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A FRAMEWORK FOR DEVELOPING PERSONALIZEABLE MOBILE SERVICES IN AUTOMOBILES

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Abstract

This paper focuses on the systematic development and implementation of mobile services (e.g. location-based services) in automobiles. It includes a design framework *that represents the requirements of automotive service engineering (e.g., the development process for supporting location-based services including contracting with network providers) and a corresponding process model that combines iterative service development with prototyping.*

The framework and the process model are applied to a new mobile automotive service called MACS[1] *MyNews. MACS MyNews is a personalizeable, interactive news service that allows the driver to specify desired topics of transmitted newscasts.*

We begin by identifying possible service scenarios*. Then a matching* network of relevant parties *is derived from the scenarios*, technologies *for service provisioning are chosen and a* prototype *is implemented. The service is then evaluated for usability and, in particular,* driving safety.

This design and implementation of MACS MyNews has proven successful with a major German car manufacturer who is considering its implementation. The application of the design approach generates insights into the chosen development approach's usefulness and usability and suggests future research.

Keywords: mobile, service engineering, design framework, process model.

[1] Mobile Automotive Cooperative Services (MACS) is a research project funded by the German Federal Ministry of Education and Research (FKZ 01 HW 0207)

1 INTRODUCTION

The automotive sector of German industry has a great impact on the German economy, contributing 18.6% of the total revenue (Verband der Automobilindustrie, 2005, p. 203). Even though the long term prognosis for this sector projects declining growth rates (Ebel et al., 2004), rising competition and changing customer needs (Mattes et al., 2004, p. 18) have led to significant structural changes in the industry. The industry now focuses on successful innovations that offer the customers added value, one such innovation is mobile services (Wildemann, 2003). This attempt to generate a sustainable advantage by differentiating the German auto industry from other automobile manufacturers has, unfortunately, failed. The main reasons for this failure are

- the high costs for data transfer (Frost & Sullivan, 2003),
- the development of telematics services that were too focused on technology (Werder, 2005)
- and services being offered that did not meet the customers' needs (Fuhr, 2001; Werder, 2005)

Now, there has been a change in the first reason for failure, namely the significantly lowered cost of data transfer and the proliferation of agreed upon protocols for data transfer. Universal digital broadband services like UMTS (Universal Mobile Telecommunications System) or DAB (Digital Audio Broadcast, digital radio) are widely available now and competition in the telephony market rose. The results are higher data rates and more sophisticated end user services at fixed "subscrition rates" instead of volume based billing. Nevertheless, the final problem of figuring out what the customer will want and need is still intractable, in particular in the automotive sector. Thus, the central research question of this paper is: "How can innovative mobile services for the automotive sector be systematically designed, developed and evaluated for inclusion in the generation of a new car?"

The rest of this paper is organized as follows: First, we present the details of the MACS Design Framework, justifying the structure and organization of this framework. We then describe the process model for applying the framework to illustrate how the framework might be used in practice. This is followed by a case study of the design of the MACS MyNews service. The MACS MyNews Service is an implementation of real-time access to digital newscasts with user selected content. The case study demonstrates the framework use in a real problem and also its efficacy. The paper concludes with a brief evaluation of the framework and implications for future use.

2 THE MACS DESIGN FRAMEWORK

In this section we discuss the MACS design framework in order to give readers an overview of the development process of a mobile service as derived from developers' input and refined while employing it. The MACS design framework was constructed using an iterative approach, comparable to the spiral model presented by Boehm (1988). Requirements were largely derived by expert discussion, with six partners coming from different scientific disciplines like IS, computer science, business sciences and automotive studies. The expert group was rounded off by two partners working for a car manufacturer in system planning and marketing respectively. Additionally related work, e.g. the studies conducted at ERTICO[2], have been taken into account as alternative approaches at designing mobile services. Receiving feedback during the early project stages was a very challenging task. While the two partners directly assigned to the project were willing to provide even critical information, other practitioners did not cooperate outright. This situation changed radically after a first diagonal prototype of one proposed service showed preliminary results at the European Exhibition on Intelligent Transport Systems and Services in Hannover.

[2] ERTICO is a multi-sector, public/private partnership pursuing the development and deployment of Intelligent Transport Systems and Services (ITS).

The following requirements for automotive services and service development were identified by systematizing expert input from a local car manufacturer continuously over a period of two years. These requirements are later used to form the different layers of the MACS Design framework to ensure a holistic view of the whole development process.

- *Services have to take end users' (i.e. the drivers') existing problems more into account*: this implies that scenarios for service provisioning have to be found in order to derive a successful business model. Additionally the use for the customer has to be extracted, e.g. in the form of use case descriptions, and, most importantly, the end user has to be integrated into the development process.
- *Services should be profitable*: hence the potential users' willingness to pay has to be surveyed, again in order to derive a successful business model. A prototypical implementation, showing the distinctive features of the new service, can be of help for this by integrating end user feedback in early development stages. In parallel a coherent business case for the service, including the value proposition, has to be written.
- *Services are not provided alone, but along with various partners*: each service has its own specification concerning the partners needed for service provisioning. For each of those partners needed, an acceptable business model has to be found.
- *Services use technology, not the other way around*: technologies have to be mapped according to the service's requirements; there is no technology-driven service development. A modular service platform enables the service engineers to exchange base technologies rather easily.
- *Services have to be safely usable while driving*: additionally the local legislation concerning secondary tasks while driving has to be taken into account. The more realistic the prototypical implementation is, the more reliable are the conclusions that can be drawn from driving tests.

In order to be able to develop mobile services more efficiently in the future, those requirements elicitated are addressed and combined in a design framework for mobile services as described below.

The MACS design framework is divided into six different levels of service design according to the requirements identified above. Each of these levels represents one step in the development of a mobile service. *Service scenarios* describe the overall composition of the service, the scope in which the service is to be used, and the use cases for the mobile service. Based on the *service scenarios* more detailed information, such as detailed user requirements or an analysis of a user's willingness to pay for the service are being derived as early as possible. The analysis of service scenarios also results in information on how contributing partners can interact in a *value added network* and what the architecture of that network should be.

One of the biggest problems faced in developing a framework in the automotive sector is bridging the large temporal gaps in the different development lifecycles of the software used in the car and the car, itself (Hartmann, 2004). While the lifespan of a car is around ten years, new technologies and new software versions replace their predecessor every two to three years, making the management of the manufacturing lifecycle a difficult exercise (Mohan, 2006). Special attention has to be paid particularly to the levels of *technology* involved .We need to pay attention to the *prototype design and the automotive platform* in order to enable the sustainable selection of technology as well as the thorough construction of an infrastructure that is able to compensate for the lifecycle mismatch between the car and its software. In addition to the technical aspects of this framework, *automotive safety must be considered in* the design.

When the service is ready for implementation, prototypes of the entire service are evaluated by potential end users. Based on the outcome of this evaluation the management decides the service's future. If the evaluation is positive and the service promising, the last level in service design is the concrete implementation and planning of the *service roll-out*.

Applying such a framework for the systematic and iterative development for mobile services includes several obstacles for the developers. Strategies for the service scenario have to be matched with the available technologies. The network of concerned parties (service network) has to be able to support the strategies found for the scenarios. People from different domains have to be able to work together to design the service. Thus, every member of the developing team has to understand the terminology used by the different domains. To find a consensus as a group, functionality is best developed through iteration and continuous evaluation using the criteria agreed upon by all team members. A process model that helps teams to overcome communication obstacles is needed in order to put the design framework to good use. The next section presents the proposed process model.

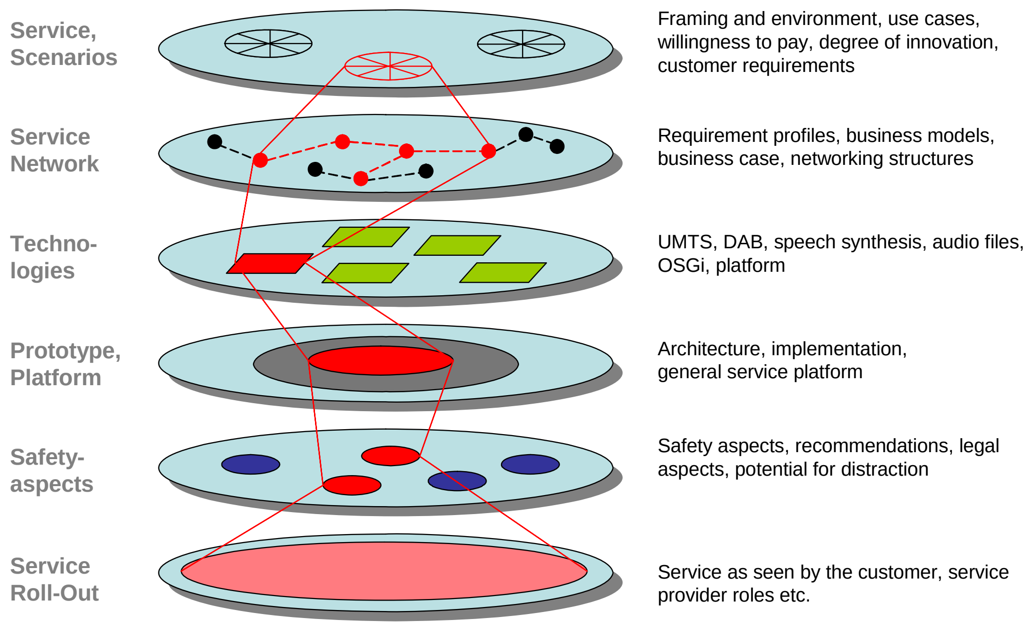

Figure 1: The MACS Design Framework (own illustration)

3 PROCESS MODEL FOR THE MACS DESIGN FRAMEWORK

In this section we present a process model for applying the design framework described above. When considering the requirements for applying the MACS design framework a set of requirements for a process model describing the Automotive Service Engineering process can be extracted.

- The newly designed services are most likely innovations, their requirements cannot be elicitated as one of the first steps in the design phase. Moreover, the requirements of those services may change over time. This means that the development process has to offer the possibility to run several iterations instead of having a sequential nature.
- The services created using the design framework should meet the users' needs as good as possible, so there is a very high need in customer integration into the development process.
- A safety evaluation for newly designed services that is both sound and valid has to take place in the future environment, i.e. in the car. Thus the level of safety evaluation in the design framework is the latest possible deadline for a prototype of the service integrated into the car. The safety evaluation is the most prominent distinctive features in mobile service design for the automotive sector. This is due to the fact the the user's main task is not using the service but driving, in contrast to services on devices like PDAs or cell phones, where using the service is the main task of the user.

From the combination of those requirements an iterative development process that includes the possibility of user integration and safety evaluation can be extracted. Linear process models often used in software development, like the waterfall model (Royce, 1970), are easy to employ but do not meet the requirements stated above. An iterative model, like the spiral model for software development (Boehm, 1988), is needed as a basis for applying the MACS design framework. In iterative models, the assumptions made in one process step are being evaluated for the next step and also provide the input for further iterations. Throughout the framework different steps can exchange information. This is true for the analysis phase (i.e. information flows "top down") as well as for the evaluation of previous steps (i.e. information flows "bottom up").

In order to be able to evaluate the service concerning its usability and its safety for the road a tight integration of a prototype is necessary. This prototype also has to be able to reproduce the different usage scenarios determined earlier. The widely used methods of horizontal and vertical prototyping (see (Floyd, 1983)) are hardly of any use in this respect. Using the horizontal approach prohibits the integration of the service into the targeted infrastructure, the car. Thus a safety evaluation or usability evaluation does not make any sense. On the other hand the service is too complex to be considered as a whole when it is completely integrated into the car using a vertical prototyping approach. As a result the findings of an evaluation would be very limited.

This dilemma can be easily solved by combining both approaches though. Using the resulting diagonal prototyping approach enables the service designer to evaluate a service's unique features in the proper environment. Unique features, like user input via voice command, are completely implemented (vertical approach). Most of those features in a form similar to what the end user will experience in the final design. This does not mean that the way the feature is implemented has to resemble the final implementation in any way, though (horizontal approach). As a result the complexity of developing software in a highly proprietary embedded environment (i.e. the car's infrastructure and its infotainment unit) is greatly reduced while it is still possible to let the end user experience the important innovations in the expected form. This allows for two different approaches to data colloection. The user can give feedback early in the development process (see 1.4) and safety aspects, which of great importance for automotive services, can be evaluated (see 1.5).

The result of the combination of the MACS design framework with its distinct levels with the diagonal prototyping approach is the process model depicted below. The foundation of this model is closely related to the service design model presented by Shostack (1991). The first phase of service design covers the top five layers of the design framework (service scenarios, service network and technologies, prototype & platform, and safety aspects). After traversing the first phase an intermediate service evaluation takes place, helping to determine whether or not to start the second design phase. This phase covers the steps from implementing the master design, and documenting the implementation, to service introduction, audits and design modifications until the final service can be finally rolled out.

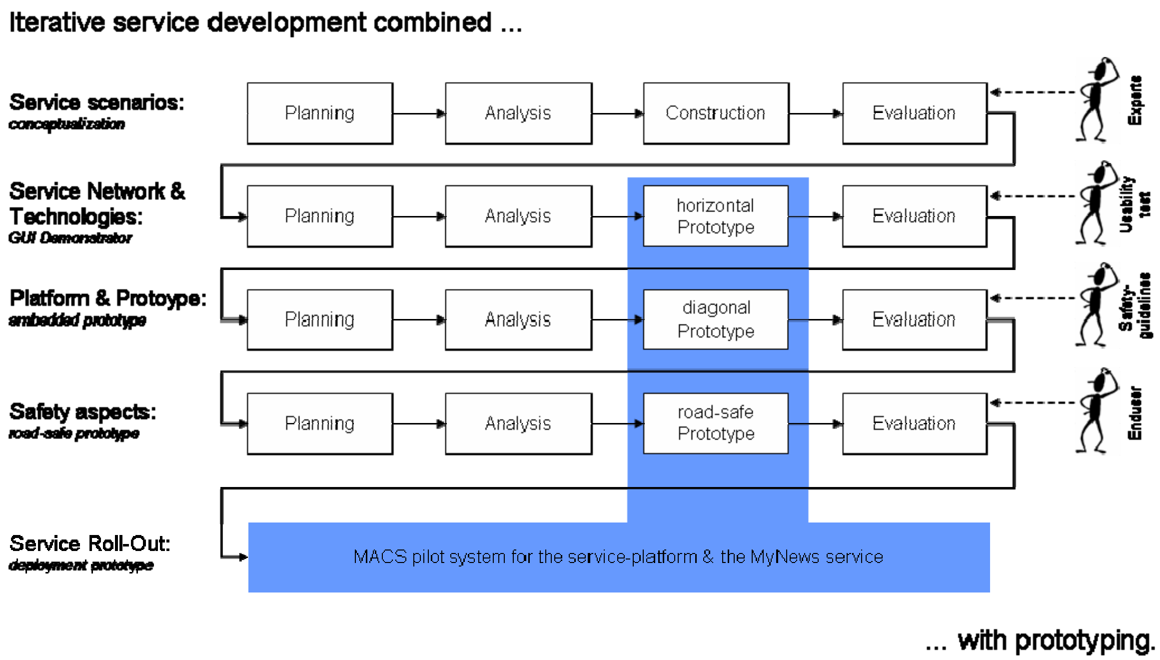

Figure 2: MACS processmodel (derived from (Shostack & Kingman-Brundage, 1991) & (Boehm, 1988))

During the initial service design the design process is highly recursive. Each level is worked off using an iterative model, like the spiral model described by (Boehm, 1988). Compared to the original spiral model an emphasize is being put on the elaboration of different scenarios and the demonstration of different (intermediate) prototypes. First and foremost this enables the tighter user integration into the design process. Each of the levels' iterations starts of with the planning of the iteration's activities, i.e. a requirements elicitation. Following that, the requirements are being analyzed, either based on prior field studies and expert interviews or based on end user and expert feedback. The artifacts designed and built during the construction phase are then being evaluated using expert or customer input. These evaluation results form the socio-technical & economical input for the following iterations.

In last step of service design is covered in the second phase of the process model. The service ready for the market is being developed based on the output of the service evaluation and a "deployment prototype" representing the later master design. The process steps are similar to those suggested by Shostack (1991). The concrete novel mobile service is implemented according to the requirements, functions and tasks defined during the previous design phase. This is the reason why Shostack (1991) calls the first design phase as a "means to an end". All the information necessary to provide the implemented service are being documented. Of course this includes information about the implementation itself, in case the service has to be altered at a later point in time. After the service is implemented and documented the service is introduced in the market, this is the first time a customer can actually make use of the service. This also means that this is the first time the value added network of cooperating partners for service provisioning is -working in "live mode". As a final step Shostack (1991) defines an iterative cycle of design modification and audits for continuous improvement of the service design.

The following sections of this paper focus on the first phase of service design, that of developing and applying the service scenarios. We omit the final roll-out processes that are specific to each car manufacturer.

4 APPLICATION OF THE DESIGN FRAMEWORK ACCORDING TO THE PROCESS MODEL

In this section, the first part of the MACS design framework will be applied to developing an exemplary service according to the process model. Special focus is put on the elaboration of insights gained in every process step towards the master design.

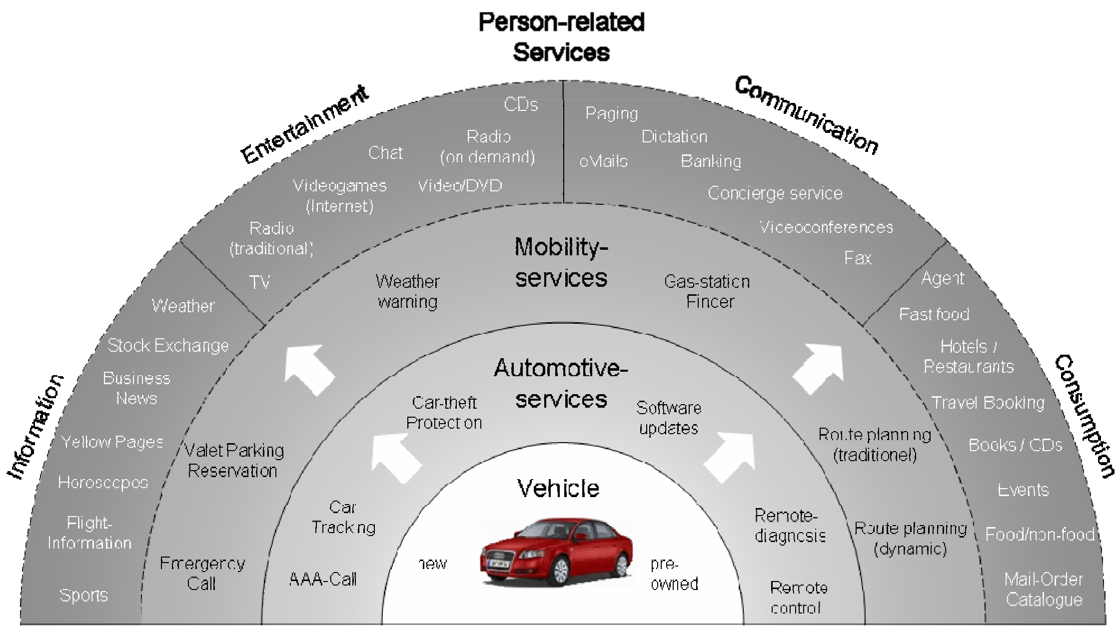

Figure 3: MACS research radar (derived from (Ehmer, 2002))

The first step is the selection of an adequate service for testing the design framework and the process model for their usefulness. As a basis for this selection a service research radar (based among others on (Ehmer, 2002)) of possible person-related mobile services was used. A personalizeable news-service, MACS MyNews, was selected from a range of 40 different services due to the high customers' benefit, the (relative) ease of establishing a price, the availability of the needed technologies and, last but not least ,the very high degree of innovation of that service in the automotive sector.

4.1 MACS Service Scenarios

In the very beginning of each customer-oriented service development three basic questions, derived from fundamental literature, e.g. (Kotler & Keller, 2005), have to be answered: *who* are my potential customers (target group), *what* do I offer them (value proposition) and *how* is that service provided (production & service delivery

“Who is interested in using mobile services and pay for them?” For MACS MyNews scenarios originating from our everyday use of cars have been identified. Almost 2 out of 3 German commuters use their car to get to work and back home, 4 out of 5 when the distance to work exceeds 10km. More than half of the commuters spends up to 30 minutes on the road for one way (Statistisches Bundesamt Deutschland, 2005). Similar situations can be found all over the world, e.g. the average commuting time in the U.S. is 25 minutes (United States Census Bureau, 2003).

“What kind of service would be useful for the target group?” Drivers are usually not fully concentrated on their main task, driving, but perform other activities, like listening to the radio. Thus personalizeable and interactive mobile services would allow the driver to use his time more efficiently. They do that by delivering purposeful information, it’s the fundamental idea behind MACS MyNews.

The whole service scenario: MACS MyNews is a personalizeable, interactive news service, allowing the user to be the editor and end user of his newscast at the same time. MACS MyNews provides up to date information at all times, not just every full or half hour as radio shows normally do. As the “editor” the driver can select his areas of interest, define the order in which topics are being presented, put weights topics etc. The newscast itself starts at the push of a button and can be paused at any time, e.g. when stopping at a gas station. It is also possible to interact with MyNews, i.e. it’s possible to skip forward and backward in the list of news items, or have the news item read again if one missed a detail of the news item.

4.2 MACS Service Network

After having specified the service scenario, possible partners for providing the service have to be identified and their associations have to be analyzed. The identification of possible partners makes use of the already defined service scenario. In the case of MACS MyNews, partners for creating news content are needed. The proper definition of a target user group helps selecting the peer in the automotive sector: commuters that can afford high prized limousines are more likely interested in a live stock ticker than in mobile games. To close the gap between content creation and content consumption the means of content delivery have to be defined. It’s important to note that neither content creation nor content delivery can always be answered right away. In both cases it’s important to work out the technological implications for the service in the next step to find concrete answers for these questions.

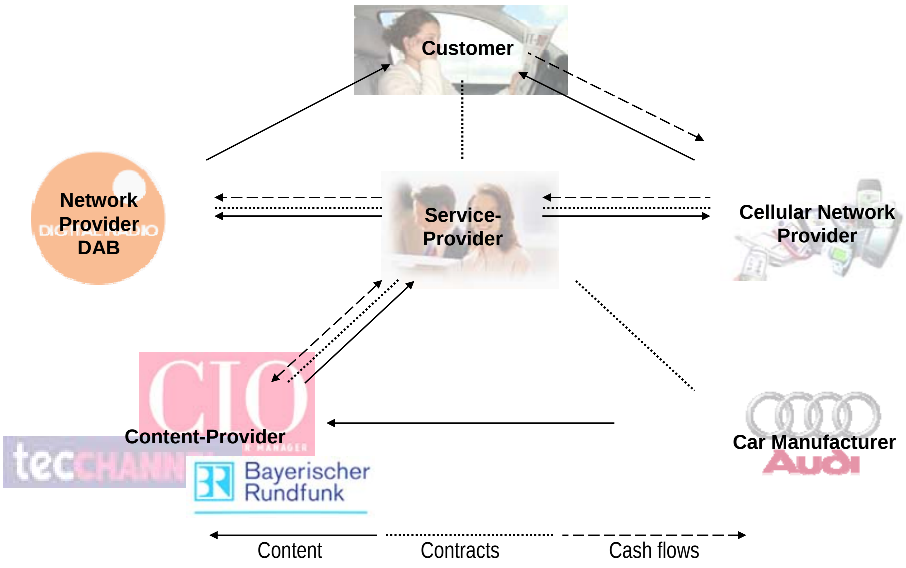

Figure 4: MACS MyNews service network (own illustration)

The service network for MACS MyNews can be deducted from the service description: the news presented to the *customer* are delivered by various *content providers*. A central *service providers* aggregates and edits the data (omitting redundancy) before they are transmitted into the *car for displaying* them. The main technology for data transfer to the customer is *digital radio* (DAB). Additional value-added services, like audio or videos, can be ordered using the *mobile phone*. The partners for the MACS MyNews service network are interconnected using a star-shaped layout: the service provider is sitting in the center, the other partners are arranged around the center according to their role in the service provisioning process.

4.3 MACS Technologies

The logical separation of mobile services as seen in the service network can be applied to the area of technologies, too. For the *creation and aggregation* of the information matching data formats have to be found. Together with the service scenario they have a great impact on the means of *data transfer*. The amount and nature of data available in the car on the other hand influences the possibilities of how to *display the information* in the car.

The assumptions made in the MACS MyNews service scenario influence both, the selection of an appropriate data format (audio/video or text) as well as the selection of transfer technologies. Since the basic information in MACS MyNews is supposed to be free of charge for the customer digital radio is preferred over the download via mobile phones. This way the service provider would cover the transmission costs. Choosing digital radio as a medium generates questions concerning data format, transmission and display of the content again. Audio files are able to deliver high quality speech recordings, their size increases transmission costs. Thus audio files are no option for the specified service, the only alternative is to transmit text information. Using compressed texts the data volume is reduced by a factor of 30 compared to audio files. To compensate the lack in quality the speech synthesis engine in the car is always kept up to date, resulting in a large phonetic database in the car.

The solution for data transfer described above has been developed independently for a project called “Journaline” (Zink, 2005). For future versions of MACS the use of this new standard would help to ensure a wide availability of multimedia devices capable of supporting MACS MyNews.

4.4 MACS Prototype & Platform

For developing a platform a good abstraction for the processes running on that platform had to be found. Since this is a nontrivial task this definition often takes several iterations (Fayad et al., 1999). To achieve a reliable design, in as few iteration steps as possible, it is mandatory to collect domain-specific requirements and to analyze the best practices in closely related areas. For that reason the combination of two methodologies for requirement analysis is used here. Requirements related to the domain, automotive services, are collected using *domain analysis* (Aksit et al., 1999). They are enhanced using results obtained by *analyzing the best practices* (Boone, 1999), of two architectures found on the market, the Siemens “Top Level Architecture” and the AutoSAR (Heinecke et al., 2004).

One of the biggest problem in todays software engineering for the automotive sector is the time lag between the first creation and the roll-out of the software. The lifecycle mismatch between cars and their embedded systems often is the reason why the whole cars’ electronics functionality is outdated by the time the vehicle roll off the line (Gumbrich, 2004). Using the example of mobile device integration into the automobile, SBD consulting proposes three possible approaches for leveraging the mismatch, namely a *vehicle gateway* for simply accessing the vehicle HMI by mobile devices, an *open architecture* for being able to add new components during the cars’ lifetime and *adaptive networking* for dynamically downloading mobile device information to the car (Hart, 2006). The approach used for the MACS platform resembles an open architecture, neither degrading the car to a bare user interface (vehicle gateway), nor binding services strictly to a car’s environment (adaptive networking).

The functionality of the MACS framework is divided into “base services” to create a strictly modular infrastructure in the car and a programming interface (API) for mobile services. Each of the base services forming the framework represents either an interface to the car’s infrastructure, ensures the safe usability (even while driving) or is a part in the underlying runtime environment. The OSGi platform (OSGi

Alliance, 2005) was chosen as a runtime environment for the components. The OSGi framework itself already offers important functions like the lifecycle management of components and “yellow pages” functionality. Furthermore it is possible to remotely update the OSGi-based system or to remotely add new components (Wong, 2001; Palenchar, 2002).

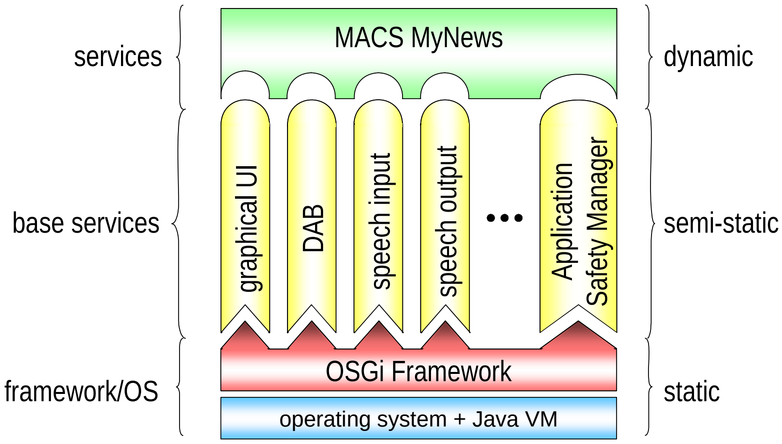

Figure 5: Architecture of the MACS service platform (own illustration)

“User interface” base services allow the output of information using a graphical display or using a speech synthesis engine or both. The haptic devices in the car can be used as input devices, the platform has also been upgraded to offer a base service for speech recognition. The appropriate type of information, the amount of information, and the appropriate output device are determined by an independent base service, the “Application Safety Manager”. The data transfer from and to the car is being handled by the “Universal Cellphone Adapter” and the “Broadcast Adapter”. One of the foundations for these base services were the specifications for unidirectional services (using radio only) and bidirectional services developed for the DIAMOND (Hallier et al., 2001; Betram et al., 2001) project.

4.5 MACS Safety Aspects

For all services in the automotive sector, safe use while driving is essential. To evaluate the risk potential of mobile services, the Institute of Ergonomics at Darmstadt University of Technology collected a compilation of safety guidelines and evaluated the MACS MyNews prototypes using them. Part of this collection is the current “state of the art”, e.g. (Becker, 1996; Tijerina, 2000), as well as the current German legislation concerning services in the car.

To ensure the safety of a mobile service on the road, the use of that service has to be safe and the service has to follow the local legislation (Becker, 1999). The prime factors to ensure this are user interfaces that can be used while driving. User input for the MACS platform is not limited to haptic devices since the driver would have to take one hand off the steering wheel and take his eyes off the road. To prevent this it is also possible to use speech input for using MACS services (Färber & Färber, 1984). The same is true for output devices: next to the visual output device there is a text to speech engine using the audio channels. This allows the driver to focus on the road instead of looking at a monitor.

To evaluate the risk potential of the prototypical MACS MyNews service, several test persons were invited to use the service in pre-defined scenarios (comparable to the work of (Wikman et al., 1998)). The use of MyNews was evaluated varying the driving situation, i.e. road, freeway and within city limits. On the other hand the mode of user interaction changed: subjects tested MACS MyNews using the haptic device as well as the speech recognition engine. As a reference the test persons used the haptic device to operate the car radio, voice control is not available for operating the radio. After each of these scenarios the subjective stress and distraction were evaluated using questionnaires. An objective analysis was conducted using video recordings showing the driving situation (front and rear view), the human-computer interface (input and output devices) and the driver’s face.

A first evaluation of the subjects’ answers shows that using the service while driving was as comfortable as using the familiar car radio. The answers also pointed out possible ways of improving the interface design, which was taken into account in another iteration of the prototyping phase. This is mainly related to a missing quick audio feedback on user inputs, which resultet in the users looking at the screen more often and longer than necessary. According to the safety experts evaluating MyNews including this audio feedback should reduce the distraction by the service noticeably.

4.6 Prototype Evaluation

To evaluate the results of the complete first service design phase the service as a whole is evaluated. Depending on the results obtained in this evaluation service development enters a second phase (see figure 2). During this phase the service is implemented for series production and rolled out to the market.

The MACS MyNews prototype was presented to the scientific community at the 6th Service Conference (held by the German Federal Ministry of Education and Research) in Berlin. Experts interested in mobile services had the chance to test the service in the car and evaluate what they experienced. Table 1 lists the responses to a questionnaire we distributed that requested and evaluation of different aspects of the MyNews service based on the prototypical implementation. As can be seen from the table (highlighted in bold) on average, more than 68 % of the respondents were favorable to the proposed service, despite the limited functionality found in the prototype.

	1 (best)	**2**	**3**	**4**	**5 (worst)**	**n=**
How interesting is MACS MyNews?	***21,6%***	***54,9%***	15,7%	2,0%	5,9%	51
How useful is MACS MyNews?	***17,6%***	***47,1%***	27,5%	5,9%	2,0%	51
How do you grade the functionality in MyNews?	***16,3%***	***55,1%***	14,3%	8,2%	6,1%	49
How would you grade the service’s usability?	***20%***	***40%***	24%	10%	6%	50

Table 1: Results of MACS MyNews evaluation

Based on the results of the service evaluation, and the feedback we received at various presentations for different target groups, it is safe to say that the service seems to be promising in the current prototypical state. This is why a car manufacturer considers the service for product development as described in the last step of the MACS design framework and as the second phase of the MACS process model.

5 IMPLICATIONS FOR FUTURE USE AND FUTURE RESEARCH

The application of the design framework according to the process model showed that it is possible to receive goal-oriented customer feedback very quickly. By using an iterative approach several prototypes were implemented, always focusing on a certain aspect of the design framework. Since every step is encapsulated and concrete output is worked out, all the partners are always aware of the current project status and can actively discuss decisions. A disadvantage is, that it is not possible to watch process steps in parallel, e.g. to evaluate new technologies and use them in a new prototypical implementation while an earlier version is still checked for safety issues. Additionally the domain knowledge on every level has to be put to a more concrete form, ideally developers would have checklists for auditing their development cycle.

The service scenarios generated more cases than we had originally anticipated, giving us a richer environment of issues to consider. For example, while we had considered driving safety issues when creating scenarios the end users did not think of driving safety when being asked about useful services. This poses the question how to proceed in the service scenario definition of future automotive services, specifically how to close the gap between what the user would like to see as a feature in his car and what is safely usable in the driving situation.

Service network development led us to consider stakeholders and their interaction with the proposed service provider which we did not initially anticipate. For example the contents have to be enriched with phonetic information to achieve a good speech synthesis quality. It still has to be determined who would generate this information, the content providers or the service provider. What we did not anticipate either is the fact that several public broadcasting stations in Europe asked for taking up the role as service provider. They would rather organize the service network, using existing content providers, than just deliver the content to the end user. To fully understand the driving factors for the stakeholders to determine a best match for the service provider is a question that has to be addressed in more depth in the future.

The technology considerations were highly dependant on the decisions made in the service scenario. But also various aspects of a service scenario depend on the availability of certain technologies. We were not able to find a better way of solving this dilemma than performing multiple iterations of defining scenarios and finding technologies until a match was found. A toolchain tailored to the process of service development in the automotive sector as described above could help to speed up this process. While it seems unlikely to us that it will be impossible to eliminate the need for an iterative work on service scenarios/service networks and the technology used for service provisioning, a rapid prototyping platform would help to decrease the time needed in each step of the iteration.

While building the prototype it became obvious that users were very willing to cooperate in service design. Also the evaluation of the prototype in the car was better compared to one setting were MACS MyNews was presented on a standard Laptop. This is not only true for the service itself, but also for different components used, like the speech synthesis engine. Using the prototype from very early stages on also gave us the time to work on improvements for those components, like building up user lexica with information about the pronounciation of common words.

The safety evaluation brought up some design flaws in the prototypical implementation as we expected. For example when using speech input to interact with the service the subjects were expecting a short feedback which command was recognized while we initially decided to execute the command right away. The videotaped tests confirm that subjects regularly looked at the screen (and not at the road as intended) to compensate for that. As a result the time needed to perform a certain task in the service is much longer than the time needed to operate the stereo.

The experiences gained from realizing different iterations of the prototype lead to the conclusion, that the service platform presented above is basically adequate, but should be extended to a full featured rapid-prototyping-platform. Such a platform would allow developers and researchers alike to illustrate services at very early stages in the car development. Overall, we have demonstrated through one case study that the model proposed adequately structures communication and development for mobile services in the automotive industry. In the future we intend to investigate the use of this framework in the development of wireless LAN based services as well as novel forms of human-computer-interaction, e.g., the use of avatars, information on cars approaching on hidden crossroads, etc.

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