

Towards Design Guidelines for Multi-Device Services

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ABSTRACT

Multi-device services need to be adapted to various devices to accommodate users. When deciding how to adapt a multi-device service, several parameters such as device capabilities, usage context, purpose of use, and usability need to be considered. Here, these parameters are discussed and based on the discussion basic design guidelines for multi-device services are presented.

Author Keywords

Multi-device services, mobile computing, guidelines, design, usability

INTRODUCTION

Electronic services need to be accessible from more than one type of device, i.e. they need to be multi-device services. Services that are used from more than one device present new challenges and opportunities both to end-users and developers, and therefore new design support is needed. However, multi-device services have been little studied and no design guidelines exist yet. Here, four basic guidelines for design of multi-device services are presented.

Multi-device services cannot present the same user interface, functionality, and interaction techniques on all devices. Different degrees of adaptation are necessary [1, 17, 23]. Several parameters need to be considered in the adaptation process. The capabilities of the devices, the purpose of using the service, and the various contexts of use all affect the choice and adaptation of the service functionality and interaction.

Users have access to a wide range of computing devices, from computers with wall-sized screens and regular desktop computers to handheld devices like PDAs, media players, and cell phones. They all differ in for example screen size, interaction techniques, network capabilities, and storage

capacity. The selection of available electronic services is even richer, and services are used for various reasons such as finding information, communicating, killing time, managing family life, or shopping. Today's mobile devices allow interaction with both on-line and off-line services in many new situations and locations such as shopping malls, city squares, bus stops, and airports or while waiting for friends, driving cars, or looking for a restaurant. The multitude of service-device-context combinations makes the need for adaptation clear.

Given the differences described above between multi-device services, it is important not to base guidelines for multi-device services on a single service, or a class of services with similar characteristics. That way, relevant issues could be overlooked and the importance of certain issues could be wrongly estimated. It is also important to study multi-device services in real-life use since their use is affected by their context which is too complex to be reconstructed in a research lab. Below, we will discuss parameters that are relevant for adaptation of multi-device services. They are derived from several research projects comprising both development work and user studies [2, 3, 16, 17][9] and will be grounded in examples from existing multi-device services.

Obviously, there is no silver bullet on how to design services for this multitude of available services, devices, and usage contexts. There are no simple rules that can tell us exactly how to adapt a service to a given device and usage context. However, it is possible to create guidelines that help us navigate the space of services, devices, and usage contexts. The parameters discussed here will provide a foundation for such guidelines.

The reminder of this paper will first briefly introduce four multi-device services that will illustrate the following discussion, and then present four important aspects that need to be considered when adapting services to different devices: device capabilities, context, purpose of the mobile use, and usability. Finally, guidelines for the design of multi-device services are presented.

THE CASES

Four multi-device services will be used to illustrate the discussion.

Joliv Mobil Omsorg

Joliv Mobil Omsorg (Joliv Mobile Care in English) is an IT support system for home care practitioners in Sweden. This service will be referred to as *the home care service* in the rest of this paper.

The work of home care practitioners is highly mobile since they assist people in their homes and move between places by car, by bike, or by foot. The work mostly consists of basic health care and assistance with everyday needs like personal hygiene, house cleaning, and grocery shopping.

The home care service has been developed to support home care, and has a desktop version and a mobile version. The desktop version is intended to be used at the office or in the common facilities of practitioners. Its main functions are work planning (easy drag-and-drop of tasks to practitioners on duty) and handling of information about patients (entering information, sort and search functions etc.). The mobile version runs on a PDA and is intended to be used when carrying out work in patients' homes, or when moving between patients. The mobile version functions offline and information is transferred to/from the PDA through synchronization at the beginning and end of the work day. A synchronized PDA contains the practitioner's work schedule for the current day, information about each task to carry out, the work schedule and contact information of colleagues in case assistance is needed from anyone of them, and basic personal and medical information about patients (personal identification number, contact information to family members, medical history when available).

Mötesplatsen – a dating site

Mötesplatsen is a Swedish dating site for people older than 18, the name meaning *the meeting place* in Swedish. This service will be referred to as *the dating service* in the remainder of this paper.

The dating service has a web site (www.motesplatsen.se) that provides members with the possibility to present themselves with text and pictures, search for members, communicate with members, see what is going on at the site, and advertise invitations to social events such as travels, parties, pub evenings etc. All presentations have a visitors log, where each member can see the last 30 members who have visited their presentation. The list of online members shows the alias of the last 100 that logged in, and a counter shows the total number of members that are currently logged in. Most of the functionality is free, but some features come to a cost.

The dating service has recently released a mobile beta version of the web site that gives members access to some of its functionality: the messaging function, the visitors list, and their own presentation (however no editing is possible). The mobile version is implemented as a WAP page and thus available from any mobile device that runs a WAP

browser (<http://mobil.motesplatsen.se>). No extra software needs to be installed.

Playahead – a teenager web community site

Playahead is a web community site for teenagers with a mobile version called Playmobile. This service will be referred to as *the teenager web community* in the remainder of this paper.

The website of the teenager web community (www.playahead.com) offers members the possibility to present themselves with text and pictures, to communicate through various channels, to search for other members, to see what is going on and what other members are doing on the site, and to join teams of members. It is possible to create and edit lists of friends and enemies, and to see if people on those lists are online. Each presentation has a visitors log where members can see who has visited their presentation, and each member can keep a personal blog. Other functionality on the web site includes a news magazine, competitions with prizes, and a shop where members can buy t-shirts and other things with the Playahead logo on. Most of the site functionality is free, but some features are only available for paying members.

The mobile version is available both as a WAP page that can be accessed from any mobile device that has a WAP browser (<http://wap.playahead.com>), and as a Java application that can be downloaded to devices that support Java. The functionality is mostly the communication features of the website (chat, messages, SMS, guest book), but also the search function, and the friends and enemies lists. It is also possible to buy images and ring tones to the phone, and to change different settings of your personal presentation.

Stockholm public transportation

Stockholms Lokaltrafik is responsible for public transportation in the city and suburbs of Stockholm. This service will be referred to as *the public transportation information service* in the remainder of this paper.

The public transportation of Stockholm city and its suburbs includes a large number of buses, subway trains, and commuting trains that transports more than 650 000 people an ordinary work day.

The web page (www.sl.se) provides information on standard traveling issues like traffic problems, time tables, maps of bus and subway lines, ways of contacting the company, and a travel planner. News about public transportation is displayed, and it is possible to get extra information on related issues like the railway museum, park and ride, and upcoming construction work affecting the railway network. It is also possible to create a personal traveling profile to make it easier to get information when using a mobile device. In the profile, bus stops and train stations that a user often travels to and from can be stored to facilitate search of transportation.

The mobile version of the web page (<http://mobil.sl.se>) gives access to a subset of the information that is available from the regular web page: the travel planner, the traffic problems, real-time information about buses and commuting trains, and contact information. The information is presented as a simple list of links on the front page. It is possible to log on to your personal profile from your mobile device. In that case, a direct link to stored travel routes and stations is shown in the list of links on the front page.

DESIGN PARAMETERS

One way of making a service available from a new device is, as the examples below will show, to create a mobile version of an existing desktop service. In such a case, adaptation is needed to make the mobile version functional and usable from a handheld device. Some functionality may need to be eliminated, or adapted, to fit the capabilities of the handheld device and the usage situations, some functionality might need to be added, and the information presentation and the navigation of the service might need to be changed. In deciding how to adapt the service, a number of factors need to be considered, of which device capabilities, usage context, purpose of use, and usability will be further discussed below, as well as their implications for functionality. These factors are not independent of each other; rather they can be intimately connected. However, for the clarity of the discussion they will be treated separately.

Device Capabilities

Mobile devices are more limited than desktop or laptop computers in many technical aspects. They have smaller screens, limited keyboards or keypads, less storage and memory, and limited network connections. Even though some of these differences are decreasing (most notably storage and memory), they still are considerable and sometimes pose huge challenges to developers of mobile services. However, benefits are also gained with mobile devices, for example integrated hardware for playing and recording sound, integrated vibrator, small form factor which allows users to always carry them, easy access, quick startup, and constant network connection.

It is important to draw upon the right capabilities of the target devices. An application that handles mostly static information does not benefit from an online information access approach. In such a case, daily synchronization in a docking cradle could be a better solution that eliminates a source of frequent problems [22, 26] and also avoids log on time and download time. On the other hand, for a dynamic application like email or messaging, a continuously online approach might be the only thing that works. But, for a service like email it will be important to provide solutions for handling large amounts of information that is neither suitable to download, nor to interact with on the mobile device, for example large attached files [16]. Offering the possibility not to download the attachment but still be able to read the message will be important. In the case of a map

application it is important to provide images that fit the screen of the mobile target device. A large map image is not only slow to download, it will also be very difficult to use when shrunk to a small screen size.

The home care service is using maximal screen estate for its desktop planning functionality, where information about current work tasks, practitioners on duty, and patients is displayed. Drag-and-drop is used to assign tasks to practitioners. The mobile version has no planning functionality and does not use drag-and-drop. It is using web style to save space, and full screen of the mobile device. Most tasks are designed to fit the screen so scrolling is quite rare. The teenager web community is also taking full advantage of the screen estate in the desktop version, using pictures and animations to create a cool design. The mobile version is not using pictures or animation but is using the same color scheme as the web page of the teenager web community. The mobile screens usually need scrolling even though the content is partitioned.

The mobile version of the home care service is developed for smart phones and thus has access to telephone capabilities. This is used by providing integrated functionality that allows users to place a phone call by clicking on a telephone number in the phone list. The service also has functionality for recording audio notes which can be quicker than text input on a small device. A design decision has been made not to use the online capabilities (GPRS) of the smart phones. The information handled in the system is considered static enough to use a daily synchronization approach to keep the information up to date [9], and thereby eliminating a frequent source of problems [26]. The advantage of having information locally stored (failsafe and no connection time) as well as avoiding additional costs outweighs the possible advantage of getting continuously updated information. Both the dating service and the teenager web community are web-based services and therefore depend on network capability for all devices that are used to access them. To handle the limited bandwidth of GPRS they only give limited access to members' presentations (for example is full presentation text not shown and access to photo album is not allowed).

The mobile Java version of the teenager web community is using the audio capability of the mobile devices and provides sound prompts for new messages or tips from the administrators.

Situation and Context

Mobile use takes place in various settings, sometimes very different from desktop settings in terms of movement, light conditions, noise, and the amount of attention users can give to the service [7, 19]. In many situations it would be difficult or impossible to carry or open a laptop computer to for example check email [16].

The primary task for users of mobile services is often not to interact with the application but to help a patient, oversee a

construction site, or drive a car [19]. Therefore it is an advantage if the service does not demand constant attention from the user, for example by prompting new messages so that users do not need to check all the time if they missed anything. It is also important that the service is easily accessible, starts up quickly, and that navigation is quick and simple so that it does not interfere with the primary task.

Time saving and urgency are aspects that are often brought up in connection to mobile use [16] (ref anna-studierna), both as advantages and disadvantages. On one hand, being able to perform certain tasks in the field, without having to return home or to the office, can save time and make it possible to attend to urgent matters sooner. It is also possible to take advantage of waiting time to read new information or check email, for example while riding public transportation. It is often quicker to check if there are new messages on a cell phone than on a laptop computer, since the phone is always with the user, is always on, and always connected. On the other hand, it can be very stressful to interact with a mobile service in a situation where users already are under time pressure from primary tasks such as helping patients or talking to customers.

The home care service is used in mainly two contexts, office like settings in the common facilities of the home care practitioners and mobile settings in the homes of patients or on the move between homes. These two contexts not only have different characteristics, the tasks that are carried out in them are different too. In office settings, mostly planning tasks, information entry, and information search (for example to follow up the work or inform family members of patients) are carried out. In mobile settings the main usage is information access, checking today's schedule and in case of emergencies locate colleagues, contact family members of patients, and accessing personal information about patients to assist medical personnel. This difference in work tasks are reflected in the service functionality. The mobile version of the service does not provide any functionality for planning, and input facilities on the mobile device only concern the work tasks that have been performed (check boxes) and notes about patients and coming work tasks (free form text input). The public transportation information service has limited the service functionality of the mobile device to a subset that is closely tied to the traveling situation or short term planning of travel, such as finding next train or bus to a certain destination or finding out if an expected train or bus is delayed. Other information that is available on the web page such as maps, time tables, or pricing information has not been included in the mobile version.

All the case services offer larger amounts of information in their desktop versions than in their mobile versions. The home care service only synchronizes contact information and work schedule of colleagues, brief personal information about patients, and recent notes about work and patients (at present notes from the past two weeks) to the mobile

version. No functionality for handling for example formal decisions on the help patients are entitled to, or their full medical history, is provided on the mobile device. The teenager web community and the dating service offer limited presentation information from the mobile version and no access to members' photo albums.

The home care service has two kinds of input in the mobile version; both of them intended to help practitioners document their field work. First, there are simple checkboxes for the tasks to make it easy to check a task that has been performed. Second, there is free form input for unplanned events, comments, or extra information about patients. The purpose of field documentation is to allow practitioners to take notes directly after an event, not hours later at the office when important information might already be forgotten. The teenager web community and the dating service both offer free form text input in their mobile versions in the form of messages. The teenager web community also offers a mobile chat which is frequently used. One reason for this is that more than 50% of the teenager web community users are younger than 19 and thus attend school where they have limited access to desktop computers during the day. The cell phone offers an alternative to communicate with friends. The public transportation information service relies very little on input both on the regular web site and in the mobile version. Most functionality downloads information to the user device with only a few key presses or mouse clicks as required input. See the section on usability for further comments on input.

The teenager web community is adapting to the mobile situation of use by providing notification for new messages, either through audio signal for users of the Java version or through SMS for all users. The SMS notification is available for all users that have access to a mobile phone, not only users that access the teenager web community from a mobile device. Another aspect of the general usage situation, not only for mobile use, is that the teenager web community users are not always logged in, and the SMS notification is available even though users are not logged in thus providing awareness of the service in non-usage situations. The teenager web community also creates bridges between users that are logged in from the desktop computer and those who are logged in from the cell phone by providing a common chat room (in addition there are a chat room for desktop users and three chat rooms for phone users). The dating service does not offer mobile users notification of new messages but users report that the possibility to check messages from the cell phone satisfies their curiosity [16].

An external factor that affects how, especially mobile, services are used is cost. Many users that pay their own cell phone bills are highly aware of costs and adapt their service use to avoid unnecessary expenses [16]. Some users radically change their usage of a service when the cost changes, for example if a service is free during an introduction period and then is associated with a cost.

Why is the Service a Multi-Device Service?

The purpose of using a service highly influences how it should be designed, and this is equally important when developing a new version. A mobile version of a service can serve multiple purposes, such as supporting mobile work tasks, making information available on the move, or staying in touch with friends or colleagues. They all pose different requirements on the service and thus the adaptation. It is important to define the purpose of the mobile use clearly enough to identify its effect on usage and adaptation.

One reason for making a service or information connected to the service available on a mobile device is to make it more available, e.g. in situations where it is difficult to use a desktop or a laptop computer. Making it possible to read and send email from other places than the office, having access to other field workers schedule, or being able to communicate with colleagues or friends while traveling are good examples. The purpose of use influences many parts of the service: the type of information to make available (amount, selection, dynamic/static), the access method to use (online, offline), and the presentation methods to use (text, images, sound). If the information to make available comes in small amounts and is dynamic, such as email, an online, wireless approach might be chosen to allow frequent updates, while large amounts of fairly static information might benefit from cradle synchronization or even installation with a regular update. If the application is background support and not the user's main focus, a sound alert or a vibration might be a better way to announce updates than an icon or a dialog box.

The teenager web community, the dating service, and the public transportation information service are all examples of increasing access to a service or the information it offers through a mobile version. The mobile versions of the teenager web community and the dating service offer increased access to checking, reading, and writing messages and in the case of the teenager web community also increased possibilities to chat with friends. The mobile version of the public transportation information service offers increased access to travel information. All three services are web-based with dynamic content and therefore an online approach is necessary.

Another purpose for making an application available on a mobile device is to facilitate a certain task that needs to be performed in the field, for example taking notes or document events in situ. By making it possible to take digital notes in the field, paper can be avoided, and thus a transfer step that takes time and could introduce errors [18]. In some situations where other note taking tools are not used, users could be relieved from keeping things in memory until they arrive to a place where documentation can be written [9, 18]. In these cases it is important that input methods are as easy as possible, for example offering alternatives to choose from rather than requiring free text input [18].

The home care service is a combination of the two categories described above. Its purpose is to support the work tasks of home care practitioners, both in office situations and when carrying out work in the homes of patients, and to increase access to information. Consequently, one of the main areas in which the service provides support is information access and entry. In office situations, practitioners can search information about a particular patient or a particular situation which makes it easy to follow up and to give information to other medical professionals or to family members. The mobile version makes it possible to have information about patients, work tasks, and colleagues accessible during field work. The mobile device is synchronized before use and contains information about the work day but also information about colleagues' work schedule, medical and personal information about patients, and other information that might be necessary in case of accident (for example contact information to family members). This means that practitioners do not need to anticipate their information need for a work day and write necessary information on a paper note (which was the previous practice). Information entry on the mobile device, no success

Usability

Usability is important in all service development, and over the years a thorough body of usability knowledge has been established for desktop computing, see for example [15, 21]. Mobile and ubiquitous computing is a relatively new form of computing and the usability work for mobile services, mobile devices, and ubiquitous computing environments is still in its starting phase. However, there is support to be found in the literature [10, 25].

The form factor of many mobile devices poses a number of problems: small screens make it difficult to get overview of service content and service state. As a consequence of the small screen, service content is often partitioned in small portions which results in many navigation steps to perform a task and possibly extra waiting time for online services since each portion needs to be downloaded separately [5].

The teenager web community and the dating service are using a combined strategy where service content is separated in portions, but not small enough to fit the screen of a cell phone without scrolling. For example, when accessing the message box 5 messages at a time are shown which places approximately 25% of the page content outside the screen. There is always a trade off between how many steps the download should be separated in versus how much scrolling is needed to look at the content when deciding the size of the content portions.

Small keyboards or keypads also make interaction and text input difficult [10, 24], something that the research community has been trying to find a solution to for a long time (see for example [6, 11, 12]).

The home care service provides functionality for information input on the mobile device allowing input during field work to eliminate the need for intermediate paper notes and avoid that information is forgot before a practitioner gets back to the office and a desktop computer. However, practitioners reported that the free form text input on the mobile device is hardly ever used since it is considered much too slow and tedious to use [9]. It is cumbersome to pick on the small screen with the tiny stylus, and most practitioners either use a paper note book or try to remember information until they get back to the office. Many users of the dating service and users of the teenager web community also reported that they found input on the mobile device cumbersome and postponed writing and answering messages until they had access to a desktop computer [16]. The possibility to make voice notes in the home care service has not helped solving the input problem, since it is not being used by practitioners [9].

The case services discussed here do not offer users many alternatives in how to organize service specific data on the different devices. The home care service synchronizes a pre-defined set of data to the mobile device, and the web-based services do not allow users to store any information locally. However, how to organize data on multiple devices can be a problem for services that allow users to do that. In [16] participants that used email on multiple devices reported problems with for example messages that were sent from the mobile device were stored in a sent mail folder that was not accessible from the mobile device. Another reported problem was that emails that were read from one device not appeared as read when accessing the inbox from another device.

Usability issues also occur when there is a mismatch in the functionality of the service and the work practice it is intended to support. One example of this is that the home care service does not provide support for connecting notes to a specific date [9]. Home care practitioners organize their work around weekly routines. Before the home care service was introduced, a paper calendar was used to organize the work. Events outside the routine, such as doctor's appointments for a patient were written down in the calendar at the date they would take place. In the home care service, a note is written for similar events, but there is no possibility to connect that note to the date of the upcoming event. This has resulted in that some events have been forgotten. Practitioners reported that they would like to be able to connect a note to a date and thus include the note as a work task for that date and show up with all the other work tasks for that date.

CONSEQUENCES FOR FUNCTIONALITY

Creating a mobile version of an existing service in some cases means that some changes have to be made in the functionality. However, as we have seen above, there are many aspects that influence the choice of functionality for a

mobile service and that lead to different choices for how to adapt functionality.

The home care service is developed for a mobile device that is network enabled, but a choice has still been made to keep the mobile version as an offline service. Due to the relatively static nature of the information handled in the system, and the fact that home care practitioners meet physically every morning to plan the day's work it has been decided that a synchronized approach is the best. This way, many problems with log in time and network failure that have caused problems in other home care systems are eliminated.

Context of use can suggest both removal of existing functionality and addition of new one. The teenager web community is adding notification to the mobile usage situation, functionality that is not available in the desktop version. One of the reasons for creating a mobile version of the teenager web community is to give users a possibility to stay in touch with the service when they do not have access to a desktop computer, and often mobile users cannot give all their attention to the service but need to keep track of other events. Audio or SMS notification keep users aware of what is going on with the service. Creating awareness is one way of taking advantage of the fact that many users carry their mobile device with them most of the time.

The combination of purpose of use and context has had a strong impact on how the example services have adapted their functionality to mobile use. For the home care service there is a natural separation between work tasks that are performed in the office and those that are performed in the field and thus the desktop and mobile version supports the two sets of tasks respectively. The teenager web community has focused on communication in the mobile version, since communication is dynamic and spontaneous. Staying in touch with friends is one of the main reasons for using the teenager web community [16]. The public transportation information service has focused on short term travel planning in the mobile version.

Usability is an important factor for all services and multi-device services are no exception. However, functionality that is awkward or cumbersome on a mobile device or in a mobile situation cannot be removed from a service without careful consideration. Even though input can be very slow and tedious on a small device, and many users avoid text input if it is not important or necessary, the possibility of input can be very important. Many users of mobile email mostly read email on the mobile device and seldom reply unless it is important [16]. Though, the fact that they *can* reply if they need it is still crucial and email without being able to reply is considered almost useless. The communication aspect of email and other messaging services is very important, even though the receiving feature is much more used than sending in mobile settings [16].

GUIDELINES FOR ADAPTATION

To the author's knowledge, there is little guidance in the literature on how to adapt multi-device services, or their user interfaces to various devices. Hutchings & Pierce have conducted some tentative work [8] as well as Nichols et al. [14] but their work has not resulted in guidelines. Therefore, our experience from working with multi-device services in several research projects has been formulated as guidelines below. This will be high level guidelines based on the parameters discussed above and focusing on the whole service, not just the user interface on the different devices.

- Create service versions that complement each other

As we have seen above, different devices have different capabilities and are more or less suitable to various tasks. When adapting a service to a new device it is important to take that into consideration and not try to squeeze in all service functionality in the new device. Taking advantage of the strengths of a device gives a better service than providing functionality that is cumbersome to use, even though only a subset of the functionality is available. Moreover, in the same way as it is important not to squeeze in service functionality in a device where it does not fit, it is not necessary to use every capability of a device. The home care service described above is an excellent example of a service that is better off without network connection even though it is used from network enabled devices.

- There should be overlap between service versions

It is important to keep an overlap in functionality between different versions of a multi-device service. Users of a service have knowledge about what their service can offer them and a new version of the same service should offer a subset of the functionality they are used to (and possibly new functionality). If service versions do not have any functionality in common they risk to be viewed as two different services by users, which could be negative from a service provider's point of view.

- Use context and purpose of use as design support

The context in which a new service version will be used gives valuable input to the adaptation process. Some usage situations are connected to certain devices and certain service functionality and therefore can provide natural choices for adaptation, such as pointing out a subset of functionality to prioritize on a device. The purpose of use can provide the same support. For mobile users of the home care service the purpose is to support field work while for mobile users of the teenager web community the main purpose of use is to communicate with friends. This has led to that the home care service has mobile functionality for information access and note taking, while the teenager web community has mobile functionality for communication. The context of use can also provide more detailed guidance for adaptation: mobile users of the home care service report that they do not have time to write notes in the application

(to difficult and slow with stylus) which indicates that only providing the standard input of the device is not enough. More support is needed, such as templates, speech-to-text or other means that makes the input smoother.

- Do not forget usability

Multi-device services must live up to the same usability level as every other electronic service. For desktop versions of multi-device services there is a solid body of literature to guide the usability work. The usability work for mobile services is less mature but there are sources. Text input for example is known to be difficult on small devices and usability guidelines recommend keeping input to a minimum [25]. However, it is important not to remove the possibility. Most mobile email users prefer to write emails on the computer and use the mobile device to check and read email, but they would not accept mobile email where it was not possible to write a reply when necessary.

TECHNIQUES FOR ADAPTATION

The adaptation of multi-device services can be carried out in different ways. Creating separate versions of a service for each device gives a high degree of freedom in the adaptation and also a high degree of control of the result. In return, a lot of development work is required as well as maintenance work for many versions. The opposite approach is to adapt services automatically to different devices. However, other automated approaches such as automatic generation of user interfaces have failed to catch on due to the lack of control of the resulting user interfaces [13]. A more promising approach is the combination of control and automation, where default mechanisms for adaptation are provided but can be complemented with presentation information [4, 17, 20]. That way the work of service developers can be automated to some extent, but never at the expense of control of the service presentation.

CONCLUSION

Multi-device services need to be able to adapt to various devices. Here, four parameters have been discussed that are important for the adaptation process and influences the choice of functionality on different devices: device capabilities, usage context, purpose of use, and usability. Based on these parameters, basic guidelines for the design of multi-device services are presented.

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