Access alternatives to mobile services and content: analysis of handset-based smartphone usage data

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Abstract

The number of radio interfaces in mobile devices is constantly increasing. In addition to the continuously evolving family of 3GPP standards, technologies such as WLANs and DVB-H provide alternative means to access content and services in the network. Furthermore, as memory cards and hard drives continue to increase in capacity, more and more content can be stored in the device and viewed or played back when wanted.

Due to the increasing number of alternatives, considerable uncertainty exists regarding the dominant ways of accessing different types of mobile services and content in the future. The preference of users regarding device formats (e.g. mobile phones, ultra-mobile PCs, laptops) and access technologies (e.g. WLAN, 3G) in different locations and contexts has a significant effect on the business of mobile operators and vendors, as well as content providers and advertisers.

This paper discusses the current and future role of alternative radio accesses and off-line use in accessing different types of mobile content and services. In the analysis, smartphone usage data collected from Finnish consumers is utilized, demonstrating the possibilities of a handset-based measurement platform in collecting rich data about the usage of alternative access methods. The results highlight the role of indoor access solutions for accessing mobile services and content in the future.

1 Introduction

Delivery of Internet and mobile services requires essentially four technical components to be in place: devices, applications, networks, and content. The usage of each component in the service system is increasingly distributed between many alternative forms (Smura et al. 2008). For example, watching video with a mobile device is possible e.g. by streaming the media from Youtube via 3G or WLAN networks, playing locally stored video files off-line, or utilizing a mobile broadcast network like DVB-H. Furthermore, alternative devices such as PCs, televisions, and portable media players offer substitutive ways for fulfilling similar needs, depending whether or not they are available in the location of the user. To illustrate the variety of choices available, some examples of access alternatives for different types of applications have been listed in Appendix A.

From the end-user point-of-view, different devices and accesses are often complementary as each can be the preferred one in a certain context and for certain application. They are, however, often also at least partially substitutive to each other, competing to be the preferred one in as many situations as possible. The choices of end-users regarding devices and accesses are of interest to many parties including device vendors, network operators, media companies, and advertisers.

Cellular networks were originally built to complement fixed telephone networks, to provide mobile users a possibility to make and receive phone calls while on the move. Rapid evolution of mobile devices and networks has gradually improved the quality of mobile services to a level where they are ever more substituting and competing with their fixed counterparts. This applies evidently to mobile voice services where fixed-to-mobile substitution (FMS) is increasingly taking place in most developed countries and, albeit to a lesser degree, also to data services in the form of mobile broadband subscriptions (see e.g. Mao et al. 2008).

In addition to the FMS trend, the trend from voice to data oriented services is evident, both in fixed and mobile networks. In fixed networks, data traffic amounts have already bypassed voice traffic, and mobile networks are following the same path. Revenue-wise, voice services are still the core business of mobile operators, and most of the revenues are generated by voice calls. In the long term, voice calls are seen to become just one data service among others, carried over converged all-IP networks.

Network connectivity to mobile devices is typically provided by 2G and 3G –based wide area technologies, with outdoor macro and micro cells providing the required coverage and capacity to both indoor and outdoor located devices. Increasing capacity demands require more densely deployed base stations to support the required data rates. In particular, indoor deployment of wireless base stations and access points has been actively discussed among the industry participants, and also commercialized by some operators (see e.g. Orange 2008, BT 2008). Technology-wise, indoor deployments may be based on WLAN access points utilizing unlicensed spectrum, or so called “femtocells” utilizing licensed spectrum and e.g. 3G or WiMAX technology.

In addition to wide-area cellular network technologies and WLANs, the set of radio interfaces available in mobile devices increasingly includes both short-range technologies such as Bluetooth as well as broadcasting technologies such as DVB-H, providing even more alternatives to access various content and services. For multimedia services, the increasing capacity of memory cards and hard drives offers an alternative to network streaming, as more and more content can be permanently stored in the device and viewed or played back when wanted.

Due to the increasing number of partly complementary, partly substitutive technologies, considerable uncertainty exist regarding the dominant ways of accessing different types of mobile services and content in the future. In dealing with this uncertainty, location and context specific data about the usage of different services and access technologies is valuable. In this paper, we demonstrate the use of a handset-based measurement platform for collecting such data from a panel of Finnish smartphone users.

The paper is structured as follows. In section 2, the handset-based measurement method and the collected data is described. In section 3, the results of the measurements, including location and access specific usage amounts of different mobile applications are presented. The paper concludes with a discussion and suggestions for further work.

2 Handset-based measurement method and data

For the purposes of this paper, we use data collected from a panel of Finnish smartphone users during November 2007 – January 2008. The data collection was carried out as part of a national research project COIN (2008).

2.1 Measurement platform

The data was collected using a handset-based measurement platform developed for Nokia S60 class of mobile devices running a Symbian-based operating system. The platform consists of a software client installed to the mobile devices that records user's actions with the phone, and writes them to a log file that is periodically transmitted to a centralized server for further analysis. The measurement platform and process are introduced in more detail e.g. in Verkasalo (2007, p. 19-25).

Among other things, the measurement client records the *active usage time* for every application launched and used by the panelists. Here, active usage time refers to the time that elapses while the application is topmost and visible on the screen of the device. For applications requiring constant attention and interaction by the user, such as phone calls, messaging, web browsing, or video playback, the measured time reflects the actual time spent using the application. For some applications such as FM-radio or MP3 players, the measured time does not correspond to the actual usage time, as the application is typically running in the background without user actively interacting with it. Typically, the devices switch to a power save mode and activate a screensaver application after a certain pre-defined time period (around 60-300 seconds) has passed without the user pressing any keys.

The measurement client also collects data about all the packet data sessions launched by the device, together with the used bearer (GPRS/EDGE, WCDMA, WLAN) and the amount of data sent in uplink and downlink directions. By mapping this network usage data with the application usage data it is possible to analyze the usage of each application with each bearer separately.

To map the application and network usage data to information about the location of the users, a "context algorithm" introduced by Verkasalo (2007) and further improved by Jiménez (2008) was utilized. The measurement client records every handover between base station cells with a timestamp, and the resulting vector of cell-ids is used as an input for the context algorithm. The context algorithm clusters the cell-ids and uses a set of heuristic rules to define the location (home, office, or elsewhere) of the user at each moment in time.

2.2 Panel description

The panelists were recruited by an SMS campaign organized by the three Finnish mobile network operators, TeliaSonera, Elisa, and DNA Finland. Recruitment messages were sent to randomly selected Finnish citizens having an age of over 18 and owning a Nokia S60 smartphone.

A total of 644 people successfully installed the measurement software to their devices. Out of these, 106 were excluded due to too few active days spent in the panel. Furthermore, to increase the reliability and coherence of the collected data, a decision was made to include only users with a newer, 3rd edition Nokia S60 device to this specific study, reducing the total number of panelists to 253.

The context algorithm was able to find all the three main locations (home, office, and elsewhere) for 98 panelists. The algorithm did not find a proper office context for many users, possible reasons including e.g. people not working regularly or working from multiple locations (Verkasalo 2008). These panelists were excluded from parts of the study dealing with location specific usage amounts.

Compared to the Finnish population in general, the sample of panelists was biased towards young men. The panelists can also be expected to be relatively advanced in using mobile devices, as they were willing and capable to install the measurement software to their devices themselves, by following instructions on a web page. A more detailed description of the panel is included in Appendix A.

3 Results

3.1 Where do people spend their time?

People's time use habits are a natural starting point for analyzing the usage of mobile devices in different locations and contexts. In Finland, the latest nation-wide time use survey was carried out by Statistics Finland in 1999-2000 (Statistics Finland 2001), as a part of a harmonized survey carried out in several European countries. More information about the harmonized European survey can be found from Statistics Sweden (2008).

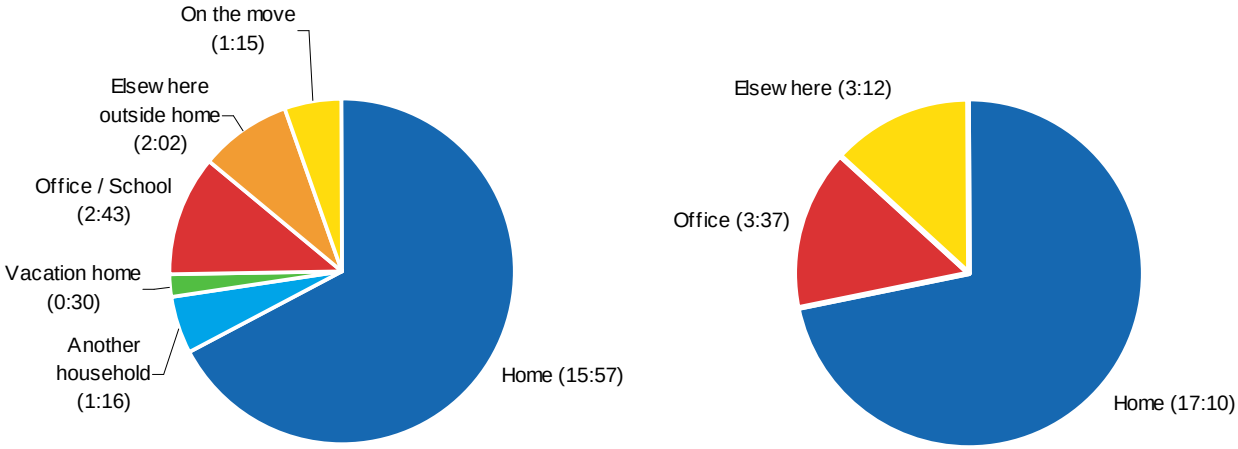


Figure 1: Left: Time use of Finnish people, > 10 yrs, average over Mon-Sun, whole year (Statistics Finland 2001) Right: Time use of panelists, average over Mon-Sun, November-February 2007. N = 98.

The left hand side of Figure 1 illustrates the time use of Finnish people (age > 10), averaged over the whole year. The graph shows how much time is spent on average each day in different types of locations or on-the-move between them.

The time use graph clearly highlights the importance of home as the dominant location of people. Even if sleeping time was deducted (average 8:27 for 20-74 year-olds), almost a half of the wake hours are spent at home. Naturally, differences exist between social groups, for example employed people spend a twice as much time at office compared to the whole population (including e.g. children, pensioners, and unemployed people).

The right hand side of Figure 1 shows the time usage distribution measured in our panel. The numbers are not directly comparable with the general time use statistics, due to the bias in sample of panelists as well as the selection of the study period, which included the holiday period in the middle.

The average time distributions of the panelists before the holiday period are depicted in Figure 2, for the working days and weekends, respectively. The figure shows that the distribution of time between the contexts recognized by our algorithm behaves intuitively throughout the weekdays. The office context is almost non-existent during the weekends, and naturally higher between 7am – 5pm during the working days.

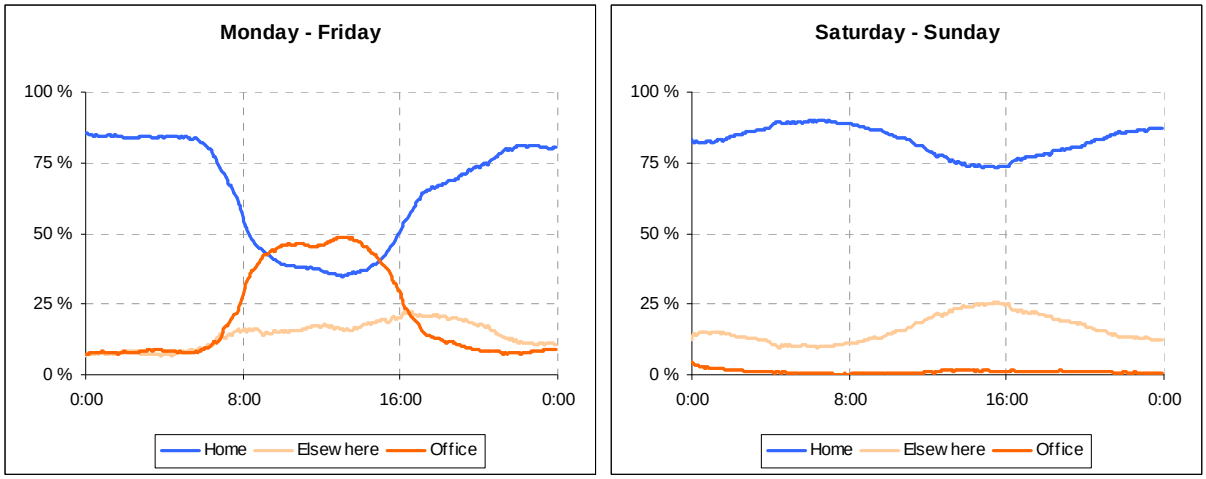


Figure 2: Time distribution of panelists, average over Monday – Friday (left figure) and Saturday – Sunday (right figure), in the time period between November 19th – December 23rd, 2007. N = 98.

3.2 Where and when do people use their mobile devices?

After having a view on the time use of people, our interest focuses on the usage of mobile devices in different locations and at different times of day. Figure 3 shows the active smartphone usage time divided between different application categories and hours of day.

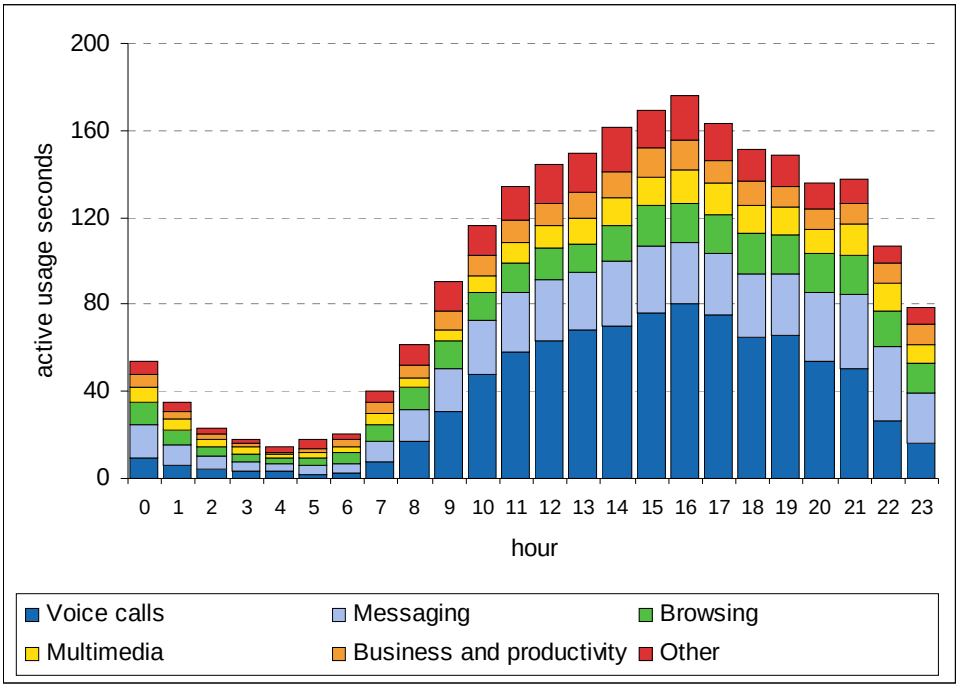


Figure 3: Distribution of active usage time between applications and hours of day, average over Monday-Sunday throughout the panel period. N = 253.

Location adds another dimension to the application usage studies. Figure 4 illustrates the active smartphone usage time, divided between the different locations and between different hours of day. As the figure shows, the majority of smartphone usage takes place while people are at home. This is only partly explained by the larger share of home in the time use distribution of people, as illustrated in Figure 5 depicting the distributions of active usage time for different application categories. In the topmost bar, the distribution of wake hours has been calculated by deducting the average sleeping time of Finnish people (8:27) from the time spent at home.

Some differences can also be noticed when comparing the different application categories. Voice calls, messaging, browsing, and multimedia applications have roughly the same time distributions, with 57-64% of active usage taking place at home, 15-21% at the office, and 20-26% elsewhere. Intuitively, navigation applications are used most actively while outside from home or office, but also quite much at home. For gaming applications, the usage outside of home or office is significantly smaller compared to other applications.

Figure 9 in Appendix C shows the active smartphone usage time separately for the four most important application categories, divided between the different locations and between different hours of day. The figures illustrate both the time and location dependence of mobile device usage, and are useful when analyzing the changing role of different applications throughout the day.

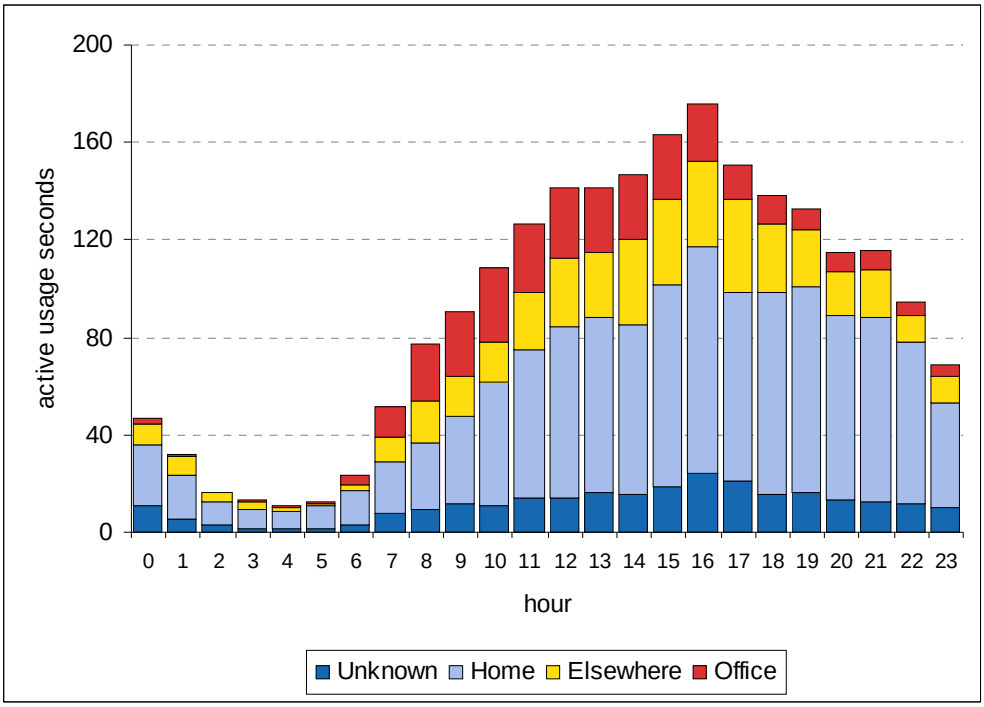
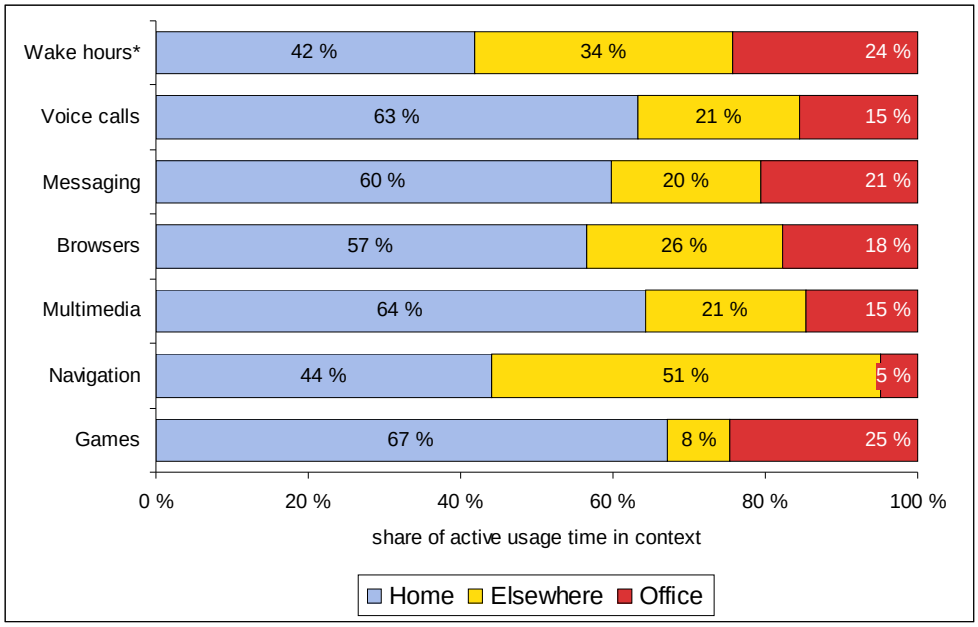


Figure 4: Distribution of active smartphone usage time between contexts and hours of day. N = 98.



* The wake hour distribution has been calculated by deducting 8:27 hours from the time spent at home

Figure 5: Distribution of active usage time between locations for different application categories. N = 98.

For voice calls (Figure 9a), the active usage amounts increase continuously after 6am, peaking at around 90 seconds of active use per panelist between 4pm and 5pm due to relatively active usage in all the locations. For messaging applications (Figure 9b), the peak hour is not as clear, and is actually clearly different for home and office use. Messaging usage at home increases steadily until 10pm, at which point it also becomes the most actively used application category over voice calling until 1am. The higher overall share of office usage for messaging applications compared to voice calling (21% vs. 15% is also clearly visible during the hours between 7am and 15pm.

Similarly to messaging, also browser applications (Figure 9c) are used in a relatively stable manner throughout the day, approximately 8-10 seconds per panelist per hour between 7am and 10pm. The relatively high share (26%) of usage outside the home and office is visible especially in the afternoon and early evening hours. Multimedia applications (Figure 9d), on the other hand, are used more actively in the evening and at home.

3.3 How do people use the alternative accesses?

The fourth dimension in our analysis, in addition to application category, time-of-day, and location, is the user's choice between the alternative access methods. WLAN usage was of special interest to us, due to its role as a potential alternative to 3G networks in many use cases (as shown in Appendix A).

Out of the total 538 panelists, 131 owned a WLAN capable device. Out of these, 73 (56%) actually used the WLAN capability of their device at least once during the panel. WLAN usage was very concentrated, both regarding the usage amounts per panelists as well as the number of access points used. Figure 6 shows the distribution of WLAN usage events, separating between users and access points for each user. On average, for each user 86% of WLAN connections were made to the same access point, 11% to a second one, and 3% to other access points.

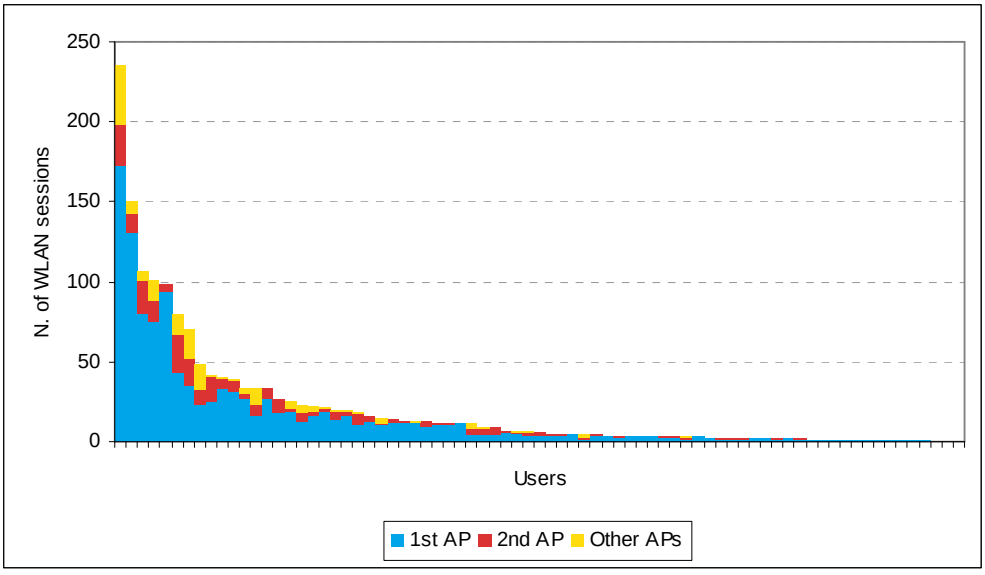


Figure 6: Distribution of WLAN usage events between users and access points, N = 73

By checking the list of WLAN access point names as well as the location information for those panelists for which it was found, it is evident that the most widely used access point is almost always a private one, located at home. Public WLANs, indicated by WLAN SSIDs of e.g. hotel chains and service providers (e.g. “RadissonSAS”, “Boingo Hotspot”, “BTOpenzone”, “homerun”, “dnawlan”), were used by 24 panelists, accounting to around 0.5% of all connections.

More than 90% of WLAN users used it for web browsing, while around a third used it for communications services (messaging or VoIP), and a fifth for streaming multimedia content, as shown in Table 1. For multimedia streaming, the number of sessions per user was lower than for the other applications, whereas the amount of data transmitted during one session was significantly higher.

Table 1: Usage of different application categories over WLAN connections

Application	Users (out of the 73 active WLAN users)	N. of sessions per user during the panel	Average data per session (kB)
Web browsing	70	18.4	611
Messaging or VoIP (e.g. email or Fring)	25	20.2	136
Multimedia (e.g. Internet radio, emTube)	15	6.4	3030

Usage of WLAN correlated clearly with usage of data services in general. Figure 7 shows the daily data usage for both WLAN and non-WLAN users, divided between different bearers. Figure 8 shows the same information for the panelists with location information available, divided both between bearers and locations.

Usage of WCDMA was significantly higher than that of other access technologies. Among WLAN users, WLAN access was used for 12% of total network data traffic. Also in homes, WLAN was used clearly less than the cellular data connections.

Regarding the usage of multimedia applications, we asked the panelists about their preferred ways of accessing music and video content (see Appendix D). 49% of the panelists answered that they are using the FM-radio in their phone to listen to music, whereas the measured usage was 39%. 67% answered that they listen to music (e.g. MP3 files) offline, whereas the measured usage level was 75%. Streaming was used by 6% of the panelists, which matched the answers in the questionnaire. Also podcasting applications were used by 5% of the panelists, although quite randomly. Consumption of video content was clearly less popular among the panelists, with 73% answering that they do not use their device for that purpose. The most popular ways for accessing video content were offline playback and streaming, as no user in the panel had a DVB-H capable terminal.

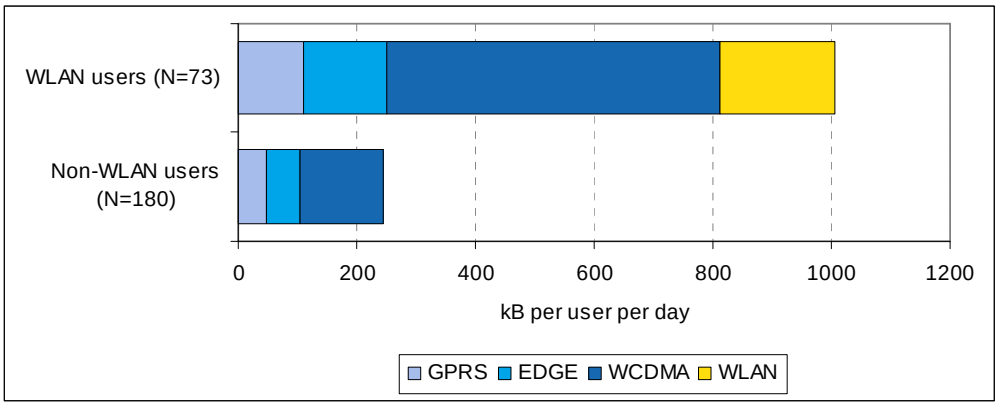


Figure 7: Daily data usage per bearer for panelists either using or not using WLAN during the panel. N=253.

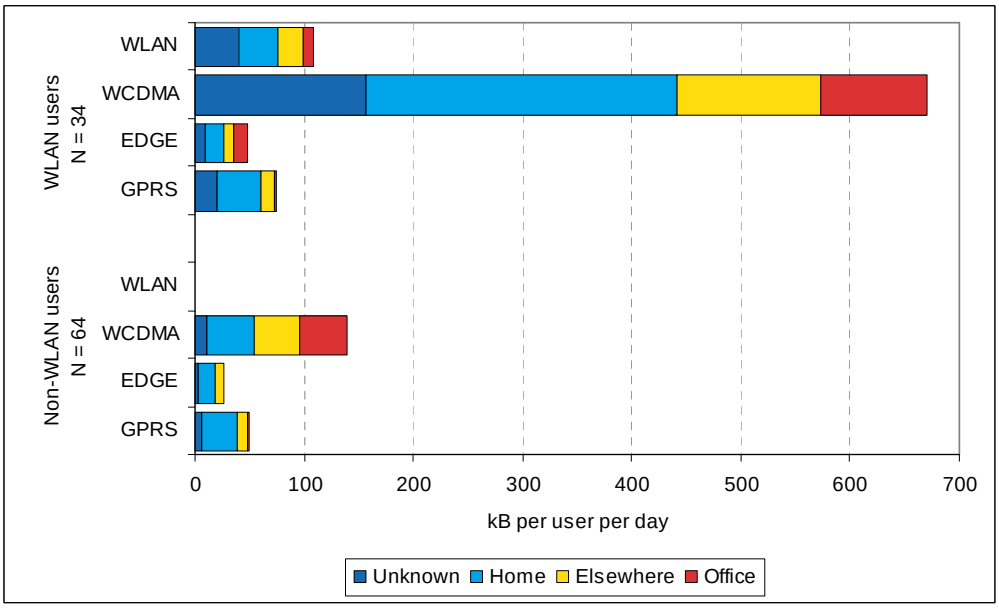


Figure 8: Daily data usage per bearer per location for panelists either using or not using WLAN. N = 98.

4 Discussion

In this paper, we have demonstrated the use of handset-based measurement data in analyzing the usage of mobile devices in different locations and with different access methods. The sample of panelists in our study included a group of Finnish consumers owning a Nokia S60 –series smartphone and willing to install a measurement client in their device. Due to these restrictions and the resulting bias towards more advanced users of mobile devices, the results cannot be directly generalized to all mobile users in Finland. However, we believe the results to be valuable in bringing forward some of the current and near-term trends taking place in the mobile industry.

The role of WLANs as a potential complement and/or substitute to third generation cellular networks has been actively discussed since the early 2000s (see e.g. Lehr & McKnight 2003).

The penetration of WLAN capable mobile devices is increasing constantly, and reached 5% of the Finnish mobile handset base in 2007 (Kivi 2008). Also the penetration of WLAN access points in homes, offices, and public "hotspots" has steadily increased, making it possible for a larger share of mobile devices' connectivity needs to be served via this alternative access.

The results of our study show that among the panelists, WLAN connections are typically made at home and used for web browsing. Usage of WLANs for communications or multimedia services, as well as outside the homes was less frequent. It also appears that WLAN is mainly used by those users that in general use large amounts of data services. Even without the contribution of WLAN traffic, the traffic amounts generated by WLAN users were more than three times higher than those by non-WLAN panelists.

Regardless of WLANs, homes are clearly the most important place of mobile service usage. Apart from map and navigation applications, more than half of mobile service usage took place at home across all application categories.

Increasing data rates offered by WCDMA and HSDPA networks, together with their constantly improving geographical coverage and penetration among mobile users were also visible in our panel. More than half of all the network traffic generated by the panelists was transmitted over WCDMA network interfaces, and also among WLAN users it was the most widely used access network in all locations.

In the future, as wireless network traffic amounts continue increasing and higher frequency bands are taken into use, the cell ranges of base stations and access points are likely to get ever shorter, increasing the importance of indoor access solutions. Together with the evolving number and intelligence of wirelessly connected devices (with e.g. automated software agents selecting between alternative accesses on behalf of the users) this will increase the role of indoor areas in the competition between operators as well as network and device vendors.

Handset-based measurement methods are valuable when reaching into a holistic view on the usage of mobile devices. Although operators are able to collect very detailed information regarding the use of networks that are operated and controlled by themselves, they have limited visibility regarding the usage of alternative access methods such as WLANs, broadcasting networks, and offline consumption of multimedia content. An automated handset-based data collection method can provide valuable support for the strategic decision-making.

Regarding the handset-based measurement and analysis process used in our study, there is still room for some improvement. In addition to improving the accuracy and reliability of the measurement client and the context algorithm, complementary questionnaire data can be utilized more efficiently. Ideally, a device monitoring system –based research would include the most important complementary and substitutive devices (laptop, 2nd phones, MP3 players, fixed-line phones, televisions). This is in contrast to the current situation, where only Nokia S60-based smartphones were monitored. However, traditional questionnaires linked to the handset monitoring process can be helpful in getting a better view on the usage of the alternative devices.

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Appendix A: Access alternatives for selected applications

Table 2: Currently available devices/services and access alternatives in different locations

	Home	Office	Elsewhere, on-the-move
Voice calls			
Alternative devices / services	Mobile* / circuit-switched Mobile / VoIP Fixed phone / circuit-switched Fixed phone / VoIP PC / VoIP	Mobile / circuit-switched Mobile / VoIP Fixed phone / circuit-switched Fixed phone / VoIP PC / VoIP	Mobile / circuit-switched Mobile / VoIP (Fixed pay phone)
Alternative accesses for mobile devices	Mobile networks WLAN	Mobile networks WLAN	Mobile networks (WLAN)
Messaging			
Alternative devices / services	Mobile / SMS Mobile / Email Mobile / IM PC / Email PC / IM	Mobile / SMS Mobile / Email Mobile / IM PC / Email PC / IM	Mobile / SMS Mobile / Email Mobile / IM
Alternative accesses for mobile devices	Mobile networks WLAN	Mobile networks WLAN	Mobile networks (WLAN)
Browsing			
Alternative devices / services	Mobile / Web Mobile / WAP PC / Web	Mobile / Web Mobile / WAP PC / Web	Mobile / Web Mobile / WAP
Alternative accesses for mobile devices	Mobile networks WLAN	Mobile networks WLAN	Mobile networks (WLAN)
Multimedia			
Alternative devices	Mobile Portable media player PC Radio, television	Mobile Portable media player PC Radio	Mobile Portable media player
Alternative accesses for mobile devices	Mobile networks WLAN FM-radio Off-line playback (DVB-H)	Mobile networks WLAN FM-radio Off-line playback (DVB-H)	Mobile networks (WLAN) FM-radio Off-line playback (DVB-H)

* “Mobile” refers to a mobile device with telephony capabilities, including e.g. mobile phones, smartphones, and PDAs

Appendix B: Panel description

Table 3: Description of panelists and their devices

	Active panelists	Active panelists, S60 3rd edition	Active panelists, S60 3rd edition, with context data
N	538	253	98
Average n. of active days in panel	53.5	49.6	50.3
Gender			
Male	79,1 %	81,7 %	86,2 %
Female	20,9 %	18,3 %	13,8 %
Age			
< 20	3,7 %	2,7 %	2,3 %
20 – 29	39,3 %	40,2 %	36,8 %
30 – 39	30,7 %	33,3 %	39,1 %
40 – 49	16,1 %	14,6 %	11,5 %
50 – 59	6,5 %	6,4 %	9,2 %
60 – 69	3,3 %	2,3 %	1,1 %
70 – 79	0,4 %	0,5 %	0,0 %
Employment			
Employed	68,3 %	68,0 %	80,5 %
Student	18,3 %	19,6 %	17,2 %
Not working	13,5 %	12,3 %	2,3 %
Device capabilities			
GPRS	100.0 %	100.0 %	100.0 %
EDGE	100.0 %	100.0 %	100.0 %
WCDMA	97.2 %	94.1 %	92.9 %
HSDPA	14.3 %	30.4 %	34.7 %
WLAN	24.3 %	51.8 %	56.1 %
Bluetooth	100.0 %	100.0 %	100.0 %
FM-radio	61.0%	88.1%	87.8 %
DVB-H	0.0 %	0.0 %	0.0 %
GPS	14.3 %	30.4 %	34.7 %
VoIP (pre-installed)	3.5 %	7.5 %	7.1 %

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Appendix C: Usage time distributions

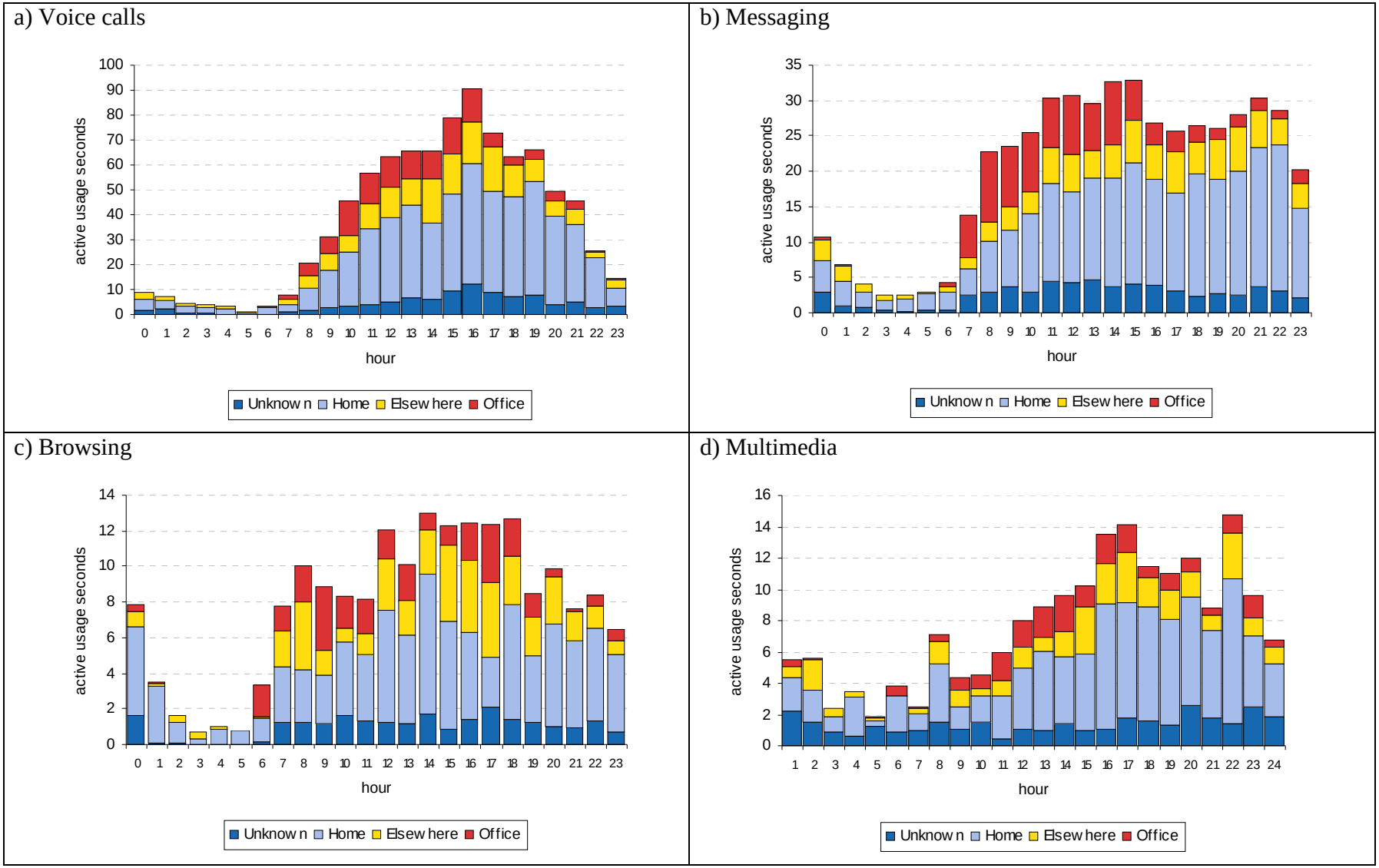
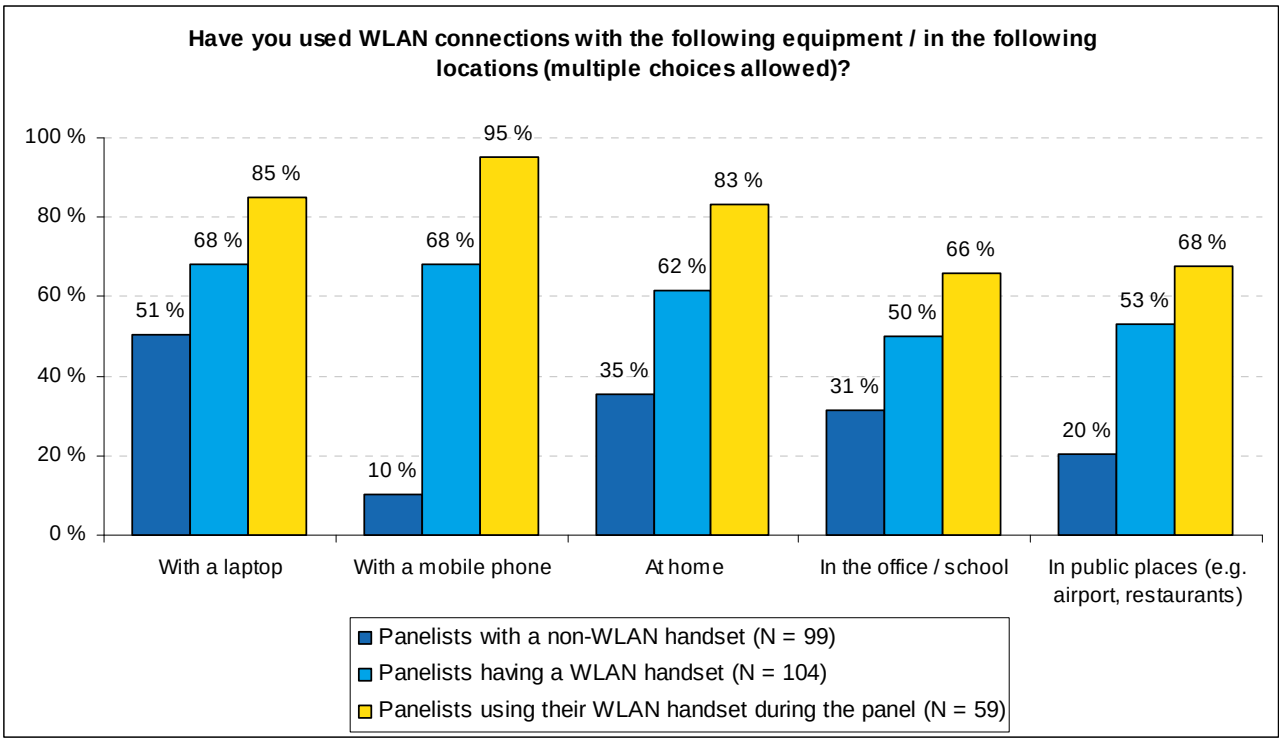
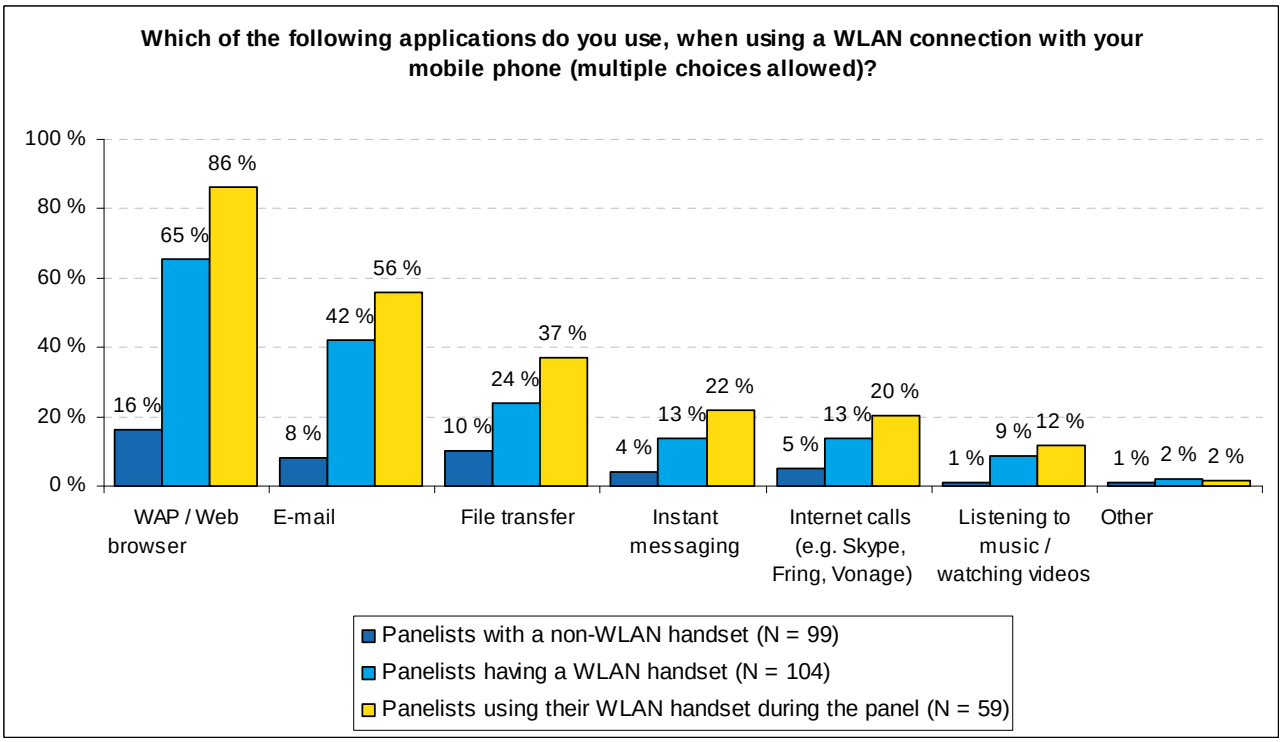
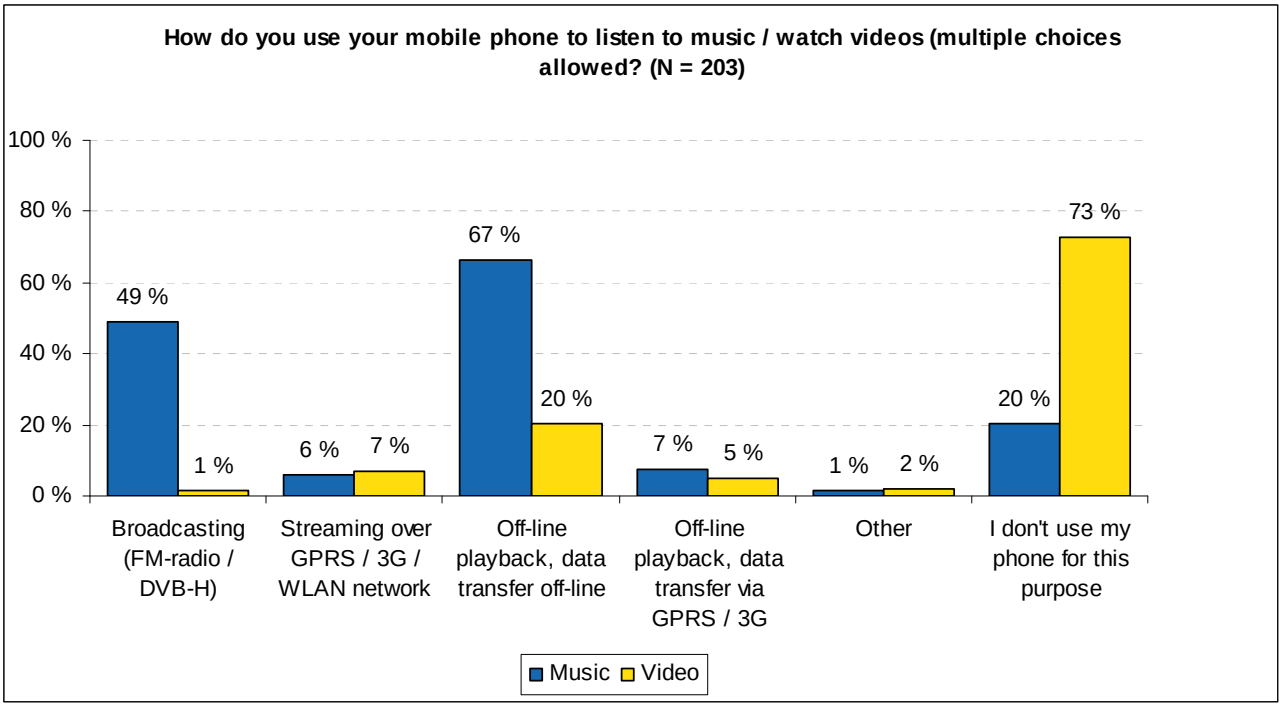


Figure 9: Distribution of active usage time between contexts and hours of day, for different application classes (active seconds per hour per day). N = 98.

Appendix D: Selected questionnaire items






How do you use your mobile phone to listen to music / watch videos (multiple choices allowed? (N = 203)
100 %
80 %
60 %
40 %
20 %
0 %
49 %
1 %
6 %
7 %
67 %
20 %
7 %
5 %
1 %
2 %
20 %
73 %
Broadcasting (FM-radio / DVB-H)
Streaming over GPRS / 3G / WLAN network
Off-line playback, data transfer off-line
Off-line playback, data transfer via GPRS / 3G
Other
I don't use my phone for this purpose
Music
Video