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Keywords: Handset-based usage monitoring, Smartphone usage, WCDMA packet data patterns, 3rd party applications

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Handset-Based Monitoring of Mobile Subscribers

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Abstract

No handset-based data on mobile subscriber behavior has been available earlier. The new monitoring software developed for Symbian smartphones provides a possibility for the fist time to obtain accurate usage-level data, making both descriptive comparisons and strict statistical analyses on various usage-level factors viable. The study finds that the WCDMA technology has positive effects on the usage of packet data services. In addition, it seems that the usage of new advanced services is best explained by demographic factors, whereas the conventional service usage can be predicted by simply measuring earlier usage activity. In addition, 3rd party application usage seems promising. From the business perspective the study suggests that advanced handsets have an effect on the data usage patterns, and that smartphone customization with e.g. 3rd party applications is perceived very important among subscribers. The monitoring platform also supports regulatory studies.

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1. Introduction

The mobile telecommunications market has grown rapidly during the past decade. Currently we are amidst a transformation to new enhanced data networks with new emerging services launched constantly. Though the rapid technological development is partly slowed due to political and regulatory problems, WCDMA networks are already widely deployed in developed countries, while developing countries probably count on GSM/Edge technologies for some time. (Garber 2002; Passerini 2003; Banerjee & Ros 2004; Gruber & Verboven 2001; Landgrebe 2002) At the same time, the development of handsets is proceeding fast. Smartphones, which are a combination of PDA devices, digital cameras and mobile phones, are gaining market share in developed markets. These devices facilitate imaging, mobile browsing and 3rd party applications (Iftode et al. 2004). There is a lot of potential for new service concepts (see e.g. Saurio 2001; Weber & Rader 2002; Cohen 2002; Vainio-Mattila 2001 and Bell 2002). The market of smartphones is dominated by Symbian-based devices (Canalys 2005).

Obtaining knowledge on the usage of these new functions or services is very difficult. Interviews, laboratory tests, surveys and other such methods provide inaccurate or subjective data. On the other hand, network-based monitoring can only provide aggregate measures (such as the amount of total packet data transmitted, without knowledge on the application which generated the traffic). It is impossible to obtain any data on handset-based functions such as application usage with network-based monitoring solutions.

The present paper introduces a specific research method that utilizes recently developed Symbian-based monitoring software. This software collects handset-based data on various usage-level factors. Handset-based monitoring has many advantages, as it is a highly objective and accurate way to measure actions and events taking place in the smartphone. The development of this kind of software requires not only understanding of the platform and its programming, but also marketing capabilities in arranging specialized panels in which mobile subscribers agree on the research method and participation disclaimers of the panel. The collection of the data must also be supported with servers, which combine the data into chunks that can then be processed and mined with various statistical software packages. The nature of the data obtained facilitates various research approaches, from social sciences (Eagle 2005) and market analyses to modeling of subscriber behavior and identification of new trends (Verkasalo 2005).

The research problem in this paper is: What are the dominant services in smartphones, and what kind of trends can we observe currently taking place? In other words, the key idea of the paper is to demonstrate the viability of the monitoring platform through both descriptive and regression statistics. We wanted to particularly compare some of the basic communication services vis-à-vis each other, obtain knowledge on packet data service usage patterns, and to identify the extent of 3rd party application usage which is facilitated by newer smartphones.

2. Research methods

Technical limitations have challenged the attempts to acquire subscriber-level usage data so far. Handsets have lacked an adequate capability of independently registering usage events. Network servers, on the other hand, do not facilitate subscriber-level data retrieval so fluently, although general data on e.g. voice call durations and traffic amounts is of course available – for operators. Among others, this problem has been identified by Minges (2005).

The monitoring software used here is a Symbian application, and the technical infrastructure (i.e. servers and databases) are based in Finland. Accurate usage-level data provides valuable information on various usage patterns of mobile telecommunications to researchers and market analysts. The handset-based software technology provides a viable alternative to network-based monitoring technologies (Verkasalo 2005; Kivi 2006). Figure 1 below illustrates the implementation of the data acquisition process. The research is carried out in separate subscriber panels.

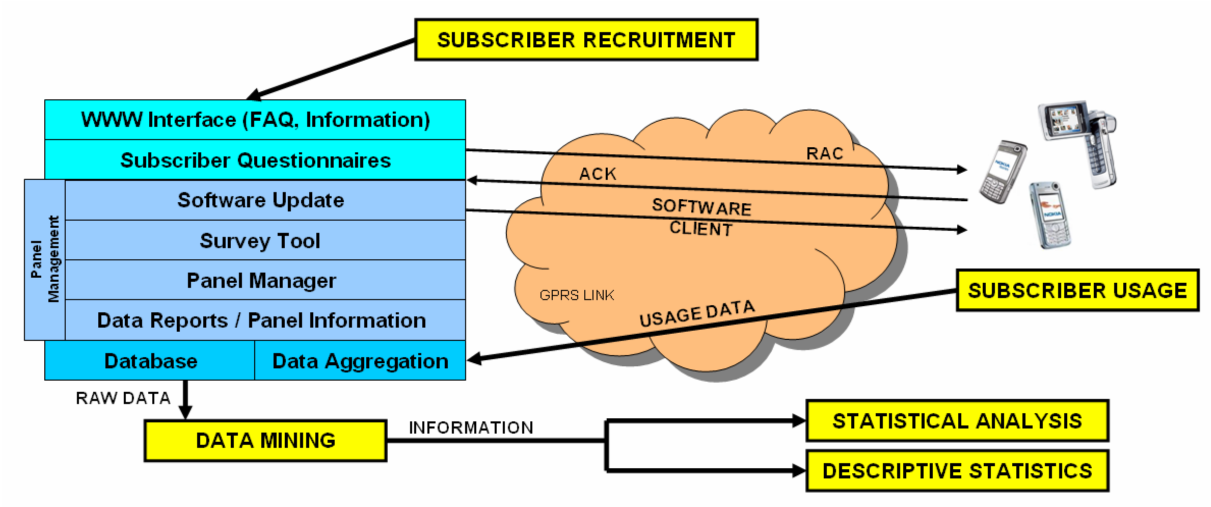

Figure 1 - The process of capturing and utilizing subscriber data

Descriptive statistics are used in this paper. In order to test for statistical significance of cross-sectional differences in smartphone usage (when linking background variables to usage-level patterns), ANOVA and MANOVA tests are used (Hair et al. 1998). In addition, various regression methods are used. In the case of purely metric dependent variables, standard OLS-regression is used. (Dougherty 2002) In many cases, the dependent variables, however, follow specialized distributions. For example, there might be binary, ratio or count variables. In these cases generalized linear models (GLM) are used, as they deal with the special statistical challenges present in studies of that kind. (Hand et al. 2001; Hardin & Hilbe 2001)

3. Data

The focal dataset in this study consisted of 562 active subscribers. The data was acquired during the period of April – November 2005. The requirement was that the panelist had been in the panel for at least three active usage weeks or 21 active usage days. The day or week being active means that the subscriber has used his handset at least once during the period of time (i.e. day or week), by e.g. launching an application or placing a call. The panelists were from all over the world: The U.K. (39 %), Germany (35 %), the U.S. (24 %) and Singapore (2 %). A clear majority consisted of men (87 %) and younger adults (most were 16-44 years old). Most panelists were either students or in full-time job. The panelists used nine different Symbian phone models. There were two WCDMA phones, which represented 27 % of all the phones. On average the panelists spent 15 weeks in the panel. Details of the panel are presented in Appendix A. These panelists are probably biased in the sense of technological orientation. (Rogers 1962)

The usage data above was complemented with some questions related to the subscriber's demographics. However, to facilitate the linking of various background variables to usage variables, we needed more comprehensive background data for multivariate statistical studies. For this purpose, a bit older data (with similar usage-level accuracy) was used through a sample of 247 panelists from Germany and the U.K. only, for which the gender distribution was more balanced (64 % male and 36 % female). This dataset was complemented with very accurate background data, covering among others the size of earlier bills and information on earlier usage patterns. This dataset is only used in explaining variance in the usage-level patters in section 5.

4. Descriptive statistics on smartphone usage

4.1 Communication usage

Though smartphones provide several other functions than merely communication-oriented ones, the fact that they are still phones reflects that it is important to be connected. Digital cellular networks provide various means of communication. In particular, voice calls and SMS/MMS/email/Bluetooth messages can all be used in connecting to others.

Figure 2 presents usage ratios in communication-oriented services. Usage ratios reflect the percentage of panelists who have tried the service at least once a month. No surprise, everybody has tried voice calls. Also SMS messaging is very popular with a usage ratio of close to 92 %. A bit more than 39 % of subscribers use MMS messaging, while only 15 % use email. Bluetooth messaging, interestingly, is used by more than half of the sample. Bluetooth messaging consists of any messages (also configuration, calendar or other message types) sent over Bluetooth, not e.g. Bluetooth headset usage. Women seem to be active in SMS/MMS messaging, while men are more active particularly in emailing and Bluetooth.

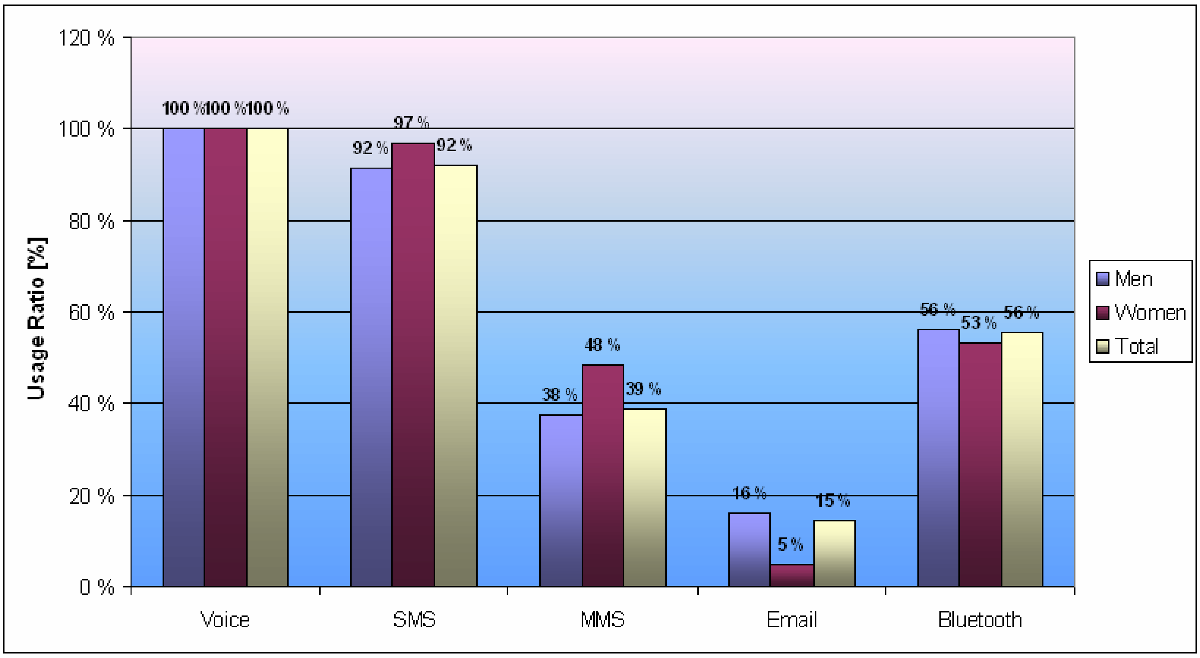

Figure 2 - Usage Ratios in Communication Services

Figure 3 reflects service usage intensity levels among the particular panelists who really used the service (thus, zero intensity levels are excluded). It seems that in terms of intensity levels, SMS messaging is the most active means of communication, an average subscriber sending 21 messages and receiving 32 messages / week. Voice calls follow second, with an average of 18 outgoing calls and 12 incoming calls / week. MMS, email and Bluetooth messaging seem still to be less intensively used.

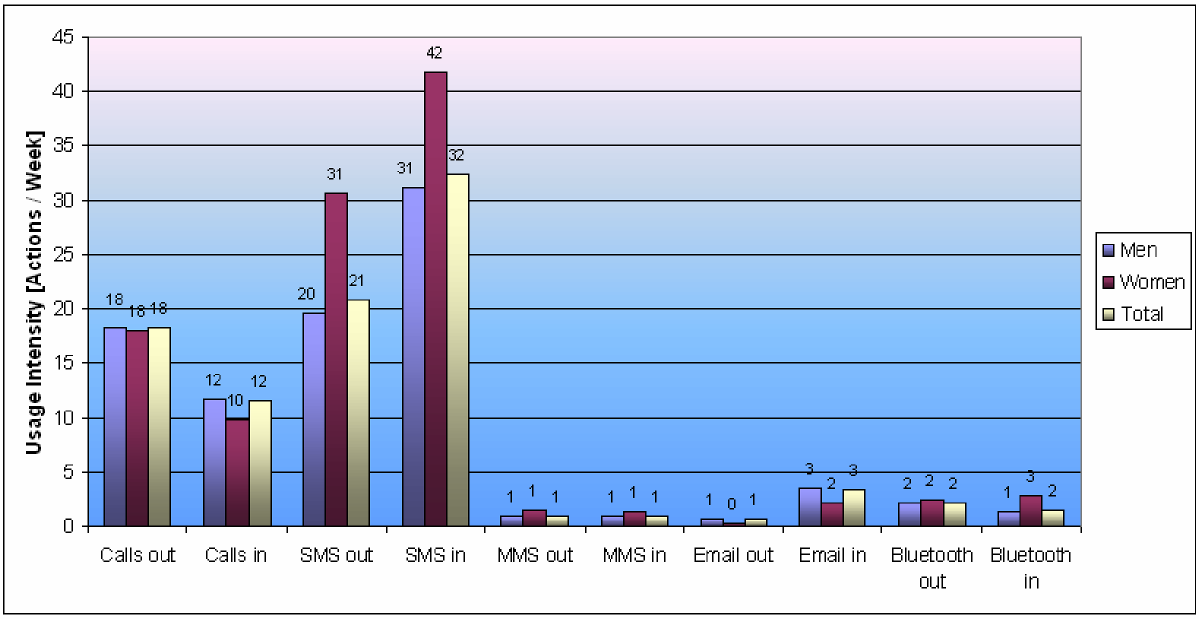

Figure 3 - Intensity Levels in Communication Services

Figure 4 tells that people commonly contact 10-15 different persons during an average week, including all means of communication (voice calls, SMS, MMS). On average, men contact 13 persons a week, while women contact 15. Comparing to Figure 3, it seems that although women place less calls a week, their contact networks are wider.

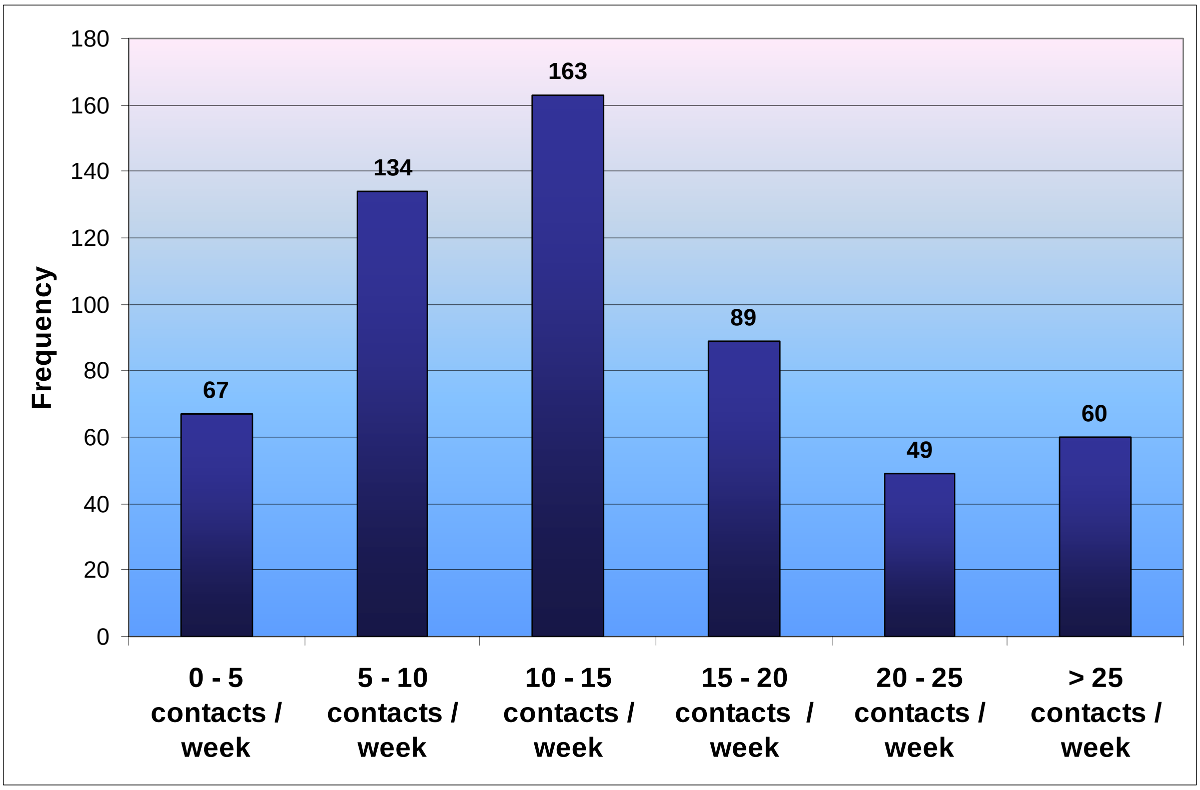

Figure 4 - Distribution of Weekly Contacts

According to more accurate contact-level data, the most popular contact usually receives 25 % of the voice calls, while the second and third receive 14 % and 9 %, respectively. In general, top-5 voice call contacts represent over 50 % of voice calls. Similar studies on SMS and MMS messaging reveal that top-5 SMS contacts represent about 90 % of SMS messages, while top-3 MMS contacts represent about 100 % of MMS messages. Thus, it seems that in messaging contact networks are more concentrated than in voice calls. People send MMS messages to only few persons, perhaps reflecting the fact that MMS messages are more personal by usually including user-created multimedia content, for example photos. These conclusions have weaknesses, too. Voice calls can be made to fixed line telephones, whereas SMS messages can only be sent to mobile phones. Also, MMS-capable handsets are still limited in number. These service-level limitations certainly have an effect in contact network studies.

4.2 Application usage

Symbian smartphones support both Java and native C++ Symbian applications. The developed applications can be installed on the smartphones by subscribers themselves, which has created a market of 3rd party applications. 3rd party applications basically refer to applications which are developed by external actors, not by the smartphone vendor. Built-in applications are standard Symbian smartphone applications which are factory-installed on the operating system / software platform.

According to Figure 5, WCDMA subscribers launch more applications than GSM/Edge subscribers. On average, WCDMA subscribers launch an application 19 times a day, whereas GSM/Edge subscribers only launch 15 times a day. Based on the available data, WCDMA subscribers on average launch 14 different applications during a normal week (e.g. Camera, Phonebook, Messenger, Logs, Media Gallery… etc.), while GSM/Edge subscribers launch an average of 11 different applications a week.

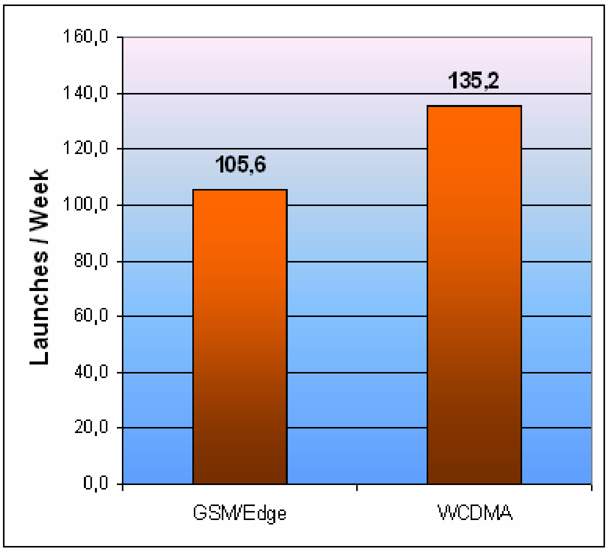

Figure 5 - Application Launches / Week

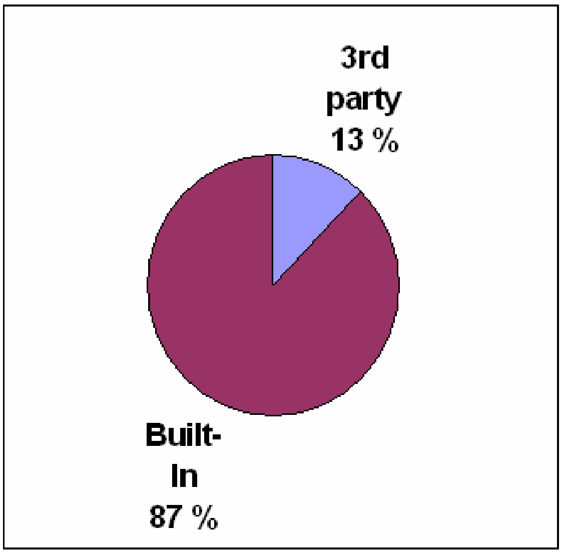

Figure 6 – Built-In/3rd Party Launches

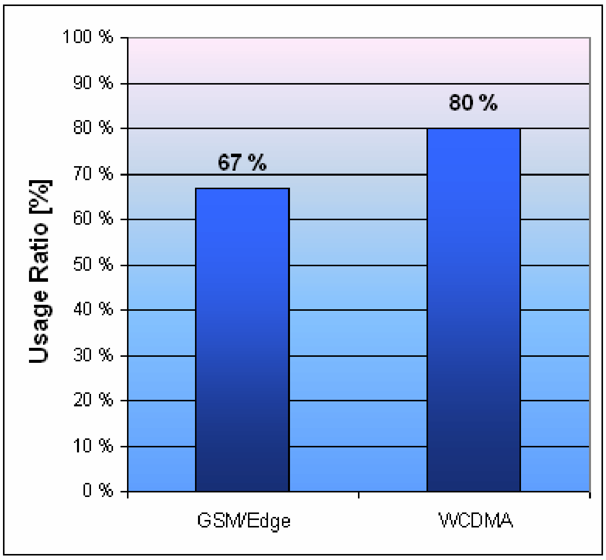

Figure 7 - Application Installations Usage Ratio

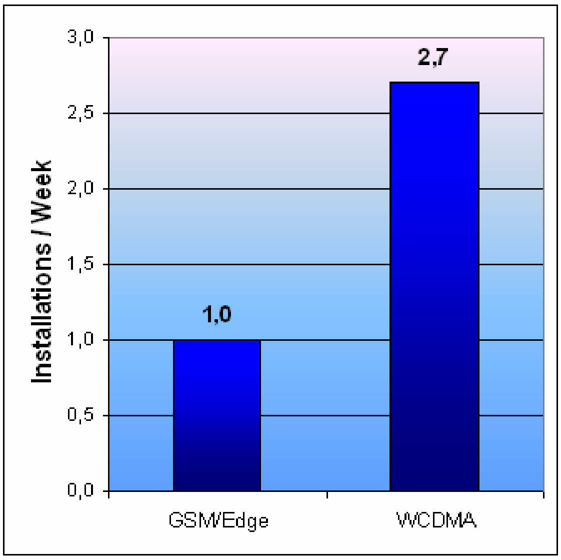

Figure 8 – Weekly Application Installations

3rd party applications already represent quite a substantial share of total application launches (13 %). It seems that 80 % of WCDMA subscribers have installed 3rd party applications, whereas significantly less, 67 % of GSM/Edge subscribers have done the same. Those WCDMA subscribers who install applications, on average install as many as 3 applications a week, whereas among GSM/Edge subscribers this figure equals to 1. Of installed applications, 46 % are Java applications and 54 % Symbian applications. This all means that 3rd party application usage is promising, while Symbian applications are the most popular type of 3rd party applications in Symbian handsets, although the handsets also support Java. These promising results suggest that the open software platform provides possibilities for external developers to enter the mobile software business through 3rd party applications.

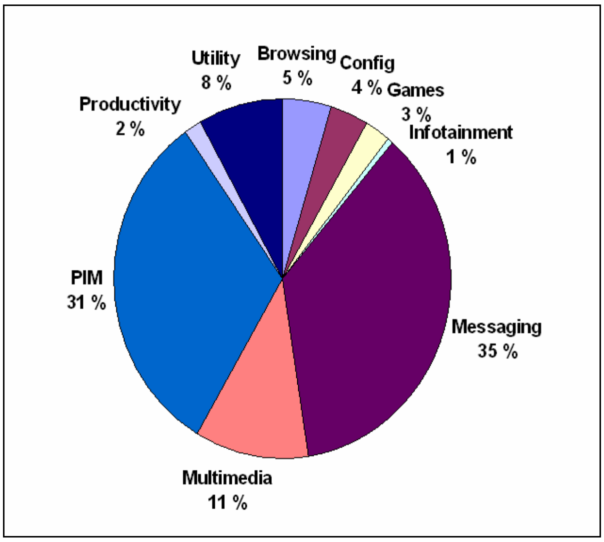

Figure 9 - Launched Applications by Function

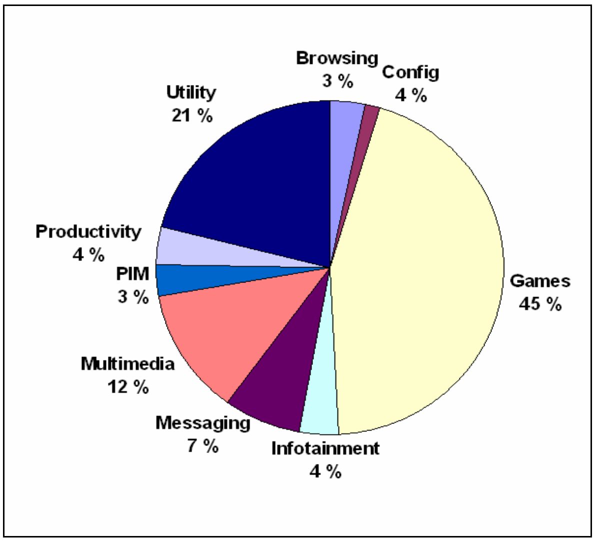

Figure 10 - Installed Applications by Function

Figures 9 and 10 provide the distribution of application functions, based on the number of application launches and number of application installations. The classification process is a bit subjective, as it is based on screening the individual applications either in practice or through application homepages. From Figure 9 it is evident that communication related applications represent over 65 % of the application usage. Personal information management (Logs, Phonebook etc.) together with messaging are clearly the most popular categories. Subscribers have not missed the opportunities for imaging and viewing multimedia, and multimedia category acquires 11 % of application launches. The rest of the usage is distributed among productivity (e.g. office applications, document viewers), utility (miscellaneous applications, such as GPS navigation, file managers etc.), browsing (both built-in browsers and 3rd party browsers, e.g. Opera), configuration (phone configuration and clock applications), games and infotainment (e.g. weather forecasts and operator portals).

Figure 10 provides the functional distribution of 3rd party applications. It is interesting to see that most installed applications are either games or utility/office/multimedia applications. In general, the results reflect the fact that still a major share of launched applications are normal platform applications provided with the phone, e.g. Phonebook and Logs. However, the 3rd party applications installed prove that people want to customize their handsets with games and multimedia, not to forget add-on utility and productivity applications, such as file explorers and PDF or MS Office document viewers. These 3rd party applications are acquired either for free or for a certain fee.

Top-10 Applications (based on launches)

Application	Usage Ratio
Logs	100 %
Messenger	100 %
Phonebook	100 %
Calendar	93 %
Browser	91 %
Profileapp	90 %
ClockApp	89 %
Camcorder	88 %
Calcsoft	81 %
Appmanager	74 %

Top-10 3rd Party Applications (based on launches)

Application	Usage Ratio
FExplorer	29 %
Opera	25 %
Photoring	17 %
AgileMessenger	17 %
Quickword	16 %
SnakeEx	15 %
Bounce	13 %
NpdViewer	13 %
Lifeblog	12 %
PhotoEditor	12 %

It seems that normal platform applications are most popular when ranking applications based on usage ratio (percentage of panelists who have tried the application at least once). Everybody has tried Logs (call register), Messenger and Phonebook applications. After these basic messaging and PIM applications, the platform calendar and browser were the next most used applications in the top-10 list (see on the right hand side). The high usage ratios of the profile and clock applications prove that many people have at least tried configuring profiles (i.e. changing or modifying the profile) or adjusting the time / setting up the alarm clock. It seems that as much as 88 % of subscribers have also launched the camera application. On average those who have used imaging have taken five photos a week. 75 % of people, who have taken photos, also take videos, on average a video per week.

Top-10 3rd Party Applications (based on installations)

Application	Usage Ratio
AgileMessenger	12 %
Opera	10 %
FExplorer	9 %
AdobeReader	8 %
NokiaSensor	7 %
Quickpoint	5 %
Quicksheet	5 %
Quickword	5 %
ProfiExplorer	5 %
PhotoEditor	5 %

When calculating usage ratios for 3rd party applications, based on the number of subscribers who have installed them, it seems that AgileMessenger (messenger client) and Opera (browser) are most popular, around 10 % of subscribers having installed them. Office applications are also pretty popular, around 5 % of subscribers having installed either MS Word, Excel or PowerPoint viewers. FExplorer (file manager) is also popular. The most popular 3rd party applications have still quite a narrow coverage among subscribers.

It is interesting to compare these results to a 3rd party application ranking, which is done based on the number of subscribers who have actually launched them. It should be noted that application launch usage ratios are higher, as a subscriber might have installed an application already before the panel started, or an application might have been already pre-installed in the phone when the subscriber purchased it. It seems that FExplorer and Opera are clearly the most used applications on this front. Office applications, except for the Word viewer, though actively installed, are not that popular when comparing applications based on the launch usage ratios.

In general, it seems that the most popular 3rd party applications are reaching usage ratios of 30 %, which is already very promising. This proves that successful 3rd party applications can easily access a market consisting of millions of smartphone users. In total there were 1997 different applications installed during the panel study period. Although there are many variants of the same application, this number reflects the size and dispersion of the current 3rd party application market.

In addition to usage ratios, it would be interesting to compare applications based on their relative usage frequency (i.e. the percentage share of active usage days when a subscriber has actually used the application) and intensity (i.e. the average number of times a day a subscriber launches the application). This information is presented in a same plot in Figure 11. The usage frequency (over all active usage days) serves as the y-axis, and usage intensity as the x-axis. The size of the circle reflects the number of subscribers who have tried the application. Only applications which had attracted at least 30 subscribers (in total 93 applications) were included in this study. Most applications fall nearby the origin, thus they are used infrequently and their usage intensity (i.e. number of daily launches) is pretty low. By identifying outliers we can draw some conclusions on the most popular applications. No surprise, all the three key communication applications – Logs, Phonebook and Messenger – are distinctively very important applications. The Messenger application tops by experiencing an average of more than five launches day, and being used almost on 80 % of the active usage days. Phonebook and Logs are used a little bit more often than 60 % of the active usage days, and are launched on average more than twice a day.

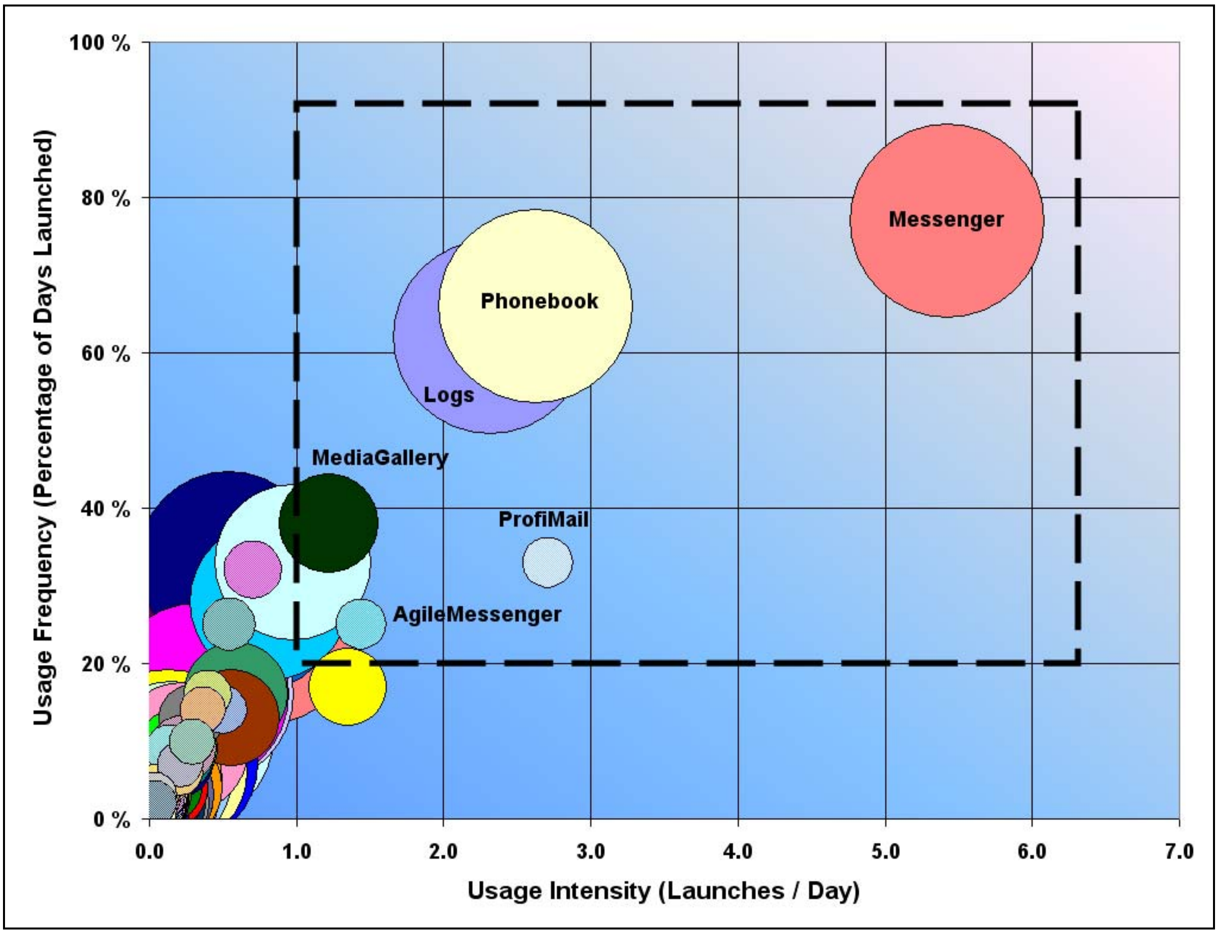

Figure 11 - Killer Application Plot

Furthermore, one could still distinguish MediaGallery, ProfiMail and AgileMessenger, which all fit in the killer application grid (requiring at least a launch per day and above 20 % usage frequencies). The popularity of the MediaGallery proves that it is a useful application among its users (remember that all average figures are drawn based on the data of the subscribers who really used the application at least once). ProfiMail and AgileMessenger are 3rd party applications. Despite that, they score extremely well. The study setting might even be a bit improper for them, as the usage rates are based on the ratio of the number of all application usage days to the number of all active usage days a particular subscriber has experienced. However, had a 3rd party application been installed during the panel period, there would not even have been a possibility to use the application before the installation, and thus the rates might be a bit downward biased for 3rd party applications.

The popularity of ProfiMail and AgileMessenger suggests that 3rd party applications can acquire sustaining, active usage among their subscriber base. It might be that future killer applications are not widely used, but instead they acquire significant usage levels among a small group of users. This is already suggested in earlier research (Iimi 2005). The mobile service and application market is segmenting into smaller pieces all the time. At least the above mentioned two 3rd party messaging applications enjoy significant success in this study. Figure 11 reflects well the popularity of applications, not only their coverage (which might be wide simply because some applications are shipped with the handset, but are possibly never really used in practice).

In the following 3rd party application study, all subscribers were identified with their installed 3rd party applications, and for each application-subscriber pair the potential number of usage days (i.e. the number of days in between the installation and removal, or alternatively the end of the panel if the application was never removed) was identified. Based on this, similar usage ratios and intensity levels were calculated as above. These ratios, in the case of 3rd party applications, better reflect the actual usage without stretching results downward.

The results are illustrated in Figure 12. Interestingly, the usage ratios are significantly higher than for most platform applications in Figure 11. This means that subscribers who customize their handsets tend to actually use the installed applications very actively. This also reflects in intensity levels, a high proportion of these 3rd party applications (which include all installed applications which had installations from at least five different subscribers) experiencing more than a launch per day (whereas not that many applications reached this in Figure 11). Actually the most popular 3rd party applications seem to achieve usage levels comparable to the most popular PIM applications in Figure 11. This means that the most popular 3rd party applications can even compete with platform applications. These results reconfirm the fact that there might be killer applications, which are used by only certain subscribers. However, among these subscribers the particular application might be used on a daily basis, thus very actively.

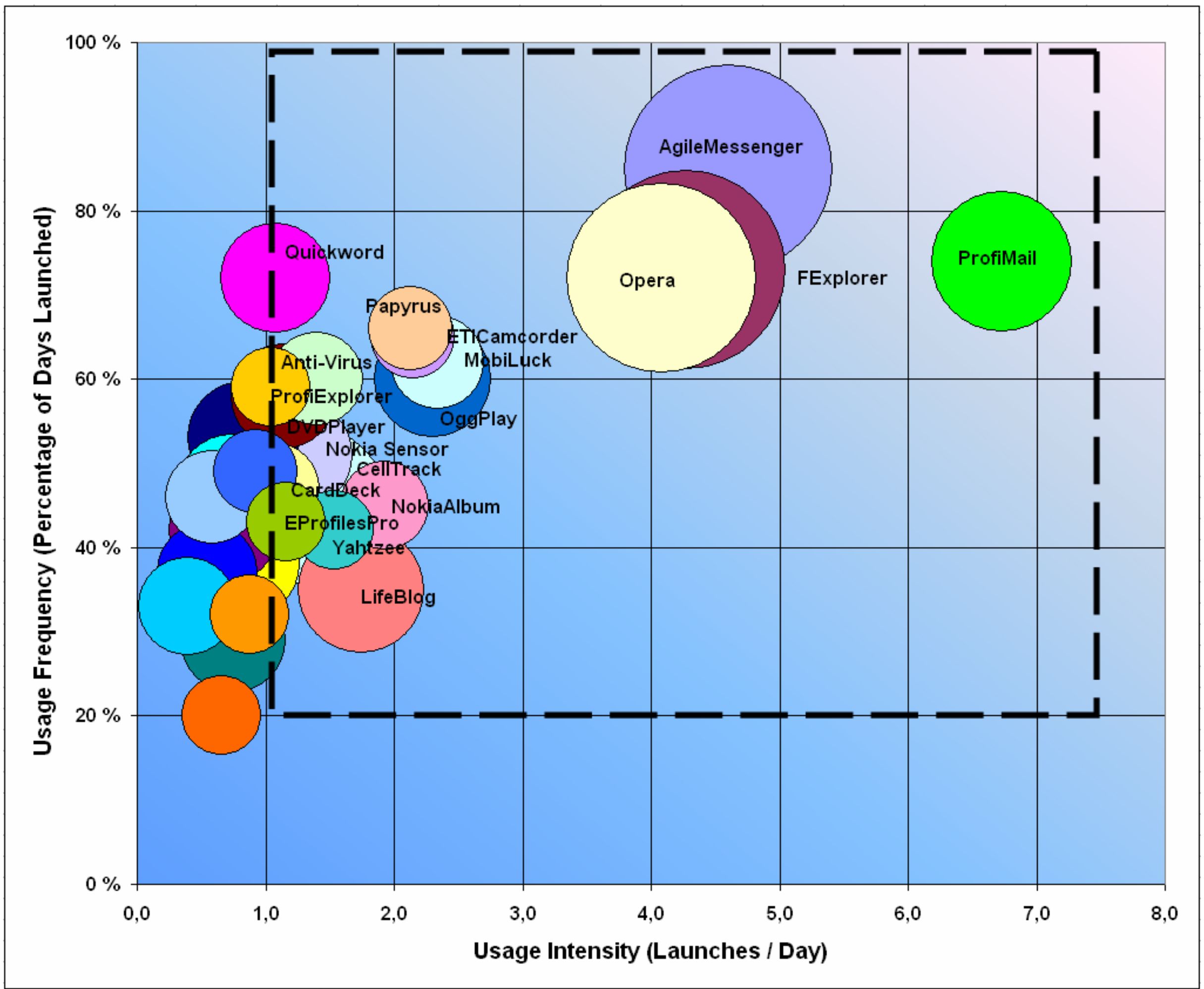

Figure 12 - Killer 3rd Party Application Plot

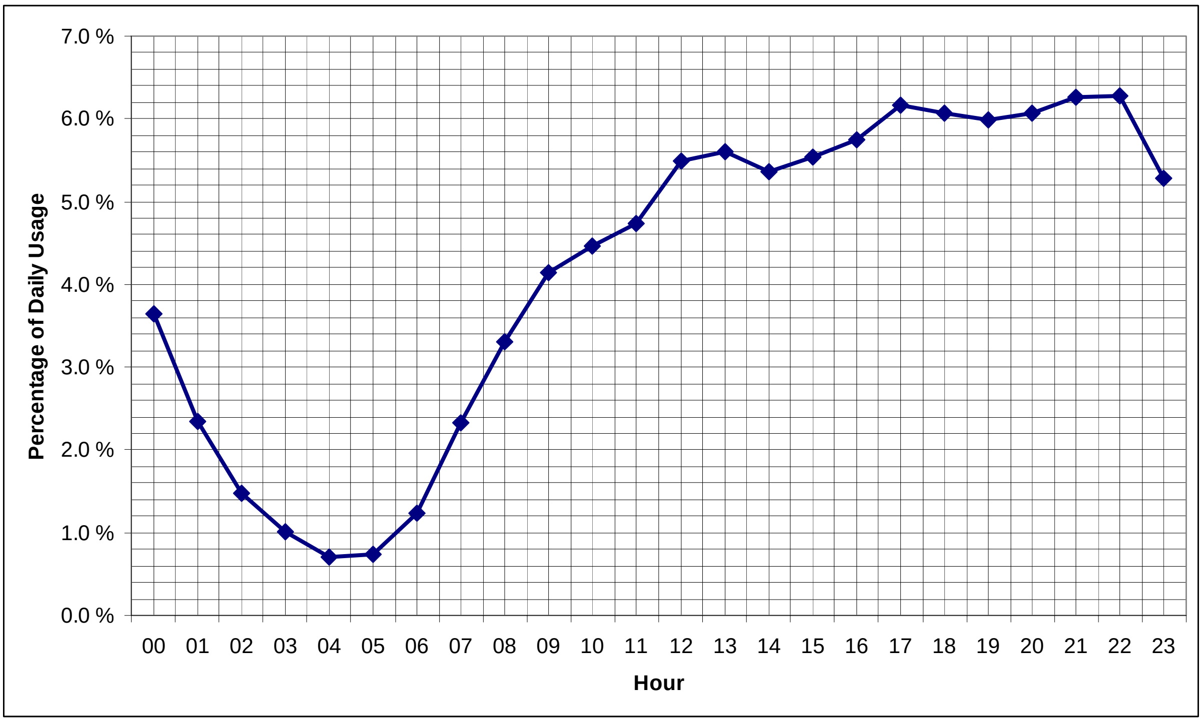

Figure 13 - Distribution of Daily Application Usage

Figure 13 provides some information on the daily distribution of application usage. All communication oriented applications (PIM and messaging) are excluded. It shows that application usage activity increases towards the late evening. This suggests that application usage might dominate the evening and night usage, whereas communication (particularly voice calls) usually takes place in daytime.

4.3 Packet data service usage

One of the key functions in smartphones is the packet data transmission over cellular networks. The mobile Internet provides venues for new services and business concepts. One of the key bottlenecks has earlier been the bandwidth in older circuit-switched GSM networks. These networks have since been replaced by packet-switched EDGE/GPRS data networks (2.75G/2.5G) or new generation WCDMA networks, which provide higher transmission rates.

Figure 14 provides results from the focal sample. In general, 88 % of the sample have transmitted on average at least 10 kilobytes / week, and thus can be considered as data users. It seems that an average subscriber receives 1.33 megabytes / week and sends 0.30 megabytes / week. There are more than four times as much inbound traffic as outbound traffic, and thus the mobile Internet is highly asymmetric. The figure also provides interesting information with regards to WCDMA subscribers, who seem to transmit almost three times more data than GSM/Edge subscribers. This might be related to the better service quality (e.g. service speed) and possibly more economical data transmission fees in WCDMA networks. This is promising from the operator’s perspective, as the increasing data transmission revenue might lead to higher profits after the price-cutting of basic telephone services such as voice calls in many developed countries due to tough competition. It is also possible that the advanced capability level of WCDMA handsets has an effect on the usage of data services.

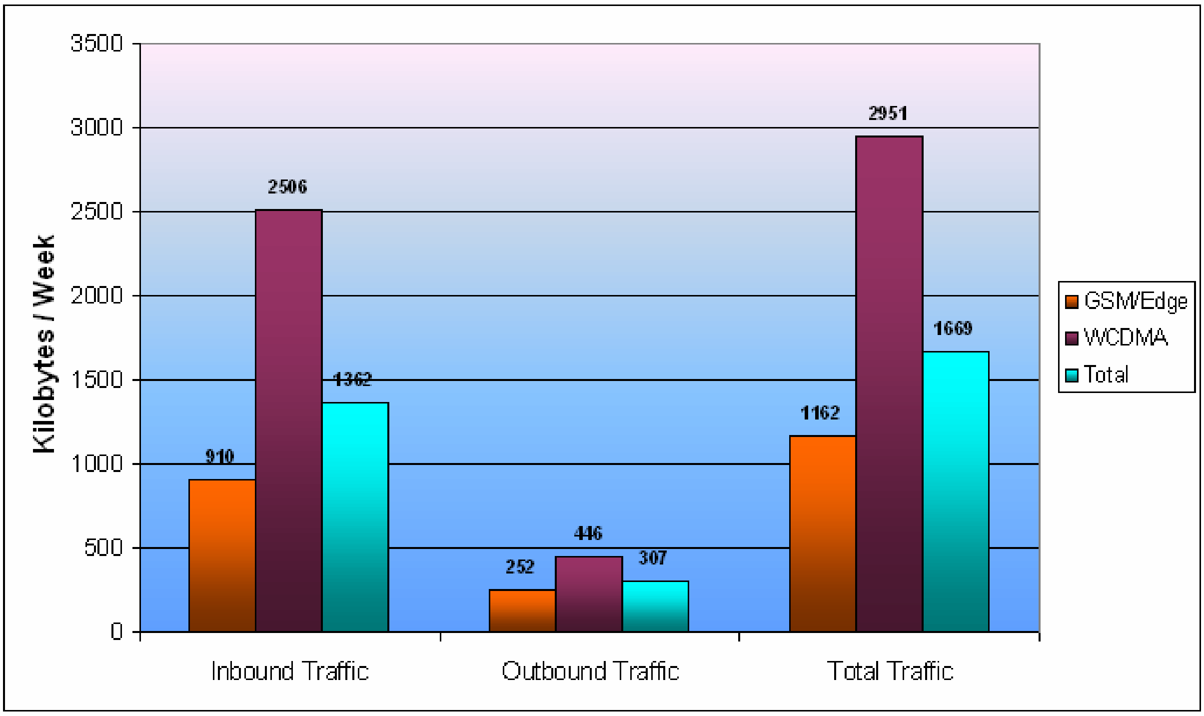

Figure 14 - Inbound/Outbound Data Transmission

Figure 15 illustrates the distribution of mobile data traffic by functional categories. It is clear that browsing generates the most data transmission usage. In fact, messaging and browsing together generate about 80 % of the mobile traffic. Other categories acquire marginal shares of bandwidth. On average, panelists receive 0.92 megabytes and send 0.19 megabytes of browsing traffic / week. WCDMA subscribers are very active in browsing, too. As a curiosity, 3rd party applications generate already 40 % of the total traffic. However, in this sample this is largely due to a number of preinstalled 3rd party browsers in the handsets. Still, both operators and 3rd party application developers should realize the mutual benefits. For example, if a prospective 3rd party mobile music service provider can assure the operator that the downloads will take place over the carrier's network, the benefit of co-operating in e.g. branding and marketing the service together might be significant, because the co-operation usually leads to a bigger cake to be divided.

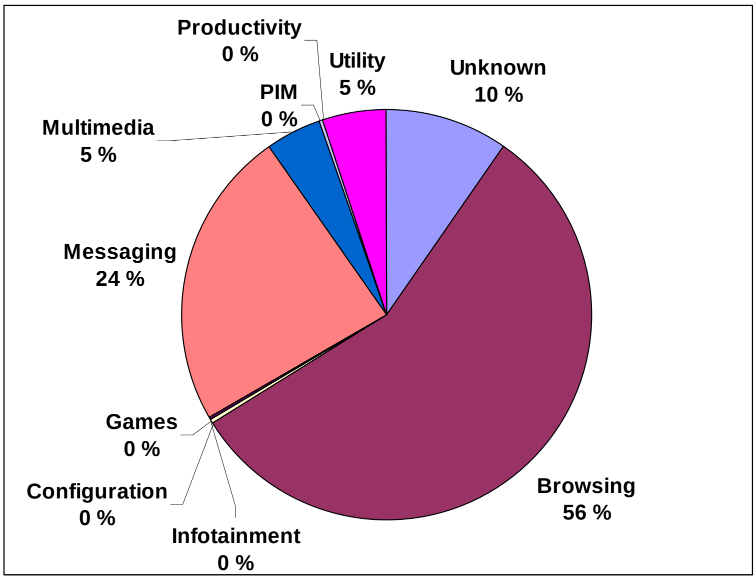

Figure 15 – Functional Distribution of Data Traffic

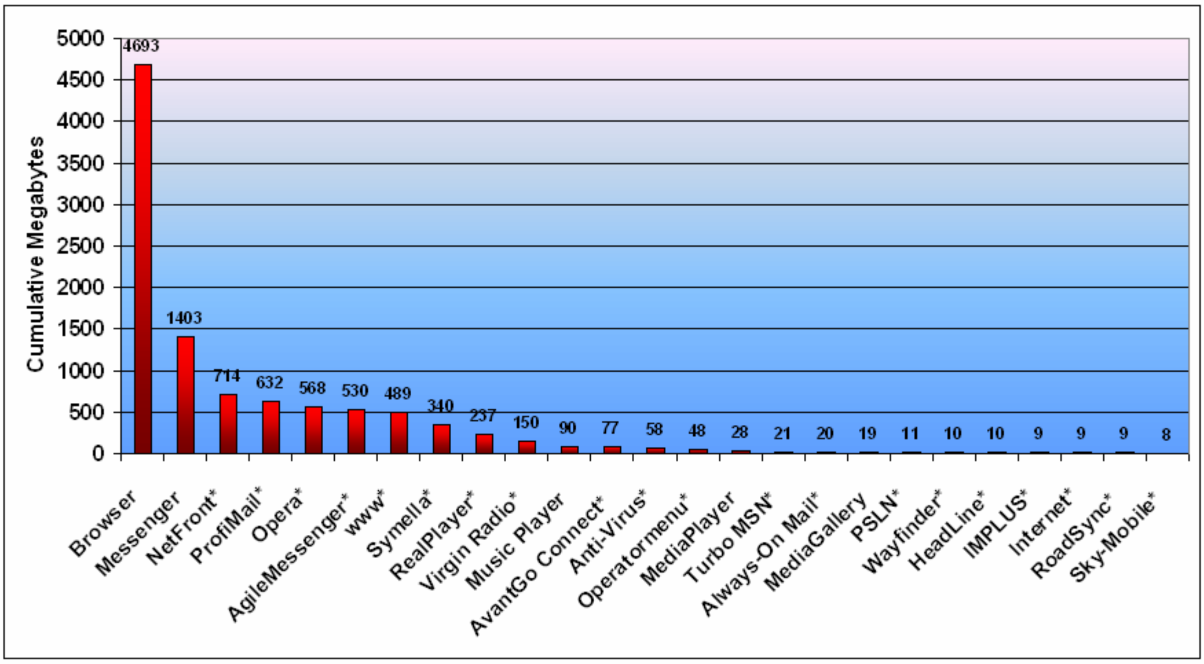

Figure 16 - Cumulative Data Generated by Applications (* 3rd party applications)

Figure 16 presents the cumulative packet data volume each application has generated during the study. The platform browser and messaging applications seem to generate the most data. 3rd party browsers (Opera, NetFront, www) are also well represented, as are 3rd party applications AgileMessenger and ProfiMail. Interestingly, a mobile P2P program Symella has generated around 340 megabytes of data in the panel, more than e.g. RealPlayer. This suggests that the mobile P2P market is not only a prospective idea, but real life today.

Figure 17 presents the daily distribution of traffic. It seems that there are two peaks, at 1pm – 3pm and 7pm – 12am. Browser usage is pretty evenly distributed from 10am onwards, until it suddenly increases at 11pm. In all parts of the day browsing traffic represents a major share of the total data transmitted. Messaging has an important role in the daytime and evening. Distribution of traffic was also studied by dividing the cumulative amount of traffic on weekdays. It seems that Thursday and Friday are the most active days (about 16 % of weekly traffic is transmitted on each day). The next most active days are Wednesday (15 %), Monday (14 %), Saturday (14 %), Tuesday (13 %), and Sunday (12 %). Thus, it seems that little traffic is generated on weekends.

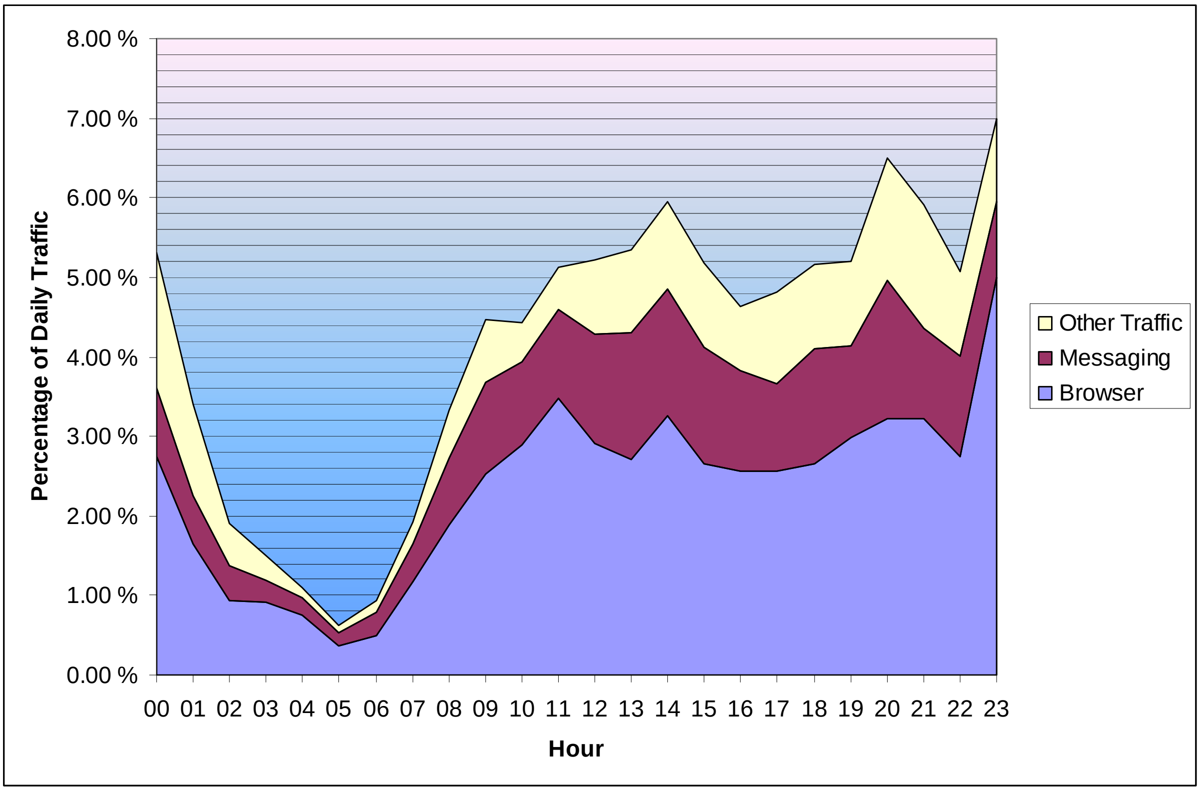

Figure 17 - Distribution of Daily Traffic

4.4 Daily distribution of handset usage

By dividing smartphone usage into voice/messaging (SMS) communication and non-communication-oriented application usage, we can project the daily distribution of usage by functions. The plot in Figure 18 reflects the daily distribution in functional handset usage.

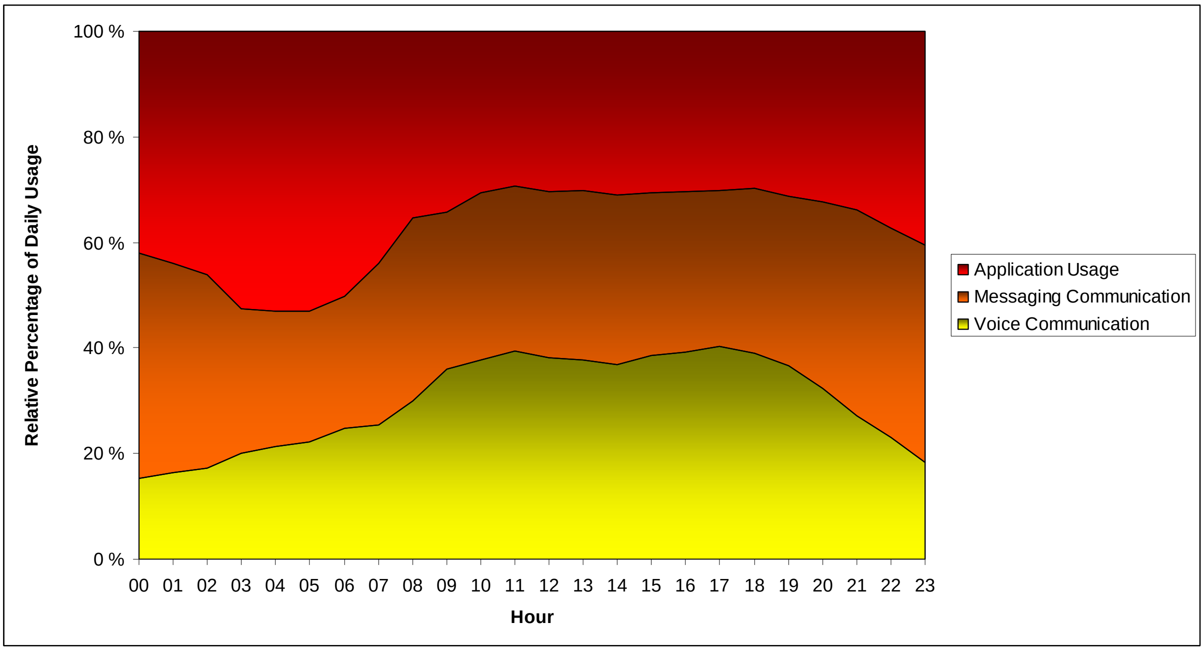

Figure 18 - Daily Profile of Smartphone Usage

Figure 18 presents a profile of smartphone usage. It reflects the general focus in smartphone usage by projecting normalized activity data (that is, each surface area is equal in size). As one can see, voice communications is relatively important from 9am to 5pm. Messaging gains importance as a means of communication from 6pm onwards, being the most important means of communication until 9am. Outside of the communication usage period, from midnight to 9am, the handset is primarily used in application usage, which ranges from browsing to imaging.

5. Discussion of the results

With regards to the obtained results on usage factors, two important questions remain. First, what explains the variance in usage-level variables? Secondly, how to utilize these results or the developed process in practice? These questions are discussed in this section.

In order to find out which background variables explain the variance in the smartphone usage, a bit smaller, but more comprehensive, dataset of 247 German/British panelists was used. Several important usage-level variables were included in the study. These variables represent the following functional areas:

1. Voice call usage
2. Messaging intensity
3. Data transmission amounts
4. Application usage
5. Propensity to Internet services and Bluetooth usage

Several explanatory variables are included in traditional OLS and specialized GLM regression models. The results are verified (where appropriate) with ANOVA/MANOVA methods. We obtained data on various background variables through questionnaires. The size of (previous) bill is very relevant in reflecting the amount of mobile service usage; it is thus included as an explanatory variable in the final study. The size of the bill does not necessarily reflect income, however. The fraction of the bill due to messaging is chosen as an explanatory variable, too, reflecting the distribution of a phone bill. Next, earlier call usage intensity is picked up, as it reflects the absolute amount of handset usage in general. There are several variables available in the questionnaire data, which seem to reflect the capability level or experience with handsets, such as earlier mobile Internet experience and earlier mobile handset performance variables. In the following study, only the variable reflecting general handset experience is included. Sex and age are key variables, and both are included. A life value variable reflects family and free-time oriented non-business issues and their importance in the respondent's life. It is included as an explanatory variable, too. Finally, also working status is included. Thus, the key usage-level variables are to be explained with the help of these eight demographic and background variables, entered into models as explanatory variables. For more information on the study specification and detailed results, see Verkasalo (2005).

Appendix B presents the results of the study in a comprehensive form. Plus cells represent positive relationships between the column variables (explanatory variables) and row variables (usage-level variables), and minus cells represent negative relationships. Only statistically significant dependencies were colored.

In general, it seems that the size of earlier bills affects many communication-oriented variables (on top) positively. This simply reflects the fact that people who have had larger bills earlier (which most probably resulted from active earlier communication usage) seem to use communication-oriented functions actively also in the present study. Messaging proportion of the bill expectedly negatively affects voice call usage and positively messaging activity. Messaging-oriented people thus prefer messaging usage. Importance of soft life values seems to be positively related to imaging and the number of daily application launches. Correspondingly, work status (reflecting people working instead of being e.g. students or part-time workers) is negatively associated with these usage variables. It thus seems that people who value e.g. free-time and family life (housewives, teenagers, the elderly), and are not working full-time, seem to prefer imaging and also launch more applications.

What is most interesting, it seems that demographics, particularly gender and age, seem to have a significant role in explaining the usage of new, non-communication oriented services (represented by the variables at the bottom). Correspondingly, they do not have that much of a role in explaining the variance in communication-oriented variables. Thus, it seems that advanced handset usage is driven by demographics, which certainly might be related to technological orientation. Also some earlier studies (Howard et al. 2001), in the Internet context, have found that men seem to be more active users. One can carefully generalize the male gender and younger age being common characteristics among early adopters and gadget-freak people. These demographics are not that explanatory in regressions studying communication-oriented variables, the only exception being the fact that age positively drives daytime voice calling usage, while younger people use handsets a lot in the evening and nighttime, too. Voice calling and messaging can better be explained simply by studying panelists' former handset usage, e.g. the size of earlier bills. These statistical tests thus suggest that earlier usage does not necessarily drive the usage of newly introduced telecommunication services and handset functions, but instead a technological orientation is more important.

How then to utilize the results? Are there any possibilities to utilize the monitoring process in practice? From the business perspective, the study points out that there are significant benefits in providing subscribers with advanced handsets. The WCDMA technology has positive effects on the absolute amounts of transmitted data. By increasing the WCDMA smartphone subscriber domain by bundling subscriptions and handsets, for example, operators could therefore gain high-ARPU customers. From the regulatory point of view the service-level usage differences between handsets with different capability levels is interesting. One of the key arguments supporting e.g. handset bundling claims that advanced handsets provide value-added to both the consumer and the producer through increased and more valuable use of services (either from the utility or producer revenue point of view). These results seem to support that 3G handsets indeed contribute to the use of packet data services.

There is also significant evidence suggesting that 3rd party applications (P2P, operator-licensed browsers, alternative messaging clients) generate not only a lot of usage by perhaps even substituting platform applications, but they also contribute to packet data transmission usage. Subscribers seem to gain value-added by customizing their handset. Browsing, instead of messaging, is the major source of data usage and revenue, implying that WWW-based services have clearly turned into the mobile age.

With patterns found in demographics, it also seems that advanced mobile usage is better adopted by younger and male-dominated subscriber domain. The study has increased the understanding of mobile subscriber behavior, which is very important for operators developing new business schemes in fighting against decreasing revenue from conventional services.

The new handset-based monitoring client could be used in various study settings. For example, cross-country comparisons of smartphone usage might be interesting, as there are definitely country-specific differences in relative importance of e.g. packet data services and communication-oriented services. These differences in the usage-level variables might be due to techno-economic or socio-cultural contexts, for example. In this study the size of the dataset did not facilitate valid country-specific comparisons, and the results were averaged based on the handset capability or demographics. Handset-based monitoring also provides possibilities to explore the market of 3rd party applications (and services), not to talk about the potential to identify e.g. killer applications. In addition to business actors, also regulators might be interested to utilize the results of these analyses, for example in evaluating the use of unlicensed radio bands (WLAN, Bluetooth).

Handset-based data provides several advantages to network-based service measurements. For example, application-level data is very difficult to obtain with network-based methods. Handset-based data also facilitates accurate measurements based on active usage days. For example, we can identify the days when the handset has really been in active use, and therefore provide valid activity measurements, e.g. sent messages per active usage day. In addition, the developed process collects additional information on background factors through questionnaires. For example gender and age seem to be important variables explaining usage patterns. On the other hand, in some situations network-based methods are better. In studying e.g. used protocols and port numbers in mobile packet data usage, network-based measurements are better (Kivi 2006). The current handset-based data acquisition process is still under developed. We still miss a lot of important background variables, e.g. subscription type, data traffic pricing etc. These factors should have an important role in explaining some of the results presented in this paper.

6. Conclusions

The study has interpreted accurate handset-based data on smartphone usage. Some of the results represent functions (such as application usage), which have earlier been impossible to study properly. The results naturally are biased in a sense that panels are comprised of technologically oriented early adopters, but at the same time they reflect usage patterns which might take place this or next year among normal subscribers (i.e. "early masses"; Rogers 1962), who are slowly getting into smartphone devices and new WCDMA services. All in all, the combined process of studying accurate usage-level data and background information provided through the research process holds a lot of potential in the future research.

The key conclusions of the study are:

- 3rd party application usage is promising, meaning that the Symbian-based software platform drives 3rd party software and service innovations.
- Data transmission levels are already significant, reflecting the fact that smartphones are bringing data networking into a mobile age. In addition, it is interesting to see that WCDMA subscribers transfer about three times more data than GSM/Edge subscribers.
- In terms of daily usage patterns, voice calls dominate in the daytime, messaging being more important a communication tool in the evening. Application and data usage dominate in the late-evening and nighttime usage.
- Conventional service usage can be largely explained by earlier handset usage patterns, but the step towards new advanced services such as imaging and the mobile Internet is better explained by (male) gender and (younger) age, which might serve as proxies of technological orientation.

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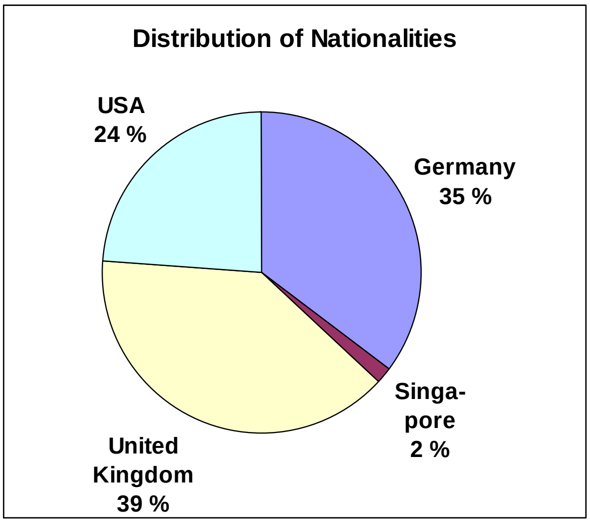
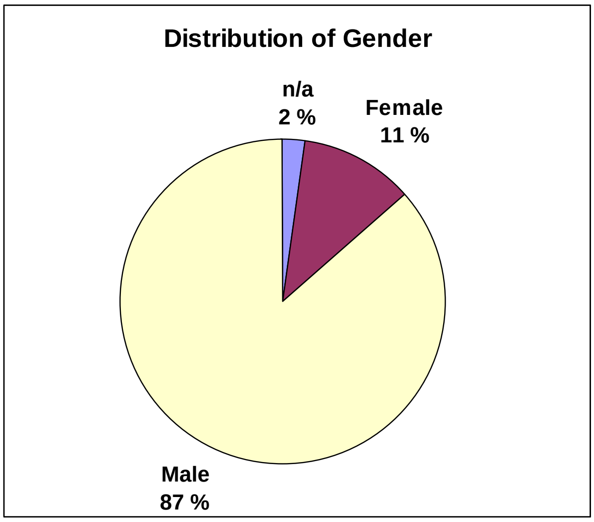
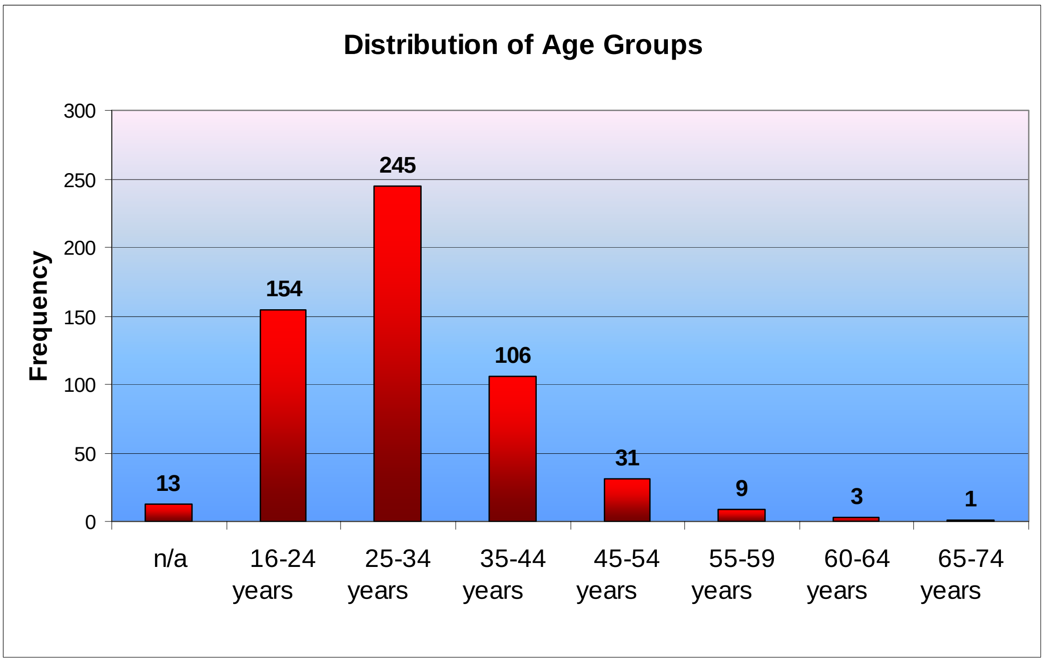
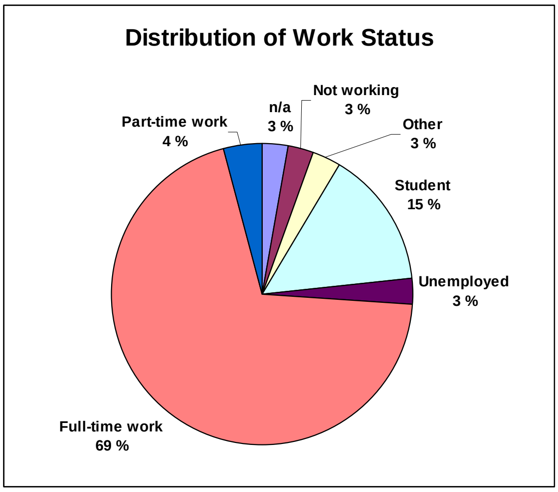
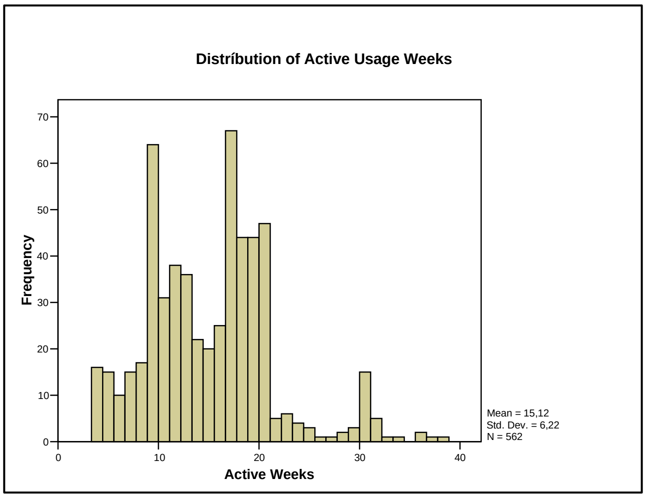
Appendix A – Structure of the panel











Appendix B – Results of the regression studies

	Size of earlier bills	Messaging proportion of the bill	Call usage intensity	Previous handset experience	Importance of soft life values	Male dummy	Age	Work status
Number of outbound calls / day	+	-				+	-	
Number of inbound calls / day	+			+				
Average call duration	+		+					
Outbound voice call minutes / day	+	-	+				-	+
Inbound voice call minutes / day	+							
Number of people contacted / week	+							
Share of voice calls in daytime							+	
Number of outbound SMSs / day	+	+	+	+	+		-	
Number of inbound SMSs / day	+	+	+				-	+
Outbound data traffic / day						+	-	
Inbound data traffic / day						+	-	
Number of pictures or videos / day		+		+	+		-	-
Number of application launches / day	+	+	+		+		-	-
Number of weekly app installations	-	-		+		+	-	+
Number of different app used / week						+	-	
Propensity to use mobile WWW						+	-	
Propensity to use Bluetooth							-	

A plus sign reflects a positive relationship and minus a negative relationship between row and column variables.

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