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München: Oldenbourg Wissenschaftsverlag, 2014, S. 199-204.

Use Case Design for AdaptIVe

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Summary

AdaptIVe is a large scale European project on vehicle automation and the pertaining human-machine interaction. The use case design process is a crucial part of the system design process and a part of the human-vehicle integration subproject. This paper explains the methodology for describing use cases in AdaptIVe. They are primarily based on sequence diagrams with main and alternative flows.

1 AdaptIVe

AdaptIVe is a large-scale European research project on vehicle automation in highway, urban and parking scenarios. Also legal aspects and the human-machine interaction play an important role. The creation of use cases (OMG, 2011) is an important part at the beginning of a system design process. In AdaptIVe it is allocated to the human-vehicle integration subproject. It is emphasizing a useful and reliable human-machine interaction, which plays an important role in the design of vehicle automation.

2 Introduction

In AdaptIVe, we define use cases as follows: "A use case is a description of a specific sequence of interaction between the user(s) and a technical system to achieve a specific goal". They are the basis for deriving more detailed technical and human factors oriented functional requirements of the demonstrator vehicles in AdaptIVe. Use cases are needed to improve communication among team members and encourage a common agreement about system requirements. They help to reveal interaction design alternatives, process exceptions, undefined terms, and outstanding issues. Furthermore, they can be helpful to expose what belongs outside the project scope and to prioritize work.

Use cases, as we handle them in AdaptIVe, consist primarily of a graphical representation based on the Unified Modelling Language (OMG, 2011) sequence diagram, as well as sketches of the surrounding traffic situation. The graphical representation was changed from standard UML in order to better accommodate the project's needs. Additionally, a verbal description, a so-called narrative, is part of the use case description.

3 Use Space Tree

Figure 1 on the left hand side shows the use space of AdaptIVe, showing the elements relevant for driver and system. On the right hand side the demonstrator vehicles from various automotive OEMs and suppliers are listed. The representation is derived from the EU-HAVEit (2014) public funded project, were a similar use space tree was applied. The overall layout is furthermore derived from the EU-interactIVe (2014) public funded project. The different elements of the use space form the basis for the use case sequence diagrams. The six elements listed describe the initial system decomposition. The first element describes the environment, which are the surroundings of a vehicle, with the street, its infrastructure and other vehicles. As proposed in Kelsch, Temme and Schindler (2013), the environment can be regarded as an autonomous entity being a part of the whole system. The environment is changed or unchanged. The system state refers to the automation system and its state, which can be normal in case everything is working well, but it may also reach its limits or have a failure. The vehicle is the host vehicle, which may also reach limits or have a failure. The HMI describes the human-machine interaction and interface comprised of various input and output modalities. The automation levels refer to the SAE definition of driving automation (SAE, 2014). The elements in this tree can be adapted according to the needs of the demonstrator vehicles and their functions. Function descriptions were collected at the beginning of AdaptIVe.

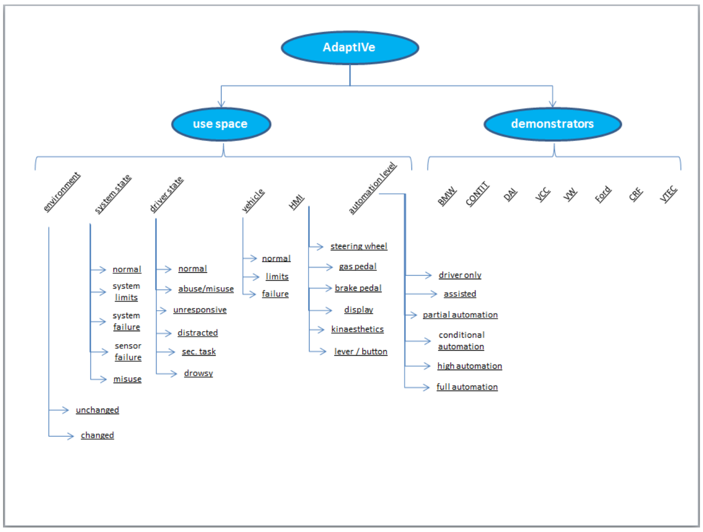

Figure 1: AdaptIVe use space tree

4 Sequence Diagram Tool and Method

For elaboration of use cases, the sequence diagrams can be used as a tool. In order to derive this tool, the use space tree is applied to form the various axes of the sequence diagram template, which can be seen in Figure 2. Each so-called agent (OMG, 2000) in this diagram is subject to state transitions. Those transitions are either intended / expected or unintended / unexpected. The SAE automation levels (SAE, 2014) used in this project are listed twice. Next to the automation agent, the actual level of automation and its transitions are shown. The list next to the driver agent contains the automation level and its transitions with regard to the mental model of the driver. This means which kind of automation level the driver currently thinks is valid. The agents communicate with each other on the time axes. They exchange messages. Regular messages are shown with black arrows. Blue arrows indicate messages leading to automation state transitions. Red arrows lead to critical situations. The HMI agent with its various input / output modalities is shown in detail to reflect the importance of the human-machine interface. Most of its elements are straightforward. Lever / button refers to input devices in general, which are inside the vehicle, but may also be outside, such as a key fob or smartphone. Display refers to visual, acoustic and haptic displays in general. Kinaesthetics is the feedback the driver perceives during movement of the vehicle. At the top right hand side, sketches of the traffic situation can be placed.

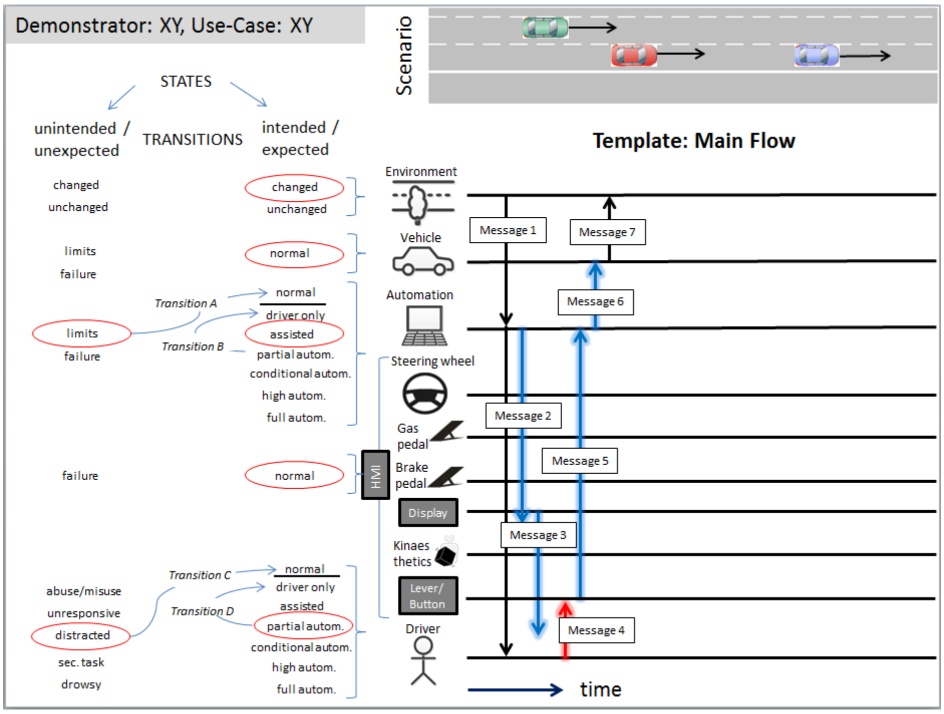

Figure 2: AdaptIVe sequence diagram and sketch template tool

Use cases can be created by applying the use case tree to each demonstrator function description. Each use space tree agent (such as automation, driver etc.) can be in different expected / intended and unexpected / unintended states. The main flow of events of a use case derived from the function description consists of the expected / intended state changes in the sequence of events. The alternative flow(s) of a use case are derived by analysing the possible unexpected / unintended state changes in the sequence of events. For each main and alternative flow there will be a dedicated sequence diagram.

In the course of AdaptIVe, a use case workshop was held at the DLR IDeElab in Braunschweig. Next to round table discussions, there was also the possibility to try out various vehicle automation and driving scenarios in the DLR theatre system driving simulator environment (Schieben, Heesen, Schindler, Kelsch and Flemisch, 2009). This way, it was possible to fill out sequence diagrams by means of the projected sequence diagram template (Figure 2) directly on a whiteboard.

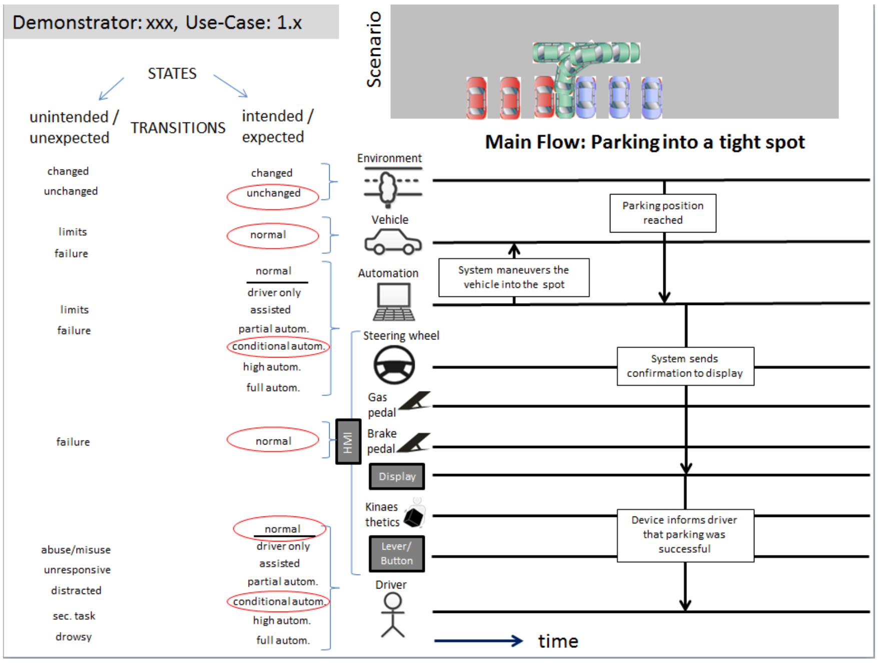

Figure 3: Main flow for parking into a tight spot

5 Results

In this chapter, an example main flow is shown. Figure 3 shows the sequence diagram for the function parking into tight spots. The host vehicle equipped with the Automated Park Assistant function follows a street (alternatively a driveway in a parking garage). The function scans the environment for a free parking spot when the driver manually passes parked cars, which are parked perpendicular to the street or next to each other in a parking garage. If a free spot is detected, the driver is asked to stop and exit the car. The driver starts the parking manoeuvre with the help of a portable device from the outside of the car. It starts backing up into the dedicated spot and the driver can walk away. Once the car has reached the park position, it will inform the driver about the success.

System activation, deactivation and alternative flows for e.g. system failure are part of additional sequence diagrams.

6 Discussion and Outlook

During the workshop discussions we pointed out that many former proposed functions are similar to each other. It gave us the opportunity to integrate and to homogenize the resulting use cases and the corresponding interaction design. Therefore, the appropriate design of the driving situations used for the design sessions in the theater system was very helpful.

Each demonstrator vehicle in AdaptIVe has got its own functions and boundary conditions. Thus, use case descriptions will vary between them. Taking into account the actual requirements of each demonstrator in use case design is more important than a strict alignment of use case appearance. Furthermore, the work on use cases in AdaptIVe is supposed to be an iterative process. It is not only intended for now, but also for the use throughout development. Consequently, the current use case descriptions are not fixed, but can be altered in the future according to the needs of AdaptIVe and its demonstrators.

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Acknowledgements

This work was also supported by the European Commission under AdaptIVe, a large scale integrated project part of the FP7-ICT for Co-operative mobility. The authors would like to thank all partners within AdaptIVe for their cooperation and valuable contribution.

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