Preprints of the 21st IFAC World Congress (Virtual)
Berlin, Germany, July 12-17, 2020

Towards a Conceptual Framework for Smart Assessment in Organisations

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Abstract: Enterprises are constantly in motion, aiming to evolve through transformations that could allow them to face various challenges. In order to carry out these transformations, there is a need for an objective view of different organisational aspects. Assessments allow to provide this view by covering diverse aspects such as performance, quality, compliance, readiness, etc. However, the assessment process could be expensive since it is often based on a sequence of complex activities that must be carried out by experts or complex systems. On the other hand, the assessment results must reflect the current state of the assessed entity. Hence, there is a need for methods to autonomously adapt the results to significant changes of the entity, and that are be able to use embedded knowledge to provide relevant assessment results. To tackle these issues, this work proposes a Smart Assessment Framework (SAF), a conceptual framework devised to guide the development of smarter assessment approaches based on the integration of capabilities from smart systems to carry out the assessment process.

Keywords: Conceptual modelling, Artificial intelligence, Learning, Reasoning, Evaluation

1. INTRODUCTION

Enterprises face challenges such as mergers, acquisitions, novel technologies, and a highly dynamic market in a daily basis (Proper, 2013). Moreover, in the current digitalisation era, enterprises are becoming cyber-physical (Panetto et al., 2019) by relying on Cyber Physical Systems to carry out operations. This leads to new challenges such as large amounts of data, the need of updated enterprise models, cooperation and collaboration between organisations, or enhanced project agility. To address these challenges, organisations are constantly in motion, carrying out transformation or improvement activities that could allow them to close the gap between the As-Is and the To-Be state of organisational aspects. This motion is directed towards the achievement of different objectives such as standardisation, quality improvement, regulatory compliance, or risk management enhancement. The first step of these motion activities are often based on performing evaluations to reveal the As-Is state (Leal et al., 2020) in order to identify the gap between it and the To-Be.

An assessment is the act of estimating or deciding the amount, value, quality, or importance of a specific entity (Cambridge University Press, 2008). In organisations, assessments are performed to evaluate aspects such as business processes maturity (Looy et al., 2011), enterprise interoperability (Guédria et al., 2015; Leal et al., 2020), or software agility (Ozcan-Top and Demirörs, 2015). Besides the descriptive purpose, based on providing a view of a specific entity, assessments could be also carried out for prescriptive and comparative objectives (De Bruin et al., 2005), the former is focused on providing improvement recommendations, and the latter allows to perform benchmarking between industries or regions. Notwithstanding, assessments are often expensive for enterprises in terms of time and resources (Proença and Borbinha, 2016). The assessment process is composed of a set of complex activities, requiring the participation of expert assessors. It also requires input data describing the assessed entity, which must be gathered and validated during a Data Collection activity. If done manually, it may lead to errors (Cater-Steel et al., 2016) in the assessment results due to possible human mistakes. If done automatically, not all the data that is representative of the assessed entity may be considered by the system in charge of the assessment, deriving into results that may reflect only a partial view of the reality. This issue is accentuated by the current move of enterprises towards digitalisation, which provides large amounts of heterogeneous data produced in real-time that must be considered when performing assessments. The Results Determination activity of an assessment is based on aggregating data and calculating the results (ISO, 2015). The objective of this activity is to provide an objective view (qualitative or quantitative) of the As-Is state of the assessed entity and, if necessary, possible paths to guide transformation or improvement initiatives (Leal et al., 2020). For qualitative assessment, the robustness of the result is highly dependent of the expertise of the assessors. Another challenge inherent to the assessment process is based on the dynamism of the assessed entity; changes of its state must be reflected on the data used to perform the assessment and, naturally, on the assessment results. Hence, in some cases it could be necessary to re-perform some activities of the assessment to reflect the new As-Is state. Moreover, the manner that the assessment results are presented to the decision-makers should be able to be adaptive with respect to their needs.

Considering these issues, there is a need for assessment approaches capable of considering and processing heterogeneous input data, that may be produced in real-time with a high level of dynamism. Moreover, these approaches must be able to use knowledge regarding the assessed entity in order to provide relevant feedback to the decision-makers. This work has the objective to cope this challenge through the proposal of the Smart Assessment Framework (SAF), a conceptual framework devised to serve as base for the development and implementation of enhanced assessment methods through smart capabilities such as reasoning, learning, and data perception. We follow the Design Science Research (DSR) method to design and evaluate the framework following an iterative cycle. The concepts and relationships contained in the framework are represented using the ArchiMate modelling language (Band et al., 2016), which provides means to describe, analyse and visualise the architecture of an enterprise. This is a work in progress, therefore we expect that the framework will evolve in future research through experimentation and the feedback from the scientific community.

This paper is organised as follows. Section 2 describes the related work and the current research challenges that motivate our work. Section 3 presents the proper conceptual framework with a brief description of its elements. Section 4 introduces an illustrative case study devised to validate the framework. Section 5 presents the conclusions of the work and enumerates future research perspectives.

2. RELATED WORK

Several works have pursued to tackle different challenges that rise when executing assessment activities in organisations. Due to the current trend towards digitalisation in enterprises, recent approaches are often focused on tools for automating some of those activities. These approaches aim at applying automation techniques to reduce the need for human intervention during an assessment. The work by Wen et al. (2008), for instance, aimed at automating the Results Determination activity of assessments through the use of a knowledge-based decision support system for measuring enterprise performance. It relies on a knowledge base containing inference rules and it considers a set of weights provided by managers regarding performance metrics to provide the assessment result. The paper by Cater-Steel et al. (2016) follows this path for IT Service Management process assessment. However, it also allows to collect data through online surveys and it provides assessment results by automatically analysing the collected data to measure process capability. The work by Adali et al. (2017) introduced a software tool for Agility assessment based on guiding the assessment through an exemplar assessment process that includes the definitions and the proper guidance to conduct assessments following a reference model named AgilityMod (Ozcan-Top and Demirörs, 2015). On the other hand, the work by Barafort et al. (2018) describes a Software as a Service tool and the process followed to develop it. The tool was devised to aid assessors that rely on the TIPA framework (Barafort et al., 2014), which is a framework comprising a set of methods and tools to perform business process assessment. Most of the works mentioned before are focused on automating single activities of the assessment process without providing fully automated approaches. Holistic approaches are also present in the literature but they are not extended and they are often devised for very specific domains. The tool introduced by Krivograd et al. (2014), for instance, allows to perform maturity assessment based on a generic data model that enables the use of different maturity models for business process assessment. The system is connected to a Business Process Management system, allowing to extract part of the information necessary to perform the assessment, and it provides an assistant function in charge of recommending possible improvements based on the problems identified during the assessment. The approach by Grambow et al. (2013) proposes a similar method for Software Engineering Process assessment, but connecting the tool to event logs and applying process mining techniques (Van Der Aalst, 2011) to automatically pre-process the data and provide results. The tool also allows the users to manually introduce assessment data.

Besides the proposal of automation tools, some works have also aimed at defining frameworks to drive the development of assessment methods, tools, and techniques to improve assessments in enterprises. The work by Gove and Uzdzinski (2013) introduced a framework for assessing the maturity of a system in terms of typical technical performance measures. To validate the framework, the authors provide an illustrative case study based on considering an automobile as a sample complex system to be assessed using the framework. On the other hand, Vásquez et al. (2019) proposed an empirical conceptual framework to assess the awareness of Small and Medium-sized Enterprises (SMEs) regarding the eco-efficiency concept and their capability to implement sustainability strategies. The framework was developed following the DSR methodology and it was validated through an exploratory study carried out on wood industry SMEs. Also regarding SMEs, the work by Žigienė et al. (2019) introduced a framework to assess and manage commercial risk using Artificial Intelligence (AI) methods. The conceptual model, introduced through a workflow, is grounded on the ISO 31000 (2009) standard for Risk Management and it was expanded with AI concepts. The paper also provides recommendations on how to implement the framework. Still regarding SMEs, a conceptual framework for assessing sustainable development in regional SMEs was proposed by Salimzadeh and Courvisanos (2015). The framework includes external and internal factors that affect the sustainability adoption of SMEs within a regional context.

The approaches presented in this section are focused on tackling specific application domains and they assess concrete characteristics such as Process Maturity, Enterprise Interoperability, or Enterprise Performance. On the other hand, the frameworks for assessment in organisations are often devised to carry out manual assessments, without introducing proper elements that consider the enhancement of the assessment process through emerging technologies. Hence, methods based on the exploitation of capabilities such as automatic reasoning or learning are not considered. In this sense, we argue that the use of these smart capabilities could mean a step forward towards the achievement of faster and more robust and efficient appraisals. Therefore, this work aims at defining a conceptual framework to perform smart assessment in organisations.

3. TOWARDS A SMART ASSESSMENT FRAMEWORK

In this work, we follow the Design Science Research (DSR) method (Von Alan et al., 2004). It aims at improving an environment by incrementally developing artifacts following a specific design cycle. The cycle is based on the feedback of the environment, scientific theories, experience and expertise of experts, and meta-artifacts within a knowledge base. We specifically consider the three-cycle view of DSR (Hevner, 2007) to devise the conceptual framework, using international standards and scientific literature regarding assessment and the capabilities of smart systems as source of knowledge within the DSR method.

An overview of the proposed Smart Assessment Framework (SAF) is presented in Figure 1. The framework uses as base a metamodel proposed in a previous work (Romero et al., 2019) and it is strongly focused on a set of smart characteristics defined through a Systematic Literature Review in (Romero et al., 2020). The ArchiMate modelling language is a standard used in this work to graphically describe the elements of the framework and their relationships. ArchiMate is specifically devised for Enterprise Architecture (EA) to aid enterprise architects to describe, analyse and visualise relationships among architecture domains through simple visual representations of architectural elements (Band et al., 2016). We use the language to represent the elements of the framework since it provides means to distribute architectural elements in layers, providing a heuristic view of the architecture of the proposed framework, reflecting the way that the components of each layer are interrelated. ArchiMate distributes the elements in three core layers: the Business Layer, which defines business services, realised by business processes and performed by business actors; the Application Layer, which depicts application services supporting the business and the application components that perform them; the Technology Layer, which describes the technology services and computer, hardware and software systems to provide those services.

Note that in this work we do not design an EA model for a specific organisation, instead we take advantage of the modelling elements and the layer organisation provided by the language to define and organise the elements of the framework. The proposed model focuses on two of the three core layers of ArchiMate: Business and Application. We do not provide elements of the Technology layer, since it ultimately depends on specific implementations in enterprises. We also use the Strategy layer of ArchiMate to represent the drivers, goals and value of the enterprise with respect to the assessment process.

Figure 1 shows the framework composed of three levels: Management Goals (Strategy), The Assessment Process (Business), and Application Services (Application). The first one, from top to bottom in Figure 1, shows that an assessment is a requirement to provide a view of the As-Is state of the assessed entity (value). This goal is driven by the need of an Enterprise to transform or improve.

The second layer within Figure 1 presents the Assessment Process. It analyses an Assessed Entity and it is triggered by a new assessment request or updated assessment data. The process is composed of three main activities: Data Perception, Results Determination, and Results Presentation. It provides an Assessment Result considering data from the Assessed Entity using an Assessment Model, which provides a reference describing the To-Be state of the assessed entity trough a set of Assessment Indicators, and the Measurement Mechanism that is used to measure the gap between As-Is and To-Be. Note that the Assessment Process has one or more individuals acting as responsible.

The final layer in Figure 1 details the elements in charge of carrying out the assessment. It is composed of three main services devised to carry out each activity of the process: Data Perception Service for the Data Perception activity, Organisation Service for the Results Determination activity, and Presentation Service for the Results Presentation activity. This layer is the core of the framework. Hence, the rest of this section is focused on explaining each of these services and their components in detail.

The **Data Perception Service** is carried out by the Perception Manager component. Its main objective is to sense the data to be used for the assessment, prepare it for the proper data processing and providing the prepared data to the Organiser component. Note that, in the scope of the framework, the Assessed Entity constantly produces heterogeneous data, which must be autonomously sensed by the Perception Manager as the Assessment Data. Note that the means to perform data filtering must be also put in place in order to use only the data that is relevant for the assessment.

The **Organisation Service** is the core of the Application layer. It is performed by an Organiser component, which receives the pre-processed assessment data from the Data Perception Service and it distributes it to three components depending on the needs: Reasoner, Measurer, and Learner. The Reasoner fulfils the Reasoning Service, and it uses Knowledge to infer new information regarding the Assessed Entity. Note that part of the Knowledge is an Assessment Model, which defines qualitative and/or quantitative aspects to provide the results of the assessment. The Reasoner is devised for automatically inferring Knowledge through reasoning mechanisms (Baader et al., 2003). For this purpose, it analyses a set of Assessment Indicators within the Assessment Model along with the Assessment Data to infer new knowledge to be provided as part of the Assessment Result. The Measurer, on the other hand, considers the Measurement Mechanism defined by the Assessment Model to calculate and provide quantifiable results. Moreover, if score aggregation is necessary and if some aggregation method is defined by the Assessment Model, the Measurer must be able to perform this task. Finally, the Learner provides the Learning Service based on updating the Knowledge. Often this component is composed of one or more human experts, who learn from the Assessment Data, the Assessment Process, and the Results, and transfer the gained experience to the current

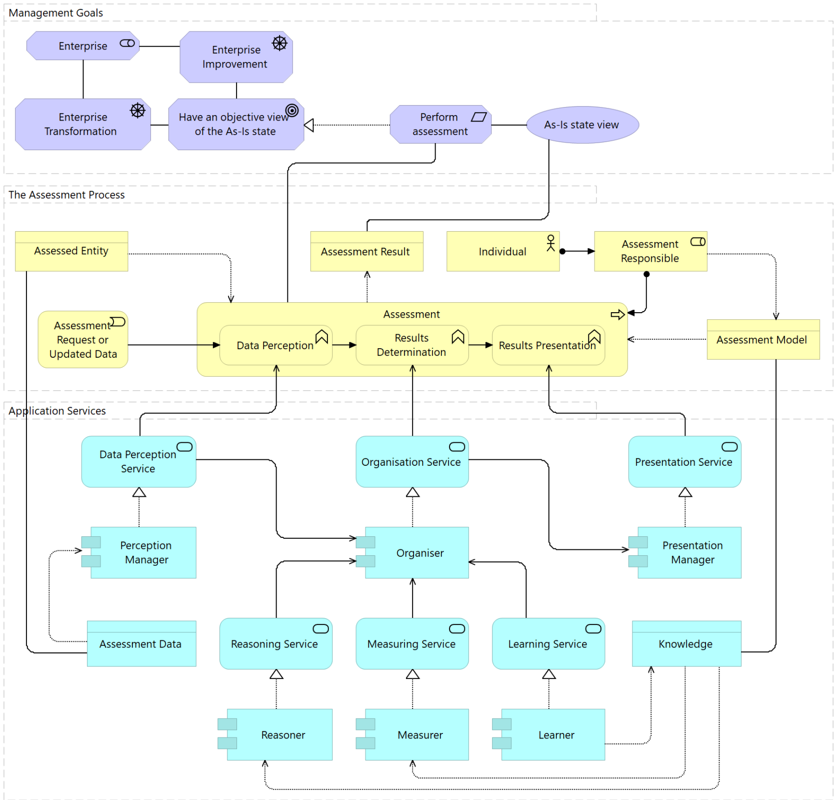

Fig. 1. Conceptual framework defining the components of a smart assessment.

Knowledge representation (the Assessment Model) so as to carry out better assessments in the future. Notwithstanding, we also argue that automatic learning could be performed by dedicated systems, and future research should target to reach a more autonomous Learner Component able to update the Knowledge so as to perform future assessments with more efficiency, robustness, etc.

The **Presentation Service** receives the results of the assessment provided by the Organisation Service and generates a structured view of those results to the stakeholders. The Presentation Manager, which is the component in charge of providing the Presentation Service, should provide a view to the stakeholders that is informative enough for decision-making. Moreover, personalisation is a very relevant aspect of this component, since it is necessary to adapt the results to the profile of the individual requiring those results. In this sense, it is relevant to emphasise the gaps between As-Is and To-Be of the Assessed Entity that are relevant to the stakeholders and how the fulfilment of certain quality or performance requirements to close those gaps may have negative or positive impact on other aspects of the entity.

4. CASE STUDY

In this section we describe an implementation example of the SAF through an illustrative case study. For this purpose, we consider a Business Process Assessment scenario. Specifically, the process to be assessed is regarding Samples Management (SM) process in an enterprise with the objective to have a qualitative view reflected by a capability level and a set of improvement recommendations for the process. First, a brief description of the process is presented. After, we introduce the Assessment Model used to guide the assessment. Finally, we describe a possible instantiation of the SAF. Figure 2 provides a graphical representation of specific elements of the framework used to perform the assessment for this specific case.

The SM process comprises the activities of reception, treatment, destruction, and returning of different types of chemical samples that are used in an organisation. The data describing the process is collected through a series of semi-structured interviews carried out by an assessment team. Since the enterprise suggested to perform the assessment in alignment with international standards, the interviews were based on asking questions guided by an ISO/IEC 15504-330xx (ISO Central Secretary, 2004, 2015) compliant assessment framework named TIPA (Barafort et al., 2009). The TIPA framework provides two main elements: the Process Assessment Model and the Assessment Method. Both correspond to the Assessment Model in the scope of SAF, which includes a set of Assessment Indicators and a Measurement Mechanism defining the method to results calculation.

The Assessment Data is composed of SM Evidence gathered by an assessment team that previously carried out interviews to the actors of the SM. This is the only activity of the assessment that is performed by humans, all other services are automatically provided by software components. The SM Evidence, registered in raw files by the assessment team, is composed of partial conclusions from the assessors regarding each Assessment Indicator and it is sensed by the Perception Service each time the files are updated. In the case study, the Perception Service

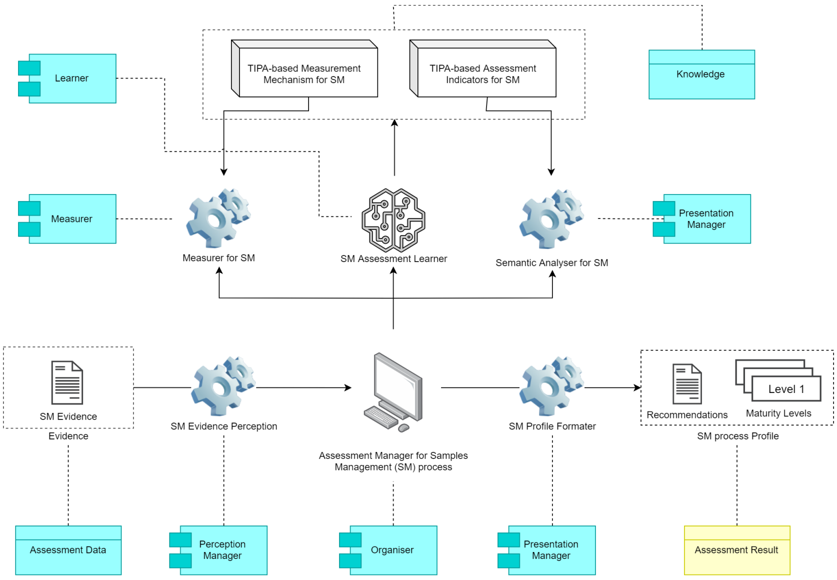

Fig. 2. Implementation example of the SAF for the assessment of a Smart Samples Management (SM) process using the TIPA framework as Assessment Model.

is provided by the SM Evidence Perception from Figure 2, which is an instance of the Perception Manager of the SAF. After being sensed, the evidence is pre-processed and passed to the Organiser component.

The Organisation Service carries out the assessment. For this purpose, the Knowledge is composed of a set of TIPA-based Assessment Indicators, and a TIPA-based Measurement Mechanism that defines the means to calculate ratings for the process and to match the SM Evidence with the Assessment Indicators. This Knowledge is used by three components: the Reasoning System, which in this case study is a Semantic Analyser able to interrelate each element of the TIPA-based Assessment Indicators with the SM Evidence; the Measuring System, which applies the calculations to produce the rating scores for the SM taking into account the results provided by the Semantic Analyser; and the Learning System, which identifies a set of Assessment Indicators that are not often matched to the SM Evidence considering some threshold, these elements are discarded or updated for future assessments. Note that, in this case, the task of the Learner is simplified so as to be fully automated. However, it could also be composed of human experts able to analyse the overall assessment process in order to update the existing Knowledge with more details.

Finally, the SM Profile Formater is an instance of the Presentation Manager. It receives the result provided by the Organiser and formats it to be presented to stakeholders. It provides the rating of the process with capability levels, and a set of final comments in plain text format. Moreover, the interviews carried out by the assessment team could also be recorded and converted into text by the Data Perception Service through the use of Natural Language Processing methods and then be provided to the Organiser to continue the SAF pipeline.

The use of specialised components with smart capabilities could represent an improvement of the assessment process in terms of cost and time. For this case study, analysing the evidence, matching it with the assessment indicators and calculating scores are meant to be performed entirely by the SAF components. Moreover, the gap between As-Is and To-Be could be represented with more fidelity so as to provide high-impact improvement recommendations. Likewise, the presence of a Perception Service able to sense changes in the data describing the assessed entity allows to provide real-time results. Note that technical implementation aspects are strongly dependent on the type of Assessment Data to be perceived by the Perception Manager and the Assessment Model that is used. Future work will focus on this aspect in more depth.

5. CONCLUSION

This paper proposed a conceptual framework for smart assessment in organisations named Smart Assessment Framework (SAF). The elements of the framework are based on concepts from the scientific literature and international standards. We used the ArchiMate modelling language to visually represent those elements and their relationships through a model that we consider as an artefact following the Design Science Research (DSR) methodology. We validated the framework by introducing an case study describing a Business Process Capability assessment scenario. We linked each element of the framework with specific entities to describe how an assessment could be performed within the scope of the SAF.

Future work will aim at evaluating the flexibility of SAF by devising different case studies beyond the one presented in this work. The case studies could be focused on different characteristics besides Process Capability. We also aim at implementing a prototype to apply the SAF in a real-world scenario in order to show its applicability. It is expected that relevant conclusions will emerge from its implementation, allowing to enhance the SAF towards a definitive version, based not only on theoretical concepts but also on empirical results. Finally, the socio-organisational aspects related to the implementation of the proposed framework will also addressed.

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