Towards augmented reality applications for it maintenance tasks based on ArchiMate models

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Abstract

Augmented reality permits to embed virtual objects in the real environment to enhance the perception of users. In this paper, we describe an approach for embedding conceptual models using augmented reality in IT maintenance scenarios. It is based on the ArchiMate modeling language that has been extended with the goal of bridging the gap to models for physical environments. This allows, for example, to guide users in IT maintenance tasks by displaying necessary information originating from the models in the real world. The approach has been implemented on a novel metamodeling platform, which natively supports augmented reality scenarios.

Keywords

Augmented Reality, Physical Modeling, ArchiMate, Maintenance, IT Infrastructure

1. Motivation

Augmented reality (AR) is used today in many domains, ranging from medicine, video games, education, and many others [1, 2]. Recent use cases include personal information systems, industrial, military and medical applications, AR for entertainment, or AR for personal workplace areas [3]. In AR, electronically generated information is superimposed onto objects in the real world using devices such as head-mounted displays, smartphones, or tablets. The use of conceptual modeling for augmented reality has so far been investigated in various domains [4]. This includes for example maintenance tasks or training, e.g., to create augmented reality applications using model-driven engineering, or to fuel knowledge from conceptual models into AR environments, e.g., by using ontologies for reasoning about the perceived environment [5]. Although it has also been explored how AR can support physical IT operation and maintenance tasks – such as removing cables or other hardware components [6, 7] – a mapping to the domain of *enterprise architecture* (EA) is missing. Thereby, enterprise architecture stands for the model-based representation of the interplay of an enterprise's organizational structure, processes, information systems, and infrastructure [8]. EA is widely used today in organizations to support decision makers in business-IT alignment projects. Typical use cases include the design and management of an organization's IT landscape, for business continuity planning to ensure resilience in the event of outages or failures in IT systems, or for migration planning for introducing new IT applications or components in an enterprise.

According to a survey by Roth et al. [9], information about enterprise architectures has

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been represented in the past primarily using text, graphs, charts, as well as 2D and 3D models. This includes also the representation using augmented or virtual reality devices for displaying conceptual enterprise architecture models in 3D space, e.g., to support decision making [10].

However, what is missing so far is a link between the high-level view of an enterprise architecture for supporting business operations via IT, i.e., the conceptual models, and the low-level view of physical IT hardware components. Integrating these two perspectives would enable maintenance tasks at the physical layer to be supported by knowledge from higher layers. This could be useful, for example, to trace problems in IT applications back to the physical environment, such as an incorrectly connected cable. Such a link could be beneficial not only for professional IT operations, but also for consumer use cases, for example, when having to connect devices in smart home scenarios.

In the following, we propose a first approach to bridge enterprise architecture models on the technology layer using ArchiMate notation with models of physical IT hardware components, thereby adding details to the enterprise architecture information to fuel it into real-time augmented reality supported work scenarios. This is achieved through an intermediary layer that acts as a facilitator for transitioning from the high-level view used in enterprise architectures to the level of physical components.

2. Model-based AR for it maintenance tasks

As shown in Figure 1, our approach is based on three layers. At the top layer, traditional enterprise architecture models in ArchiMate notation are used. These may be connected to other ArchiMate models, e.g., for specifying IT services on the application layer, which in turn support particular business processes on the business layer. On the intermediate model layer, a first transition towards physical models is described.

The information from the enterprise architecture needs to be mapped to a conceptual repre-

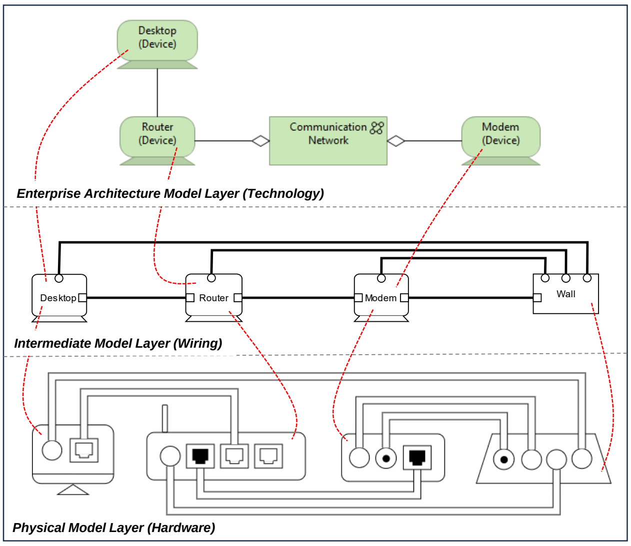

Figure 1: Layers for transitioning from *Enterprise Architecture* models using *ArchiMate* technology concepts to *Physical* models via an *Intermediate* layer

sentation that focuses on abstract physical devices and their connections. Thus, for example, the concept of a *communication network* on the EA level needs to be translated into network components and cables for connecting them. Finally, at the bottom layer, a model of the actual physical devices is shown. Here, the concrete devices with the detailed positioning of their ports are shown. Depending on the goals of the intended AR application, further details on coordinates or markers may be added on this layer to permit the positioning of virtual objects in the AR environment.

Figure 2 shows an excerpt of the integrated metamodel for our approach. It features three different types of diagrams corresponding to the three model layers, cf. Figure 1, classes, and relationclasses, as well as references between the layers. Due to limitations of space only a subset of concepts is shown here. As an example of references between layers, traces between the *Device* class on the enterprise architecture model layer, on the intermediate model layer and the concrete manifestations on the physical model layer are depicted. This highlights how high-level concepts from the EA perspective need to be mapped to concrete physical devices on the bottom layer.

In the example, the device needs to be specialized into either a PC, Switch, Modem, or Wall concept on the physical layer. Thereby, the Wall concept has been introduced as an additional concept only in the intermediate model layer, as it is necessary for the physical operation, but has not been part of the models at the EA level.

3. Implementation and preliminary evaluation

The approach has been implemented using a new metamodeling platform based on [11], which is currently under development, and aims to natively embed model information into augmented

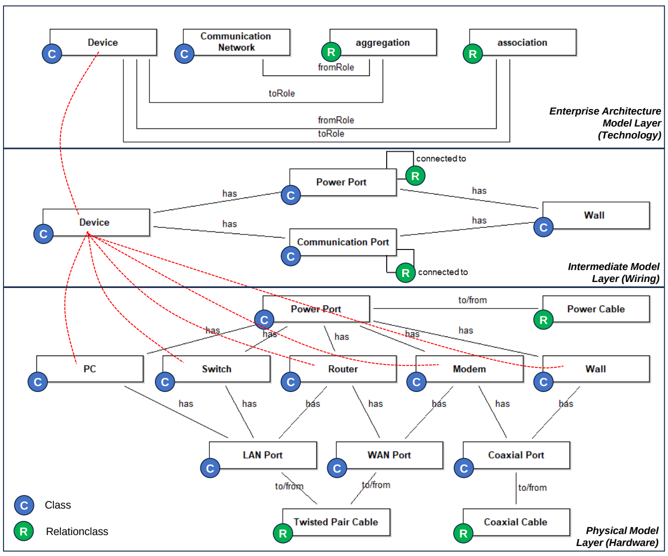

Figure 2: Excerpt of the *Integrated Metamodel* showing *Classes* and *Relationclasses* on the *Enterprise Architecture* model, the *Intermediate* model, and the *Physical* model layer and an exemplary inter-layer reference for *Devices*. The three *Metamodels* correspond to the three *Layers* introduced in Figure 1

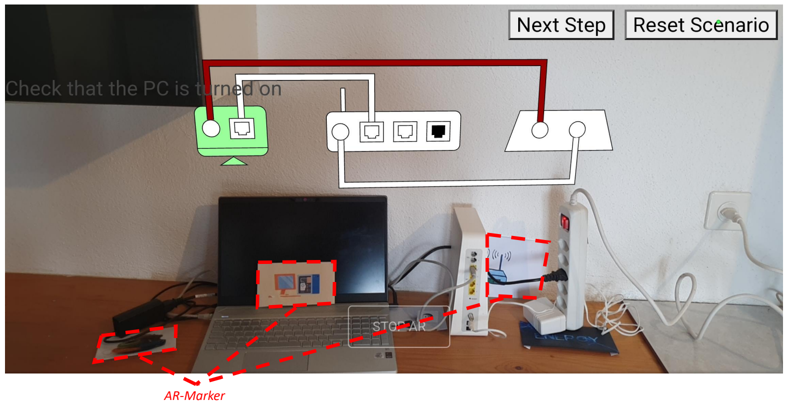

Figure 3: Resulting Augmented Reality application showing the embedding of the *Physical* model, recognized AR markers for detecting the current scene and hints for the next steps to be performed.

reality environments using the W3C WebXR proposal [12]. In particular, three scene types have been created that contain the concepts from the metamodels shown above. All classes and relationclasses have been complemented by a corresponding graphical specification. As shown in the exemplary prototype application, this permits to visualize for example, the information from the physical model layer directly in an AR environment, as well information from connected models – see Figure 3. In addition, mechanisms have been added to guide the user through different steps by checking the properties of the models. This is depicted, e.g., in Figure 3 by the red visualization of a connection between two devices.

Based on the implementation of the metamodels and a separate rudimentary prototypical application[1], it was possible to evaluate the approach in four usage scenarios. These included scenarios such as fixing a broken Ethernet cable, the interruption of a network connection to a network attached storage (NAS) due to a malfunctioning Ethernet port, an unplugged coaxial cable that caused a missing internet connection, and a broken LAN port on a desktop PC. All scenarios were first modeled in ArchiMate notation to represent the general architecture components and their conceptual linkages. Subsequently, the intermediate and physical models were added. In addition, a BPMN diagram was elaborated to specify possible resolutions of malfunctions that could be applied to all scenarios. With the help of the prototypical AR application, the models could be displayed on a WebXR compatible tablet and embedded directly in the user's view based on recognized markers, which acted as surrogates for a full object detection.

4. Conclusion and outlook

In this paper, we could briefly describe our vision towards model-based augmented reality applications using information from enterprise architecture models. In particular, we highlighted how an intermediate layer may help to transition to actual physical models that depict how the information from high-level enterprise architectures maps to the real world. In the current state of the modeling platform, the processing of multiple models is not yet supported. Future work will include the integration of the processing and visualization of the created models directly in

[1]Available on: https://zenodo.org/record/7889218

the modeling platform, as well as the addition of functionalities for reasoning about the current state of the environment for displaying the necessary model information [5].

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