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An Android Tablet Tool for Enterprise Architecture Modeling in Small and Medium-Sized Enterprises

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Abstract. Enterprise architecture (EA) is used to improve the alignment of different facets of a company. The recognition for the need of EA in small and medium-sized enterprises (SMEs) has recently risen as a means to manage complexity and change [1]. Due to the specific problems and characteristics of SMEs, a different approach is necessary. CHOOSE was therefore developed as an EA approach focused on and adapted to the characteristics and needs of SMEs [2]. During case studies performed with CHOOSE, the need for software tool support became apparent. This paper describes a mobile software tool in support of the CHOOSE approach that should guide the CEO as enterprise architect throughout the entire EA process and facilitate the implementation, management, and maintenance of the resulting EA model. The generic development decisions make this software tool widely applicable for a multitude of models. Finally, evaluation in two Belgian SMEs is presented.

Key words: Enterprise architecture, small and medium-sized enterprises, CHOOSE, Android tablet software tool

1 Introduction

If you are about to build or rebuild a house, you will probably appeal to an architect to make sure the house fits your needs both structurally and functionally. The same can be said when starting, running or growing a business. An enterprise is a complex system of people, knowledge, fixed assets, projects, processes, and many more brought together to fulfill a common shared vision [3]. Enterprise architecture (EA) can help to guide this process and consists of principles, methods, and models to achieve its main objective, which is a coherent and consistent organizational design. Originally EA was focused on IT and its alignment with the business side. However, over the years the concept has grown into a much broader technique and is applied across the borders of IT and the alignment is therefore sometimes called enterprise coherence [4]. Although a lot of research is being done on EA, hardly anything is known about its use in the context of a small and medium-sized enterprise (SME) [5]. Some have pioneered in this field of study through the development of an EA

approach adapted to the specific needs of this target group called CHOOSE (section 2.1) [2,6]. The application and implementation of EA in general and the CHOOSE approach in particular, has proven to be a complex and challenging task. Though these techniques could offer significant benefits to SMEs, hardly any SME uses EA and adoption is far below par [1,7]. Analysis of widely accepted adoption models like the technology acceptance model (TAM) [8] and the method evaluation model (MEM) [9] has shown that software tool support could significantly contribute to solving this paradox [2]. The research question of this paper is a design science [10] question: "How could such a software tool in support of the CHOOSE metamodel and method be developed?". This software tool guides the SME's CEO in his function as enterprise architect throughout the EA process and facilitates the implementation, management, and maintenance of the resulting EA. Evaluation by means of case studies in two Belgian SMEs provides the necessary proof of both the importance and efficacy of the software tool. This evaluation process was further used to provide valuable insights and measurements for the evaluation of the efficacy of the developed software tool.

In section two, a short introduction on EA and its applicability in SMEs is discussed after which the need for tool support in this area is illustrated. The third section elaborates on the development of the tool itself and explains the design and development choices. The fourth section elaborates on the evaluation of the software tool. Finally, the paper ends with a conclusion and future research directions.

2 Enterprise Architecture Software Tool Support

EA is employed to improve the alignment in companies. If we look at the term architecture it is clear that it is not without ambiguity [3]. A definition of architecture is given by IEEE Computer Society [11] and is described as "the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principle guiding its design and evolution". Multiple frameworks, models, and tools to create the structure of these components and their relationships exist. Examples of software tools currently in use include Rational System Architect [12], Aris [13], and QualiWare [14]. The drawback is that these tools are not disposing of analysis tools [15], nor are they supporting the CHOOSE metamodel, or are they adapted towards an SME target group.

2.1 CHOOSE for EA in SMEs

The current EA tools are primarily targeted at large enterprises. This focus is hard to justify since SMEs comprise up to 99.8% of all firms in the European Union while globally they account for 99% of business and 40% to 50% of the gross domestic product [16,17]. One of the major causes preventing the growth of SMEs is the lack of business skills [1]. Other than business skills, SMEs lack specialized IT knowledge and technical skills [18]. SMEs are constantly busy dealing with day-to-day business,

leaving them little room for strategic issues [19]. Bernaert et al. [2] derived several requirements from these SME characteristics.

To manage the change and complexity in smaller enterprises, using EA could be a good solution [1,2]. In this light, the CHOOSE metamodel for EA (Fig. 1) is being developed based on the defined requirements for EA and SMEs [2]. CHOOSE is an acronym for "keep Control, by means of a Holistic Overview, based on Objectives and kept Simple, of your Enterprise", incorporating these requirements in its name. The CHOOSE metamodel addresses the specificities and problems SMEs face by creating an overview of the business architecture layer of EA, including elements from the information systems and technology layer. Four dimensions are distinguished to create this overview. A strategic goal dimension (why), an active actor dimension (who), an operation dimension (how) and an object dimension (what). The creation of an EA model in CHOOSE involves creating specific entities of the four dimensions and modeling the relationships between them.

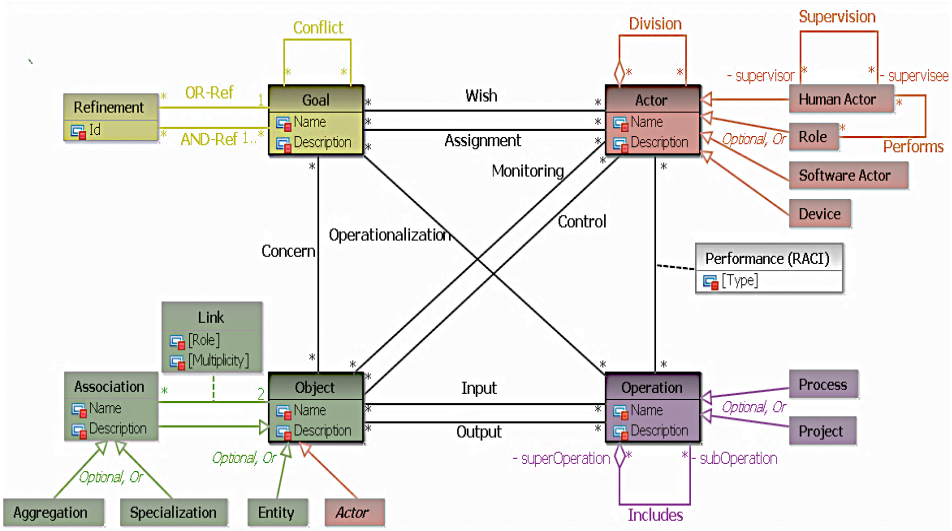


Fig. 1. CHOOSE metamodel [2]

2.2 Need for Software Tool Support

Despite the customized EA approach offered by CHOOSE with its intrinsic qualities aligned with the characteristics of SMEs, it is also very important to take the adoption of the approach into account. Techniques that are technically superior or fully customized to the needs of the user will not yield the expected benefits as long as the techniques are not effectively used in practice. To help optimize, facilitate, and speed up the adoption process, Bernaert et al. [2] investigated different adoption models and proposed the MEM [9] to evaluate the CHOOSE approach. MEM supplements the widely used TAM [8] to be better applicable for the evaluation of methods. MEM provides a model that helps discern external factors and their impact on the attitude,

evaluation, and behavior of practitioners towards the adoption of IS methods, such as EA. Central determinants in this model are perceived ease of use and perceived usefulness. The conviction of the end-users that the information technology will help them better perform their job relates to the perceived usefulness. Perceived ease of use alternatively deals with the amount of effort and time needed to learn how to work with it. Both aspects influence the attitude towards the method and subsequently the behavioral intention to use. Crucial for the adoption is that the increase in performance is perceived as being of higher influence to adoption than the effort necessary to learn the developed technology and work with it [8,9]. Fig. 2 gives an overview of MEM and its main components. The biggest difference with TAM is the introduction of actual efficacy coming from Rescher [20]. This difference is subtle but nevertheless very important. It implies that when explaining human behavior, the subjective reality is often much more decisive than the objective reality and therefore perceived efficacy mediates the impact of actual efficacy on adoption in practice [2].

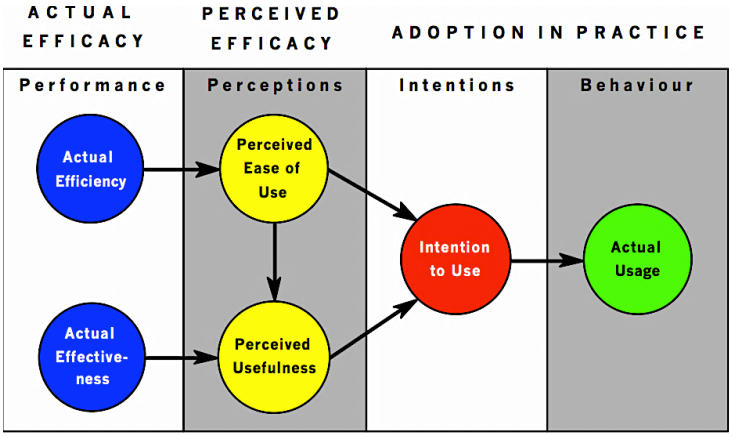


Fig. 2. The Method Evaluation Model

The development of a software tool supporting the application and implementation of CHOOSE could significantly contribute to the actual efficacy, leading to a higher adoption and added value through an increase in the subjective perception of this efficacy. Hence, measuring the perceived usefulness and perceived ease of use of the software tool during the evaluation process (section 4), will provide valuable insights with respect to the ability of this tool to increase adoption of CHOOSE, which reflects the notion of rational selection [20], which states that, generally, those methods or tools will be adopted that outperform others in achieving intended objectives.

Next to the contribution of a tool to the adoption of an approach, research concerning the implementation and use of EA in practice stresses the complexity and need for guidance by means of tool support. In general, there are three main areas where critical problems arise in the process of EA: modeling, managing, and maintaining EAs [21]. An important driver of problems in these areas is the inherent complexity of the EA process [22]. An enormous amount of information has to be transformed using the semantics and syntax of the modeling language. A tool can

offer the much needed support and guidance for the development, storage, and analysis of an EA [22]. This drawback emphasizes the importance of an integrated tool for building, analyzing, and communicating the EA to all stakeholders. Other advantages of tool support include [3]:

- A tool can help to standardize the semantics and syntax used during the development of the EA within a company.
- The use of a tool contributes to the construction of correct and consistent architecture artifacts by guiding the development process and through the application of mistake proofing techniques. Tools can impose rules to make sure the desired practices and guidelines are followed.
- Tools facilitate the comparison of alternatives by providing impact of change and quantitative analysis features.
- Software tools can use computational power for the analysis of the architecture.

Although the aforementioned research confirms the importance of tool support, these findings cannot simply be extrapolated to the environment of SMEs and the importance of tool support for the implementation of the CHOOSE approach. However, case studies performed by Bernaert and Callaert (upcoming paper) confirm this need for tool support. During these case studies, the CHOOSE technique was applied in six Belgian SMEs by means of simple post-its on a whiteboard. The CEOs were convinced of the added value of having access to a software tool supporting this EA process. Fig. 3 shows a small fraction of the resulting EA model and pinpoints the importance of a tool for the development, storage, and analysis of the EA artifacts, since the use of post-its created an unmanageable EA model. The post-its should not be readable due to confidentiality issues.



Fig. 3. Partial EA artifact of a Belgian SME

2.3 Software Tool Requirements

On the one hand, the lack of business and IT skills in SMEs causes the need for user-friendly intuitive ways to model the EA in order for the SMEs to have an overview of the company and to enable growth [1]. On the other hand, we see that in our current society, a new organizational form called the mobile enterprise is rapidly emerging [23]. Defining a mobile enterprise is difficult. In a narrow way, specific mobile solutions are used for specific problems in the organization. In a broad way, mobile solutions can be part of the strategy and are diffused throughout the entire company [23]. The combination of this particular need and the trend of increasing mobility creates a need for mobile applications to model the EA. This can help with the process of becoming a mobile enterprise and can leverage other information technology support systems. The use of the CHOOSE metamodel for such a tool is further supported by the proposition that a software tool should be based on a metamodel and be capable of representing EA information in customizable graphical and textual forms [24]. Further, a lot of companies still use Microsoft Office (29% of respondents) (e.g., Word, Excel, PowerPoint) or Visio (33% of respondents) to model their EA [25]. Export to and import from these Office tools could offer benefits.

Based on these insights, it is safe to say that the development of a software tool adjusted to the specific needs of SMEs, based on CHOOSE and incorporating these requirements could substantially improve the added value of EA for SMEs.

3 Software Tool Development

It was decided to let the software tool resemble as close as possible the use of post-its on a whiteboard to copy the case study process. The graphic processing power of Android tablets was chosen to enable this graphical drawing behavior and adhere to the increasing trend of the mobile enterprise. In the following paragraphs, a generic solution for the development of a software tool for making CHOOSE models is proposed. It is generic in the sense that any framework composed of entity types and relations between them is a possible candidate to be developed in the same way. First, the CHOOSE metamodel is mapped onto a graph data structure and the database model is developed. After this, a possible software design is proposed. During each step, the specificities of developing for the Android platform are explained.

3.1 Representation

The CHOOSE metamodel (Fig. 1) consists of four different types of entities and various possible relationships between them. This structure can be unambiguously represented by a directed graph, where entities correspond to vertices and relationships to edges. Both the vertices and the edges require a type attribute for the graph to be a correct representation of the EA. Furthermore, vertices have a name and a description. In its most basic form, the CHOOSE metamodel can be represented by the relational database model in Fig. 4 top.

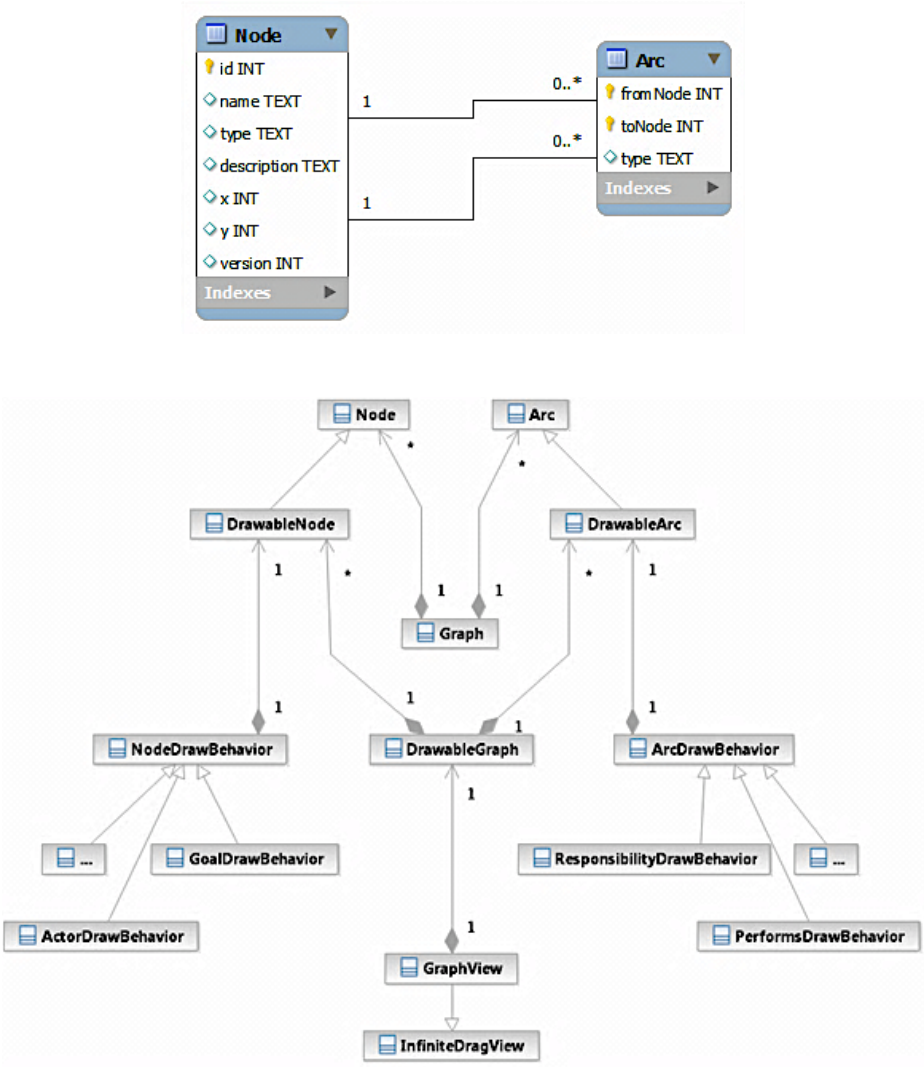


Fig. 4. Database model for a graph data structure (top) & Class diagram of the tool (bottom)

The Android framework offers an abstraction of data in the form of a content provider, which separates the user of the content provider from the backend of the storage. A content provider provides a way to add and manipulate data and is accessible from every application on the Android device. In that way, companies can create their EA in the modeling application and use this database in other applications specifically designed for the company. This could further increase the perceived usefulness of the CHOOSE approach. In this case, the SQLite database management system natively present in the Android framework is used.

3.2 Software Design

The given design allows for maintainability and extendibility of the metamodel as well as the software and is illustrated in Fig. 4 bottom. The basis is formed by the InfiniteDragView class, which allows for an infinitely scrollable field to be shown to the user. The use of this field is extended by the GraphView class, allowing for a graph structure to be shown. The graph data structure is achieved by using a Graph class, consisting of collections Node and Arc objects (Attributes are hidden) [26]. These objects are extended so they have drawing properties in order to visualize them. In that way, the GraphView class uses a DrawableGraph as input.

For the implementation of the drawing of the Nodes and Arcs, the strategy pattern is used [27]. A DrawableNode and a DrawableArc have a DrawBehavior object. All DrawBehavior classes implement the clickable interface. The specific draw behavior is added at runtime. When the GraphView calls the draw methods on the DrawableNode and DrawableArc objects, the DrawBehavior determines how a Node or Arc should be drawn. This depends on the type of Node or Arc but also on the state of this Node or Arc. It can be focused, disabled, pressed or normal. These states are chosen according to the Android design guidelines [28].

3.3 Use of the Tool

The tool is designed to be used on Android tablets but can run on every device running Android 4.0 or higher. It consists of three main panels that can be accessed through a tab interface. In the edit panel, users can create and edit their architecture. The view panel serves for users to adjust the visualization of the architecture. The analyze panel delivers useful output using the earlier created architecture. The view and analyze panels are software tool benefits that were not possible when only post-its and a whiteboard were used. These three panels are further explained with an example of a Belgian SME selling car tires [6]. In this example the tire company has to make sure customers leave safely with the proper tire pressure.

Edit

The users are welcomed in the edit tab, in which the architecture can be created and edited. In this screen, users can add, delete, and change entities and relationships of the architecture. To create a new entity, users need to press on an empty point on the plane. This plane is scrollable by swiping a finger across the screen and zooming is done by making a pinching gesture, both according to Android design guidelines [28]. Users are then subsequently asked which type of entity they want to add, which name it needs to have, and an optional description can be given. This process is done in multiple dialogs, which makes the action to complete more intuitive and clear to the user [29]. The entity is then placed where the user originally pressed. An important object in this SME is obviously a tire. The process of creating a tire object is illustrated in Fig. 5. In the last screenshot four more related objects have been created.

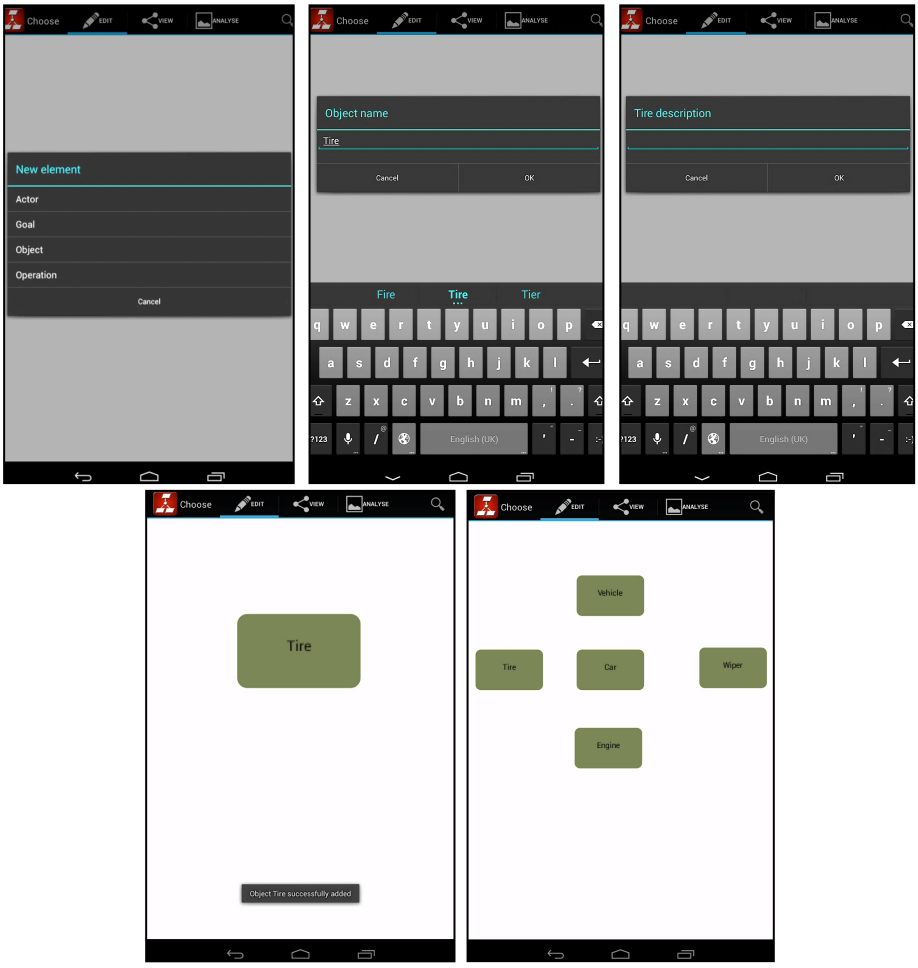


Fig. 5. Creation of entities

Changing the properties of an entity can be done by pressing on it in the edit panel, after which a dialog appears. In this dialog it is possible to change the name of the entity as well as the description. It also offers one of the two ways to create a relationship between different entities. Typing in the “Create relationship with” textbox lets the search function look for matching entities, which are then suggested. This function adds value if compared with post-its on a whiteboard. If different relationship types are possible, a dialog will ask which type it is. A second way in which a relationship can be created is by long pressing on an entity. The user hears a sound and the device will vibrate, which means it is now possible to draw a relationship between two entities. This is a fast way to model small parts of the EA.

In the car tire center example, there exists a composition relationship between the car and the engine and also between the car and the wiper. A specialization relationship exists between the car and the vehicle entity and there is also an

aggregation relationship between the car and the tire. The change dialog and the creation of the relationships are shown in Fig. 6. The relationship between car and wiper is purposely created in the wrong direction and can be reversed or deleted by pressing on this relationship as shown in the last screenshot of Fig. 6.

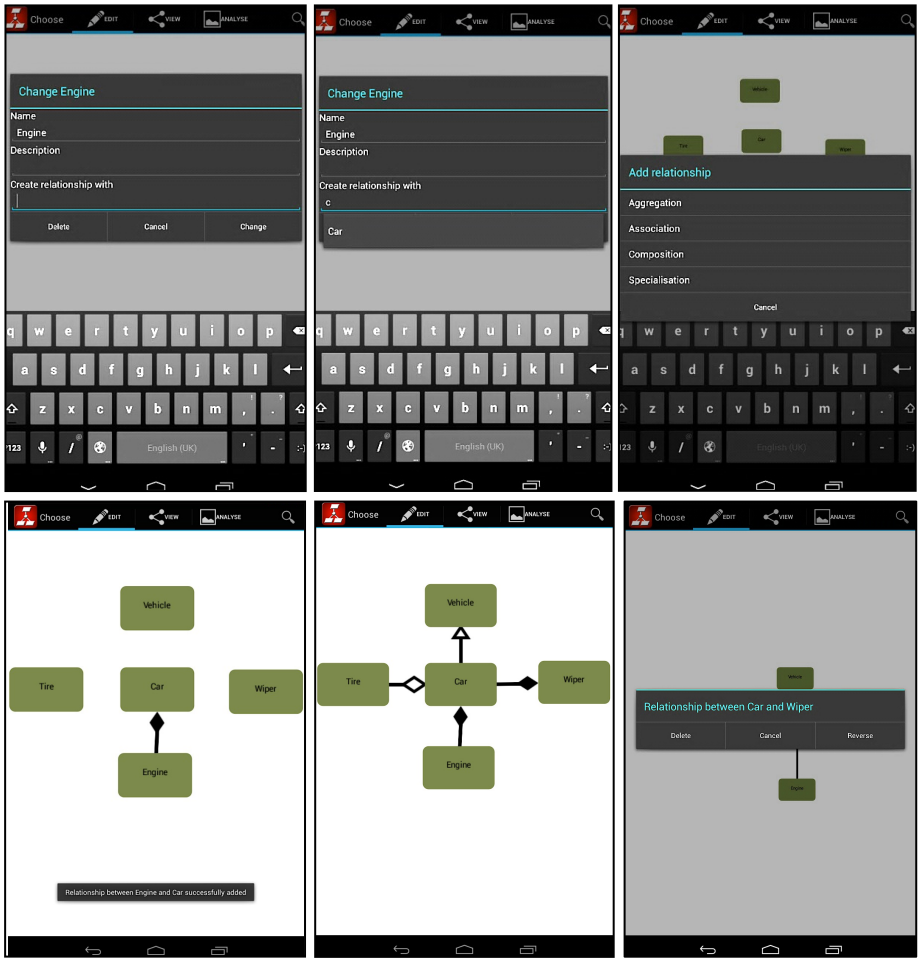


Fig. 6. Changing entities and creating relationships

During the creation, the user can let the application draw the architecture. At the moment, this happens using a force-directed algorithm around the center coordinates of the plane [30]. In its most rudimentary form, all vertex objects in the graph are modeled as point charges that are all exerting a repelling force on each other. The arcs are modeled as springs with a certain length. Letting the system react by computing the exerted forces and moving the vertices leads to a state with at least a local minimum in kinetic energy and an equilibrium in the whole system. The benefit of this algorithm is the flexibility. It allows for users to place certain vertices on fixed positions and additional positioning rules can easily be enforced. The downside is the

fact that the global optimum is not guaranteed. For both small and large architectures, this creates an aesthetically pleasing structure. It must be noted that for larger architectures there is the possibility of a loss of overview on the user's side since entities will be relocated. The possibility to fixate certain vertices can help to prevent this. The process and result for a more complex graph is shown in Fig. 7.

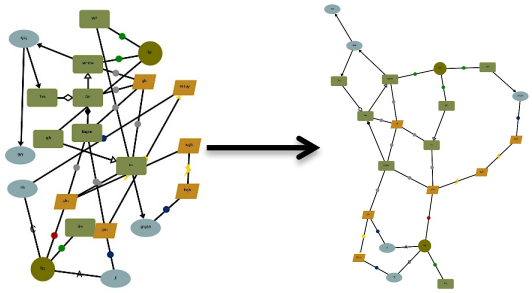


Fig. 7. Automatic drawing of the architecture

View

During the first case study it was clear that the overview is lost very quickly even with the automatic positioning due to the non-planarity of the generated graphs representing the architecture. This problem is tackled by letting users select and isolate entities on which they can work separately in the edit tab. In this way, the user will never have to deal with large unmaintainable structures. It is in this situation that the method to add relationships by typing and searching the related element is the most useful as a lot of entities will not be reachable on the screen. In the tire company example, a few more entities are added such as a safety goal, a customer actor, a process of driving a car, and others. We will isolate the objects to work on them independently (Fig. 8).

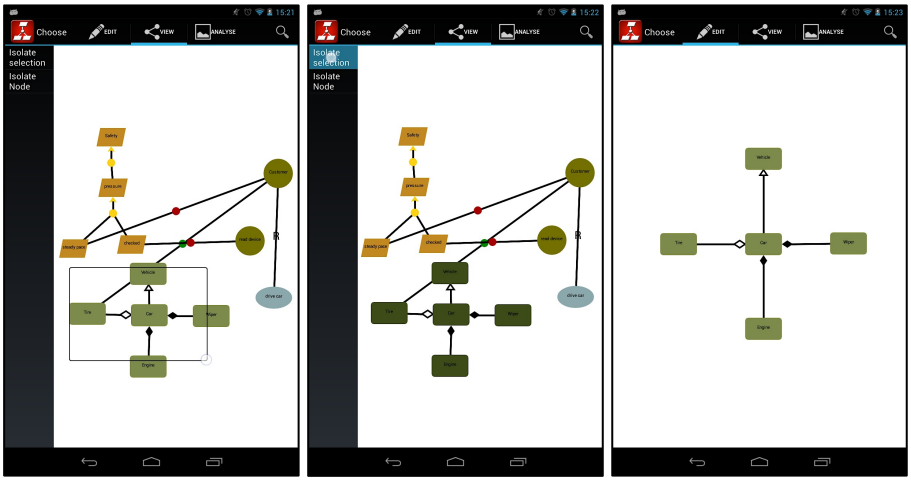


Fig. 8. Isolation of parts of the architecture and changing the visualization

The view panel also allows for multiple viewpoints to be selected, which isolate specific parts of the EA [11]. The goal viewpoint isolates all goals, allowing the generation of a goal tree. The operation viewpoint isolates all processes and projects while the operation flow viewpoint also adds the objects to show possible streams of objects throughout the operations. The other viewpoints are similar (Fig. 9).

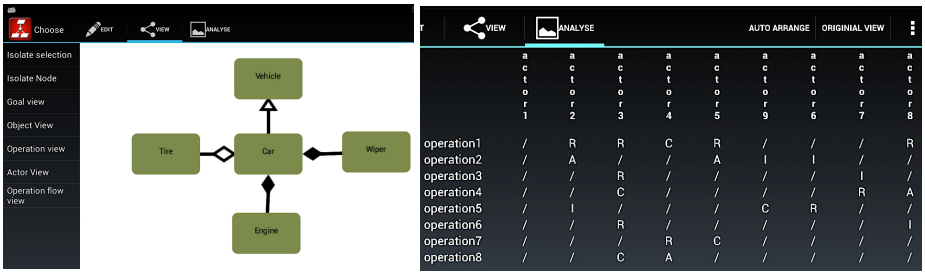


Fig. 9. The view panel (left) & RACI chart (right)

Analyze
The analyze tab is designed to create output for the user. First, it allows the user to generate a RACI chart with export functionality to Excel using the RACI relationships modeled between actors and operations. Second, reports are generated to point out suspicious loops or other problems. Third, it is also the start of an as-is/to-be analysis. Once clicked, users can edit their architecture while the tool keeps track of the changes. This feature is already implemented in the code and saves the changes in the database. The output, as well as indicating that the user is working on the as-is/to-be analysis, however still have to be implemented.

4 Case Studies

Case studies were performed in two Belgian SMEs to evaluate the software tool according to the perceived ease of use (PEU) and perceived usefulness (PU) dimensions of MEM. It was decided to have interviews instead of questionnaires to get the most possible feedback and recommendations on both dimensions of MEM.

4.1 First Case Study

During a first case study at a Belgian chocolate factory, the application was tested by adding elements and relationships during the interviewing process. It was clear that after the creation of just a dozen entities, the overview is lost easily. Very soon, when modeling at an average speed, the architecture becomes a web of entities between which the relationships and the complete structure are no longer clear. This was the incentive for the creation of separate viewpoints so that users could work on parts of the architecture (PEU). The results of the adaptations allowed for faster entry of the architecture (PEU) and let the user make an abstraction of parts of the architecture

that are already modeled (PU). The CEO's recommendations were also the incentive for the as-is/to-be analysis (PU) and the RACI chart (PU), which were implemented.

4.2 Second Case Study

The second case study was performed at a Belgian vendor of window glass. The SME's CEO used the application without any further explanation and the case study led to several useful conclusions. First, although the application is made according to the Android design guidelines, it was not completely intuitive what actions the user can trigger. A tutorial when the application is started for the first time is therefore necessary (PEU). Second, for users to independently create their business architecture, it is necessary that they have an insight in how the CHOOSE model works. This is especially true for users who are not familiar with EA modeling. When the application is started for the first time, a second tutorial explaining the CHOOSE model would be very useful (PEU). A wizard based on the step-by-step guidelines of the CHOOSE method could guide the user in developing a CHOOSE model from scratch (PEU). Third, once the SME's CEO knew how the program works, the business architecture was created without much effort (PEU). The creation of entities and relationships went fast (PEU) and the CEO could fully use his mental ability to create the architecture instead of focusing on how the software works. From this perspective, the implementation of the visual approach was a success.

4.3 Case Study Conclusions

Moody's MEM [9] is proposed by Bernaert et al. [2] to assess the intention to use of CHOOSE, which is positively correlated to the actual usage. The CEOs were asked how the tool could improve their perceived ease of use and perceived usefulness, which are both positively correlated to the intention to use.

Related to the perceived ease of use, the tool was better than using only post-its on a whiteboard, but could be improved by incorporating guidance for the user, like the earlier mentioned tutorials and wizards. The search functionality and viewpoints were already implemented to increase the perceived ease of use.

The perceived usefulness was the part where most of the added value could be delivered by the software tool. This confirms the research of Moody [9] and Davis [8]. The RACI chart with export functionality, as-is/to-be analysis, and some additional viewpoints were already implemented and perceived as increasing the usefulness. Other functionalities could increase the perceived usefulness even more. As a first example, a querying functionality with export to Excel could enable different analyses and viewpoints. A CEO could for example get a list of all employees who are responsible for less than three operations. A second example of a useful functionality is automatically checking the SME's CHOOSE model based on the defined CHOOSE hard and soft constraints. This could deliver interesting insights for the CEO. For instance, an operation (process or project) which is not linked to any goal could then pinpoint a forgotten link in the CHOOSE model that could be added, or could discover operations that are not contributing to any of the company's goals.

Although some additional functionalities could be added, the feedback during the case studies revealed that during the creation of the SME's CHOOSE model, the perceived usefulness was already increased. The CHOOSE metamodel, and thus the software tool whose data model is based on this metamodel, explicitly links goals with each other in a goal tree and also links these goals to operations. This enables explicit traceability from highest-level goals all the way down to operations, which was perceived as very valuable for the SMEs' CEOs. It also triggered critically thinking about the structure of the SME.

5 Conclusion and Further Research

This research has investigated the need for a software tool in support of the implementation of EA in the environment of SMEs as pioneered by the CHOOSE approach from Bernaert et al. [2]. Both literature review and case studies have confirmed this need and the paper presents a software tool in support of this need.

An overview of the main features of the software tool was given and an initial evaluation by means of two case studies has confirmed the potential of the software tool in increasing the adoption of CHOOSE and providing the much needed guidance and support.

The software tool addresses the specific issues SMEs face (time, IT skills, and financial constraints) by being simple, intuitive, and user-friendly. By designing only parts of the EA model at once, users are capable of keeping an overview. Together with the overview users have of their company, the analysis functionalities provide them with useful information and strategic insights. Further, the generic architecture allows for other software tools using metamodels to be developed in the same way as the software tool described in this paper [31].

The case study evaluation in two SMEs revealed more insight in how the software tool helps CHOOSE in increasing its perceived ease of use and perceived usefulness. The case study evaluation was primarily used to get as much insight and as many future research directions as possible by interviewing the CEOs when they were using the software tool. Future evaluation of this software tool in accordance to other software tools or no software tool (e.g., to identify problems arising from a lack of EA modeling experience instead of arising from the tool) could be performed by means of a questionnaire based on the perceived usefulness and perceived ease of use dimensions of MEM through the adapted six-item scales of TAM [8]. This would make the evaluation more rigorous and could dig deeper into the shortcomings of the tool's prototype, like extra features enhancing the overview (e.g., drill down capabilities and extra search functionalities) or possible user-defined customizations to the metamodel (e.g., user-defined properties).

Some recommendations from the CEOs were already implemented and the software tool increased the added value of CHOOSE. Nevertheless, the software tool is still under development and the case studies have identified multiple improvement paths to be tackled. Further research with respect to additional valuable functionalities

is required and continuous fine-tuning will contribute to the overall added value of the software tool in support of CHOOSE.

In this stage, only an Android version of the application exists. The architecture is made in such a way that it can be transferred easily across platforms so that it is available for most of them. A more appropriate future solution could be the development of a web application using HTML 5 in combination with the jQuery JavaScript library. These technologies have the potential to create an application accessible from every device running a browser. It also would make the transfer between different platforms [32,33] easier as users can access their architecture everywhere and it could then also support multi-user use with one common database server. Other areas of improvement include the architecture of the software and the analysis part of the business architecture. The graph structure allows for mathematical analyses generating useful information using straightforward graph algorithms.

The tool will soon be available in the Android Play store. In the meantime the tool can be installed using the following link, leading to the installation file:

https://www.dropbox.com/s/716ecd87jo3n167/BusinessModeller.apk

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