.	Boston, U.S.A.	9	10/2004	WLAN
3.	Helsinki, Finland	6	3/2005	WLAN
4.	Tokyo, Japan	7	5/2005	Phone browser
5.	London, UK	7	11/2005	Phone, WLAN

Table 2. Our user studies on mobile Web browsing

In studies 1, 4 and 5, several interviewees mentioned that they had once received a huge phone bill, and cut down the amount of mobile browsing after that. It is easy to believe that many people who do not use mobile browsers today have quit browsing totally after receiving a huge bill.

3.1 Saving by minimizing connection time

Seven participants in Finland, Japan, and UK perceived the billing as by connection time, and we saw dramatically different usage patterns here compared to the users who perceived the billing being by bytes.

When users think it is the connection time that costs, they plan the online session more carefully and try to minimize the time the connection is open. When connected, they do not waste time for reading, but just quickly scroll to the target position where they know the needed form field or link is located. Once they reach the target page, they first cut the connection and only then read the content. If one wants to check several pages, the ability to download pages at the background to several windows helps saving online time.

Also, the time for text entry needs to be minimized. One user in Tokyo had cleverly noticed that she could save the text entry time by storing a page with a form in the phone, cutting the connection, and entering the text offline. After submitting the form, train route information in this case, the connection was opened again. She also reused the saved forms to fetch the route information next time with a minimum period of time online.

Slow page loading times over wireless networks were particularly irritating if the participant thought s/he was paying by time. User satisfaction figures would probably look quite different for people who think payment is by the connection time and for people who know that waiting time does not pile up browsing costs. It is important to inform people properly when they do not have to pay for the waiting time or cut the connection to save money.

3.2 Data traffic indicators

Connection and loading indicators did have an effect on how our participants perceived the billing rules. In systems where the user paid for online time, the indicator for elapsed connection time provided important feedback about cost accumulation. Also other indicators, such as a LED or an icon, were used for communicating that the connection is open. If the LED or icon was blinking, it was perceived as a warning signal. In Tokyo, we saw a blinking icon used also for a connection that was paid by transferred data, not by connection time. The user thought that the costs cumulate as long as the icon is blinking, so she wanted to cut the connection as soon as possible. We think the blinking icon was a major influencer for this misunderstanding.

Now that payment is typically based on transferred data, browsers often indicate the amount of data transferred when downloading each page, not the elapsed connection time. Unfortunately, an indicator of form “3.2kB” did not help much an average user to estimate cost. Mobile phone users should not need to understand how 435kB relates to actual costs, and how kB is related to MB. The indicator is for each page separately, so participants complained that keeping the cumulative costs in control based on this information was not an easy task.

How did the participants follow the costs of their mobile phone use? Most of them did not know any way to follow the costs, whether for phone calls or for data traffic. There might have been a cost control service available from the carrier, but participants did not know that such a service existed, or they did not use it because it was too expensive. The bill that came a few weeks after the billing period was closed was often the first chance to check the phone costs.

3.3 Controlling costs

The most frightening scenario in mobile browsing is probably the huge bill surprise, especially when roaming, reported both in press [15][16] and in our studies: After discovering the opportunities of mobile browsing, a person was eager to use sites on their mobile device. After a month of browsing, s/he received a huge phone bill e.g. of 200€. The bill may be double the device price. At this point, one easily makes the decision not to use the mobile browser at all.

If the user still wants to use mobile browsers, s/he tries to figure out what was it that cost so much, and find ways to control the costs in the future. We have seen that only technical people understand how they can control costs when browsing the Web with a mobile device. They understand that they pay for bytes transferred, and that textual content is inexpensive whereas images and embedded content on pages are expensive. Non-technical people cannot see the relation between image down-loading and browsing costs. This means the function in many current mobile browsers to set image loading off does not help non-technical people to control costs.

Even if an end-user understood how mobile data traffic costs cumulate, it is impossible to estimate how much a link click will cost you. This is because estimating the heaviness of the page behind a hyperlink is impossible if one does not know the page from earlier experience. We have seen that many expert users try to avoid the heavy main pages of Web sites, and sometimes use Internet search engines to bypass the main page and to get to the target page directly.

The option for mobile browsing was seen most useful when one spends long times away from a PC, e.g. while traveling. Unfortunately, data traffic costs today are huge when roaming abroad, and it is very hard to find out the data traffic tariffs of each local carrier. To save costs, it is possible to buy a prepaid SIM card provided by one of the local carriers and use that for mobile browsing, but none of our interviewees had realized or used this opportunity.

4. PROVIDE CONTROL FOR END USERS

There are several ways to help users understand, follow, and control data traffic costs. In the following sections, we discuss solutions applicable on carrier side, on a gateway, and on the mobile device.

4.1 Carrier discloses cost information

The carrier is in a key position to help users follow and control the cost of mobile data traffic in an easy, understandable way. The carrier is the only one who exactly knows the current expenses of data traffic, because the carrier will take care of billing.

Not all carriers are willing to provide the cumulative cost information for users, since they think seeing the costs all the time does not drive increased usage. From another perspective, knowing the current balance could increase usage, in case the user has a false idea about browsing expensiveness. As mobile data traffic prices come down and consumers do not have the means or motivation to keep track of each price cut, many users do think that browsing is more expensive than it really is.

In many phones, there is a data counter that allows the user to check the amount of data transferred and to reset the counter. Converting kilobytes to money is a challenging task for many users, however. A data counter might be a useful tool with fixed data block plans where the user should be aware how much of the data block is consumed, but unfortunately, there are many challenges there. First, resetting the counter should be done at the start of the billing period, but few people remember to do that manually. Second, data counters do not always offer reliable information because not all data traffic is charged in a consistent way (e.g. MMS messages and carrier portal traffic), and carriers often round data traffic to the next kilobyte in their internal billing system. Third, when the user is traveling abroad and roams in a foreign network, the normal billing rules do not apply. So, plain information about the kilobytes transferred does not communicate the real expenses, but the information must come from the carrier that knows the exact billing rules.

The best way to follow costs would be to see the actual cost accumulation in real-time in the local currency in the loading progress indicator. The users could see the cost of the upcoming data even before loading was started, and cost-conscious users could choose to receive a notification on whether to download big data blocks or not. The main challenge here is to exchange the information between the network carrier (both in the home country and abroad) and the various types of phone terminals and applications.

We have discussed with some European carriers this challenge, and there have been considerations to implement improved methods to let users monitor and control their costs. However, the complexity to manage complicated and quickly changing pricing plans between the client and the billing system have prevented the development of such a system to date.

4.2 Gateway provides end-user control

A gateway is a node in the network through which data traffic can be routed. The gateway can act not only as a proxy server and firewall, but also as a content optimizer. The content optimizing gateway is typically provided by the telecom carrier or by the browser manufacturer.

On large Web pages, most of the content is irrelevant for the user. When looking for just one hyperlink, one should not need to pay for the full page. If the user wants to save money, s/he could ask the gateway to minimize the amount of data traffic over the expensive wireless connection. This can be done by splitting the page into pieces, by removing irrelevant content or by transforming content to a lighter format. Common methods for data compression used today in gateways are gzip and deflate filter to compress text as well as changing the depth of images.

All gateway optimization solutions share some problems, first being scalability. For each page request such a content adapting proxy needs to retrieve the needed files, process, package, and

deliver them to the client. For fast performance such servers need to be in good physical proximity to the client and be able to handle a large amount of requests at a time. Serving multiple of million subscribers requires extensive hardware and software investments instead of leveraging the processing power of the client device.

Another restriction is privacy. The user needs to trust the proxy server provider who is able to follow all browsing activities of mobile users. Many sites relevant for mobile browsing require secure encrypted communication all the way from the service to the client, so the proxy cannot optimize these pages.

Carriers also need to inform users that content is altered in the gateway and the content displayed may not be the exact content provided by the content provider. For legal copyright reasons user need to submit their permission to allow such content modifications, and carries may need to renew such an agreement on a periodic basis.

Because users do not want to define optimizations separately for each page, and different users have different preferences for content optimization, the gateway needs to keep track which optimizations each user wants. This requires identifying each user, providing a way to change the optimization settings at any point during browsing, and storing the preferences of every user to a database.

For end users, it is hard to understand that there exists a gateway that changes the content. If the gateway optimizations are provided by one's carrier, changing the carrier may suddenly make the pages look different or the browser behave strangely. The situation is worst if the browser and the gateway provide similar optimizations but do not know of each others. Setting image loading on the browser may not make images visible, if the gateway continues to remove images.

Despite of these problems, proxy optimizations may greatly benefit mobile browsing both in terms of cost savings and usability.

4.3 Client provides end-user control

The best way to guarantee personalized cost control for mobile data traffic is to offer it right on the mobile device. Having the client controlling the costs allows all applications to use the same rules, and also encrypted content can be processed.

For Web browsing, a major opportunity for client side cost control is the fact that Web browser fetches first the HTML file and only then requests for the images on the page. So, the browser is able to control whether images are loaded or not. As we noted earlier, the problem with simple image loading on/off setting is that many end users do not see that this setting would decrease their browsing costs. As pages contain an increasing amount of different types of embedded content, it would be too complex to provide an on/off setting for each type. We think most users would benefit from a simple setting where they can adjust browsing costs, whatever the means for cost saving are (Figure 1).

A different kind of opportunity is to utilize free wireless networks when available. If the mobile device is WiFi compliant, and a free-of-charge WiFi network is available, the user could be encouraged to use this free WiFi connection instead of the cellular connection for Internet access. As the user may not have the time to access the Internet while in WiFi range, the device could automatically fetch as much relevant data from online sources as possible, so that the user could access this material offline later on (Figure 2).

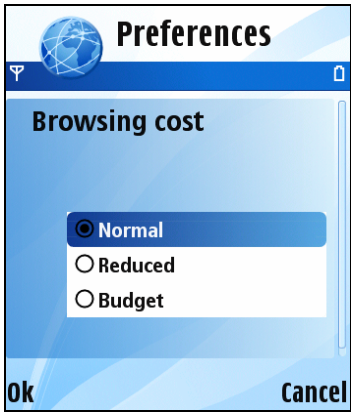


Figure 1. A simple user interface for controlling browsing cost.

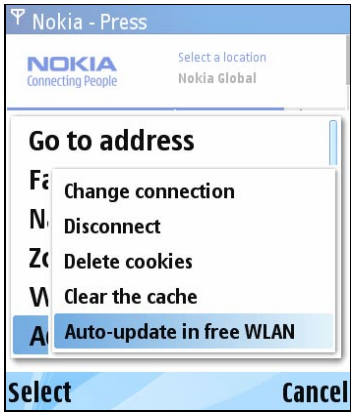


Figure 2. User could define the pages s/he wants to automatically fetch over WiFi connection.

The WiFi utilization for pre-fetching online material is in particular promising for subscription based solutions using Really Simply Syndication (RSS) technology. Already widely successful on the desktop this technology will allow users to subscribe to certain services or feeds that are delivered on a periodic basis controllable by the end-user. This solution can be highly economical for carriers, for example, by using excess available network capacity during off-peak hours, and convenient for end-users as the data can be updated when the device is connected to a WiFi network or over night.

5. CONCLUSIONS

Cost and billing models of mobile data traffic have a substantial effect on mobile browsing user experience. According to our 35 in-depth interviews of individual mobile data users in 4 countries, mobile data traffic cost problems are severely hindering the use of mobile services on handheld devices today.

In this paper, we discussed the difficulties participants had with mobile browsing costs:

- Hard to know how costs cumulate
- Hard to follow cost accumulation
- Hard to control costs

It was interesting that users try to understand the billing rules even when the carrier does not provide this information. Based on connection indicators, information visible on the phone bill, and previous experience on data traffic billing, people create a perceived billing model that affects their mobile browsing usage patterns.

The best solution for customers would be a very simple billing model for mobile data traffic, e.g. a reasonable fixed monthly fee. Mobile carriers are not eager to provide a flat rate, however, because the current cellular networks do not have the capacity to handle the increased traffic that VoIP calls, music sharing, and other heavy content downloading would generate in a flat rate system. We believe that reasonably priced flat rate systems without upper limits for data will not become widely available for several years.

We outlined several ways how the telecom carrier, gateway provider, and the players on client side can tackle the cost problems. The pricing models need to be simplified and user needs to be offered simple, unobtrusive ways to follow the cost accumulation. We presented some example designs on the client to let the user control browsing costs. If the carrier does not provide a flat fee, it should provide information on cost accumulation.

We hope that carriers will see an interest in providing better data cost transparency to users. We believe this will be an incentive for users to use mobile browsing, since many believe today that mobile browsing is simply too expensive.

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