

# BPMN4SGA: A BPMN Extension for Smart Glasses Applications to enable Process Visualisations

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**Abstract:** New mobile technologies such as smart glasses cannot be described adequately with standard process modelling languages. This leads to insufficient process documentation, hindering a correct integration of these technologies in business processes. In this paper, we focus explicitly on smart glasses-based processes. We analyse the domain of smart glasses-based processes and develop a smart glasses-based process ontology. Furthermore, we investigate smart glasses-based process concepts and BPMN concepts semantically. Thereby, extension requirements for a new BPMN extension are derived in the domain of smart glasses, using the method for domain-specific development of BPMN extensions. In addition, we include model-driven software development concepts. Finally, we present a part of the graphical syntax with an exemplary smart glasses-based process and the connection with the model-driven architecture.

**Keywords:** BPMN Extension, Smart Glasses, Extension Requirements, Model-Driven Software Development

## 1 Introduction

Smart glasses offer opportunities to enhance business processes [RBR15]. But standard business process modelling languages such as the EPC and BPMN are not practical to describe technological aspects. Further, more and more domain-specific extensions have arisen for business process modelling in the last decade [BPS14], but only a few address the representation of these technologies within modelled processes, even though process models can be beneficial for businesses if they consider specific domain concepts and are used to steer the implementation of information systems [Tr07]. One of these technological domain-oriented language extensions are uBPMN [Yo16] or Context4BPMN [DS17] that integrate technological advances such as mobile devices into process modelling languages. However, to the best of one's knowledge no explicit domain-specific modelling language for smart glasses-based processes exists.

Hence, key focus of this research is the conceptualisation and specification of a BPMN language extension for a model-driven process visualisation on smart glasses. Besides the derivation of requirements for a BPMN extension, this paper also presents the conceptual idea behind model-driven process visualisation on smart glasses. We focus explicitly on the technology of smart glasses for several reasons. First, smart glasses are a relatively new technology and businesses face several problems with its integration.

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Moreover, little research has been done so far for an effective implementation of smart glasses [RBR15]. Further, smart glasses as mobile devices have many boundaries with other technical aspects in the enterprise context. Frank et al. recognize that new forms of organisations and cooperation possibilities arise and these lead to new requirements regarding the representations of information systems [Fr14]. Smart glasses as a hands-free and always visible mobile device have an influence on future organization-centric and collaboration-focused information systems. Thereby, smart glasses are well suited for the embedding into business processes, as they do not interrupt the work process [RBR15]. In addition, smart glasses are already used in the work process for the provision of information [Me17]. In future, smart glasses can serve as the technology that implements ubiquitous computing and IoT technologies for visualisation and control. Hence, this paper defines the following research question:

*RQ: How can mobile and wearable functionality be integrated within a BPMN Extension, whose represented process models can be utilized and automated on smart glasses?*

We proceed as follows: In section 2, we present related work regarding domain-specific modelling languages in IoT, ubiquitous computing and general new technology contexts. Further, we provide insights regarding challenges with the implementation of smart glasses in businesses and define the objectives of the solution. Then in section 3, we describe the research method that was used to streamline this research and generate the outcomes. After that, we present both the resulting smart glasses-based process ontology and a semantic check between the concepts of the domains smart glasses and BPMN. In section 5, an exemplary smart glasses-based process and the associated model-driven approach is presented. Finally, the last section discusses the implications of our research and an outlook.

## **2 Overview of BPMN Extensions in Literature and Challenges in the Smart Glasses Domain**

In a prior research project involving smart glasses [Ni17], we used the Business Process Model and Notation (BPMN) as modelling language to describe potential use cases. Noticeable was the extensive use of text annotations or technical descriptions in the business process models for smart glasses users. In addition, we realized that a comparison between the process models was not possible. Sperner et al. conducted a study whether BPMN concepts such as text annotations, data objects or pool lanes are sufficient for the representation of Internet of Things (IoT) concepts [SMM11]. They discovered that the existing BPMN concepts are not adequate for the representation of

IoT aware processes. Zhu et al. also recognize that the location as a parameter can be represented in business processes with swimlanes (pools), text annotations and data objects, but the main problem with that kind of representation is that the parameter cannot be used well for process execution systems [Zh11].

Especially for the BPMN, many different domain extensions already exist. The main reason for that is the available BPMN extension mechanism [OMG18]. It allows a domain extension at the meta model level. This is an advantage over other modelling languages, such as the EPC. Braun and Esswein conducted a literature review about BPMN extensions, which resulted in a detailed classification of domain-specific BPMN extensions [BE14]. They identified 30 domain-specific BPMN extensions but only a few publications were related to new technologies. Hence, they did not identify any BPMN extensions in the technical domain of smart glasses. Only the developed uBPMN by Yousfi et al. (2016) for the modelling of ubiquitous business processes has a close relation to the topic of this research [Yo16]. Further, they only identified two methods for the methodical extension of the BPMN. Stroppi et al. provide a method for the extension of the BPMN at the meta model level [SCV11]. Braun and Schlieter extend the method from Stroppi et al. with a prior domain analysis and a comparison between the domain and BPMN concepts, which leads to a more domain-oriented development of BPMN extensions [BS14].

In terms of smart glasses, various research was done on different limitations and challenges concerning the presentation of content on small and mobile screens. Due to the design of smart glasses opting for a lightweight and comfortable architecture, only batteries of limited capacity can be integrated in the framing. Furthermore, the screens of smart glasses are relatively small, as they should not obstruct the field of view of the user. In their work, [Ta11, Uc13, IWM09, Na10] recommend that information should best be displayed in the inner middle (towards the nose) of the screen, with a high contrast between the background and the information to be displayed. Furthermore, textual information should best be supported by symbols or pictographs, and be limited to a manageable amount of content. Thus, various steps of a process should appear as separate screens after one another in a sequential flow.

We aim to minimize the mentioned concerns with a new implementation approach for smart glasses-based information systems. This will be realized by using a model-driven approach. A correct representation of the smart glasses domain occurs through a BPMN extension and is an important groundwork. The concept aims at a 100% model to information system transformation. Thus, smart glasses challenges related to visualisation are explicitly covered by the BPMN extension and the model-driven development system. Business users take care of these challenges on an abstraction model level, which aims to reduce the complexity of an implementation of smart glasses in businesses. Moreover, further objectives of the solution are the reduction of the implementation tasks for smart glasses in businesses and an agile implementation.

### 3 Research Method

The research method for this paper is shown in Figure 1. The overall research project applies the problem-oriented Design Science Research Method (DSRM) [Pe08]. The first two phases of the mentioned method such as problem identification and the definition of the objectives of the solution are covered in [Vo18]. The following design and development phase is covered by this paper essentially through the application of the designed method for the domain-oriented development of BPMN extensions by Braun and Schlieter [BS14]. The domain requirement analysis occurs through use cases in the domain of smart glasses and literature in the domain. This step results in 12 distinctive domain requirements for an automatic process visualisation on smart glasses. These domain requirements are used for a justification of BPMN as an appropriate modelling language. After that, we created a smart glasses-based process ontology, which brings the concepts of the modelling language in relation with the extension domain. In an element equivalence check, the extension requirements for a BPMN extension in the domain of smart glasses-based processes are derived. This method step reveals which concepts are missing in the business process modelling domain in order to represent smart glasses in business process models. This paper focuses on the identification of missing concepts in the modelling language BPMN for the representation of smart glasses-based processes. Hence, we executed the first half of the method, for a first emphasis of missing concepts in the domain. Subsequently the method provides further suggestions for the development of the BPMN extension, which results in an abstract syntax represented in a UML notation and the concrete syntax symbolised by the new domain-specific notation elements and attributes.

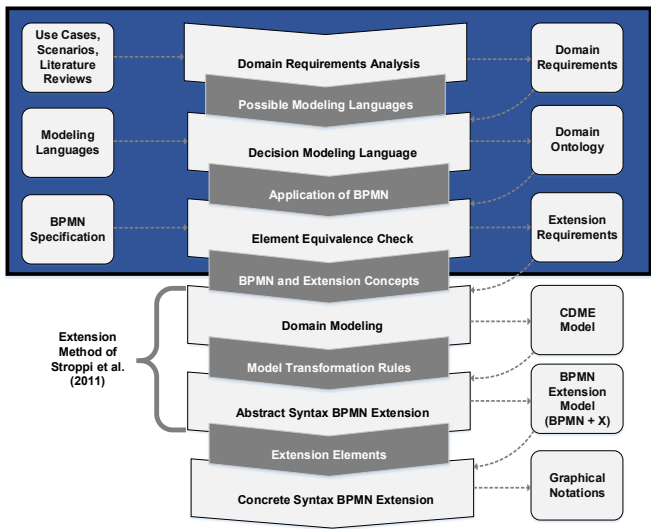


Fig. 1: Method for the domain-oriented Development of BPMN Extensions [BS14]

## 4 Design and Development

The adequate modelling of smart glasses-based processes is quite challenging and only possible with limitations in current process modelling languages. The main reasons are the huge diversity of technical functionalities of smart glasses, the range of different software-based implementations and further the interconnection between the technical and software-based side. An extraction of these challenges is shown in Figure 2. The process in standard BPMN represents the use case movement of goods internally in a distribution centre with smart glasses.

The logistics employee wears smart glasses and has to move a package internally in a distribution centre from one gate to another. The worker has to enter the article number, e.g. “304”, by speech commands. Based on the input and the position of the worker, the navigation route is calculated and presented. Followed by a confirming speech command, the navigation sub-process is completed. After that, a decision is executed, based on the workers position, whether the package is positioned at the right gate. Finally, the process ends with a visual feedback or starts the navigation process again.

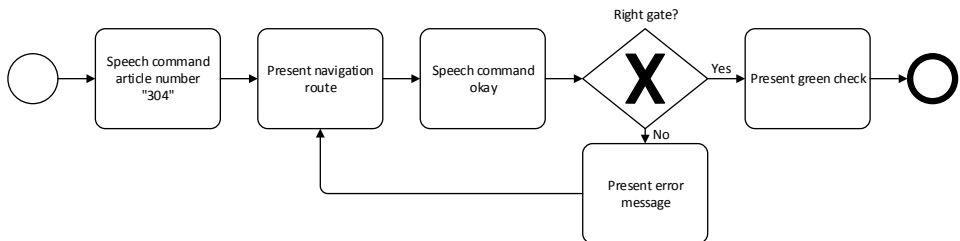


Fig. 2: Movement of goods internally in a distribution centre with a Smart Glasses

Based on standard BPMN, it is difficult to interpret the smart glasses-based process in a first view. Further, a technological interpretation of the process for a model-driven approach is not possible. The non-existent standard description of smart glasses functionalities from the technical and software-based side do not allow any model interpretation. Therefore, we define domain requirements from the technical and software-based side and their interconnection. The domain requirements (DR) are derived through use cases identified in the research project [Ni17] and literature in the domain of smart glasses applications. The derivation of the requirements was carried out as an iterative process and a permanently comparison if identified missing concepts are listed in the requirements list. These requirements result in a smart glasses-based process ontology, which integrates domain requirements from the technical side and from the software-based side.

#### 4.1 Technical Domain Requirement Analysis

In Niemöller et al. [Ni16], a comprehensive literature and market study has been carried out for the identification of smart glasses functionalities. They define six main groups for smart glasses functionalities. In the first group Tracking, the feature GPS navigation is relevant. The next group includes Glasses Interaction and the respective features hands-free content navigation, voice recognition and gesture recognition. In the third group Environment Identification, especially the feature identification of objects e.g. with RFID or QR-Codes are mentioned in the literature and market data. Picture and Video is the next group as well as feature. These functions are followed by the group Information Provision with search information, contextual information, real-time statistics and information overlay as features. The last group is Advanced Communication and consists of the features like textual communication, video conferencing, real-time translation and live streaming [Ni16].

These functionalities are the foundation for the technical-based (TB-DR) and software-based (SB-DR) domain requirements. The tracking concept is considered in **TB-DR 1: *A modelling language for process visualisation on smart glasses should support concepts to represent the tracking of the smart glasses user, e.g. identify the user's location.*** Different interaction possibilities for the process steering can be used. Therefore, in a smart glasses-based process the interactions for the process steering have to be well defined. For example, Stocker et al. implemented touch buttons, speech recognition and hand gestures for the steering through a checklist visualised on smart glasses [St16]. The steering concepts have an influence on the ease of use, cycle time and cognitive load [Hu17]. Thus, the steering concepts are defined in **TB-DR 2: *A modelling language for process visualisation on smart glasses should support concepts for the exact definition of the possible interactions for the steering through the process.*** For instance, the speech command “next” triggers a request for the next process step. Possible interactions are gestures, touch buttons, speech recognition and head movements. The permanent smart glasses display in the user's view allows a continuous feedback. Due to the small display size software designers have to be aware of regarding special design guidelines as in [Uc13]. Therefore, the user interface has to be adapted considering the brightness of the environment and the specific content. These issues are formulated in **TB-DR3: *A modelling language for process visualisation on smart glasses should support concepts for the adequate graphical representation of the process and notation elements.*** The camera of the smart glasses is an important feature to capture the environment e.g. through pictures or videos. From another point of view, the camera can raise privacy and employment law concerns [Be17]. The privacy-by-design pattern is integrated in **TB-DR4: *A modelling language for process visualisation on smart glasses should support concepts to activate the camera only for necessary tasks to fulfil a privacy-by-design pattern.*** Smart glasses include different kinds of sensors, for instance the Vuzix M 300 is equipped with an accelerometer, internet connection through Wi-Fi, Bluetooth, a digital compass, head tracking, GPS and a gyroscope [Vu18]. These sensors allow a detection of the context and they can change the process flow [DS17]. Consequently, sensors have

an impact on smart glasses-based processes. **TB-DR5** imply them: *A modelling language for process visualisation on smart glasses should support concepts to reflect the context via sensors in the process model.* Due to the availability of a microphone and audio speakers, smart glasses are suitable as a communication system. The display complements smart glasses to a suitable information and communication system. Communication tasks are covered in **TB-DR6**: *A modelling language for process visualisation on smart glasses should support concepts to represent smart glasses-based communication tasks.*

## 4.2 Software-based Domain Requirements Analysis

Software-based domain requirements are interconnected with the technical hardware features of smart glasses. For instance, a camera can be used as a barcode reader with the correct software-based implementation. Software-based implementations extend the application area of smart glasses based on the technical functionalities. The following SB-DRs cover the main software-based aspects and do not purport to be complete. In use cases of the logistics domain, which is a promising field for the adoption of smart glasses, one major issue was the possible distraction through the devices, which could lead to accidents e.g. with persons who drive a forklift or a truck. This aspect is not specifically critical for monocular smart glasses like the Vuzix M100 or the Google Glass, but can be an issue on binocular smart glasses with a see through display such as the Vuzix Blade 3000. As we could expect more see through, binocular smart glasses in the future, we decided to respect these concerns in **SB-DR 1**: *A modelling language for process visualisation on smart glasses should support concepts for the definition if distractive visualisations are allowed.* Because of the diversity regarding the information provision possibilities of smart glasses, we argue for a detailed definition of these content types, which should result in a suitable visual representation in the user interface. Further different forms of the information provision e.g. FAQ or checklists have to be considered. Graphical concepts are included in **SB-DR 2**: *A modelling language for process visualisation on smart glasses should support concepts for the detailed definition of content types and their different shapes.* The effective implementation of the new technology of smart glasses can lead to an improvement of the process information, if the users have an interface for the reporting for improvements, for the documentation and verification for processes and for the monitoring of processes [Ni17]. These concepts are defined in **SB-DR 3**: *A modelling language for process visualisation on smart glasses should support concepts for the monitoring and documentation of processes with the aid through smart glasses for a better collection of ideas through improvements.* Smart glasses applications should support the provision of optional, contextual information for the user during the process execution [Ni17], [Ni16]. Additional context information can be simple text, pictures, videos, checklists or FAQs. Particularly for untrained labour or sectors of industry with a high labour turnover rate, smart glasses can be a significant learning and support tool, if all possible information is detailed, optional for the labour anytime available [St16]. Contextual information concepts are considered in **SB-DR 4**: *A modelling language for process visualisation on*

*smart glasses should support concepts for the provision of additional information for the smart glasses user, who can request these optionally.* The identification of objects is important to start new processes or to verify process steps. The smart glasses camera allows an identification and verification of objects on the software side e.g. with a Barcode or QR-Code reader. More powerful smart glasses can use computer vision to identify objects without any necessary additional identification number. The software-based identification supports **SB-DR5: A modelling language for process visualisation on smart glasses should support concepts for the software-based identification of objects with the usage of the camera.** The software-based communication system can have different facets, e.g. push messages, text messages via e-mail, audio messages or video-based remote systems. The diversity of communication systems is mention in **SB-DR6: A modelling language for process visualisation on smart glasses should support concepts for the declaration of communication types in the process.**

#### 4.3 Decision Modelling Language

Several reasons exist for the choice of BPMN as a suitable modelling language to be extended. Firstly, the BPMN is a standardized construct, actively being maintained by the Object Management Group (OMG). In addition, the meta model of the BPMN explicitly allows extensions and provides elements as support [OMG18]. Further, the BPMN has evolved as a standard for process modelling and has reached a wide dispersion in the process modelling domain [Re10]. Thus, many different modelling tools exist in the market, whereof a big part is freely available. Besides, the BPMN has an effective interchange format with the XML. The last mentioned points are crucial for a model-driven approach, since an implementation of the conceptualized extension in an open source-modelling tool poses less effort in contrast to a completely new development of a modelling tool. The transformation of the graphical representation of a model in an XML document is the main link between a model and the corresponding smart glasses-based information system. Additionally, we can use the already modelled use cases in BPMN from the previous research project for a direct comparison. Overall, the choice of the corresponding modelling method leads to BPMN due to the mentioned points.

#### 4.4 Smart Glasses-based Domain Ontology

Because BPMN is suitable for our approach, we created a specific domain ontology as intended in the development method. A domain ontology for smart glasses-based process visualisation represents the main concepts in the domain and relates to BPMN concepts. We used the representation of OWL as recommended in [BS14]. The evolved ontology is shown in Figure 3. To reduce the complexity, we focus on the BPMN core concepts identified in [Re10]. These are the process flow, activities, start/-end events, pool and data-based XOR. Further, we include the concept of events and data objects in general.



These basic BPMN concepts are highlighted in grey. The mentioned concepts are represented in the smart glasses process ontology. An exception are pools and thus lanes. These concepts are not included in the ontology, because the focus lies at the smart glasses user. The user should interact with the smart glasses and can use e.g. communication activities during the process execution for an organisational comprehension. Parallel split and a synchronisation are not included as concepts, since the smart glasses user should only focus on one task during process execution [Me17].

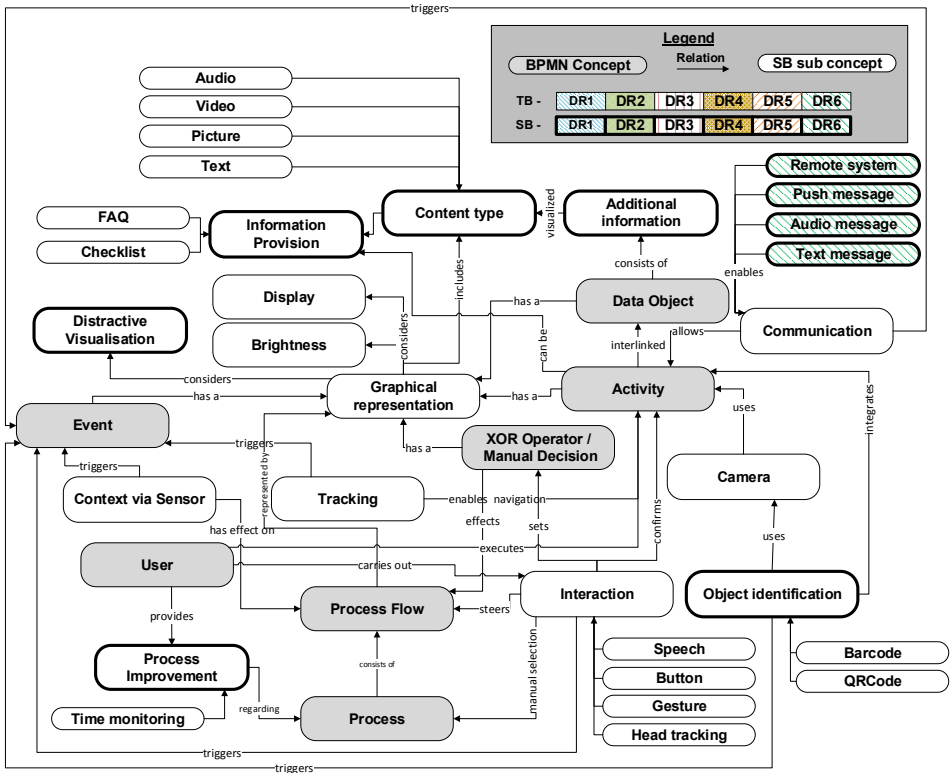


Fig. 3: Smart Glasses-based Domain Ontology

The DRs tracking (TB-DR1), interaction (TB-DR2), object identification (SB-DR5), communication (TB-DR6), information provision (SB-DR2) and camera (TB-DR4) have a close relation to the concept of activity. Further, most of them can trigger events as well. The sensor, scan and speech events are covered by the uBPMN of Yousfi et al. [Yo16] and are suitable for a smart glasses-based BPMN extension as well. A perceived context via sensors can trigger events also and can have an effect on the process flow. For instance, the sensor start event can trigger the process execution. These domain concepts represent TB-DR5 in the ontology. The user carries out interactions that steer the process flow (TB-DR2). Moreover, the user can control the process flow with manual decision at XOR operators. The process flow is represented adequately through a

graphical representation of the edges and the further notation elements (**TB-DR3**). Further, each process element and the process on the whole should support concepts for a graphical representation such as the content type, display size and brightness (**TB-DR3**, **SB-DR2**). The permission of distractive visualisations is considered in **SB-DR1** and has a close relationship with the graphical representation. A time monitoring concept, which refers indirect to the process flow and the option for process improvements by the smart glasses user are integrated (**SB-DR3**). Lastly, a concept for additional optional information for activities should be supported (**SB-DR 4**). The additional information can be understood as data objects, which can be added to the actual activity and contains different content types. The camera enables the object identification. An activity integrates the object identification concept directly because the user has to view aware onto a barcode or QR-code (**SB-DR5**). The smart glasses communication system enables software-based communication systems in different forms (**SB-DR6**). The additional software-based sub concepts declare superordinate concepts and can be more expanded e.g. information provision with sub concepts checklist and FAQ.

#### 4.5 Element Equivalence Check

An element equivalence check ensures that no smart glasses concept will be implemented in the new domain-specific BPMN extension that would already be covered semantically by the standard BPMN. Therefore, we use the comparison rules by [BS14]. A classification occurs in equivalence (E), conditional equivalence (CE) or no equivalence (NE). Table 1 shows the results. The concepts from the smart glasses process visualisation ontology are semantically compared with the BPMN concepts. If a concept is not covered sufficiently by the standard BPMN, we suggest an extension as a new graphical element or attribute. The highlighted concepts in grey are not covered, because they are per se equivalent with BPMN concepts. We identified 14 extension requirements, where no equivalence between the domain and BPMN concepts exists. In the research method no hint regarding the graphical or attribute declaration is given [BS14], therefore we decided for a graphical extension for specialized and for an attribute extension for general concepts. We proposed a graphical extension for the seven derived smart glasses functionality activities and equally for the five event types. The main intention is a better visual comparison between modelled smart glasses-based processes with additional graphical elements. Further additional elements allow for a more precise technical interpretation. Five domain concepts are conditionally equivalent with BPMN concepts. The concepts manual decision, additional information and general process visualisation are represented through attributes as extension format. The manual decisions need a specification regarding the steering options for the selection. The additional information is conditionally covered by the Data Objects, but this causes appropriate definition attributes for the representation format to be missing, e.g. checklist, image, video or text. General visualisation concepts regarding the process or each notation element itself, e.g. covering the display size or brightness, should be

covered by new attributes. The communication concept is conditionally equivalent with the activity or event concept. For instance, BPMN already has a start message or send task. We argue for a graphical extension to differentiate between communication systems enabled by the smart glasses and external communication systems, which can be symbolised by the standard BPMN.

DR	Domain Concept	BPMN Concept	Equal?	Extension Format
TB-DR1	Activity and event support by the tracking concept	Activity Event	NE NE	Graphical Graphical
TB-DR2	Interactions steers the process flow, can trigger events and confirms activities.	Process flow Event Activity	NE NE NE	Attribute Graphical Graphical
TB-DR2	Manual decision trough the input via interactions	XOR Gateway	CE	Attribute
TB-DR3	Visualisation of the process, brightness and display size	Process flow Notation elements	CE	Attribute
TB-DR4	Camera to take pictures or videos	Activity	NE	Graphical
TB-DR5	Context via sensor	Event	NE	Graphical
TB-DR6	Communication	Activity Event	CE CE	Graphical Graphical
SB-DR1	Distractive Visualisations	Process Flow	NE	Attribute
SB-DR2	Information provision Content type	Activity Activity	NE NE	Graphical Attribute
SB-DR3	Process Improvements	Process	NE	Attribute
SB-DR4	Additional Information	Data Object	CE	Attribute
SB-DR5	Object identification	Activity Event	NE NE	Graphical Graphical
SB-DR6	Communication system	Activity	NE	Attribute

Tab. 1: Element Equivalence Check and Extension Format

## 5 Model-Driven Architecture

Frank et al. suggest a better integration of modelling tools into information systems towards a comfortable, user-friendly adaption of software systems as a future scientific research topic in information systems [Fr14]. We address this point with a concept of an effective integration of the process models through a model-driven approach [Tr07], which allows an automatically generated process visualisation on smart glasses. The model-driven architecture is depicted in Figure 4. The BPMN extension for the smart glasses-based process domain is used for a model-driven approach. The example process from Figure 2 is modelled in a modelling tool with an extraction from the concrete syntax of the BPMN Extension. The modelling tool generates a domain-specific XML File that is in the process stack after an upload. A process interpreter reads the process files and activates the process into a trigger system. The user triggers through voice commands, manual selections or an object identification the chosen process from the process stack. After that the process gets interpreted by the process interpreter and delivers the process visualisation in runtime through a software-based call of different

subsystems that are interlinked with the notation elements e.g. the navigation activity calls the navigation subsystem.

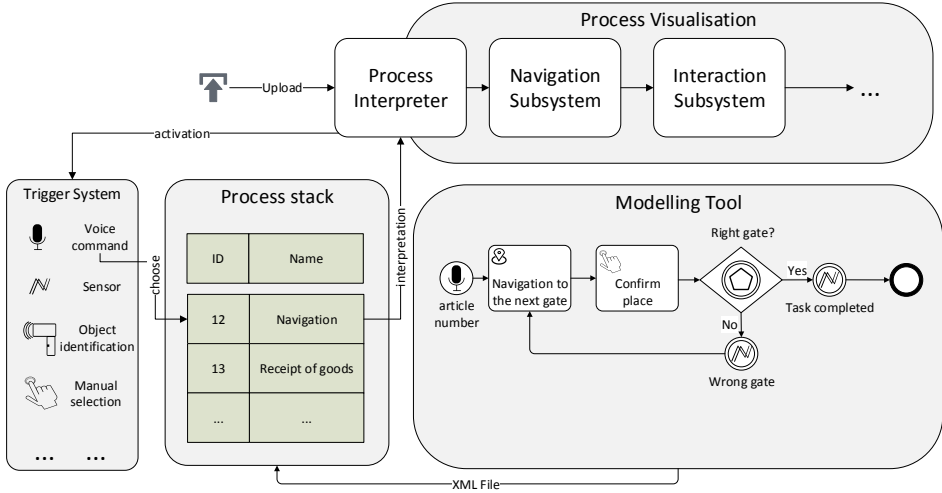


Fig. 4: Model-driven Architecture for Smart Glasses-based Information System

## 6 Conclusion

We propose a new concept for the documentation and implementation of smart glasses-based processes. In an initial state, we emphasize the relevance of a domain-specific smart glasses-based process visualisation modelling language. A BPMN extension for the domain of smart glasses should lead to enhancement of documented processes. The combination with a model-driven approach can improve the usage of the processes. The development of the specific BPMN extension with the method by Stroppi et al. [SCV11] have to be further investigated. In this paper, we performed and presented the first part of a development of a smart glasses-based BPMN extension. We identified 19 extension requirements for a BPMN extension in the smart glasses domain. In a next step, the actual extension method by Stroppi et al. [SCV11] will be realized and the extension requirements are implemented at the meta model level and also as a concrete graphical syntax in a modelling tool. Lastly, the link between the modelling tool and model-driven architecture for smart glasses-based information systems has to be conceptualized and implemented. Further investigation topics would then include an evaluation, if the new graphical syntax and properties are practically necessary and can lead to an improved technical documentation of the processes. An evaluation with smart glasses experts with knowledge in the process-modelling domain can further explore the advantages of the model-driven software development approach within a domain-specific BPMN extension for smart glasses. In addition, further iterations are essential to strengthen the developed BPMN extension for smart glasses-based processes.

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