MobileSage – A Prototype Based Case Study for Delivering Context-Aware, Accessible, and Personalized On-Demand Help Content

Till Halbach & Trenton Schulz

Norwegian Computing Center
Oslo, Norway
Email: {till.halbach,trenton.schulz}@nr.no

***Abstract*—We present the system design decisions for the MobileSage prototypes, a service for the on-demand delivery of multimodal and accessible help content to anyone in general and seniors in particular. Findings from user-centered research formed the system requirements, as well as design considerations and decisions. The design of the system also includes availability, relevance, accessibility, conciseness, and comprehensiveness of multimodal content. The prototypes have been evaluated in multiple user trials with good results, showing the participants' high appreciation of such a service and a moderate to high degree of satisfaction with the prototypes.**

***Keywords*–Mobile; smartphone; application; assistance; guidance; help on demand; personalization; adaptive; accessible; usable; multimodal; context; location aware; content management, Ambient Assisted Living, AAL JP.**

I. Introduction

Previous work [1] has documented that the ever increasing number of machines and devices surrounding us in our everyday lives poses a challenge to many, and elderly persons in particular. Many senior citizens view solutions based on Information and Communication Technology (ICT), such as ticket machines and web services, with anxiety. These solutions add to an experienced rise of complexity in their life and, instead of being task enablers, hinder their ability to accomplish the task. At the same time, modern elderly – here defined as people aged 65 and older – live longer, are healthier, more active, mobile, independent, and more demanding customers than ever [2]. Estimates mention approximately 87 million elderly in Europe [3]. They are increasingly looking for useful, user-friendly, and personalized ICT services that add value to their active and mobile life, that help them solve everyday tasks instead of complicating them, and they also desire services that can help them stay active despite various impairments.

MobileSage provides a timely approach and solution to these problems. Its main idea is to provide assistance to virtually anybody, but particularly elderly, in solving everyday tasks. Someone with interest in assisting an individual can register instructional help content, potentially split up into several steps, in multiple languages and multiple modalities, such as images, text, video, audio, and accompanied by geo-locational data. The content can then be accessed upon demand; for instance, upon scanning a QR code, scanning an NFC tag, through plain text search, and through location search.

This work is based on a previous conference article [1]. The article has been extended with related research and the description and results from two more user evaluations. Its contributions include:

- an overview of related solutions and research projects,
- the discussion of technical considerations and decisions regarding system architecture, functionality, and design,
- the results from a three user evaluations, and
- a method for efficient user involvement throughout IT projects.

The article is organized as follows: First, we give an overview of MobileSage and related research, before presenting the system architecture and all main components. Next, we lay out the requirements for these components and their consequences for system design and content production. Then, we present and discuss the three user evaluations in Norway and their results. Finally, we present conclusions from the project.

II. MobileSage Overview

MobileSage stands for *S*ituated *A*daptive *G*uidance for the Mobile *E*lderly. The name refers to the project and its main deliverable, a mobile app. The consortium was a mix of software companies, research institutions, industry partners, and end-user organizations from Norway, Romania, and Spain. The project lasted from July 2010 through April 2014 and was funded by the Ambient Assisted Living Joint Programme (AAL JP).

This program had been created to fund ICT-based innovation projects targeting elderly individuals [4]. The main goal of AAL is to improve "the quality of life, autonomy, participation in social life, skills, and employability of older people", while service delivery enhancement and care costs reduction are secondary targets. Solutions in form of products, services, and systems should aim at a market introduction within the next 2-3 years after the project end. The third AAL JP Call was issued in April 2010 with the title "ICT-based Solutions for Advancement of Older Persons' Independence and Participation in the 'Self-Serve Society"' [5].

The Call also specifies the target groups that the projects should be tailored for. The *primary* end-user group, consisting of elderly individuals with or without impairments (motor, perception, cognition), might have little or no familiarity with technology. Ideally, these individuals have the explicit wish to remain active members in the digital society.

Then, there are family members and care persons, both of whom stand close to the primary end-users, and which add up to the *secondary* user group. As amateurs, they may have an interest in producing or finding help content relevant for the primary users.

The group of *tertiary* end-users denotes NGOs teaching digital literacy to the elderly, public actors like city authorities, and private actors such as transport companies and machine vendors. As with the secondary user group, tertiary users may want to produce, modify, or make help content available to the primary users.

III. Related research

As part of the preparation of the project, an effort mapping updated information about state of the art in the field was carried out[1]. The study revealed that there are few, if any, existing solutions as described in the MobileSage project. Especially rare are related projects and solutions of this particular kind directed towards elderly and impaired users. However, the study showed that there is a number of recent and ongoing international projects related in various ways to the topics addressed by MobileSage; they are discussed subsequently.

A number of international projects fall within the same *scope*.

The (ongoing) APSIS4ALL project – Accessible Personalised Services In Public Digital Terminals for all – deals with personalizing public digital terminals such as ATMs and ticket machines [7]. An adaptive interface and personalized interaction is achieved by the human communicating with the machine through a smartphone.

The ASK-IT project – Ambient Intelligence System of Agents for Knowledge-based and Integrated Services for Mobility Impaired users – developed a framework that provides intelligent agents for service provision and search for suitable semantics [8]. It also allows to personalize service and content, and personalizes user interfaces. The project focused on daily life and travel scenarios.

The ongoing MyUI project – Mainstreaming Accessibility through Synergistic User Modeling and Adaptability – addresses specific user needs towards ICT products in general through adaptive personalized interfaces [9]. Its ontology-based framework collects user and context information in real-time during use in order to establish an evolving user model to which user interfaces of various personal applications can adapt, by means of empirically based design patterns, as such data is shared among services.

GUIDE – Gentle User Interfaces for Elderly People – is an ongoing project to design tools and aids for developers to efficiently integrate personalization, user-friendly interaction, and accessibility features into applications [10]. Here, the focus is on Web, TV, and middleware like set-top boxes.

The goal of the DIADEM project – Delivering Inclusive Access for Disabled or Elderly Members of the Community – was to make electronic and online forms adaptable to the cognitive skills of the user [11]. It employed an expert system that monitored the user actions and behavior; it personalized and tailored the user interface based on this observation.

The ongoing GPII Project – Global Public Inclusive Infrastructure – is building a framework that stores universal user profiles in the cloud [12]. The profile can be accessed to adapt the user interface of any device to a user's needs and preferences. Also, a marketplace will be established for developers to share assistive-technology tools for accessible services and content.

The following research projects are related to *user interface* aspects of MobileSage.

The aim of SNAPI was to develop a data format for the storage of user profiles, with a focus on smartcards [13]. Personal preferences and other settings could be stored in the user profile to personalize the human computer interface of public digital terminals and adapt it to the user's needs. The format has recently become a CEN European standard [14].

The objective of the ongoing GoldUI project – Adaptive embedded human interfaces designed for older people – is to offer the elderly a number of cloud services that are deemed useful in the everyday life [15]. These services can be accessed through a variety of platforms, including telephone, smartphone, tablet PC, TV, and radio. The services include traditional broadcast services like news syndication, music playback, and weather forecast, combined with services like calendar, task lists, online shopping, and social media.

The following research projects address transportation. The ongoing WayFiS project – Way Finding for Seniors – addresses the topic of travel challenges [16]. The project plans include both a web based pre-planning service and a mobile application. Route calculations take account an individual's desired physical activity, nutrition needs, necessary facilities along the route, and disease restrictions, while trying to avoid inaccessible places.

Mediate – Methodology for Describing the Accessibility of Transport in Europe – is a completed project that has developed criteria and tools to measure accessibility in public transport, including accessible ticketing and information systems [17]. Also, a database has been erected with accessibility information of public transport system in Europe.

In the Access2all project – Mobility Schemes Ensuring Accessibility of Public Transport for All Users – the accessibility of public transport was considered [18]. Concrete outcomes of the project were a number of guidelines, recommendations, roadmaps, and new research initiatives.

The AmbienNet – Ambient Intelligence Supporting Navigation for People with Disabilities – created an indoor location system based on intelligent infrastructure and a sensor network has been developed [19]. The resulting navigation system could assist users with and without disabilities.

The following projects address *multimodality*.

[1]This section was first presented in a conference [6].

The ongoing HAPTIMAP project – Haptic, Audio, and Visual Interfaces for Maps and Location Based Services – develop a cross-platform toolkit for the design of user interfaces incorporating haptic, audio, and video input and output that goes beyond guidelines and checklists [20]. The project focuses on the retrieval, storing, and manipulation of geographic data.

The MAPPED project – Mobilisation and Accessibility Planning for People with Disabilities – developed a mobile application that provides accessibility information on buildings and traveling on buses or trains [21]. The service employed localization techniques to increase the relevance of the information.

The HearMeFeelMe project – Compensating for Eyesight with Mobile Technology – aimed at replacing visual and textual information with audio, combined with touch-based interfaces for information access [22]. The project included a mobile application and a system for object mapping and tracking in indoor environments. The application employed near-field technology to gather information about items to buy, such as food and medication [23].

IV. MobileSage Components

The MobileSage prototype consists of two components: the Help-on-Demand (HoD) mobile application and the Content Management Service (CMS). Figure 1 shows the overall architecture.

A. *Help-on-Demand Service*

The HoD application is a personal agent, i.e., a thick-client application running on a smartphone. It is built up in a service-oriented manner, as shown in Figure 1. The user interacts with the Dialog Manager through the User Interface. The Dialog Manager uses information from the Profile Service, which takes care of the user profile. The user profile stores personal preferences and usage patterns. User behavior and User Interface events are logged and analyzed by the Personalization Service, upon which the user profile is re-adjusted [24–28].

The Dialog Manager is in contact with the Reasoning Service to help determine the user's context. Reasoning makes use of network services such as Media Service, Search Service, and the Content Service. The Reasoning Service gets help from the Localization Service, which can determine the user's location based on technologies like A-GPS, WLAN, GSM/GPRS, NFC, and triangulation methods.

The HoD Service requests any content from the CMS upon initiation of the user.

B. *Content Management Service*

The CMS is a cloud service running on a web server. Content producers interact with the service's Dialog Manager, which in turn controls the User Interface on a User Agent like a web browser. The logic for handling the multimodal content lies in the Content Manager, which has a modular design to be able to add additional modalities in a simple way. The prototype supports the modules Video (with or without captions), Animation, Image, Audio, Text, and Formatted Text (basically simplified HTML). The content is stored by the Content Service. It is also possible to refer to content located elsewhere (e.g., from other video services) through proper hyperlinking and HTML redirects.

There is no limitation to the kind of content that can be served. This includes manuals, usage instructions, descriptions of travel routes, and geographical points of interest. We anticipate that machine makers and service providers will generate most of the content. For instance, a particular vendor might provide manuals for their ticket machines, or the railway operator that runs these machines might do so. Even a municipality might be interested in producing such help content as a special service for their citizens and visitors. Other interested parties are expected to add content to the CMS to fill in the gaps left behind by product makers and service providers, like caregivers, relatives, and friends, as they are likely to have a direct interest in helping particular individuals. Finally, there is nothing that prevents users of the HoD from producing and making help content available themselves.

V. User and System Requirements

The following sections address the formulation of the requirements and constraints for the system design.

A. *Requirements for Primary Users*

The derivation of the requirements of primary users is split into the gathering of the users' expectations towards the system (user needs analysis), and the collection of user requirements. The system requirements were derived from the latter.

1) User Needs Analysis: Focus group work was conducted in the three countries Norway, Romania, and Spain to find the needs of primary users [29]. The focus groups had 39 participants and represented a broad range of parameters, including age (48 to 96), gender (24 female vs. 15 male), disabilities (sensory and cognitive impairments), nationality (four foreigners), and ICT experience and usage. Two scenarios were presented to the participants: a traveller with reduced vision in a foreign country who was not proficient in the language, and an elderly lady at home trying to understand how to use an electric household appliance.

The focus groups' results show that "modern elderly persons" are a heterogeneous group with a wide range of – sometimes contradictory – needs and wishes. This applies also to the users' familiarity with ICT in general and mobile technology, which ranges from none to advanced users. However, it was possible to identify themes of functionality the solution should have [29]. More specifically, the solution should

- lead to higher independence of elderly people according to the help-for-self-help principle,
- increase a person's mobility and be usable for transportation and travel, including holidays and visits,
- be applicable in the home environment and throughout daily living,
- provide relevant, useful, context- and location-sensitive and multimodal (and hence accessible) assistance in an on-demand manner,

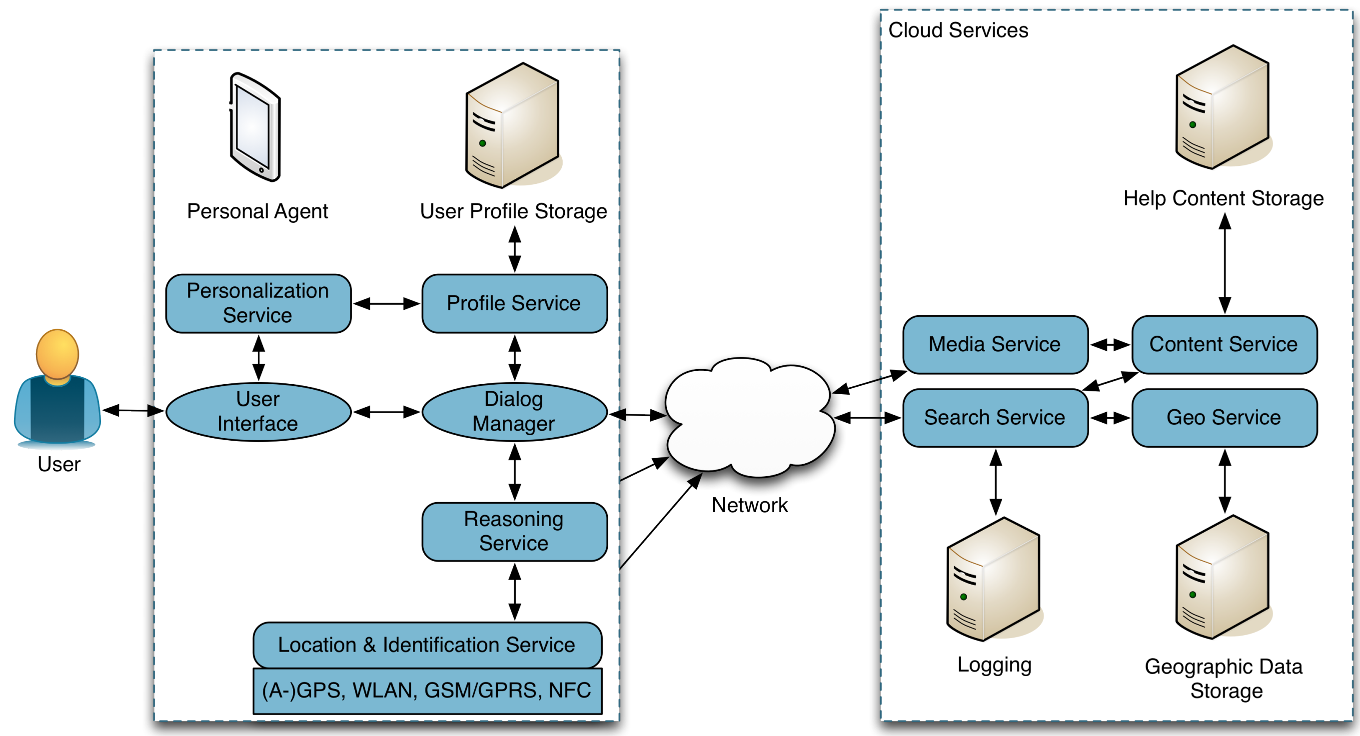

Figure 1. System architecture and major building blocks for HoD (left) and CMS (right)

- be accessible, user-friendly, designed for all, possible to personalize or customize, adaptive, social, and
- honor privacy, security, and trust matters.

2) User Requirements: The results from the user needs analysis were collected and formulated as user requirements [30]. The roughly 50 requirements mirror the expectations of primary users regarding HoD, but were extended to be valid for the CMS as well. The user requirements served as input to the process of formulating the first draft of the system requirements for the service's two components.

3) System Requirements: The technical requirements for the Help on Demand and Content Management services were derived from the user requirements.

The requirements specification for HoD has over 60 requirements [31], while the CMS specification contains only 40 [32]. Both address topics such as system functionality, user interface, and input and output matters. Also included are sections on the technology choice and mockup examples regarding the services' user interfaces.

B. Requirements For Secondary and Tertiary Users

MobileSage's focus is on primary users. Secondary and tertiary users have been accounted for by formulating a set of requirements representing the needs of the transport company participating in the project. These are as follows:

- It should be possible to identify one or several points of interests with a unique ID.
- There could be multiple help topics per ID.
- One topic could be presented in multiple languages.
- The service should support content hosted elsewhere ("upload once, available everywhere").
- It should be possible to edit help content in order to add locations, languages, and modalities.

VI. System Design

For the HoD service, a user profile lays the ground for personalization and adaption of the service. It contains the user's settings and preferences, such as font size, emergency number, accepted media types, and additional languages. Also other parameters are stored there, including usage log. This log is the basis for system adaptation. Screenshots of the HoD are shown in Figure 3.

Both primary and tertiary users have requested that it should be possible to associate content with specific locations or points of interest. However, it should also be possible to link certain content to several locations (e.g., "how to buy a ticket" could be valid for any ticket machine in a municipal area). Moreover, there are situations where several pieces of content are relevant at a single location (e.g., how to validate a ticket, arrival time of the next bus, or choosing the correct platform for departure).

These issues have been solved by the Content Item, see Figure 2. This uniquely identifiable item is a logical unit to gather content that is related to each other. Multiple locations in terms of latitude, longitude, and altitude can be linked to a

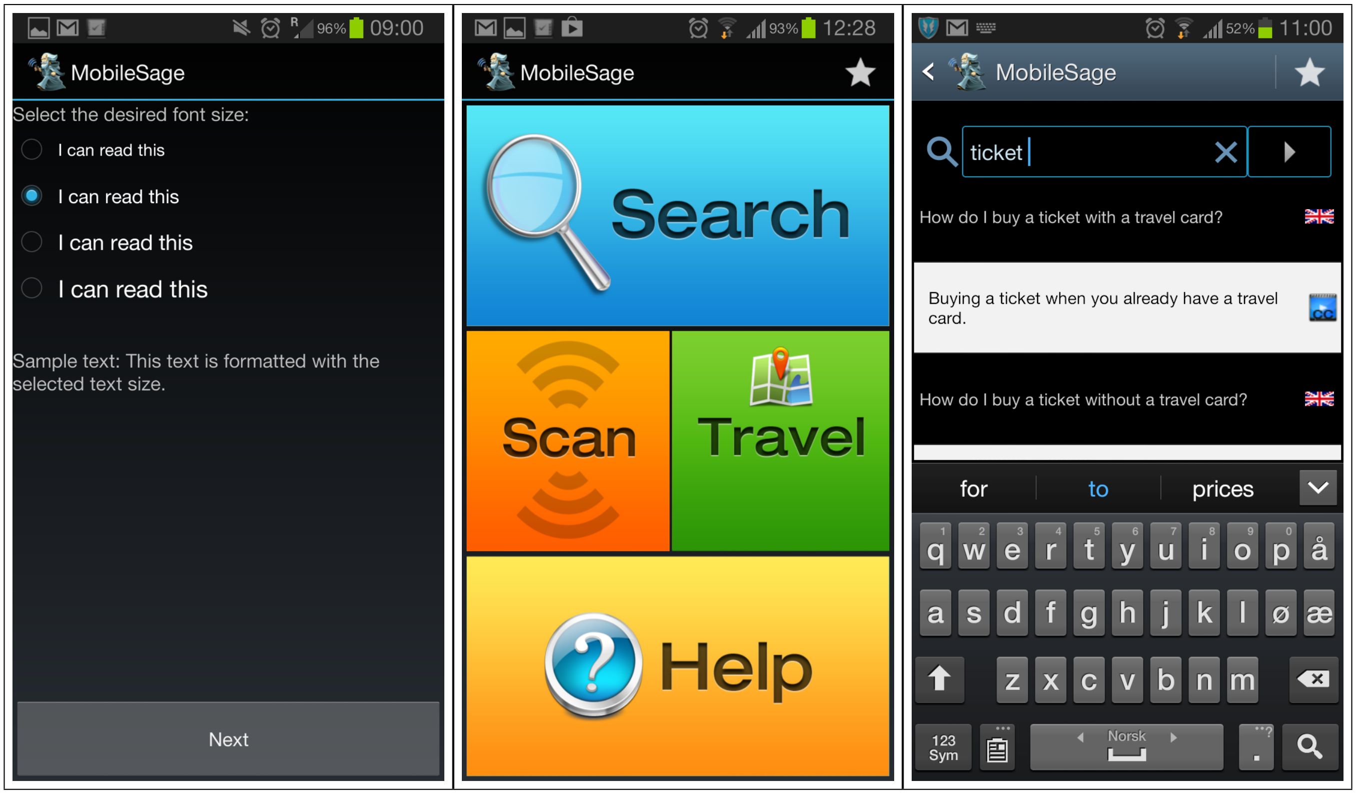

Figure 3. Screenshots of the Help-on-Demand application (V1.0): set up (left), home screen (middle), and search (right)

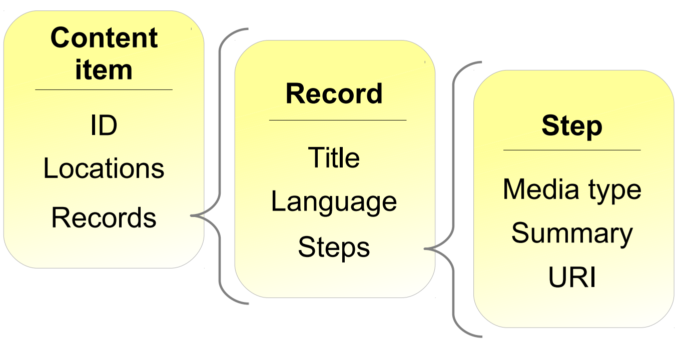

Figure 2. Data model of the content

single Content Item, and so can Records, each representing a particular topic. The topic itself is described by a Record's title together with a language identifier. Language translations of a topic become a new Record. To avoid topics being mixed in the result listing, the results are ordered according to language first, and alphabetically by topic. The user needs analysis recommended further to split content into several steps or segments, and to promote segmented content, something the presented data model is capable of by combining multiple Steps into a Record. A Step has the same language as the Record it belongs to and has one of the Media Types: text, formatted text (HTML), audio, an image or animation, video, or a video with captions. Further elements are a brief Summary and an URI/URL pointing to the media itself. The URI can point to a server that is part of the CMS, but it may also point to external resources (e.g., a video on YouTube). For such external resources, the CMS effectively functions as a service holding metadata on indexed resources. This model supports multiple media types not only for the same Step but also mixing of media types per Record (i.e., several Steps) depending on what type suits a particular step best. For instance, video might be best suited to illustrate a movement, while often a still image is beneficial for highlighting a specific region of a visual.

MobileSage is about just-in-time guidance and *on-demand* assistance. Based on suggestions from the primary-user studies, it was deemed too intrusive to let the mobile application initiate requests for help based on the location of the phone at points of interest, nearby radio fields, etc. Thus, the user indicates a wish for assistance either by scanning a QR code or NFC tag, or by sending a text phrase to the CMS. In the former case, the code or tag carries the ID of a particular Content Item that is read by the mobile app and sent to the CMS, resulting in a list of all topics associated with that ID. Regarding the search phrase, topics are viewed as relevant regardless of the ID, accounting for both Record titles and Step summaries.

One of the challenges of MobileSage is to find *relevant* content and not to confuse the user with extraneous information [32], which helps individuals with orientation and problem solving challenges. The key to this problem is determining the user's context, in terms of location, time and date, user habits, and other aspects. Nearby objects are considered relevant in the CMS by calculating a proximity radius around the user's current position; only Content Items with a location within this circle are returned as results to the phone. The exact radius of the circle was based on heuristics and set to roughly 40 m.

Records are sent in "pages" to the phone, meaning that HoD tells the server how many results per request to return. This is done first of all for practical reasons, i.e., bandwidth limitation, and second because the user is likely to be interested only in the most relevant results, which are presented first. The client on the phone keeps track of the number of transmitted records and is hence able to request a particular page with results, say, page 3 with the records 21 through 30 in case of 10 allowed records per page. If the user scrolls down while being at the bottom of the results list, the client fetches more results if available.

For simplicity, any media content is offered to the HoD as a file for download through HTTP. While this works great with text-based content, the performance in terms of responsiveness of the playback on the media player is suboptimal when connected over a channel with very limited capacity, as discussed in Section VIII-B because media downloads in most clients have to finish before the media is rendered on an output device. Clients that support (true) media streaming and pseudo streaming methods like HTTP Live Streaming will start rendering the output as soon as sufficient data become available. These methods would require the proper setup of a streaming media server.

VII. CONTENT PRODUCTION

This section focuses on the production of content for MobileSage in particular, and educational and instructive content in general.

The content found should be relevant, concise, and comprehensive. However, as recent research surveys show [33–36], it is extremely difficult to develop methods that can check exactly these properties in a satisfactory manner. MobileSage offers a manual approach in its CMS [32]. As mentioned before, the splitting of longer content into shorter steps is encouraged. The content producer now provides the content abstraction on two levels: A summary of the step itself, and a title wrapping-up of the entire record (see Figure 4). The content producer must tag the content with the proper descriptors for language and its location, if applicable.

Currently, the content must be uploaded in a format accepted by Android OS. This applies to both the format of the content tracks, be it video, audio, or captions, and the format of the embedding media container. In the future, the CMS could be extended to accept any format with transcoding into a proper format supported by the OS.

While the video material could be presented at any resolution, we chose to encode video with a resolution of 480×360 pixels and a bitrate of roughly 200 Kbps @12 fps in H.264 Baseline Profile Level 2.2 format, and embedded in an MP4 transport container. The audio tracks (both stand-alone and as part of a video) had a rate of roughly 48 Kbps @22 KHz mono and were encoded in AAC format. A video containing one visual and one audio track thus had a bitrate of roughly 260 Kbps, which includes overhead data used for track muxing and the container format. The length of the content varied from approximately 10 s to 4 min, but most of the content was between 30 s and 45 s.

We used open-captioning, where the titles (captions) of the voices' transcript are always visible on the screen, instead of

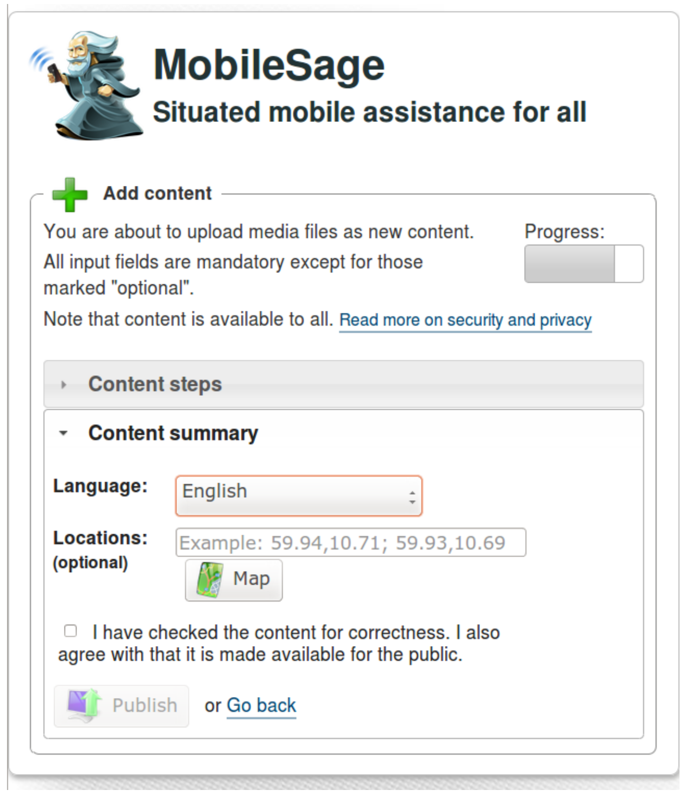

Figure 4. Screenshot from the uploading of new content to the CMS (V1.0)

composing a separate captions track. This avoided the extra work of producing a captions file and ensured that the video player always worked properly, without requiring the user to turn it on. We chose a "slab serif" font that was originally designed for fax machines, with a size of at least 36 points. One disadvantage of this approach is that more space is taken up on the content server to store each captioned video, but as the videos were short and at a low resolution, we believe this is a minor issue.

The content is currently provided in a single quality in terms of resolution, sampling frequency and bitrate as mentioned above. Both have implications for the bandwidth necessary to transmit a given content file to the client's media player: the larger a picture (in pixels), and the higher the audio sampling frequency (in Hz), the more bandwidth will be necessary. Likewise, the higher the encoder bitrate (in bps), the more bandwidth is required. Channel capacity of the cellular link, however, is a limited resource for physical reasons. It takes time to transmit a particular amount of data over a channel, which also has an impact on the user experience. The service is thus required to respond to user interaction within a reasonably short time span [30].

This requirement is honored by measuring the duration of packet downloads at the client side (which may vary over time according to the signal strength and coverage), and including this information in the server requests, together with information about the phone's screen size. Content can now be provided in several resolutions or sampling frequencies, and several bitrates. Media searches at the server side can then use this information about the channel conditions and limit the results to media qualities that meet the bandwidth constraints. For example, a phone with a 480×800-pixel screen is connected to the network over a GSM (2G), and the bandwidth averaged over 20 s is measured to be 100 Kbps. Based on the different resolutions and bandwidth, the server decides that a $480 \times$ 360-pixel video will still render acceptable to good quality. Yet, the $480 \times$ 360-pixel video comes in two different bitrates; one encoded at a rate of 260 Kbps, and one encoded with 130 Kbps (assuming a constant encoding bitrate). The latter is closest to (but still above) the estimated channel capacity and will be sent to the phone to minimize the service's responsiveness, together with a notification about poor channel conditions.

VIII. User evaluations

The MobileSage prototype was developed in three major iterations where the release of a software deliverable – dubbed Beta, V1.0, and V2.0 – marked the end of an iteration. Each release was evaluated involving end-users. The first and the second evaluations were carried out in Norway, Romania, and Spain; the last evaluation was conducted in Norway only. In total, around 70 informants were part of the evaluations in the three countries.

The subsequent sections summarize the findings from all iterations, with a focus on the set up in Norway.

A. Beta setup

The Beta evaluation in Norway consisted of a travel situation at a subway station in Oslo where participants used the Beta prototype to find help with getting to a subway station, finding a ticket machine, buying and validating a ticket, and choosing the correct platform. We created content for all of these scenarios, with a minimum of audio and video for each. All but one of the scenarios had captioned video, and some had a textual modality in addition. Each of audio, text, and video was done both in Norwegian and in English to allow users to choose an additional content language. We then created several NFC tags for each of the scenarios and used it as a way of getting the information. Testing of QR codes was postponed to a later evaluation due to its unreliability in the Beta version of the app. We tested on two smartphones with an Android OS 4.1 and screen sizes of 480×800 and 720×1184 pixels without any discernible difference in the results.

Eight participants were recruited for the evaluation. They were between 65 and 76 years old, and four of them had no experience with smartphones; however, they were somewhat experienced with computers, and a few of them were familiar with the area. A session consisted of a short introduction to the MobileSage idea, followed by a brief interview concerning their experience with mobile phones. Then, we demonstrated the application and let the informants work on the tasks. One evaluator took notes, while the other would guide the participant to make sure a task wasn't forgotten. After completing all of them, there was a short follow-up interview about the service and the participant's experience about it.

B. Beta results

In the first task, the participants had to create a profile that matched their preferences for text size, language, and types of media they wanted to receive help in. The users understood the concept of several content languages, and the majority (75%) added English to their profile. The user-specific media types ranged from a single one to the entire range as detailed in Section VI, where captioned video, i.e., the richest media type, was chosen most often. The majority (90%) of test persons checked 4–5 media types including audio, even though some participants said they would avoid wearing earbuds or headphones. Text was never requested. Choosing video and captioned video was inconsistent, hinting on a potential misunderstanding of the user concerning the meaning of "captioning". It was recommended to improve the description of media types or show brief examples of them. All participants but one expressed that making the profile was sufficiently easy.

The second task concerned navigation, where the participants had to get from their current location to the nearest subway station. All were able to enter the information needed, but the phone's ability to find the participants' location was unreliable, sometimes placing a participant a block further south or facing the wrong direction. This issue sorted itself out when walking to the location.

The next task dealt with getting help at the ticket machine. Two participants were not able to finish this task due to a technical issue that caused no results to be returned from the CMS, which was corrected subsequently. All others succeeded with using NFC tags or by manually searching for information about where the ticket machine was, how to purchase a ticket, how to validate the ticket, and which platform they had to go to. Though only one was familiar with the technology, two had heard about it, and the rest were unaware of what it was; all participants really liked the technology and experienced it as easy to use.

One problem encountered was the effect the environment had on the signal strength in the phones. While above ground, it was possible to get video and audio without any issues, and the selected item would show up almost instantly. Yet, underground in the subway station, it became very troublesome for the phone to contact the content server. The main reason for this is that the only connections that are currently available in this particular station are so-called Edge (2G) connections, which are much slower compared to a 3G connection, and also very latent. This was no big issue when retrieving, say, the results list. Participants had to wait a long time, though, if they wanted to watch a video. The audio fared a little better, but downloading would not always complete. Sometimes, the application on the phone would simply give up and it would be necessary to download the audio or video from the beginning. Most participants noted that it took a while to get the information in this case. With the continuing widespread of 2G connections in many countries, it is recommended to produce at least one version of low-resolution low-bitrate content, and to use techniques that increase the responsiveness of media players, such as media streaming, as discussed in Section VI.

No users complained about the size, resolution, quality, frame rate, or length of the video. Some participants noted that the font used for the captions indeed was sufficiently large and easy to read. There was only one instance where people commented on unclear information, where a video showed an unreadable display on a ticket machine.

All participants felt that a help-on-demand system was something that would be useful for them. One even claimed that she was scared of using the ticket machine and always went to a counter instead, but now she would continue to use the machine since she felt confident to manage buying a ticket based on the app and the provided instructions. Concerning potential improvements, the most popular suggestions were a shorter response time for videos (when in the subway station) and dynamic information, such as time schedules. Those familiar with mobile applications suggested to include MobileSage's functionality in the public transport provider's current smartphone application.

C. V1.0 setup

In the V1.0 evaluation all of the attention was given to the user experience when using the HoD app. The Norwegian evaluation involved 10 informants from the local senior user group, aged 67 to 83, from both genders, all with varying ICT and mobile-phone experience (though none were novice ICT users), and a few with a mother tongue different from Norwegian. All informants received a small financial gratituity for the participation. Two Android phones (Galaxy Nexus and Nexus S) were used in the tests.

The scenario's focus was on matters not tested in the last trials and emphasized multilingual content, the concept of steps, and QR codes. The following tourist situation was considered: A visitor to Norway arrives at the tourist information center in Oslo, and a poster mentioning the famous Kon-Tiki Museum catches the visitor's eye. The poster provides both an NFC tag and a QR code. The visitor scans either of them with the MobileSage app, and several pieces of information are presented: information about the museum and how to get there from the user's current position, how to buy a ticket at the nearby machine, how to find the proper bus stop, when the next bus is arriving, and when to get off the bus while riding to the museum.

Most of these five steps were presented in multiple modalities, such video, audio, and formatted text, others were available just in a single media type. The latter two steps – the expected duration of the waiting time for the next bus and the expected duration of the arrival of the bus at the proper bus stop – showed dynamic content (real-time data) from the servers of the municipality's transport company Ruter. This was achieved by HTML redirects from the content provided by the CMS to Ruter's server.

The informants were first briefly introduced to the MobileSage idea in general, and scanning of NFC/QR in particular. After that we went to the nearby tourist information where we had hung up some of the poster as described above, and simply watched as the participants went through the steps of travelling to the museum. In case of problems we would also assist the user with clarification and also give some technical aid (Figure 5). Throughout a single trial, the participant moved from the poster to the ticket machine, and then to the bus stop; the last step (the bus ride to the museum) was simulated only for practical reasons. After that, the user was questioned about their user experience and had to fill out a brief questionnaire to gather their opinion.

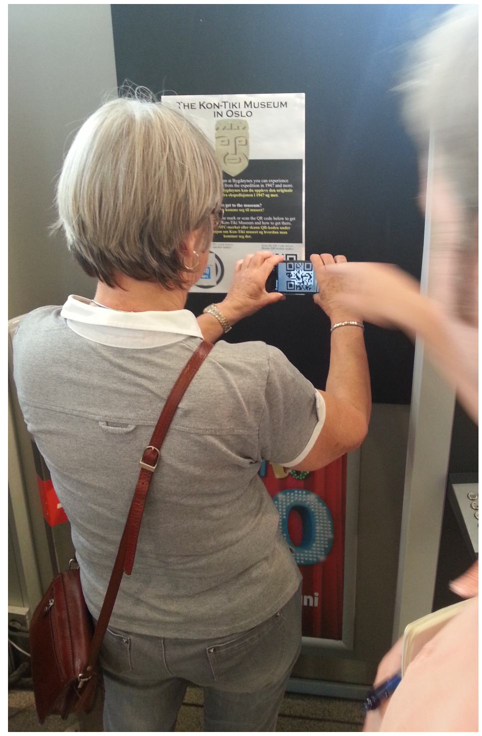

Figure 5. Example situation in a user trial, a participant scans a QR code

D. V1.0 results

Subsequently, the findings from the Norwegian trials are presented as an excerpt from a larger report [37].

Overall, the English MobileSage version was acceptable for the English-speaking testers, even though they commented on several non-translated page elements in the dynamic webpages from the travel company. Integration of services, including the proper communication of the user's language, is key here, besides the mandatory translation of all language strings.

The participants found the prototype in general accessible, but there were several issues related to real-life situations: traffic, crowd, and town noise was a problem when trying to hear the sound of the videos, both indoors and outdoors. All participants would use the relatively weak speakers in the smartphones. As one of the participant remarked, "elderly never use headphones, you know." Here, video captions were useful to the participants. Next, bright outside sunlight reduced the screen contrast, making it difficult to read what was displayed. Here, automatic adjustment of the display's brightness and contrast and improved displays would help, but this is beyond the scope of this project. Some participants found the text size and also the virtual-keyboard letters too small. However, even though it had been pointed out to participants that they could adjust the settings according to their own preferences, none actually changed the default text size. The size of the keyboard letters could not be changed, and this might be the reason why the users found NFC and QR codes so attractive when searching for information.

The informants all agreed that the ability to customize and personalize media modalities and output was valuable for them and other elderly as well. Due to time constraints, though, this topic was not tested systematically. The fact that no user changed the settings shows on the other hand the necessity for suitable default values, such as captioned videos as default media type as it combines a visual with audio and text.

Regarding adaptivity, the trial observers noticed that the most used functionality was automatically placed in a prominent position in the user interface (on top). However, the participants did not seem to notice. We did collect usage data for each participant, but due to the small duration of each trial, a sufficient amount of data for each participant was never generated. Future work should test out adaptivity in a realistic manner.

The participants had quick access to the content and were all satisfied with the response time. It surely helped that the evaluations were held in an area with a good GSM signal, but contributing to this was also the strategy to switch from plain downloading in the first trial to HTTP pseudo streaming, which shortens the time after which the media player starts playing drastically.

Most informants had heard about QR codes or at least said they had noticed them, but very few knew about NFC, let alone its logo. All participants preferred scanning over text-based search during the trial. Here, nine out of 10 found that NFC was easier to use than QR due to a shorter response time. With QR, many found it cumbersome to find the correct distance and angle between the smartphone camera and the QR code on the poster. In contrast to the beta trial, NFC tag scanning went smoother, mainly because we now carefully had placed the tags with some distance to any metal surfaces.

As opposed to the beta evaluation, the app now rendered the content of the result directly if only one had been found. Most participants preferred this, but were in turn confused when the result consisted of several steps, as showing a step overview had been omitted. Other than that, steps as a concept was well understood and accepted.

As one of the outcomes from the user interviews, Table I shows the general user acceptance, measured by means of the System Usability Scale (SUS). The table clearly documents the improvements in user experience on almost all topics as compared to the Beta version. The largest positive change occurs related to the app's ease of use, with an increase from 3.1 (uncertain) to 4.4 (clear agree) average score. Overall, our participants had a positive view on the MobileSage system and found it useful and relevant. The scale also shows potential for improvement, however, when it comes to opinions concerning the app's ease of use.

E. V2.0 setup

The following paragraphs are an excerpt from the more detailed evaluation report [38].

In the V2.0 evaluation, we looked at the final version of the CMS to see how well it worked, and the final version of the HoD app to get feedback on changes to the app. It was a limited evaluation held in cooperation with three participants from the local senior user group that had been involved in the project. Due to time constraints, the evaluation was held as a workshop with all three participants using the system and giving comments simultaneously.

The participants were given a short introduction about the CMS and were then asked to create instructional content that they subsequently uploaded to the CMS. Participants chose to create a video in three parts (steps) for heating water in a microwave. They shot the video on one of the phones, copied the videos over to laptop, and proceeded to put them on the CMS.

For the HoD part, many of the tasks were borrowed from the previous evaluation. We gave the informants a short introduction to the HoD, specifically focusing on the media types setting. The participants were then instructed to find a video about tickets by using the scanning functionality after having changed the media type settings to accept only formatted text and plain text.

The session was concluded with a short discussion about the app and the CMS.

F. V2.0 results

Concerning the CMS, participants were in the beginning confused about how content was organized and had in particular problems to understand that a record can consist of multiple steps. Related to this is that a user needs to fill in two titles, one for a step, and another for the entire record. This information was not included on the web page itself and needed to be explained by the trial observers. Once the concept was understood, participants were able to create and add content containing multiple steps.

Participants encountered problems related to the media type of the content to upload. Depending on the file type (MIME type), particular buttons ("Continue", "Publish") were shown or hidden. As mentioned in Section VII, only a limited number of formats are allowed to be uploaded in the CMS. However, the negative result from the media type check was not communicated to the user who then had to assume that the upload form did not work. Hence, the user needs to be properly informed about each requirement to an input field, and each conducted check. On the other hand, the participants were able to complete all the steps and fill in the content summary, but they could not actually add the content to the CMS.

All participants commented on the necessity of extra information for creating and adding content in terms of tips on how to create videos so the videos would be most instructional. One participant was afraid to pack too much information into the content. A take-away here may be to provide thought-through tools and also assistance for proper content generation.

The CMS makes content available for all, which turned out to be of concern for some participants. They commented that users could hesitate to upload information if it was public for everyone, even though the trial observers pointed out that the location information helps to limit exposure for information, and that the majority of all information intended for MobileSage is designed to be for public access. It is noted here that it is technically possible to restrict access to a record say with a passphrase, but this of course adds to the complexity of the system.

TABLE I. THE SYSTEM USABILITY SCALE COMPARISON BETWEEN BETA AND V1.0; 1=STRONGLY DISAGREE, 5=STRONGLY AGREE.

Question	Beta	V1.0
I think that I would like to use this system frequently	3.5	4.0
I found the system unnecessarily complex	1.6	1.7
I thought the system was easy to use	3.1	4.4
I think that I would need the support of a technical person to be able to use this system	1.7	1.9
I found the various functions in this system were well integrated	3.0	3.8
I thought there was too much inconsistency in this system	2.5	1.4
I would imagine that most people would learn to use this system very quickly	3.8	4.3
I found the system very cumbersome to use	1.3	1.3
I felt very confident using the system	2.6	3.2
I needed to learn a lot of things before I could get going with this system	3.5	2.3

In the settings of the app, when choosing media types, users were presented with the jargon terms for the types in the database and not a suitable translation in their own language, leading to questions about the meaning of each term. The built-in help in the app does indeed explain these types without using jargon, but this help is not available when choosing types. The conclusion here is that technical jargon should be avoided, and that concise and explaining help should be available where challenges might arise.

Using the different help-on-demand functions in the HoD app, including scanning of QR codes and NFC tags, worked as expected. One phone, however, was a bit large, and users had to move the phone forth and back to get to read the tag. We believe this problem would vanish as the users become used to their phone.

Generally, the participants were excited about the possibilities of the MobileSage service and wanted to use both systems (app and CMS) more. We are going to address a number of the issues found in the various evaluations before a final version of each system is released. The CMS is currently available online [39], and the HoD app will shortly be offered through Google Play [40] and the MobileSage website [41].

IX. CONCLUSION AND OUTLOOK

We presented MobileSage, a service for delivery of context-aware, accessible, and personalized help content in an on-demand manner, examplified by two prototypes, a smartphone application and a content management system.

In the prototypes, we incorporated results from related research as well as the needs of the primary, secondary, and tertiary users. The system employs multimodality as an accessibility measure, as well as internationalization and data mining for user personalization, multi-resolution and multi-rate transmission techniques for device adaptivity, and location-aware media searches for relevance. The system can index both internal and external media databases.

The findings from our focus groups and the three user evaluations show that there is a strong desire for context-dependent and adaptive help content, and that such a service is highly appreciated by its end-users. Moreover, the high degree of user involvement in the project ensured products which reflect the wishes and needs of all stakeholders in general, and the primary users in particular. The prototypes have improved quite a bit throughout the user evaluations, as reflected by increases in the System Usability Scale.

At the end of the project, we now have the proof of concepts and the proper technology with development maturity, as according to the AAL JP vision. A final service with production maturity could be released within 1–2 years time. Among remaining issues are: the proper handling of offline and low-signal situations, proper tools and an improved user interface for the generation of content, including content access control, and assistance and guidelines for the production of usable and accessible content, such as the length of timed media, phrasing of information, and how multimedia content should be organized. Also, the integrity of the content is currently not controlled in any way. Here, a review system and content credibility management could offer a proper solution.

Another area for future exploration is a long-term evaluation of the adaptation module. All of our evaluations were too short to see how much adaptivity affected the participants. One way to solve this is to provide the HoD app to users for a longer period (weeks or months), to see how the app adapts to their usage, and if users would notice and appreciate these changes.

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