

PASSAge - *Personalized Mobility, Assistance and Service Systems in an Ageing Society*

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Abstract The demographic change in modern societies has a significant impact on the future planning of self-determined mobility and mobility means. An optimized accessibility of the means of transportation is required, as well as their connection towards buildings and residences. These connections have to be modular and compatible to the mobility means of the users. Barrier-free accessibility according to the existing norms can address these problems only partially. Broader and holistic concepts are needed here. The project *PASSAge* aims at the implementation of seamless

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mobility chains that smoothly connect private and public space. Mobility shall be ensured by the extension of existing mobility means with user-oriented components. The project follows the approach to complement the barrier-free access and usage of public transportation with mostly electrically powered compact vehicles and micro vehicles. These have to be adapted by physical means and information technology means to residences and building structures. Core of the project is to develop a flexible socio-technical infrastructure with a multitude of mobility means and modular buildings, thus creating synergy effects. An important goal of the approach is the development of business models, which allow for and ensure the allocation and coordination of mobility services. Interfaces will be created for all compact vehicles and micro vehicles that extend their functionality both digitally and physically and thereby enable their ubiquitous connection to the envisioned services.

1 Motivation and Background

“Everyone wants to grow old, but nobody wants to be old.” This saying can be heard quite often. In most cases, it refers to the ailments accompanying the process of growing old. Especially the physical handicaps have a serious negative effect on the mobility of the elderly people. Distances young and healthy people can do in minutes on foot can get an insuperable barrier for the elderly. In rural and small-town contexts, larger distances have often to be traveled to reach, for example, the next clothing shop or specialist. At the same time, public transportation is often underdeveloped in these contexts. That means, for example, the nearest station is too far away for reaching it on foot, or the timetable is very sparse. In order to ensure the self-determined mobility of elderly people seamless, it is essential to create seamless mobility chains that can be used at any time.

Mobility aids and assistance systems appropriate for the age of the users can heavily contribute to the maintenance of independence of older people. The devices and services can further assist and promote the physical activity [10, 5]. In that way, the physical functions as well as the quality of life and the social participation could be improved. However, these effects can only occur when the aids and systems are accepted and used by the elderly people.

A broad variety of technical products and solutions exists that can contribute towards ensuring the mobility. The examples range from walking aids to electric vehicles. By offering safety, navigation systems and medical alarm systems can also improve the people’s mobility situation. However, isolated usage of single aids cannot create a seamless mobility chain. An integral approach is necessary that combines existing aids with information and communication services as well as with health services and mobility services. A special focus has to be on intermodality, i.e. changing between mobility devices has to be ensured. The project “PASSAge - Personalized Mobility, Assistance and Service Systems in an Ageing Society” addresses this fact and develops a system for ensuring seamless mobility chains, public transportation, and added value in society as a whole.

2 PASSAge – Intermodality, Mobility and AAL

The project *PASSAge* focuses on ensuring the mobility for elderly people by extending existing mobility means with user oriented components. Barrier-free access and usage of public transportation is complemented with mostly electrically powered compact vehicles and micro vehicles. Core of the project is to develop an interconnected flexible socio-technical infrastructure with a multitude of mobility means and modular buildings, where the individual elements do not compete but complement each other and thereby create synergy effects. An important goal of the approach is the development of business models, which allow for and ensure the allocation and coordination of mobility services.

2.1 An Innovative Approach

The technical and economic questions are dealt together with medical and nursing users' needs right from the beginning. At the same time, consequences on society, environment and architecture are examined. The inclusion of all related subject areas is an innovative approach in this field.

By involving the target group in design and development of solutions and products, the probability of high demand and user acceptance shall be maximized. The planned modularity and adaptability to the individual user and to environmental conditions allow creating individual mobility supporting solutions. In that way, it can be ensured that each user can maintain her/his self-determined mobility without being limited by unnecessary aids.

2.2 Means of Mobility

Electric mobility is a necessary and (not only) energetically meaningful addition to the existing means of mobility (cf. Nationaler Entwicklungsplan Elektromobilität [2]). The project *PASSAge* wants to exploit this technology for the elderly population in order to strengthen their individual mobility. Due to special mobility equipment, people with disabilities and physical limitations are nowadays able to drive their cars on their own. This special equipment, e.g. manual control units, entrance and loading aids, could partly also be used for supporting elderly individuals with ailments. The ongoing rapid changes in the automobile industry requires constant further development of these mobility aids for vehicles. Especially since the project is focusing on electrically powered compact vehicles and micro vehicles, the aids have to be adapted to the constricted room.

The market demand for mobility aids is constantly increasing, since more and more disabled and elderly people want to maintain their self-determined social life.

Especially in rural areas it is important to support the mobility in a way that allows traveling larger distances independently.

In this project, a broad range of mobility means is considered, starting from aids for pedestrians over bicycles to traditional cars. Besides existing models (e.g. walking frames, scooters, electrical bikes), the consideration also includes future devices (e.g. “wearable robots”, exoskeletons) which are currently only available as prototypes. However, the focus is on already widely-used mobility means and aids, such as walking frames or wheel chairs.

The rising cost pressure in the field of aids and appliances has intensified the tendency towards developing more modular mobility concepts that can cover a larger range of applications. Interconnectability is another trend on this sector. For example, for electric wheel chairs it is expected that they get more and more connected to the periphery in the future. Especially the usage of mobile devices has revolutionized this area in the last few years. In this project, both concepts, modularity and interconnectability, shall be combined in order to improve the mobility situation for the elderly.

2.3 Information and Communication Technology

For promoting the activity of the users and creating synergy effect in the *PASSAge* mobility chains, the different means of mobility will be interconnected by integrating information and communication technology (ICT) into them. That way, *PASSAge* mobility chain users can not only access a broad range of means of locomotion, but can also access online services, for example, for ordering goods, getting information on medical topics or for leisure activities. Car pooling, or finding and meeting nearby people with similar interests can also be simplified by using ICT.

The development of live-in laboratories [4] as a foundation for later commercialization of intelligent environments and homes for the general public and especially for elderly people allows for seamless and comprehensive ICT support for all individuals. An example is the Fraunhofer inHaus [9]. However, mobility is missing in all these approaches – comprehensive and seamless mobility chains especially outside of large cities, as considered in *PASSAge*, have not been investigated in detail so far. The interconnection is usually realized autonomic, automatic and ad-hoc. It is based on modern communication technology, such as ZigBee, 6LoWPAN, power line communication or dedicated bus systems, such as KNX. The field of application ranges from private homes to large production plants. It is used for automation, ambient assisted living [8], or autonomous production. Today’s modern information systems allow presenting location and context based information from various sources that are also connected to the Internet [6]. Parts of this information (e.g. latest news, public transport interruptions, etc.) can also be presented on public displays. Since it is possible to have an Internet connection without the need of wired infrastructure, a broad range of context sensitive applications can be realized. The

user is no longer limited to a certain place and new interaction approaches are possible:

- (multi dimensional) bar codes: taking a picture of the bar code allows to get additional information.
- Near field communication (NFC) [1]: bidirectional transmission of information via NFC tags and NFC readers and writers.
- Motion controlled interaction: sensors in mobile devices create new interaction possibilities.

2.4 Augmented Reality

Augmented reality (AR) is in general a view of the real-world environment augmented with virtual data. As a basic technology, AR can be used wherever three-dimensional and/or additional information could be added.

The diversity and amount of available information as well as the complexity of products and daily processes (e.g. the operation of an ATM) is increasing from day to day. Especially elderly people that are not used to modern devices cannot access information via the Internet and thus cannot benefit from it. Although AR can be seen as a powerful assisting technology, content providers are not yet offering solutions for elderly users. For the establishment and the long-term usability of the *PASSAge* mobility concept it is crucial that the serviceability is suitable for the target group. In order to allow individual shaping of one's life, the user needs support for accessing and comprehending the necessary information. This can, for example, be done by providing a central device that allows accessing the latest information and using the available services. Augmented Reality systems, especially mobile AR applications, show an immense potential for context sensitive assistance solutions.

AR is, for example, used for furnishing planning. These applications allow the visual evaluation of virtual furniture from different vendors within one's own four walls or in the garden. A similar application could, for example, also be used for planning barrier-free homes. Other AR scenarios that will be examined by the *PASSAge* project team are intuitive AR supported instruction manuals, AR shopping lists, and an AR navigation system for the elderly users. Virtual information, so called points of interest (POIs), can be integrated in the live camera image and connected to a real reference point. An example for such a system is the AR browser *junaio* [7] developed by *metaio*. This kind of information presentation allows for an intuitive interaction with virtual content and can create a better connection between reality and virtual data.

2.5 *HealthPhone*

The *HealthPhone*, an all-purpose smartphone, will be the mobile interaction device which allows using the navigation and health system anywhere anytime. In order to help the user monitor her/his health state, it integrates devices and interfaces for measuring vital parameters. The integrated inertial sensors together with the GPS module and the camera will be used by the augmented reality based navigation system. That way, a localization system with a high positioning accuracy can be implemented. Currently available localization systems either need additional devices for reaching a high accuracy, or do not make use of AR for creating an intuitive illustration of the surrounding. This gap shall be closed by the *HealthPhone*.

An accurate AR based navigation system allows for reliable orientation, even in unknown environments. In this way, it can reduce the fear of getting lost and can extend the mobility beyond the district. For integrating the different means of mobility in the intelligent mobility chain, they will be extended with digital interfaces. These interfaces can be used, for example, by the *HealthPhone*'s services and apps for acquiring their current state (e.g. battery level) or for controlling them. By using individual independent apps, the *HealthPhone* can be matched with the user's demands and her/his utilized mobility aids. Advantages of using mass market smartphones over dedicated hardware as hardware basis for the *HealthPhone* are lower prices, easier integration and many extension possibilities.

2.6 *Car Sharing Concept*

In contrast to public transport, car sharing can deal with personal needs. The user is not limited to certain lines and stations (except to certain areas the vehicle has to be returned to). It is not to be mixed up with car pooling which is focusing on users sharing the same route where a driver shares her/his car with other passengers while driving to her/his destination.

Car sharing vehicles are normally equipped with a mobile data connection which connects the vehicle with the car sharing provider's infrastructure (e.g. for getting the current location or for reservation and billing). This connection could additionally be used for coupling the system with a central traffic guidance system and a parking lot management system, in order to assist in finding the optimal route and parking space which matches the user's needs. By integrating information from public transportation, e.g. the current timetables and the loading, recommendations for changing the means of transport could be given.

Due to the steadily increasing amount of more and more complex functions in today's cars, human-computer interaction has become a central part of the car development process in the last few years. The integration of mobile devices allows users to control the in-vehicle infotainment systems with their mobile devices' interaction paradigms they are used to [3]. Especially when the means of mobility are changed

frequently, as it is the case with car sharing, this can enormously simplify the operation for the user, since the users are more familiar with the handling of their mobile devices than with handling changing systems.

One of the planned *PASSAge* services is a car sharing like system for giving users vehicles equipped with different mobility aids on loan. This can immensely reduce the costs for the individual user and, thus, enable her/him to stay mobile.

3 Methodical Approach

Common aids try to reduce the mental effort for movements and sensory, for example, by the usage of walking frames, fall protectors, or remote controls. In that way, the user of the aid can concentrate on other tasks; the mobility task gets into the background. This can be further optimized by a system that can automatically adapt itself to the user's needs, behavior and current situation.

In order to be able to support an user with such a modern technology, it has to be ensured that the system matches the user's cognitive abilities. This means, among other things, that the operation of an aid must not need more concentration than the user can gain by utilizing the mobility aid. When this is not fulfilled, additional risks can occur. At the same time, the technology may not force the user to completely give up her/his own remaining competences when using the aid. The aids shall only support the user's abilities in order to be maintain her/his social life, autonomy and activities of daily living. Hence, the system has to be able to adapt itself to the current situation of the user. In order to create an effective and efficient mobility system, a complementary combination of actuators, sensors, ICT and decision-making components is necessary. The system has to support and/or replace weakened competences that influence the user's mobility negatively.

Four use cases are considered for covering all relevant urban and small-town mobility chains. They refer to different scales: mobility at home, in the district, in the city, and in the surrounding area. An overview of the use cases is depicted in Fig. 1. All four mobility chains are made out by a detailed analysis of existing means of mobility and users' demands. After that, possible solutions for bridging identified gaps are compiled. Three field studies spread over the project's duration will support and ensure the purposeful and target group oriented development. In addition, the experiences of companies working regularly with elderly people will be included. These experiences are also the basis for the development of corresponding business models for the allocation of mobility services and system components. Sound business models are an important element for the success of the project.

In order to establish standardized laboratory conditions, parts of the field studies will be conducted in and around an experimental flat. Intermodality shall not only consider changing between different means of mobility at junctions in public space outside of buildings, but also the mobility in buildings. Especially at the entrance area, a clear discontinuity between indoors and the building's surrounding can be

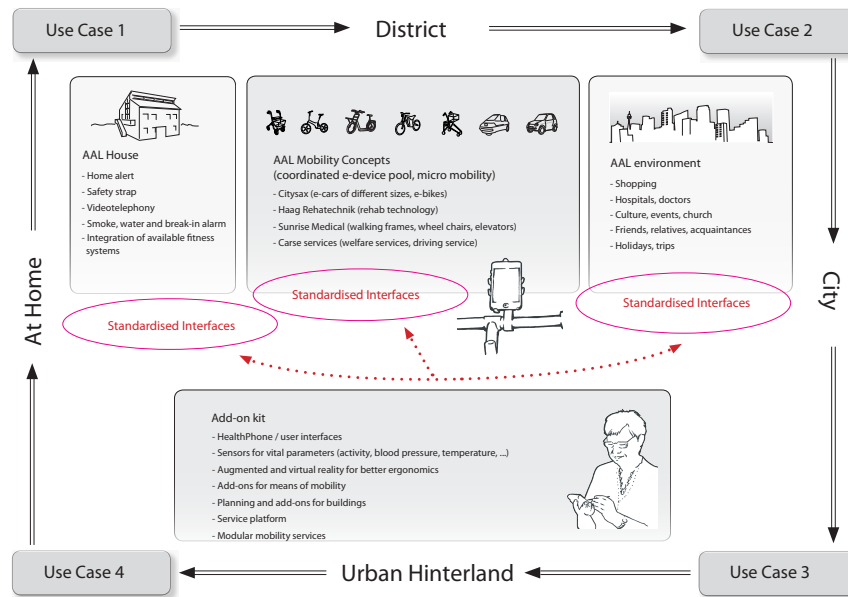


Fig. 1 Four use cases are considered in the *PASSAge* project. They refer to different scales: mobility at home, in the district, and in the surrounding area. Standardized physical and information technology interfaces shall enable a seamless mobility chain for the elderly.

noticed. Besides the physical dimension (e.g. steps, different means of mobility, unloading of goods), there is also a discontinuity at the information technology level (e.g. privacy, display sizes, Internet connection speed). In contrast to currently existent solution which are only focusing on single aspects (e.g. Toyota Shopping Car, eTRON Home Delivery Box), the *PASSAge* project is focusing on a comprehensive approach.

Studies have shown that the biggest problem besides traveling longer distances are differences in height. Examples are the common two or three steps in front of buildings, the threshold between rooms, or the different height and gaps between the means of mobility and the pieces of furniture. The mentioned mobility hindrances and many more can be evaluated in and around the experimental flat. An adjacent parking space that can be reached via fliers help in analyzing and optimizing the interface between indoors and the individual means of mobility for longer distances (e.g. electrically driven compact vehicles and micro vehicles).

The group of subjects will be composed of elderly people without physical limitation, elderly people with physical limitations and where applicable people suffering from dementia. Blind individuals will not be part of the group of subjects, but people with limited eyesight can take part. Before taking part in movement experiments the subjects' capabilities will be analyzed (e.g. ability to walk, fall risks, cognitive abilities, etc.). The results from the analysis will be part of the metric for

measuring improvements all over the project. For that reason, it would be beneficial when the most subjects take part in all three field tests. In order to ensure statistical meaningful results, the number of subjects will be chosen high enough so that retirements of subjects can be compensated for. The studies will be conducted with questionnaires, interviews, 3d sensor recording, vital parameter recording, and by observing the subjects in daily situations.

The advantages of the planned solution in comparison to existing approaches can be summarized by the following points:

- An individual device which allows elderly people and users with physical limitations accessing mobility services.
- A platform that provides location and context sensitive services.
- Technical aids for daily situations.
- Reduced costs due to shared usage of systems, such as adapted means of mobility

The *PASSAge* system's modularity shall allow for adapting the available components to the individual needs of the users. The modularity enables an inexpensive solution which can be smoothly extended in the future.

4 Conclusion and Outlook

The project *PASSAge* aims at safeguarding seamless mobility chains, safeguarding public transportation, as well as safeguarding of the added value related to society as a whole. Mobility shall be ensured by the extension of existing means of mobility with user-oriented components. The project follows the approach to complement the barrier-free access and usage of public transportation with mostly electrically powered compact vehicles and micro vehicles. Core of the project is to develop a flexible socio-technical infrastructure with a multitude of mobility means and modular buildings, thus creating synergy effects. The development of high-tech aids is not only an end in itself, but shall create an aesthetic functional aid that matches the users' needs. An important goal of the approach is the development of business models, which allow for and ensure the allocation and coordination of mobility services.

The multi-functional, interconnected system components are not limited to the main target group of elderly people. They can be used by anyone that needs support in mobility. The whole system is intergenerational and can be upgraded with aids when needed. Based on the comprehensive consideration of the mobility chains, new research fields in the area ambient assisted living (AAL) may be identified which could be a combination of the topics AAL home, AAL city and AAL mobility.

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