A framework for analysing the usage of mobile services

Timo Smura, Antero Kivi and Juuso Töyli

Abstract

Purpose – Collecting and analysing data on mobile service usage is increasingly complex as usage diverges between different types of devices and networks. The purpose of this paper is to suggest and apply a holistic framework that helps in designing mobile service usage research as well as in communicating, positioning, and comparing research results.

Design/methodology/approach – The framework was constructed based on longitudinal and cross-sectional mobile service usage measurements carried out in Finland annually in 2005-2008, covering 80-90 percent of all mobile users and service usage. Broad use of multiple data collection methods and measurement points enabled data and method triangulation, as well as analysis and comparison of their scopes and limitations.

Findings – The paper suggests a holistic framework for analysing mobile services, relying on service science approach. For measurements and analysis, mobile services are decomposed into four technical components: devices, applications, networks, and content. The paper further presents classifications for each component and discusses their relationships with possible measurement points. The framework is applied to mobile browsing usage studies.

Research limitations/implications – Future work includes adding an actors dimension to the framework in order to analyse their roles in the value networks providing mobile services. Extending the framework to Internet services more generally is also possible.

Originality/value – The paper presents an original, broadly applicable framework for designing mobile service usage research, and communicating, positioning, and comparing research results. The framework helps academics and practitioners to design and to recognise the limitations of mobile service usage studies, and to avoid misinterpretations based on insufficient data.

Keywords Mobile communications systems, Internet, Finland

Paper type Research paper

1. Introduction

The internet is of growing importance for businesses, enabling a virtual supply chain for marketing and delivering products and services, as well as in facilitating the production of digital services and content. Using internet as a distribution and marketing channel is widely expected to increase companies’ performance (Geyskens et al., 2002) as well as consumer surplus (Brynjolfsson et al., 2003) and it is increasingly important for competitiveness in most industries and markets today. Advances in mobile technologies are promising further benefits by decreasing the spatial and temporal constraints of service provisioning and use (Balasubramanian et al., 2002).

In most developed countries, mobile phones have become an inseparable part of everyday life and a majority of people carry them all the time. In addition to complementing and expanding the use of various internet-based services, the evolution of mobile devices also enables entirely new types of services to be introduced, utilising, e.g. location and context-specific information and higher degree of personalization of the devices. Furthermore, aside from their role as a channel to services, mobile devices are also...
utilised for various other purposes, including, e.g. advertising (Leppäniemi and Karjaluoto, 2005) as well as collecting behavioural data from the users (González et al., 2008; Eagle and Pentland, 2006).

Because of the rapid pace of development, the need for measuring and analysing how people adopt and use the existing and emerging mobile services is evident, to support different stakeholders, including service providers, content creators, mobile operators, handset manufacturers, and regulators in their decision-making. At the same time, however, collecting and analysing the required information is becoming increasingly complex as usage diverges between different types of devices and networks. Statistics collected and disseminated by companies, policy-makers, consultants, and academics are often narrow-focused and miss a holistic view on service usage. Comparing the findings is difficult, and even the use of key terms such as “mobile” and “service” is often ambiguous and context-dependent.

Mobile services are typically (and often implicitly) understood as services that make use of mobile devices and/or mobile networks. In reality, however, it is often difficult to draw a line between mobile and non-mobile networks, as, e.g. wireless local area networks (WLANs) offer more limited mobility compared to cellular networks. Furthermore, mobile networks are increasingly utilised by devices other than mobile phones, including less mobile devices such as laptop PCs or even home alarm systems. In the future of “ubiquitous” technologies and computing, the variety of wirelessly connected devices as well as the importance of machine-to-machine communications is expected to grow significantly, adding to this complexity (see, e.g. Uusitalo, 2006).

Additional ambiguity is related to the term service having many incompatible definitions. This paper relies on a service science view. In general, Vargo and Lusch (2004) argue for a service-dominant logic to replace the traditional goods-dominant logic in marketing, and define service as the application of resources (competences, skills, and knowledge) for the benefit of another entity or the entity itself. Furthermore, service systems are defined as value-co-creation configurations of people, technology, other internal and external service systems, and shared information (Maglio and Spohrer, 2007; Spohrer et al., 2007). According to these definitions, service systems include businesses, government agencies as well as individual people, and both the client and provider of service are considered as service systems.

A wide variety of mobile services exists, each fulfilling different types of needs (e.g. Anckar and D’Incau, 2002; Bouwman et al., 2008). Thus, organizing, structuring, and analysing mobile service usage data raises a need for classifying the services. Ideally, classification should be based on consistent use of relevant criteria, and should produce categories that are mutually exclusive and jointly exhaustive. Mobile service classifications have been proposed by many authors, for different purposes and using different criteria. Velez and Correia (2002) take a network viewpoint and classify mobile broadband services and applications based on the characteristics of the traffic produced by them (Interactive/Conversational, Interactive/Messaging, Interactive/Retrieval, Distributed/Broadcast, Distributed/Cyclical). Holma et al. (2007) divide UMTS services to five main categories (person-to-person circuit switched services, person-to-person packet switched services, content-to-person services, business connectivity, and location services), and further to twelve subcategories. Pura and Heinonen (2007) take an end-user point-of-view to classification, identifying four dimensions of mobile services: type of consumption (hedonic vs. utilitarian use), temporal and spatial context, social setting, and relationship between the user and the service provider.

The purpose of this paper is to construct a holistic framework that supports designing mobile service usage research as well as communicating, positioning, and comparing research results. The framework helps academics and practitioners to design and to recognise the limitations of mobile service usage studies, and to avoid misinterpretations based on insufficient data. By mapping research settings and results to the framework, it is possible to recognise areas where further data collection and analysis might be required. The
framework also helps in selecting the most appropriate methods and measurement points for different research questions.

The paper is structured as follows. First, we discuss the research process that resulted in the proposed framework and identify four relevant measurement points that can be used to collect data on mobile service usage. Then, we introduce our framework, comprising of the measurement points and technical components of mobile services, together with suitable classification criteria and resulting categories. We then proceed to discuss the relations between the measurement points and service components. Finally, after introducing the framework, we apply it to the analysis of mobile browsing studies, an important and timely topic area in the convergence point of mobile and Internet services. The paper is then closed with discussion and suggestions for further research.

2. Research process and methods

The framework presented aggregates our experiences from a series of longitudinal and cross-sectional mobile service usage measurements carried out in Finland annually in 2005-2008, covering 80-90 per cent of all mobile users and service usage. Although relatively small and remotely located in Northern Europe, Finland is well-suited for studies concerning advanced mobile services for a number of reasons. With a population of 5.3 million, it ranks among the 12 richest countries in the world using GDP/capita as a measure. Finland is a highly industrialised open economy, and was No. 6 in World Economic Forum’s Global Competitiveness Index in 2007-2008 and 2008-2009 (www.weforum.org). It was also the first country in the world to launch GSM-based digital mobile communications networks in 1991, and led the global mobile service penetration statistics throughout the 1990s. Furthermore, the world’s largest mobile manufacturer Nokia has its home and origin in Finland.

Our mobile service usage measurements have taken place annually in 2005-2008. Descriptive results from these measurements have been published in Kivi (2008) and Verkasalo (2008). The measurements were carried out in close collaboration with the key players of the industry, including all three mobile network operators and Nokia. This wide support of the national mobile industry allowed us to collect data of comprehensive scope. Broad use of multiple data collection methods and measurement points has enabled data and method triangulation, as well as analysis and comparison of their scopes and limitations.

Information on the usage of internet and mobile services can be collected from a range of different sources (see, e.g. Kivi, 2009). In our measurements, data were collected by:

- capturing the IP traffic from mobile operator’s central network nodes;
- by utilizing the usage accounting systems of mobile operators;
- by monitoring end-users’ mobile handsets.

Furthermore, the handset-based measurements were complemented with questionnaires filled by the participating users. To our knowledge, synchronised data of the same detail and scope have not been earlier available to researchers from any other mobile market.

In general, mobile service usage data can be collected from four main sources, as illustrated in Figure 1.

1. **End-users.** Surveys are a commonly used data collection method for studying mobile user behaviour and service usage. Surveys are conducted on samples of real end-users, and can be implemented using various methods. Time series data can be produced by repeating a certain set of questions. Continuous panel studies, where the participating panellists register usage events manually to an online or paper diary often result in data of higher accuracy and granularity.

2. **Usage monitoring systems.** Usage monitoring includes both user monitoring as well as device monitoring systems. Device monitoring is common in studying PC and Internet usage, and is also used in TV audience measurements. The evolution of mobile phones towards computer-like devices has made it possible to conduct device monitoring also at mobile handsets (see, e.g. Verkasalo and Hämmäinen, 2007), regardless of whether any
traffic is generated in the mobile networks. Device monitoring is typically conducted as panel studies, where the manual registering of usage events is replaced with the logging functionality of monitoring software or hardware installed in the device. In mobile handset monitoring, a software agent in a monitored device records what the user does with the device, and sends that information further.

3. Network nodes. The accounting systems that register the usage of chargeable services by individual users are natural sources of information for any service provider. In GSM/UMTS networks, this function is typically called charging and billing, whereas for an IP network access provider, the accounting function is a part of the AAA (Authentication, Authorization, and Accounting) system. More specific TCP/IP traffic measurements (a.k.a. "network sniffing" or "packet sniffing") can be also conducted at various intermediary network nodes between terminals and servers. Network architecture is in an important role, as points of convergence of mobile data traffic should be found at the network to attain comprehensive and representative measurements. In contrast to GSM/UMTS networks that provide a centralised point for traffic measurements, efficient measurement in WLAN networks is more challenging because of the small size of individual WLAN hot spots and lack of centralised routing in larger deployments.

4. Servers. At the server side, in addition to the above-mentioned TCP/IP traffic and usage accounting system-based methods, service usage and behavioural patterns can be studied by collecting log files. The various servers where usage of many end-users converges include, e.g. portals and individual Web/WAP sites/servers, search engines, and proxy servers.

3. The framework

The framework for analysing the usage of mobile services is depicted in Figure 2. The framework consists of two layers: measurement points, and technical components of mobile service systems. The technical components comprise of devices, applications, networks, and content. In addition, the framework presents classifications for each component and the relationships between the components and available measurement points.

As our focus is specifically on the technical components of mobile service systems, the value network and actors responsible for offering each of the service components, including, e.g. mobile operators, device vendors, and content providers, are not visible in the framework. These aspects are omitted to avoid unnecessary complexity, but if needed can be taken into account by adding an additional actors dimension to the framework.

3.1 Devices

End-users, both consumers and corporate, have a number of digital, network connected devices in use, partly for different and partly for the same tasks. From the end-user point-of-view, different devices are complementary as each one is preferred in different contexts and for different applications. The devices are, however, also competing with each other in order to be the preferred ones in as many situations as possible.
Regarding mobility, a question arises how to distinguish between mobile and ‘non-mobile’ devices. In addition to basic mobile phones and smartphones, a number of other devices are offering some degree of mobility to the users. Current laptops offer WLAN and Bluetooth connectivity, possibly complemented by, e.g. 3G mobile network interfaces. In addition, personal digital assistants (PDAs, like HP iPaq) and ‘Internet tablets’ or ‘Ultra-mobile PCs’ (Nokia N810, Microsoft UMPC) are available in the market, each one with different strengths in different applications. The variety of wirelessly connected devices is expected to extend further, and to include, e.g. more narrowly focused devices such as digital cameras and gaming devices.

Convergence of multiple features and functionalities in the same device makes it harder to make the distinction between device classes. For example, advanced mobile devices such as Nokia N97 or Apple iPhone, although often classified as mobile phones, also integrate a music/video player, a digital camera, as well as PDA functionalities into the same device. Mutual exclusiveness between feature/functionality-centric device classes is therefore difficult to achieve.

Previously, mobile devices have been classified based on criteria such as mobile technology generation (2G vs. 3G) or, e.g. the capability of installing third party applications to the device (Sugai, 2007). Our classification of mobile devices is based on three classification criteria: the physical size of the device, the capability to make 2G/3G circuit-switched (CS) voice calls with the device, and the type of operating system running in the device. Based on these criteria, we have recognised the following, sufficiently well disintegrated mobile device classes:

- mobile phones;
- smartphones and PDAs;
- ultra-mobile PCs;
- laptops and tablet PCs; and
- other devices.

The classification criteria, together with examples for each of the classes, are presented in Table I.
3.2 Applications

Mobile phones are essentially small computers capable of running a number of software applications, each required for delivering certain services, such as voice calls, SMS messages, or e-mail. Voice calling and SMS messaging applications are typically deeply integrated into the software platform of mobile phones. New, more advanced mobile devices support also various other functionalities, and applications for mobile phones are getting closer to computer software. The emergence of more open mobile operating systems such as Symbian, Windows Mobile, and Google Android makes it possible to run software applications developed by third parties in the devices, much in the same way as in the PC domain. Applications can be running independently only in one device, or be distributed between multiple computers communicating over a network. An emerging trend towards “cloud computing” is shifting computing from locally installed programs to large, centralised servers in the internet (see e.g. Hayes, 2008).

Consequently, when classifying applications, we are effectively classifying computer software. Examples of software classification frameworks include, e.g. the North American Product Classification System (NAPCS), which divides application software into general business productivity and home use applications, cross-industry application software, vertical market application software, utilities software, and other application software (US Census Bureau, 2007). Classification on this level is, however, not sufficiently fine-grained to give insight to the developments taking place in the dynamic mobile marketplace.

In our classification, the key classification criteria are the nature of interactivity that the application provides (person-to-person communications, content retrieval, content viewing/playback, synchronization, or standalone), as well as the type of content handled by the application. The resulting classification is similar to those used by major PC software libraries such as Download.com, or Versiontracker.com, and includes ten mobile device application classes:

1. calling;
2. messaging;
3. browsers;
4. infotainment clients;
5. servers and file sharing;
6. multimedia;
7. games;
8. business/productivity;
9. system/utilities; and
10. other applications (Table II).
The classification is seen to be relatively stable, covering the essential applications available and in use today. In the future, as mobile devices and available applications evolve, the classification may need to be updated to include new classes.

### 3.3 Networks

Mobile networks based on, e.g. GSM/GPRS, EDGE, and WCDMA/HSPA radio technologies provide are central in providing wireless network connectivity to mobile devices. In addition, WLAN technologies provide a low-cost alternative mostly in indoor areas, such as homes, offices, and certain hotspot locations such as hotels, airports, or cafes. Alternative wireless access network technologies such as WiMAX may become an option in the future.

One way to classify wireless networks is based on their geographical range, resulting into such classes as WWAN (Wireless Wide Area Network), WMAN (Wireless Metropolitan Area Network), WLAN (Wireless Local Area Network), and WPAN (Wireless Personal Area Network). In our classification, we use the term “mobile networks” instead of WWAN. To complete the wireless network classification, we have included two additional classes: “offline” to account for those use cases where only local device features are used and no network connections are required (e.g. taking photos with a camera phone), and “other networks” to account for, e.g. fixed connections or mesh technologies. In sum, our six wireless network classes are:

1. mobile networks;
2. wireless MANs;
3. wireless LANs;
4. wireless PANs;
5. offline; and
6. other networks (Table III).

<table>
<thead>
<tr>
<th>Class</th>
<th>Classification criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calling</td>
<td>Person-to-person</td>
<td>Real-time voice/video calls, video calls, Push-to-Talk over Cellular, and “rich calls”</td>
</tr>
<tr>
<td>Messaging</td>
<td>Person-to-person</td>
<td>Non-real-time voice/video/text/images</td>
</tr>
<tr>
<td>Browsers</td>
<td>Content retrieval</td>
<td>Generic HTML/WAP pages</td>
</tr>
<tr>
<td>Infotainment clients</td>
<td>Content retrieval</td>
<td>Client-specific data</td>
</tr>
<tr>
<td>Servers and file sharing</td>
<td>Content retrieval and sharing</td>
<td>Various Web servers, Bittorrent, FTP, media servers</td>
</tr>
<tr>
<td>Multimedia</td>
<td>Content creation, editing, and playback</td>
<td>Music/video/image files or streams</td>
</tr>
<tr>
<td>Games</td>
<td>Offline/data synchronization</td>
<td>Game data Offline and network games</td>
</tr>
<tr>
<td>Business/productivity</td>
<td>Offline/server access</td>
<td>Office documents Calendars, personal information management, word processors, spreadsheet and presentation applications, enterprise systems</td>
</tr>
<tr>
<td>System/utilities</td>
<td>Offline/server access</td>
<td>Local data/files File managers, configuration, security, system updates, compression</td>
</tr>
<tr>
<td>Other applications</td>
<td>Various</td>
<td>Various Uncategorised applications</td>
</tr>
</tbody>
</table>
3.4 Content

As the fourth mobile service component, we consider the content transmitted via the wireless networks and/or consumed with the mobile devices and applications. Traditionally, and dominantly today, the majority of mobile operator revenues are collected from voice calls and short message services (SMS). Rapid evolution of handset and network technologies is, however, enabling new types of Internet and multimedia contents to be delivered to the users.

Classification of content could be done on a purely technical level, separating between voice/audio, video, images, and text/data. In this case, information about the file formats, i.e. filename extensions (e.g. html, .mp3, .jpg, .wmv) could be used to distinguish between content classes. Another option is to use servers where content resides as a proxy for the content, and classify the servers. Servers can be recognised by their IP addresses or URLs (e.g. cnn.com, youtube.com) and classified, e.g. based on the nature of content they are holding (e.g. news, entertainment).

In our framework, content classification is strongly linked both to the applications as well as to the utilised networks. An important criterion in our classification is whether the content is mobile-specific or generic internet content (e.g. WAP vs Web pages). Furthermore, content classification is based on the application accessing and transferring the content. The classification is based on our view on the most relevant and widely accessed types of content, and includes the following ten content classes:

1. mobile calls;
2. mobile messaging;
3. mobile portals and sites;
4. personalization and applications;
5. multimedia;
6. internet calls;
7. internet messaging;
8. web sites;
9. web search and portals; and
10. other content (Table IV).

3.5 Relationships between measurement points and service components

Table V illustrates the relations between measurement points and the technical components of mobile service systems. Each measurement point can provide data on several components, and the quality of the collected data differs between the measurement points. In Table I, these differences are presented, separately in two dimensions: data coverage and granularity.

<table>
<thead>
<tr>
<th>Network classes</th>
<th>Classification criterion</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile networks</td>
<td>Nationwide, worldwide</td>
<td>GSM, CDMA, WCDMA</td>
</tr>
<tr>
<td>Wireless MANs</td>
<td>Citywide/regional</td>
<td>WiMAX (IEEE 802.16)</td>
</tr>
<tr>
<td>Wireless LANs</td>
<td>Local, e.g. inside a home, office, café</td>
<td>Wi-Fi (IEEE 802.11)</td>
</tr>
<tr>
<td>Wireless PANs</td>
<td>Short-range</td>
<td>Bluetooth (IEEE 802.15)</td>
</tr>
<tr>
<td>Offline</td>
<td>None</td>
<td>Use of phone camera</td>
</tr>
<tr>
<td>Other networks</td>
<td>Various</td>
<td>Fixed networks, uncategorised networks</td>
</tr>
</tbody>
</table>
By data coverage, we mean the proportion of the technical service components and component classes that can be captured by using a certain measurement point. By granularity, we mean the level of detail of the collected data. The ‘+’ and ‘–’ signs in the table indicate a relative strength or weakness of data collected from a certain measurement point on a certain component, considering coverage and granularity separately. For instance, data collected from end-users on usage of devices have good coverage (+) but limited granularity (–). It should be noted that data representativeness is still a separate issue, and independent of data coverage. Regardless of the measurement point, representativeness can be better or worse depending on the properties of the selected sample.

Data collected directly from end-users by, e.g. interviews or surveys has typically good coverage across the service components, as it is possible to ask which devices and applications are being used, and what types of content is being accessed. To some extent, it is also possible for end-users to give information about the networks they are using, but not in the same detail as network accesses are increasingly transparent to end-users. The granularity of data collected from end-users is relatively limited compared to other technical measurement approaches.

Usage monitoring systems provide accurate, factual information about the used applications and consumed content. Different networks accessed by the monitored devices can be identified, as well as those use cases where no network connections need to be established. Granularity of the collected data is typically good across all the service components. Usage monitoring systems are, however, typically applicable only to one or few of the devices possessed by the end-user, therefore neglecting all the usage that takes place with other devices. For example, by installing monitoring software to a mobile handset, it is not possible to know how the user might be utilizing mobile networks with their laptops or MP3 players.
Measurements at network nodes provide accurate and fine-grained data on the usage of the networks, and the devices used within those networks are accurately identifiable. However, all usage out of the scope of the operator’s usage accounting system or the central network point selected for traffic measurements can not be observed with these methods, ignoring, e.g. WLAN and offline use. This leads to relatively poor coverage of data across the service components. Typically, applications and content, especially those that are not controlled by the operator, are not easily identified by the accounting systems. Traffic measurements enable the use of more advanced (and more resource consuming) analysis methods than those available in the accounting systems, resulting in better knowledge about, e.g. the accessed content.

Measurements done at network servers provide accurate information about the devices and applications used to access the content on those particular servers. Regarding devices, data granularity is rather good, as it is possible for servers to accurately recognise, e.g. the operating systems of the devices connected to them. Unfortunately, single server based measurements cannot give a holistic view on the usage of mobile services as the usage is typically fragmented over many servers. Even the most central servers, such as Google’s search engine or operators’ portals, can capture only a portion of the mobile service usage.

4. Application of the framework to mobile browsing usage studies

In the PC-centric internet, Web browsers are the dominant way of accessing content and services. Increasingly, also the audio and video content is played using the browser application, instead of dedicated media players. Similarly, as mobile devices are becoming internet-capable, mobile web browsing is expected to be in central role when accessing the internet while on the move.

Web browsing on mobile devices has attracted the interest of many academics. The success of NTT DoCoMo’s i-mode service in Japan compared to the poor acceptance of Wireless Application Protocol (WAP) services in Europe in the early 2000’s resulted in many studies comparing the two. Lindmark and Bohlin (2003) find many of the common explanations for i-mode’s success (Japan’s low fixed line penetration, socio-cultural differences, technology choices) inadequate, and propose a systems explanation of co-evolving technical and actor systems. Haas (2006) compares the innovation strategies and processes of Japanese and European companies, and their effects on the success of mobile internet services. Numerous other contributions can be found related to the technical network architectures and protocols designed for mobile Web browsing, as well as usability of mobile browsing software (e.g. Roto, 2006). In this paper, however, our focus is on empirical measurements and analysis of the actual usage of mobile services.

Regarding service usage, a number of studies on mobile browsing can be found in the literature. In our literature review, we have identified four groups of studies with relatively different scopes and viewpoints on mobile browsing. The four groups include studies utilizing data from end-users, handset monitoring systems, network traffic measurements, and server measurements.

Figure 3 illustrates the differences in the scopes of the groups of studies, making use of our framework.

Figure 3A maps two survey-based studies to our framework. The scope of survey-based studies is defined by the questions asked from the respondents. Ishii (2004) compares the mobile internet and PC internet use in Japan, whereas Habuchi et al. (2005) collected data on mobile phone and mobile web usage in order to describe the recent conditions of mobile communication in Japan. Considering devices, the use of PCs is differentiated from mobile phones in the former study, while only mobile phones are in the scope of the latter. Mobile networks and wireless LANs are presumably in the scope of both studies, but not separately identified or treated. Regarding content, the authors of both studies have identified and differentiated between a large number of web site categories.
Figure 3 | Application of the framework to mobile browsing usage studies

A) End-users | Usage monitoring systems | Network nodes | Servers

- Device
  - Mobile phones
  - Smartphones and PDAs
  - Ultra-mobile PCs
  - Laptop and tablet PCs
  - Other devices

- Application
  - Calling
  - Messaging
  - Browsers
  - Infotainment clients
  - Servers and file sharing
  - Multimedia
  - Games
  - Business/productivity
  - System/applications
  - Other applications

- Network
  - Mobile networks
  - Wireless MANs
  - Wireless LANs
  - Internet calls
  - Web sites

- Content
  - Mobile calls
  - Mobile messaging
  - Mobile portals and sites
  - Web search and portals
  - Other content

B) End-users | Usage monitoring systems | Network nodes | Servers

- Device
  - Mobile phones
  - Smartphones and PDAs
  - Ultra-mobile PCs
  - Laptop and tablet PCs
  - Other devices

- Application
  - Calling
  - Messaging
  - Browsers
  - Infotainment clients
  - Servers and file sharing
  - Multimedia
  - Games
  - Business/productivity
  - System/applications
  - Other applications

- Network
  - Mobile networks
  - Wireless MANs
  - Wireless LANs
  - Internet calls
  - Web sites

- Content
  - Mobile calls
  - Mobile messaging
  - Mobile portals and sites
  - Web search and portals
  - Other content

C) End-users | Usage monitoring systems | Network nodes | Servers

- Device
  - Mobile phones
  - Smartphones and PDAs
  - Ultra-mobile PCs
  - Laptop and tablet PCs
  - Other devices

- Application
  - Calling
  - Messaging
  - Browsers
  - Infotainment clients
  - Servers and file sharing
  - Multimedia
  - Games
  - Business/productivity
  - System/applications
  - Other applications

- Network
  - Mobile networks
  - Wireless MANs
  - Wireless LANs
  - Internet calls
  - Web sites

- Content
  - Mobile calls
  - Mobile messaging
  - Mobile portals and sites
  - Web search and portals
  - Other content

D) End-users | Usage monitoring systems | Network nodes | Servers

- Device
  - Mobile phones
  - Smartphones and PDAs
  - Ultra-mobile PCs
  - Laptop and tablet PCs
  - Other devices

- Application
  - Calling
  - Messaging
  - Browsers
  - Infotainment clients
  - Servers and file sharing
  - Multimedia
  - Games
  - Business/productivity
  - System/applications
  - Other applications

- Network
  - Mobile networks
  - Wireless MANs
  - Wireless LANs
  - Internet calls
  - Web sites

- Content
  - Mobile calls
  - Mobile messaging
  - Mobile portals and sites
  - Web search and portals
  - Other content
Figure 3B brings out the different characteristics of handset monitoring compared to surveys. Kivi (2007) analyses the diffusion and usage of mobile browsing services in Finland utilizing handset measurement data from panels of smartphone users. M:Metrics, Inc. (2008), an analyst company specializing in measuring the consumption of mobile content and applications, also monitors a panel of smartphone users, and publishes mobile browsing statistics from, e.g. the United States and the United Kingdom. The scope of the measurement and coverage of the data is limited to those smartphones where the device monitoring system can be installed (Nokia’s Symbian S60-based devices for the former and Windows, Symbian, and Palm handsets for the latter study). Generally, the use of various browser applications can be accurately identified by the monitoring systems, and also the usage of WLAN networks can be separately measured and analysed. All relevant content categories are identifiable and measurable from the data.

Figure 3C presents the characteristics of network traffic measurements. In his mobile browsing study, Kivi (2007) uses also traffic measurement data collected from mobile operators’ networks. The measurements are limited to Internet-bound traffic in the mobile networks of Finnish operators, and, e.g. data on browsing that takes place via wireless LANs is not available. The identification of browser applications is based on transport protocol port numbers, possibly resulting in some inaccuracies in the results. Regarding devices, all categories are in the scope of the study as long as they are using mobile networks for data transmission. Content-wise, generic web sites and portals are within the scope of the measurements, whereas mobile operators’ portals are not.

Finally, Figure 3D maps three different server based measurements in the framework. Kamvar and Baluja (2007) examine mobile web search queries, by analysing data collected from Google’s server logs in the US. Similarly, utilizing query log data collected from Yahoo! Japan’s servers, Baeza-Yates et al. (2007) study the characteristics of search queries on mobile phones in Japan. Both studies represent relatively central points in the network, but still the measurements are capturing only a small subset of browsing traffic generated by mobile devices. All devices capable of running browser applications are in the scope of the studies, and have been also identified and categorised as phones, PDAs, and PCs. Opera Software ASA (2008), the company developing the popular Opera Mini mobile browser, collects data from proxy servers routing all Opera Mini traffic and publishes statistics on the mobile browsing patterns of users from different countries. Opera’s content adaptation proxy servers provide a central point in the network, but only for users utilizing the Opera Mini mobile browser. All three measurements capture mobile browsing regardless of the used access network, but differentiation of, e.g. WLAN usage from mobile network usage cannot be made.

As Figure 3 and the discussion above shows, existing studies on mobile browsing usage differ considerably in many aspects. Due to these differences, the results of the separate studies are not directly comparable, without taking into account the limitations of collected data. Studies relying on data from technical measurements (Figures 3B, 3C, and 3D) are able to give a detailed view on a limited subset of mobile browsing usage (i.e. with specific type of phones, via a specific mobile network, or to a specific server). On the other hand, studies utilizing end-user survey data are more flexible in their scope, but same level of data granularity is not achievable.

Our framework brings out the scopes and limitations of the different studies illustratively, and aids in comparing the coverage and results of the studies and in recognizing the complementarities between them. Evidently, to create a holistic view on the usage of mobile browsing services, a combination of measurement points and methods is needed. The ability to collect data simultaneously with several or all of the available methods improves the overall reliability of the findings. If and when this is not possible, proper care should be taken when interpreting and generalizing the findings based on data of limited scope.

5. Summary and discussion

In this paper, we have constructed a framework for analysing the usage of mobile services and applied it to mobile browsing studies. Analysis of mobile service usage requires a
holistic view taking into account the wide selection of devices, applications, network
technologies, and content. The value of the suggested framework lies in its systematic,
explicit and comprehensive way of treating mobile services. As such, the framework helps in
interpreting and comparing the results of various service usage studies and in deterring from
too broad generalizations based on data that does not provide sufficient basis for it. By
mapping research settings and results to the framework, it is also possible to recognise
those areas where further data collection and analysis might be required. The framework is
valuable for researchers in selecting the most appropriate methods and measurement
points for given research problem and in designing and communicating the scope of their
studies and measurement settings.

The framework consists of two layers: measurement points and technical service
components. Regarding these, the framework is considered to be generic enough to be
applicable in mobile service usage studies in general. Since the general architecture and
building blocks of mobile services are expected to remain the same in the foreseeable
future, new measurement points or service components are not likely to be needed in the
framework. Regarding the classifications of service components, the situation differs due to
the fast evolution and innovations in mobile devices and networks, as well as in application
software and content. For all service components, new categories are expected to emerge,
requiring changes and additions in the framework.

Future work includes adding an actors dimension to the framework in order to analyse the
roles of different players in the value networks that provide mobile services. Extending the
framework to Internet services more generally is also possible; measurement points and
service components are seen to be suitable as such, while the classifications of the service
components necessitate modifications.

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Further reading


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