# Towards a Modular Reference Architecture for Smart Glasses-based Systems in the Logistics Domain

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**Abstract:** While smart glasses-based systems have potential to support users through context-adaptive information provision, implementations are still scarce and limited to pilot and test projects. This lack of design and implementation experience as well as research hinders deployment of these devices in organizations. Through a comprehensive consortium research project, we defined a system architecture addressing various implementation issues. By presenting this architecture as reference model, we make this design knowledge accessible and support future projects, both in research and in practice.

**Keywords:** Smart Glasses, Domain-Specific Modelling Language, Information System Architecture, Logistics

## 1 Smart Glasses for Logistics Services Functions

Smart glasses have potential to support logistics service tasks along the whole value chain [Ni17]. With context-adaptive information provision in the user's field of view and hands-free navigation options, smart glasses are especially beneficial as a service support system for information intensive and bimanual tasks [EV15]. Implementations of smart glasses-based systems are still scarce and limited to pilot and test projects [Ca15]. Due to this lack of design and implementation knowledge, organizations face uncertainties how to deploy smart glasses. Implementation projects face technical and social risks. Smart glasses such as the Google Glass face adoption barriers because of a negative social impact [KKA15]. Smart glasses are equipped with sensor and camera technologies to gather data from the user's environment. The privacy invasive functions need to be considered in the system design from the beginning [Be17]. In terms of the technical realization, questions arise on how to implement system modules and how to integrate processes into the support system. The integration of processes into the guidance system has high resource costs as modelling experts and domain experts are both required to model the processes [Me16].

In the three-year consortium research project Glasshouse, we developed a system architecture addressing these implementation issues. We introduce a reference architecture to make this design knowledge accessible. Reference models aim to bring design knowledge of specific information models into a reusable form [Th06]. We argue that

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reference models for smart glasses require the integration of a modular implementation approach, privacy compliance aspects and process models. The reference architecture for smart glasses-based support systems ensures compliance with privacy regulations and provides guidance in the technical implementation.

Against this background, the questions that guide our research are: (RQ1) How can smart glasses be implemented in logistics services? and closely connected to the previous question: (RQ2) How can a reference architecture for smart glasses in logistics services be build? To address our research questions, we proceed as follows: In Section 2 we provide a concise overview on the consortium research project. In Section 3 the reference architecture for smart glasses-based support systems in logistics services is introduced. The discussion and an outlook are provided in Section 4.

## 2 From a Research Project to a Reference Architecture

In cooperation with a globally acting logistics service provider with a focus on contract logistics, a medium-sized logistics company with a focus on fashion logistics as well as a software implementation company, we defined potential use cases for smart glasses in logistics [Ni17]. The target of the project is the development of modular solutions to pilot a support system for smart glasses along the logistics supply chain. We target reliable processes, ergonomic workplaces, and we address technology acceptance of smart glasses. As part of the requirements engineering and prototyping process, we integrate the factors privacy, usability and acceptance from the beginning to guarantee usable and accepted smart glasses-based systems for real and practical applications [Be17, Be17b, Zo16].

Through the course of the project, we implemented three smart glasses prototypes from different application areas. They integrate process guidance and modelling aspects. Furthermore, we implemented a web application to model business processes for smart glasses. While creating first prototypes, requirements from software-, technology- and backend-side appear. We refined the requirements after each development phase. This leads to different prototypes based on the use cases and ending up with a clear need of a smart glasses-oriented software architecture addressing technological, software- and backend- requirements [Be17b].

## 3 Architecture

Technology adoption can be impeding once existent architectures or data have to be connected and integrated. Hence, careful and thorough planning of the technical architecture of a smart glasses system is essential. We conducted three focus groups with functional requirements from the logistics domain and the technological capabilities of smart glasses in mind. We decided on applying a microservices approach, garnering from its small overhead and advantages in terms of modularization and code reusability. Furthermore, this approach enables the implementation of independent prototypes. We drafted and discussed a holistic architecture for a smart glasses-based system in the logistics domain, without restrictions of specific use cases or processes. The architecture (cf. Figure 1) resulting from the focus group discussions is based on two main parts, further being divided into six subsystems. The logistics worker, initially independent of his or her specific tasks, only has access to the frontend modules. These consist primarily of a visualization system on smart glasses guiding the users through their respective work processes. The devices display useful information directly into the user's field of view, or retrieve input. With the modelling system, selected business processes can be altered, corrected or added easily and quickly. Smart glasses and modelling tool are both connected to a cloud-based project system as the key hub of the architecture. This subsystem provides all processing modules of the potential functionality. Through outsourcing most of the functionality into the backend system, the mobile devices are primarily used as input and output periphery, increasing battery runtime and sparing the limited processing power in the frontend. To address privacy concerns of smart glasses, we added a privacy gate between the backend hub and the frontend application. By default, all privacy-invasive functionalities, such as camera access or voice recording, are deactivated. The authentication service unlocks the individually necessary functions. With this approach, we apply the two technical and organizational measures of *Privacy by Design* and *Privacy by Default* of Article 25 of the EU-GDPR. If needed, the system can further establish a connection to the internet via an external communication service, e.g. for using proprietary modules such as voice control. All data is stored in system-specific databases. Aspects outside of the system, which either are necessary for the information system (such as mobile data) or can lead to system advances (such as 5G connectivity) were modelled as part of the outside environment.

We tackle the previously noted challenge of integrating the system into other enterprise applications (e.g. warehouse management systems) by defining a client interface service, connecting to the backend system of the logistics company. Through modular information inquiries following a Software-oriented Architecture (SOA)-Approach, data can either be retrieved or uploaded from and into the client system. One important aspect of the system is the usage of technological domain-specific modelling languages (DSML) to request the defined microservices and their functionality in the architecture. Hence, we suggest a new desktop-based DSML for a model-driven IS development that allows for a flexible combination of the microservices and therefore a highly customizable smart glasses-based frontend application. The approach is similar to the usage of conceptual models (e.g. EPC or BPMN) for the design and execution of service-oriented information systems like in [TB10] and serves as a significant supplementation. Standard process modelling languages such as EPC or BPMN do not have the capability to represent all of these aspects adequately. Therefore, new DSML are necessary that allow for a representation of microservices, functionalities of a wearable device, definition of interfaces, the control of the data flow and the final representation on the wearable device. Such a DSML would have to be well-defined regarding new concepts and how this reflects to new notation elements and attributes. Further new desktop-based modelling tools are necessary to represent the mentioned dimensions for one notation element in an efficient way. The presented architecture should serve as the enabler allowing a new DSML to steer the interlink of microservices and enabling model-driven information systems. The combination of this architecture with new technological DSML could increase the process modelling relevance within the IS research community and in practice, since it creates a novel implementation approach with potential business value.

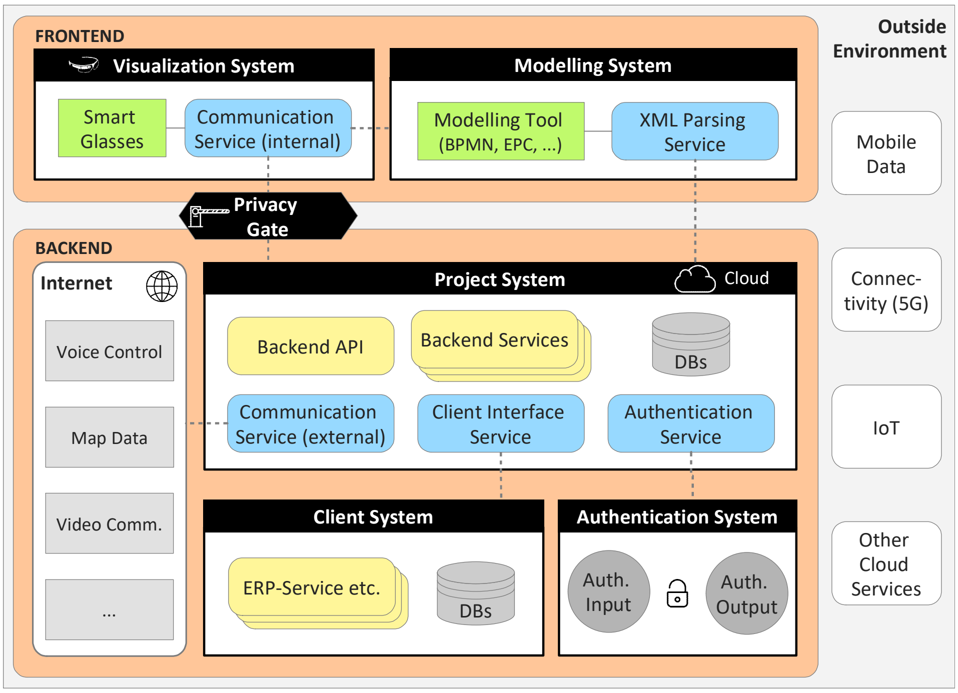


Figure 1: Reference architecture for smart glasses-based systems

## 4 Discussion and Outlook

Through focus groups and thorough planning, we deducted a reference architecture for smart glasses-based systems. The primary business domain of our architecture is the logistics sector, and as we started the creation process with specific requirements in mind, we present our architecture as a practice-oriented construct in need of further evaluation and validation. Through the ongoing evaluation of the already implemented and following systems, we work towards validating and maturing the proposed architecture. Despite these limitations, we expect that the approach can be generalized towards other domains building on procedural workflows with manual tasks. Through the strict separation of functionality on the frontend and the backend, durability of the devices' battery-life and a controllable privacy aspect can be supported. Consequently, this approach intensifies the importance of technological interfaces, introducing potential for interface issues. This strengthens the strategic value of upfront planning and stakeholder involvement.

An ongoing development of IoT-possibilities and technologies enables everyday support of work processes. Through increasing connections and integrations of an information-provision device (smart glasses) with information-collecting hardware (smart sensors, IoT), the future of the workplace may lie in an always knowledgeable and informed user. Future research has to investigate the potentials of this rising interoperability and connection of different mobile systems.

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