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The present work was submitted to
the RESEARCH GROUP
SOFTWARE CONSTRUCTION
of the FACULTY OF MATHEMATICS,
COMPUTER SCIENCE, AND
NATURAL SCIENCES

MASTER THESIS

Towards a Framework for Evaluating the Prudence of Enterprise Architecture Debts

presented by
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Aachen, December 30, 2021

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Acknowledgment

First and foremost, I would like to extend my sincere thanks to my supervisor, M. Eng. Peter Alexander, for allowing me to work on this fascinating topic, for supporting me throughout the entire process of writing this thesis, and for providing valuable feedback, which I will forever be grateful for.

I would also like to offer my special thanks to Prof. Dr. rer. nat. Horst Lichter for his support, insightful comments and suggestions at various stages of this thesis.

Additionally, I would like to thank all members of the SWC at RWTH Aachen University for creating a wonderful working atmosphere during my work on this thesis.

Next, I would like to express my sincere gratitude to all evaluation participants, who agreed to provide their time and feedback, which provided me with valuable insights and allowed me to broaden my understanding.

Finally, I would like to appreciate and cherish the support and encouragement that I received from my friends and my family, especially my husband and my mother. Without their understanding, it would be impossible to complete my study.

Ada Słupczyński

Abstract

Enterprise Architecture (EA) framework was introduced to support the companies in reaching their to-be goals. By combining the overview over the whole company, EA provides a more holistic view of the enterprise. Enterprise Architecture Debt (EAD) is used to describe the deviation of the as-is state of the company from its hypothetical, ideal to-be one. One problem is not all stakeholders involved in the decision making process are aware of EAD, resulting in lacking awareness and understanding of the consequences resulting from the decisions taken. Unawareness of EAD can affect the decision making process such that the decision is taken without considering all required information, which can result in the lack of understanding and acceptance of involved stakeholders. This can introduce additional debt on top of the one caused by a wrong decision. Finally, such debt can result in various, severe to the project or company consequences. It is important that all stakeholders are aware of the debt, its causes, and the possible consequences in order to work with it, as without understanding the underlying root cause, finding an appropriate solution is impossible.

The existing approaches of considering EA Debts focus on identification of the EADs, providing means for discussion about the existence of such debt in a project. Another aspect considered is the prioritization of the debts and consideration which debt needs to be paid back and when. Differentiation of various EADs and smells causing them was studied as well, allowing to identify different measures needed to work with the debt. However, although widely used intuitively, a clear distinction between reckless and prudent debt has not yet been elaborated to our knowledge. Prudence first adapted from Technical Debt Quadrant has the potential to improve the understanding and communication between stakeholders of various technical backgrounds, explaining the need and reasoning behind the decision made. Additionally, it could provide confidence when making an important and complex decision. The distinction of the two debt types could allow to establish organization-wide guidelines, which would ensure that the debt is recognized correctly and that an appropriate action towards it is chosen.

This paper discusses the existing published information on prudent and reckless approaches towards decision making in the context of enterprise architectures by gathering the definitions from related fields by means of a Scientific Literature Review. Additionally, it proposes a framework meant to evaluate the prudence of a debt. The framework is introduced to support the decision makers in gathering the required data, documented and undocumented, to strengthen the argumentation for or against taking the debt. It is also meant to allow to identify appropriate measures, to use when dealing with the debt, in a way that would benefit the enterprise. This in turn can positively affect the quality of the decisions taken, and as a result the quality of the company, by raising the awareness about the deviation of the as-is state from the hypothetical, ideal to-be one.

Contents

1. Introduction	1
1.1. Contributions	1
1.2. Structure of this Thesis	3
2. Related Work	5
2.1. Prudence in the general understanding of it	6
2.2. Prudence in areas close to the EA context	8
3. Defining Prudence in Debt Management	11
3.1. Scientific Literature Review process report	12
3.2. Review result	23
3.3. Proposed definitions of prudence and recklessness	27
4. Framework for evaluating the prudence of Enterprise Architecture Debt (EA Debt)	31
4.1. General requirements	32
4.2. EA requirements	32
4.3. Building blocks	36
4.4. Demonstration	47
5. Evaluation	53
5.1. Methods for evaluation	53
5.2. Results	54
6. Discussion	65
6.1. Research questions findings	65
6.2. Evaluation results	66
6.3. Implications of results to practitioners and researchers	69
6.4. Threats to validity	71
7. Conclusion and future work	73
7.1. Summary	73
7.2. Future Work	74
A. Mindmaps	77
A.1. Prudence	77
A.2. Recklessness	78

B. Transcription of evaluation	81
Bibliography	91
Glossary	103

List of Tables

3.1.	The selection of the databases for the Scientific Literature Review	15
3.2.	Search strategy for the search for prudence	16
3.3.	Search strategy for the search for recklessness	17
3.4.	The selection criteria applied when searching for papers during the performed SLR	17
3.5.	The changes in the number of papers on prudence based on the exclusion criteria	18
3.6.	The changes in the number of papers on recklessness based on the exclusion criteria	19
5.1.	The questions asked during the evaluation of the definitions and framework	55
A.1.	Criteria describing prudence along with the corresponding list of citations and their short descriptions	79
A.2.	Criteria describing recklessness along with the corresponding list of citations and their short descriptions	80

List of Figures

3.1.	Steps performed in the SLR. The numbers represent the number of papers considered, unless stated otherwise on the graph.	14
3.2.	The prudence distribution, depending on the context in which prudence was defined. Others considers fields such as Agriculture, Airline Industry, Artificial Intelligence, Computer Vision, Mathematics, and Psychology. . .	22
3.3.	The recklessness distribution, depending on the context in which recklessness was defined. Others considers fields such as Computer Vision and Psychology.	22
3.4.	The publication years distribution, depending on the searched definition (prudence or recklessness).	23
4.1.	The framework for evaluating prudence. It represents the steps and the data used by the framework. The up and down arrows represent input and output documents respectively.	36
4.2.	The scenario, in which the <i>PEF</i> can be used to support the decision making	48
4.3.	The detailed image of the toy example scenario, in which the <i>PEF</i> can be used to support the decision making	48
6.1.	The framework for evaluating prudence after evaluation. It represents the steps and the data used by the framework. The up and down arrows represent input and output documents respectively.	69
A.1.	The mindmap representation of the criteria related to prudence	77
A.2.	The mindmap representation of the criteria related to recklessness	78
B.1.	Evaluation transcript page 1 of 8	82
B.2.	Evaluation transcript page 2 of 8	83
B.3.	Evaluation transcript page 3 of 8	84
B.4.	Evaluation transcript page 4 of 8	85
B.5.	Evaluation transcript page 5 of 8	86
B.6.	Evaluation transcript page 6 of 8	87
B.7.	Evaluation transcript page 7 of 8	88
B.8.	Evaluation transcript page 8 of 8	89

1. Introduction

Real programmers don't comment their code. It was hard to write, it should be hard to understand.

ANONYMOUS

Contents

1.1. Contributions	1
1.2. Structure of this Thesis	3

With the development of technology, it became important in supporting the work of enterprises. As the enterprises grew, more data needed to be analyzed. With time it was harder to analyze the data, especially with various viewpoints in mind. What remained was to make decisions that are beneficial to the company.

The concept of Enterprise Architectures (EA) is an attempt to organize the data organization-wide. In 2019, Hacks et. al [Hac+19] introduced the concept of Enterprise Architecture Debts (EA Debts) to consider the consequences resulting from a decision made in the context of not only the technical aspects, but also those of business representing the goals of the company. Another concept worth noting is the technical debt quadrant as defined by Martin Fowler [Fow09], especially the part on recklessness and prudence. Fowler proposes the classification, introducing intuitive understanding of the prudence and recklessness.

As EA Debt can lead to various, also negative consequences, such as increased development costs, lowered productivity of the development team or difficulties in management, we wanted to consider the prudence of EA Debts. In the context of Technical Debts, prudence can help us to better understand the debt. Due to that, one can prepare for the debt-related consequences by, for example, preparing a mitigation plan. One can also go one step further and identify the root causes to remove the source of the consequences and/or watch out for them in the future. The purpose of this study is to consider the classification of debt into reckless and prudent in the context of Enterprise Architecture Debts.

1.1. Contributions

Even though the concept of prudence exists in literature, it is yet to be defined properly in the context of Enterprise Architecture (EA) Debts. Introduced in 2009 [Fow09] in the context of Technical Debt (TD), prudence is yet to be defined uniformly in a way

beneficial to the enterprise. As both prudence and recklessness are currently used intuitively, it is hard to hold anyone accountable for their conveyed meaning, as the two concepts are not uniformly defined - abstract concepts are easier understood when using a uniform, unambiguous definition. This is particularly dangerous when dealing with *EA Debts*, as intuitive understanding of prudence can lead to misunderstandings, which in turn can result in serious consequences. This is a motivation for us to identify the meaning of prudence and recklessness in the context of Enterprise Architecture (EA) Debts. Intending to support the stakeholders when making a decision, we propose the following research question:

RQ1 How to evaluate *EA Debts* prudence in large-scale enterprise environment?

The main contribution of this paper is to gather existing definitions of prudence and recklessness. Even though various Scientific Literature Reviews (SLRs) have been performed in the context of *EA Debts* [GEA20], [Da +21], they did not consider the concept of prudence, rather focusing on methodologies and tools. In order to analyze them and propose uniform definitions of the two, which would provide means for evaluation of prudence in the context of *EA Debts*. To accomplish this, we performed an SLR (please refer to Chapter 3), according to the methodology proposed by Kitchenham et al. [KC07]. The main goal of the SLR was to identify papers containing the definition of either prudence or recklessness in the contexts such as technical debt, financial debt, decision making, and similar. We searched for the definitions in some of the most renowned databases with the intention to gather scientifically valuable data. One of the limiting factors was that we wanted to gather definitions, which could be applied in the context of *EA Debts*. Based on the results of the performed SLR, we selected 43 papers relevant for prudence and 10 papers relevant for recklessness. We analyzed the gathered definitions and identified common criteria relevant to either of the two concepts. This allowed us to propose uniform definitions for both prudence and recklessness (please refer to Section 3.3).

To make use of such definition, one would require a methodology to assess the prudence of existing and future debts. A dedicated framework could be used for that purpose. Frameworks are used to gather good practices and methods in one place to organise the work that needs to be done. This is not the only benefit of the frameworks. According to van der Merwe et al. [vGv13], frameworks can improve the communication in an enterprise, and allow for confidence and credibility in the investment resources. As the evaluation of prudence is to be used in decision making environments, having confidence in the performed evaluation is one of the crucial aspects. To support the decision makers in the evaluation of prudence, we propose a framework (please refer to Chapter 4) to establish actions supporting the prudence evaluation. This framework is defined with the help of four easy steps that are general enough to be adapted to the individual needs of an enterprise. The framework can be used to analyze the common root causes of the consequences resulting from the decision taken, possibly also negative ones, helping enterprise architects identify what should be modified to avoid the negative consequences in the future. We believe such a framework could help realize the potential strategies

by documenting the process, ensuring understanding of all relevant stakeholders, and helping establish a culture meant to consider the debts and their prudence. This would allow to communicate the decisions to various involved stakeholders with the help of documentation, further increasing the credibility of the chosen solution by providing arguments gathered in the process of making the decision. Finally, we believe such a framework can support the decision makers in making the accept/reject decisions, when considering a debt, by providing reports based on the identified and gathered information. In this way, business stakeholders could obtain information in a way that would only provide them with the data concerning them, allowing them to focus on creating an investment portfolio most beneficial to the enterprise with respect to the goals of said enterprise.

The contribution of such a definition is the ability to communicate information about a decision or a debt in a more clear and intuitive manor, allowing to bridge the gap between technical and business stakeholders. We believe prudence, and the documentation resulting from the evaluation process, can be used to argue why a debt is needed, and whether it is prudent to take the debt. Additionally, we believe that this concept could be used to raise awareness of and communicate the existence and importance of the debt to all relevant stakeholders.

1.2. Structure of this Thesis

The thesis is divided into seven chapters. This report starts with Introduction, which is this chapter. The next section considers related work (please refer to Chapter 2) including the consideration of the papers identified by means of an Scientific Literature Review. Related work is followed by the report of the performed SLR (please refer to Chapter 3). Next is the chapter considering the framework supporting the evaluation of prudence (please refer to Chapter 4). Both the definitions and the framework underwent an evaluation and the results can be verified in the next chapter (please refer to Chapter 5). This leads to a chapter based on the authors consideration of the previously performed activities (please refer to Chapter 6). This thesis concludes with the consideration of the current status and future work needed to be done in this field (please refer to Chapter 7).

2. Related Work

Don't panic!

DOUGLAS ADAMS

Contents

2.1. Prudence in the general understanding of it	6
2.1.1. How to define prudence?	7
2.1.2. How to accomplish prudence?	7
2.2. Prudence in areas close to the EA context	8
2.2.1. Technical debt	8
2.2.2. Financial debt	9
2.2.3. Decision sciences	9
2.2.4. Project management	10

EA is a field focusing on the interaction between business and IT. As the field of *EA* is relatively new [GEA20], not all aspects are identified, researched, and considered. This provides a challenge and an interesting research field for many. One of the main challenges is how to provide a communication mechanism between various stakeholders, who possess various levels of knowledge in the field. As *EA* provides means for a better understanding when making a decision, it is an important discipline to consider. Each enterprise is often faced with complex choices, often requiring to verify tons of data, where even one document may change the perception and context of the decision. As such, establishing an understanding between all involved stakeholders can be crucial, as the ultimate goal of the enterprise is to bring it closer to its ideal state. Another aspect is to consider the factors that need to be taken into account when making a decision. Plataniotis et al. [PKP14] introduced the concept of *EA* Anamnesis, which focuses on considering the decisions in detail, including observing their impact and a post analysis to better approach making a decision in the context of *EA*. In their work, the authors "identify factors influencing the decision making process". They focus on splitting the decisions into two concepts, namely decisions made "ex-ante" and "ex-post". Such classification allows to consider the anticipated and unexpected consequences respectively, with "ex-ante" focusing on predicting the future possibility. The consideration of all kinds of debt consequences allows to, in the long run, mitigate them. It is important as such consideration allows to, among other benefits, identify and understand the warnings related to a decision better.

In the context of making a decision in *EA* specifically, it is worth considering the aspect of how to make a decision in a way that reduces the gap between the to-be and as-is state of the enterprise. Such gap can be understood as an *EA* debt taken by the

company. The term of *EA Debt* was first coined by Hacks et al. [Hac+19] in 2019 and resulted in defining *EA Debt* as a *metric depicting the deviation of the currently present state of an enterprise from a hypothetical ideal one*. This definition allows us to consider the debt in terms of how far is the existing solution from the ideal one. As the goal of the enterprise is to ultimately get as close as possible to the hypothetical ideal state, it is worth considering which decision could increase the debt and how to mitigate it. In the context of an enterprise, there might be decisions that need to be taken in-spite of the debt, often resulting in negative consequences, and that is why such debt should be evaluated to understand the need behind it. To consider and manage the debts, Alexander et al. [Ale+20] proposed in 2020 an *EA Debt Management Framework*. In their work, the authors focus on identifying activities that are relevant to consideration of the debt. The activities provided by the authors that provide a core to the consideration of *EA Debt*. The authors provide the meta-model in order to motivate and guide future research in the topic. One of the proposed areas of future work is to explore approaches that exist in consideration of *TD* and adapt them to the context of *EA*.

Even though the concept of prudence in relation to the area of *EA* was not systematically studied, prudence was often used in other fields, including that of *TD*. One of the most known examples is the Technical Debt Quadrant as introduced by Fowler [Fow09]. In their work, Fowler proposed a Technical Debt Quadrant dividing debt into four categories, namely – reckless, prudent, deliberate and inadvertent. However, Fowler did not formalize this definition, explaining these concepts intuitively by providing examples. This makes it harder to adapt into the context of *EA*, as the examples can be interpreted from various perspectives with varying results. Another aspect to consider is that Fowler always considers recklessness and prudence inseparable from deliberateness and inadvertence.

In this section, we will consider the existing literature on prudence to further underline the need to consider prudence in the context of *EA*. The focus on the related work will be divided into prudence in fields that are considered as related to this work, and prudence in general, which we believe might contribute towards a definition of prudence.

2.1. Prudence in the general understanding of it

The focus on prudence was first adapted in the English language in the middle of 14th century. It was adapted from Latin *prudencia*, a more condensed form of the Latin word *providentia*. In Latin the word considered being foreseeing and meant practical judgement. The latter of the two was also used as applying precaution. This was then adapted to Old French in the 13th century as *prudence*, which was used to represent *wisdom to see what is virtuous* [Onl]. In the English language those meanings were combined together in the concept of prudence.

Currently, prudence as defined by the Oxford Learner's Dictionary is defined as "*a sensible and careful attitude when you make judgements and decisions; behaviour that avoids unnecessary risks*". This poses an interesting topic for all areas related to decision making and risk management. As such prudence was specifically considered in the context of considering the law, which introduced a new term of *jurisprudence*. Being a relatively

general term, it is widely considered in various areas.

In scientific literature, prudence can be considered in two ways. One is to consider the definition thereof in order to ensure common understanding. The other is the consideration of how can one accomplish prudence.

2.1.1. How to define prudence?

Many people tried to grasp the concept of prudence in a definition. We focus on selected few to provide an initial understanding thereof.

Prudence is often associated with the characteristic of a person making a decision. One aspect is that of an egoistical approach, considering ones own benefit before taking an action [Yoo11], [Goo+08]. In the context of *EA*, this can cause placing ones own benefit above that of a company. However, one can interpret it in another way, namely as considering the benefit of the company as ones own, when making a decision. This would be dependant on the approach of the stakeholder towards the company.

Another attempt is to try define prudence with the help of some metrics that would provide additional insight to the decision making process. One approach is to consider risks, along with their impact, and the related future uncertainties [CTB17]. This could be used in *EA* to establish mitigation strategies, when considering risks of a decision taken. Another one is to consider the benefit with respect to the cost of the work [Rue88]. The two approaches can also be combined in order to consider the risks with respect to the benefits [WO19]. We believe it might be necessary to consider the cost, risk, and quality together. The risks affect the final costs, similar to how cutting the costs can cause a reduction of quality, and worse quality can increase the risks one should consider.

2.1.2. How to accomplish prudence?

Even though the consideration of what exactly affects prudence is difficult, it is necessary to establish methods and actions affecting prudence.

One approach would be to consider actions that would be preventive in order to increase prudence of the decision made. One such action is the introduction of guidelines meant to support the stakeholders in decision making [JW12]. Introduction of guidelines will affect the behaviour of all stakeholders, trying to adapt to company rules. Another possibility is to introduce preventive methods meant to reduce the risks and the corresponding results [KCK20]. This can be achieved with the help of mechanisms meant to detect unusual behaviour and trigger a warning in response to it [Ami+18]. Another preventive measure would be to avoid action, if the gathered data presents that the thresholds are crossed considerably [Per+10].

Another approach is to approach prudence proactively. This can be done using the previously mentioned metrics and the identified thresholds to assess the situation [Waq+20]. This can be beneficial in a situation, where the data and risks are changing constantly. Additionally, one can actively use the information to consciously propose a portfolio considering the risks and the abilities of the company [BK16]. The goals of

such consideration are defined as the security, quality, liquidity, and profitability of the portfolio as a whole.

Additionally, one can consider the aspect of making an informed decision by ordering the available information, and the corresponding decisions. This can for example be done with the help of a *prudent order* or the close concept of a *prudent walk* [Sch10] [BM10]. A prudent order is a ranking method, allowing to minimize the influence of strongest opposition by making it minimal [Lam07a]. That aspect can also be understood as maximizing the minimum support [Lam07a]. This operation can be performed on sets and is then called a *prudent composition* [Hou11]. Those constructs can be then applied to decision making [Hou10]. Lamboray [Lam07b] considers the application of prudent order in decision making. As such, the authors propose an example, in which a team of experts needs to make a decision considering various perspectives that they represent. This could prove to be an interesting approach towards the prioritization of decisions to be taken or otherwise considered.

2.2. Prudence in areas close to the EA context

In this section, we need to consider how prudence was considered in fields related to *EA*. As such, we consider the areas of technical debt, financial debt, decision sciences, and project management. Those were selected as one needs to consider aspects represented by those fields when considering a decision in the context of *EA*, as *EA* focuses on bringing the IT closer to the business/financial domain.

2.2.1. Technical debt

The main aspect considered in relation to the context of *TD* is that of awareness. Awareness is the approach that is attributed to Fowlers description of prudence in the *TD* Quadrant. Tsoukalas et al. [Tso+18] associate the distinction of prudence and recklessness to consideration and analysis of awareness. They do not define further what should one be aware of to consider a decision to take a debt prudent. Nugroho et al. also consider the awareness as the differentiating factor, but they are more explicit saying it is the awareness of committing the debt [NVK11]. An interesting aspect to consider is whether being aware is enough to consider a decision prudent.

Another aspect is to consider the interest and the corresponding probability to assess prudence. The authors, Sas and Avgeriou [SA20] foresee little interest probability on the rushed parts and define it as prudent. They also indicate that to make a prudent decision, it is crucial to gather data potentially influencing said decision. Silva et al. [SJT18] propose a similar approach considering the benefits and when to repay the debt in order to define prudence. According to them prudent debt decision can be strategical, meaning beneficial to the project. They also underline the need to prepare an action plan to repay, and eventually eliminate the taken debt. In the context of Architecture Debts specifically, it might be also important to analyze the consequences with respect to risks [Zal17]. As the architect would be responsible for identifying the consequences related to

their own decisions, the measure of prudence would be their attitude to decision making.

As recognized by Ernst et al. [Ern+15], most debt occurs in the “inadvertent/prudent” part of Fowlers Quadrant. This means that a prudent decision is one that was taken deliberately and seemed correct at the time it was made. This further strengthens the need to document the debts. An additional aspect to consider is that the teams, which consider the debt might change with time, resulting in a debt not being recognized anymore [Bre19].

As the consideration of debt is always context dependent, it is also worth noting that reusing implementation/solutions is not always prudent [Wal+20]. This might be due to for example, the approach becoming unsuitable. It is also often hard to manage reused TD and difficult to predict future negative effects, making the old solution hard to adapt.

2.2.2. Financial debt

The financial sector mostly considers the assessment of risks as a prudent approach. To that, they identify various aspects to consider. One aspect is the consideration of the risks in relation to their mitigation strategies [Den+03][Wol13]. This is meant to reduce the risks with the help of risk management strategies. In order to do that, they assess the profit with relation to the costs, which in turn are compared with the available assets [AA74]. This allows to avoid overspending and make a decision which could prove to provide highest return (profit - cost). Such an approach allows to identify several rules to making prudent investments. The approach of considering risks and costs can be used to assess the loss, resulting from not paying off the bad debt [Ego+20].

One aspect to consider is that a larger gain, usually comes with a larger risk. An important note is that given a larger risk, one requires a larger preventive measure [JNN13] and higher patience to make an informed decision [Whi08] to finally be able to save more of the assets in the face of large risks [CG13]. This can even go as far as preferring to classify the debt as bad in the face of uncertainty [Bec+20].

2.2.3. Decision sciences

One of the most important aspects recognized about prudence in the decision sciences is that of prudence being an informed and context dependant decision approach [BM13]. This is very important, when considering making a decision, as context provides the information that might affect the perception of debt. Naturally, it is important to note that possessing information does not equate to the understanding of the possessed knowledge. If the data is too abstract, one might require an expert to assess it [Pau+15].

When considering the context, it is important to gather the data. Various factors can influence the decision that is considered. Information such as the benefit, competition to consider, and the deadline should be considered to be able to determine a prudent compromise [Sim04]. Such compromise can be reached when the relevant information is considered and its impact is assessed in order to find a common ground between opposing parties. It is important to consider data relevant for a given project, company, and context, as using inappropriate attributes can waste valuable evaluation resources [LC04].

Such resources can be related to financial funds, worker time, and others. In a company, resources are usually scarce for the amount of work that needs to be performed, so it is important to manage them wisely.

Another aspect is the consideration of risk. In decision sciences, one can consider the risks and their mitigation strategies. A prudent approach to risks is to assess them and determine thresholds meant to prevent them [Men09]. The strict approach is to consider prudence as downside risk aversion [EW11].

2.2.4. Project management

The first aspect, similar to psychology, is focusing on the aspect of stakeholders and their approach to decision making. One approach is [KR09] focusing on correlating prudence to conservatism. In this context, conservative means that better information is available with fewer signals, meaning that we obtain a higher gain at a lower cost. Another aspect that they consider is that of risk aversion, which combined with prudence should result in conservatism. The authors mention the sensitivity of prudence to risks resulting from a decision, making the risk mitigation crucial.

Inversely, one can [KL05] identify a case, where project managers tend to consider themselves prudent risk takers only based on the fact of them identifying risks with the help of intuition. They tend to omit the consideration of risks that would require additional information to be taken into account. As such, a portion of risks remains unidentified, causing disruption at a later point in time. A relation between the risk-aversion/risk-tolerance and two aspects, namely the visibility of the project and its impact, was also observed. If a manager displays a strong drive to succeed, they will be more prone to making decisions identified as high risk, but also high gain, in projects that are easily noticeable. One of the important aspects mentioned is the common understanding of the goals to be reached and following the agreed upon mitigation measures in order to avoid risks.

The second aspect, is to consider a more calculating approach towards prudence. An approach [ML01] is to focus on the analysis of the trade-offs between costs and risks. This in turn might result in the identification of when to make an investment into a project. It is important to consider the timing of such a decision, as for example being too prudent might result in an increased risk of a missed opportunity. This further underlines the relation between the consideration of prudence and the context of a given decision.

3. Defining Prudence in Debt Management

There are no facts,
only interpretations.

FRIEDRICH NIETZSCHE

Contents

3.1. Scientific Literature Review process report	12
3.1.1. Motivation for the SLR	13
3.1.2. Research Questions (RQs)	13
3.1.3. Scope	14
3.1.4. Search strategy	15
3.1.5. Selection criteria	17
3.1.6. Selection procedures	18
3.1.7. Data extraction	19
3.1.8. Data synthesis	20
3.1.9. Conflict of Interest	20
3.1.10. Excluded SLR steps	20
3.1.11. Demographics	21
3.2. Review result	23
3.2.1. Prudence	23
3.2.2. Recklessness	26
3.3. Proposed definitions of prudence and recklessness	27
3.3.1. Prudence	27
3.3.2. Recklessness	28

Decision making is one of the wider researched areas of management of any kind. What often happens, is that the practitioners considering the benefit of the decision refer to the concept of making the right decision, often combining it with the concept of prudence. Although perceived as a synonym of a good decision made and often used in literature, not much research was contributed to the concept of prudence in the context of debt management. The important aspect of what exactly contributes to an EA Debt decision being prudent. To date the use of prudence is left at an intuitive level, leaving space for misunderstandings. Hence, it is important to identify what is a prudent decision and what contributes to a prudent decision being taken. This is particularly relevant as an imprudent decision taken, following Fowler a reckless one, is often considered bad, even though that is not necessarily the case. One instance of that in the context of TD, is with the Fowler’s [Fow09] definition itself. Fowler introduces the Technical Debt Quadrant mostly by providing intuitive examples. The problem with this is that various readers might interpret prudence and recklessness in various ways. Another one is that

for Fowler, the concepts of recklessness and prudence are to be considered inseparable from deliberateness and inadvertence. This was then replicated in other papers, when considering the two concepts. As such, we decided to perform an SLR study, researching the concept of prudence. The main purpose was to identify what is prudence and what contributes towards it. An analogous study was performed for the concept of recklessness. This chapter will focus on providing all SLR related aspects. This chapter will also consider the research questions that we would like to answer with the help of the SLR, as well as describe the strategy used to search for the information, the selection criteria meant to select relevant information from all that are gathered ones, the procedures used to ensure the application of the criteria, and the method used to extract the data. We will also describe the conclusions reached and the resulting definitions that we would like to propose. Finally, we would like to consider the use of prudence in the context of EA.

3.1. Scientific Literature Review process report

Even though the concept of prudence is widely used in the literature related to the debts, it has not been considered in the context of Enterprise Architecture Debt (EA Debt). This might lead to an increase in the number of misunderstandings when analyzing the EA debts. As such we wanted to perform a study to find available definitions of prudence in order to propose a prudence definition, which could be used in the context of EA.

After some consideration, we decided to use the method of a Scientific Literature Review (SLR) as defined by Kitchenham [KC07]. One of the alternatives we considered was a Mapping Review. The reason why a Mapping Review was not chosen in the end is that it focuses on a broad overview of papers in a given topic. Mapping Review does not allow for an in-depth analysis of gathered material, but an in-depth analysis is needed when searching for the common aspects of existing definitions. Another aspect is that a Mapping Review does not usually have a concrete issue to solve, it rather focuses on identifying gaps in existing literature. This is contrary to our needs - we are searching for precise type of information in a concrete field. This is why we chose to perform an SLR. The basic idea of performing an SLR is relatively simple. Kitchenham [KC07] has proposed a set of SLR guidelines, which are meant to help in "identifying, evaluating and interpreting all available research relevant to a particular research question". As one of the aspects to evaluate a theoretical work based on existing literature is to provide a clear and re-usable process, we decided to follow the approach proposed by the author. When performing an SLR, the first step is to identify the need for a review. During our initial literature review, we observed that even though the concepts of prudence and recklessness are widely used in the context of technical debts, they are yet to be formally introduced. The two are used intuitively, leaving open the possibility of misinterpretation when discussing the debts. This is slightly easier in the financial domain, as it mostly considers the two concepts in relation to risks in investments. However, the context of Technical Debts is broader and needs to consider additional factors. The same holds for prudence and recklessness in the context of EA Debts, where they need to combine multiple levels of enterprise representatives agreeing together, while being from various

domains. The proposed definitions would need to consider this. However, although widely used, prudence and recklessness are yet to be formally defined.

3.1.1. Motivation for the SLR

The first step to performing an SLR is identifying a need for a review. We identify the need of a common, equally understood by various participants of the decision making process, definition of prudence. Even if prudence is currently widely used, as prudence is not formally defined, it is hard to hold prudence accountable. Defining prudence would allow the stakeholders on various company levels to discuss the decisions and their respective opinions on a more equal footing. As such, the definition could allow us to combine the theoretical side of the enterprise with the practical one. Additionally, the determination of prudence as a process would allow one to have a more in-depth insight into the relevant information, which will be used for the determination of prudence. Such information might allow for identification of information missing in the data gathered up-to-date. The concepts of prudence and recklessness are difficult to consider especially due to their inseparable nature. A reckless decision might still be needed to be made for the improvement of the company. In the context of TD, a reckless decision is mostly needed for start-ups, where the need to produce any product is higher than for example that of marketing. Although the risks are high, taking a reckless decision might allow to release the product earlier beating the competition to it. The take-away is that debts sometimes need to be taken. Analyzing the prudence and recklessness of debts can help to understand better which decisions and, more importantly, which debts to take. All in all, the consideration of prudence is the first step to classification of decisions and their consequences, which might even prove to be the first step to automatizing the decision making.

3.1.2. Research Questions (RQs)

This lead us to consider the following research questions.

RQ1 How to evaluate *EA* Debts prudence in large-scale enterprise environment?

This is the main question we want to answer. To help determine the answer, this question was divided into three auxiliary questions.

RQ1.1 What are the existing definitions of recklessness and prudence?

The first one refers to performing a literature review search for and gather the existing definitions to establish how prudence and recklessness have been defined in related fields.

RQ1.2 Which criteria contribute to debt being reckless or prudent?

The second research question is meant to elaborate, which criteria contribute to this classification. The goal of this question is to help identify and differentiate prudent from reckless decisions in debt.

RQ1.3 Which steps should be taken to create a sound judgement?

Finally the third question, whose goal is to focus on the steps needed to provide a sound judgement. Also, it helps determine when it is necessary to repeat the assessment.

3.1.3. Scope

Kitchenham's main goal was to unify the procedure of performing literature research and also allow to provide valuable results. One of the main aspects raised by Kitchenham is the comparison between the approach used in Software Engineering fields and those of Medical Sciences. As such the author wanted to ensure the integrity of provided results, by proposing a research process meant to support the researchers.

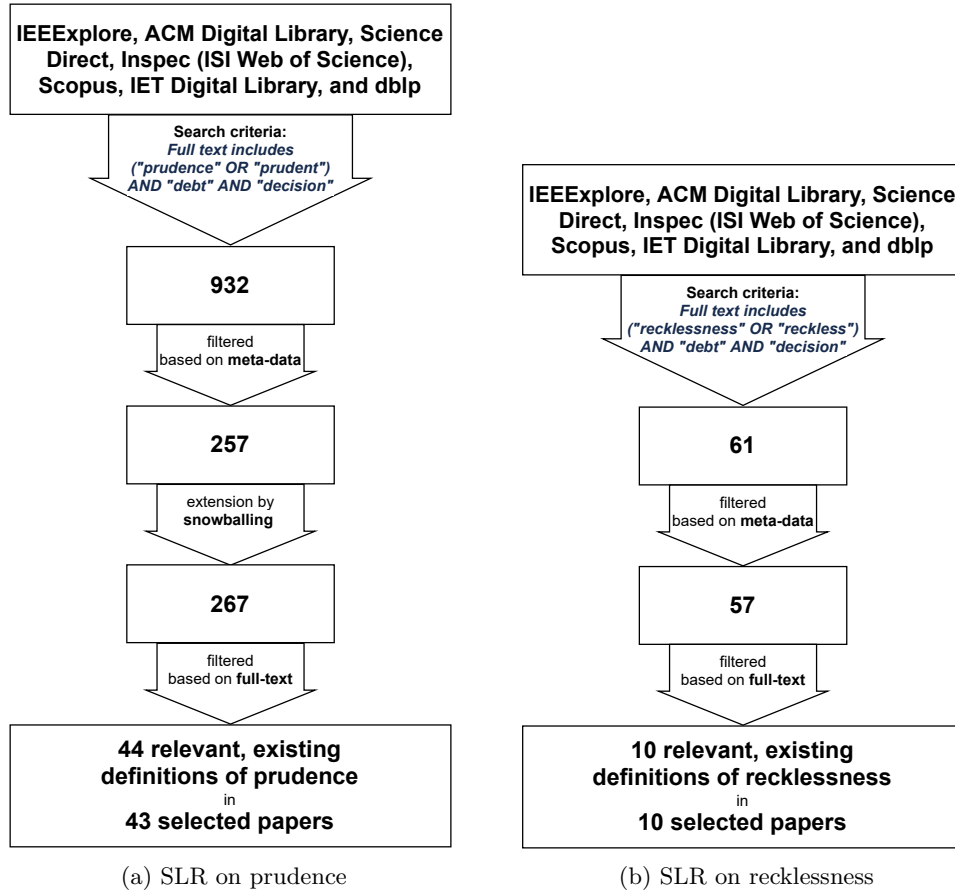


Figure 3.1.: Steps performed in the SLR. The numbers represent the number of papers considered, unless stated otherwise on the graph.

We performed a SLR, during which we searched for prudence in the context of debt and decision making in a couple of major scientific databases. As we wanted our search to be as exhaustive as possible, we decided to use the databases proposed by Kitchenham et al. [KC07] with the addition of dblp as presented in Table 3.1. To identify the existence of previous *SLR* and to assess the volume of the results, we performed a preliminary search. We observed lack of *SLR* related to neither prudence nor recklessness in the context of EA. After the preliminary search and multiple trial searches, to adapt the search string, we decided not to include some of the databases. We rejected databases

DB#	Database Name	Included? (Yes/No)	Date of access
DB1	IEEEExplore	Yes	10.12.2020
DB2	ACM Digital Library	Yes	10.12.2020
DB3	Science Direct	Yes	10.12.2020
DB4	Inspec (ISI Web of Science)	Yes	10.12.2020
DB5	SpringerLink	No	-
DB6	Scopus	Yes	10.12.2020
DB7	CiteSeerx	No	-
DB8	Wiley InterScience	No	-
DB9	El Compendex	No	-
DB10	IET Digital Library	Yes	10.12.2020
DB11	dblp	Yes	13.01.2021
DB12	Google Scholar (as extension)	No	-

Table 3.1.: The selection of the databases for the Scientific Literature Review

that had limited filtering possibilities, resulting in large volumes of papers pertaining to other topics than the ones searched for. This removed *SpringerLink*, *CiteSeerX*, *Wiley InterScience* and *Google Scholar*. Additionally, we had to remove *El Compendex* due to the lack of access. During our initial searches, we worked on the improvement of the search string and selection of the search criteria. During that time the *dblp* was not accessible due to some works on the improvement of the database. We decided to include *dplp* in the end, as it yielded results during our later trial searches. The final search was performed on 10th of December 2020 for all databases apart from *dblp*, which was still not accessible at the time. On 4th of January 2021 we noticed that the *dblp* was running again. As such, we performed the preliminary search for *dblp* on that day. We again were adjusting the search method to the capabilities of the database search engine. This resulted in the final search on *dblp* being performed on 13th of January 2021. This concluded our selection of the databases.

3.1.4. Search strategy

Trial searches

As already mentioned, we performed multiple trial searches, meant to increase the accuracy of the results of the search. Those searches were performed on all of the mentioned databases. Each of the results was consulted with the supervisor of the thesis, who is an expert in the field.

Search string - prudence

As we were interested in finding definitions of prudence in the context of EA debts, we decided to use a search string that would be as general as possible. The most important

3. Defining Prudence in Debt Management

aspect was that prudence could be defined either as a noun *prudence* or as an adjective *prudent*. We wanted to find either of those in the text of the paper, so the main part of the search string was *Full text includes prudence OR prudent*. Given the context in which we wanted to define prudence, we decided to search for the two terms in relation to *debt*. Even though in the context of EA debts, prudence was yet to be defined, that was not the case in relation to technical and financial debt. This meant the addition of the *AND debt* in the search string. Finally, we wanted to consider the aspect of prudence when making a decision in relation to the debt. As such, the final part of the search string was *AND decision*. The search string that has been selected as a result is **Full text includes ("prudence" OR "prudent") AND "debt" AND "decision"**. This search string was then adapted to the possibilities of the search engines of the online databases. The advanced strings are presented in Table 3.2.

AS#	Database Name	Advanced Search String
AS1	Science Direct	<i>("prudence" OR "prudent") "debt" "decision"</i> <i>("manager" OR "management")</i> <i>-"bank" -"saving" -"patient"</i>
AS2	Inspec (ISI Web of Science)	<i>(ALL=prudence OR ALL=prudent)</i> <i>AND ALL=debt AND ALL=decision</i>
AS3	dblp	1. <i>Separately for "prudent" and "prudence"</i> 2. <i>"pruden*"</i>

Table 3.2.: Search strategy for the search for prudence

For the *Science Direct* we had to limit the number of unrelated papers. This allowed us to lower the number of results from 2641 to 57. For *Inspec (ISI Web of Science)* it was simply adaptation to the syntax of the databases search engine. Finally, for *dblp* we could not find any information on limiting the search criteria. As all three results yielded an acceptable amount of results, we decided to include *dblp* as is. The remaining four databases were searched with the original search string. while trying to filter out papers that are outside the fields of economy, computer- and decision sciences. The search yielded relatively few results. We gathered them in a Citavi project to make the operations as fluent as possible.

Search string - recklessness

Similar to the search of definitions of prudence in the context of EA debts, we wanted to find the definition of recklessness. This meant that the search string should be as general as possible. Similar to prudence, recklessness could be defined either as a noun *recklessness* or as an adjective *reckless*. We wanted to find either of those in the text of the paper, so the main part of the search string was *Full text includes recklessness OR reckless*. As the context in which we wanted to define recklessness was the same as for prudence, we decided to search for the two terms in relation to *debt and decision*. As such, the final part of the search string was *AND debt AND decision*. The search

string that has been selected for recklessness is **Full text includes ("recklessness" OR "reckless") AND "debt" AND "decision"**. This search string was then adapted to the possibilities of the search engines of the online databases. The advanced strings are presented in Table 3.3.

AS#	Database Name	Advanced Search String
AS1	Science Direct	<i>"recklessness" OR "reckless") "debt" "decision" ("manager" OR "management") -"bank" -"saving" -"patient"</i>
AS2	Inspec (ISI Web of Science)	<i>(ALL=recklessness OR ALL=reckless) AND ALL=debt AND ALL=decision</i>
AS3	dblp	<i>"reckless*"</i>

Table 3.3.: Search strategy for the search for recklessness

For the sake of uniform results, we kept the search criteria same as in the case of prudence.

3.1.5. Selection criteria

During our work, we determined multiple inclusion and exclusion criteria. The most important restrictions, applied when gathering literature, were listed in the Table 3.4.

Name of criteria	Values selected
Subject areas Publication topics (IEEEExplore) Web of Science Categories (Inspec (ISI Web of Science))	Decision sciences Economics and Finance Business and Management Psychology
Article type Filters applied (IEEEExplore) Document type (Scopus)	Conferences Research articles Journals Books
Publication stage	final complete
Language	English

Table 3.4.: The selection criteria applied when searching for papers during the performed SLR

The criteria were applied where it was possible. The values are listed in no particular order. Concerning the article types, we also included their sub-types. We did not limit the year nor any other criteria than ones mentioned above. In general, we wanted to include as many papers including the word prudence as possible. To present uniform results, we applied the same criteria for the reckless SLR as for the prudence one.

3.1.6. Selection procedures

This left us with 932 papers for the prudence and 61 for recklessness (please refer to Figure 3.1). We included all papers in especially prepared Citavi project. This allowed us to easily manage the resulting PDFs. We began by searching for the PDFs containing the full text of the paper.

Prudence

Exclusion criterion	Number of papers balance	Remaining papers
Meta-data selection		
Missing PDF	-21	911
Unknown format	-11	900
False positive	-6	894
Different form	-4	890
Name or surname	-334	556
Language	-2	554
Retracted	-1	553
Duplicates	-296	257
Full-text selection		
Missing definition	-148	109
Not applicable in EA	-76	33

Table 3.5.: The changes in the number of papers on prudence based on the exclusion criteria

The *Unknown format* criterion considered mostly incomplete meta-data, making it impossible to find the corresponding literature. The *False positives* considers papers without the word prudence in the full text. The *Different form* describes the various variations of the word "prudence" like for example "prudential" (all instances in dblp, due to the least restricted search string). A special case thereof was the *Name or surname*, where the only instance of prudence was in the name or surname of one of the authors (also only in dblp). After the selection by meta-data, we were left with 257 selected papers. We did not remove any papers through selection by abstract, as we were interested in all definitions of prudence. During the selection by full-text we focused on definitions from the relevant related fields. Most of the papers rejected in this phase contained the word prudence, but did not contain the definition. This was important, as our main criterion was the search for the existing definitions. The second criterion we applied was whether the definition would be applicable to the context of EA. This criterion was discussed with the supervisor of the thesis, who is an expert in the field. After selection by full-text, we were left with 33 papers. During one iteration of snowballing, we found 10 additional papers. As such, the 10 papers need to be added to the selected papers, leaving us with

the final 43 selected papers. The entirety of exclusion criteria used for prudence search, along with the corresponding number of papers, were listed in the Table 3.5.

Recklessness

Exclusion criterion	Number of papers balance	Remaining papers
Meta-data selection		
Missing PDF	-2	59
Conference proceedings	-2	57
Full-text selection		
Missing definition	-42	15
Not applicable in EA	-5	10

Table 3.6.: The changes in the number of papers on recklessness based on the exclusion criteria

The SLR for recklessness was easier to perform as it yielded fewer results. One cause of that was that recklessness does not seem to have any other meanings (contrary to prudence being for example a name). The *Conference proceedings* exclusion was due to the meta-data being conference proceedings instead of a paper. This concluded our exclusions due to the meta-data analysis, leaving us with 57 papers. Similarly to the exclusion criteria for prudence, we did not remove any papers through selection by abstract, as we were interested in all definitions of recklessness. During the selection by full-text we focused on definitions from the relevant related fields. Most of the papers rejected in this phase contained the word reckless/recklessness, but did not contain the definition. This was important, as our main criterion was the search for the existing definitions. The second criterion we applied was whether the definition would be applicable to the context of EA. This criterion was discussed with the supervisor of the thesis, who is an expert in the field. In the search for recklessness, the snowballing did not provide us with results. After the selection by full-text, we were left with the final 10 papers. The entirety of exclusion criteria used for recklessness search, along with the corresponding number of papers, were listed in the Table 3.6.

3.1.7. Data extraction

After performing the filtering of papers, we focused on extracting the data to answer the posed questions. We first searched for all definitions of prudence, resulting in exclusion of all papers that used the concept without defining it. We grouped the definitions based on their usability in the context of EA into three categories exists, maybe, does not exist. Then we looked at those categorized as maybe in more detail, identifying their core idea. Based on this some were sorted into the exists category. Finally, all papers gathered in the exists category were considered in detail. We then identified core idea considered by the definitions and marked them as such. For prudence, 44 definitions of prudence

were identified and analyzed. The same approach was used for the consideration of recklessness and it included 10 identified definitions. The core ideas for both prudence and recklessness were then grouped with the help of a mind map tool.

3.1.8. Data synthesis

To answer the presented RQs, we wanted to not only gather the existing definitions, but also identify criteria contributing to prudence or recklessness of a decision. For this we used a mind map to organize all of the definitions efficiently. We first categorized them based on the field they were defined in. We identified fields closest with relation to considered aspects to the consideration of Enterprise Architecture Debt (EA Debt), which allowed us to focus on them in the following steps. For that, we used definitions from the fields of Technical Debt, Financial Debt, Decision Sciences, Management, and Artificial Intelligence. Then we tried to look on them more abstractly, in order to identify common criteria that could contribute towards proposing a unified definition. Concerning the prudence, we identified eight criteria appearing most often. For recklessness, we identified five relevant criteria. We will discuss them in detail later. Our data synthesis step was fairly straightforward as we only needed to identify the definitions and the criteria mentioned in them.

3.1.9. Conflict of Interest

There are no conflicts of interest, nor secondary interests of the authors of this SLR report. All opinions presented are that of the author alone, and not any institution to which they are or were affiliated. The author consulted their progress and work with their supervisor, who is working as a Research Assistant at RWTH Aachen University. This is a known standard for both Bachelor and Master theses. Neither the author or the supervisor of the thesis have other engagements that could have influenced the results of this thesis. This thesis was prepared for scientific reasons as a required part of Master studies. The author declares *having no financial conflicts of interests, not using company's (RWTH Aachen University) resources, time, or any other resources for this thesis (excluding having the thesis supervised by an RWTH Aachen University employee), not presenting patents, copyrights or royalties without an indicated citation, and finally not holding shares in any company that might benefit or be otherwise influenced by the paper.*

3.1.10. Excluded SLR steps

During our SLR, we omitted two of the steps as proposed by Kitchenham et al. [KC07]. We will now briefly mention our reasoning behind such a decision.

Study quality assessment

The study quality assessment is a step meant to consider the systematic error of the papers, their internal and external validity. As most definitions were not the goal of the

studies performed, it would be difficult to assess their internal and by extension external validity. Similarly, the bias seems to be non-existent as the authors did not focus on changing the definitions between what they considered and what they presented, because they were not the results based on which the authors were evaluated. As such, we believe that the study quality assessment could be omitted in our case, due to the focus on a very specific aspect, which was not the main goal, presented as a theory background by the papers. Additionally, we recognize the limitation of our assumption that if the definition was not stated, it was not prepared. We tried to mitigate that by identifying the meaning from the context in which the word was used. This can be noted as a take-away for future SLRs performed in this context.

Dissemination strategy

As this SLR is part of the Master Thesis, this work will be under evaluation of other researchers and practitioners. All remarks to the thesis and the process of evaluation are described in the appropriate chapter of the paper (for this, please refer to Chapter 5). However, to date the reported SLR was not assessed by the means of a formal peer review. The thesis is supervised by a Research Assistant of RWTH Aachen University, qualified to supervise both Bachelor and Master theses. Their work involved discussing the strategy used, verifying the progress, assessing the work performed and other usual tasks of a Master Thesis supervisor. Additionally, the completed thesis will be assessed by two RWTH Aachen University professors to grade the work of the student (here, author of the thesis). The papers cited and referred to in the paper were mostly ones published in the well-known databases, meaning most were peer reviewed before publishing. Other contents were evaluated as mentioned above.

3.1.11. Demographics

One of the interesting observations we wanted to indicate in addition is the distribution of definitions based on the context they were identified in. For prudence (please refer to Figure 3.2), we observed that many papers even with filtered context information were found outside the specified context. This context mismatch might be caused by incorrect meta-classification or faulty filtering of the databases. However, we found those papers to be relevant either way and as such they were included.

For recklessness (please refer to Figure 3.3), we observed a more tight correlation between the existence of a definition and the context of Technical Debts. This might be due to lesser focus on the concept of recklessness, as presented before. Another aspect might be that consideration of recklessness in this context follows from Fowler's TD Quadrant.

Another interesting observation comes from the publication years demographics (please refer to Figure 3.4). One can observe a growing interest in the concept of prudence in the recent years. This further signifies the need of providing a uniform definition of prudence in the context of *EA*. Even for recklessness, which is far less considered in literature, the trend seems to show that it became more considered in the past five years.

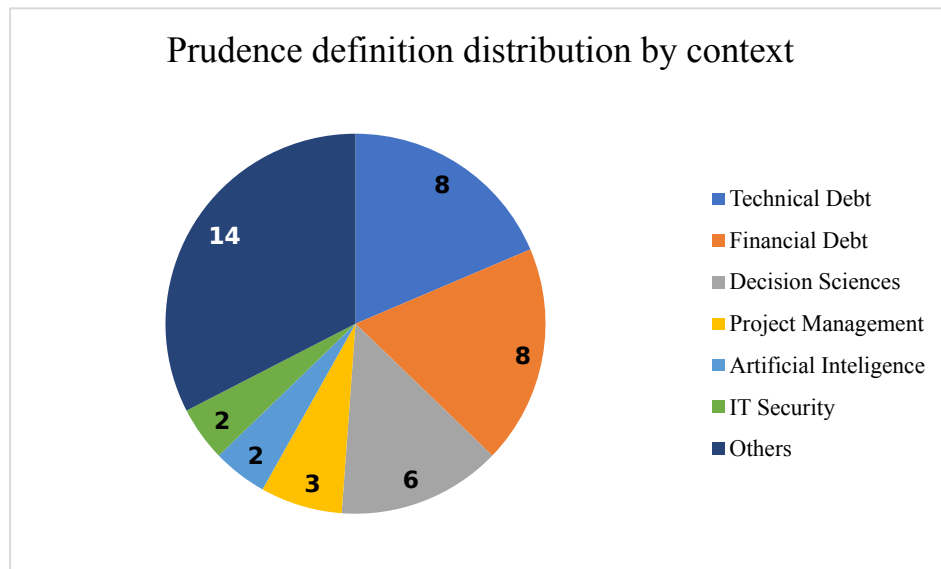


Figure 3.2.: The prudence distribution, depending on the context in which prudence was defined. Others considers fields such as Agriculture, Airline Industry, Artificial Intelligence, Computer Vision, Mathematics, and Psychology.

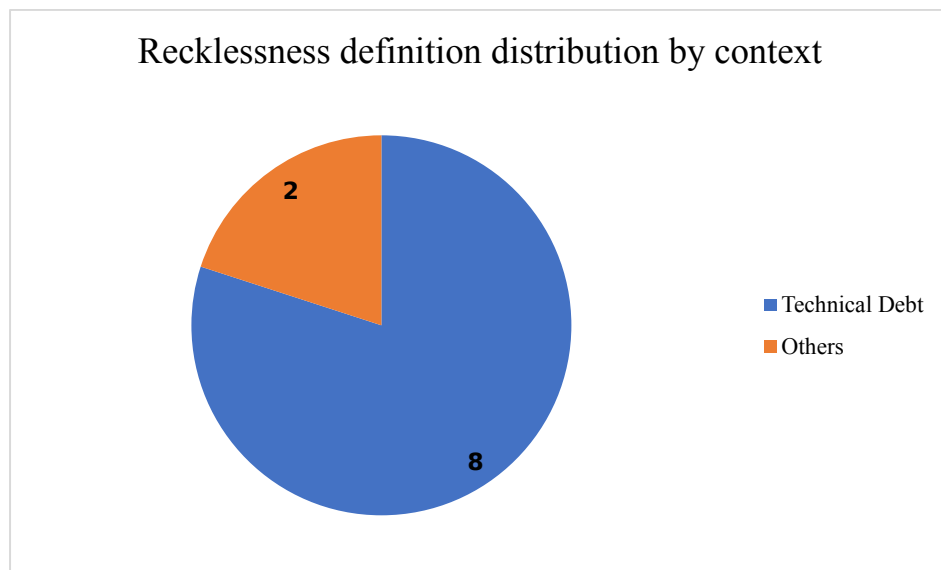


Figure 3.3.: The recklessness distribution, depending on the context in which recklessness was defined. Others considers fields such as Computer Vision and Psychology.

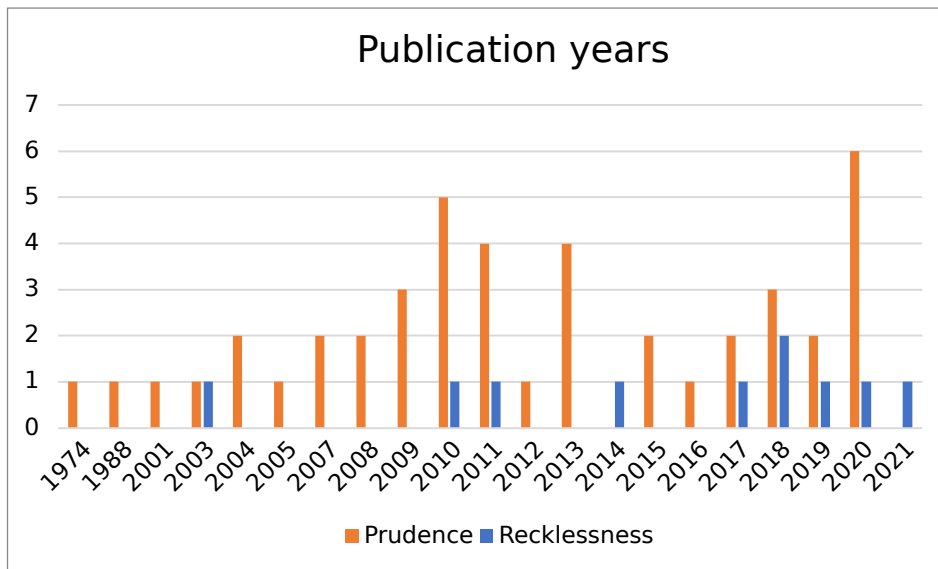


Figure 3.4.: The publication years distribution, depending on the searched definition (prudence or recklessness).

3.2. Review result

After the identification of existing definitions by the means of SLR, we created a mind map to support the process of categorization of results. The mind map was initially structured based on the field in which the definition was used. This allowed us to obtain a clear overview over multiple fields and approaches. We focused on the fields of Technical Debt, Financial Debt, Decision Sciences, Management, and Artificial Intelligence as closest to the context of Enterprise Architecture Debt (EA Debt). From the definitions used in those fields we identified criteria that could be applicable in the context of *EA Debt*. This meant the abstraction of the identified core ideas and adaptation into the context of EA. A simple example of that would be the consideration of risks in the domain of Financial Debt. Such a risk can be related to the inability to pay back the accumulated financial debt when betting. For us such risk would be defined then with respect to the project and enterprise. As such, an example of the risk in the context of *EA Debt* could be the risk of insufficient security of data. Although the EA risks can also refer to financial aspects, they are not limited to them.

3.2.1. Prudence

As such, we identified eight criteria, which we used to categorize papers based on the core idea. We will now consider them in detail.

Payoff greater than cost

One of the identified criteria was that considering the relation between payoff and cost. This means that when making a decision, one should consider all potential gains and relate them to the potential costs. One of such costs to consider are risks. One of the approaches towards prudence was to only make a decision if the cost of the decision and the cost of the risks is lower than the gain related to said decision. This line of argumentation follows Fowler approach to prudent debt.

All consequences considered

Another criterion considered identifying and assessing all consequences. This pertained to not only negative consequences, but also positive ones. This criterion also considers short-term and long-term consequences. Consequences are results of a decision as happening in the future, i.e. after a decision is made. One can, however, consider the possible consequences along with their probability of becoming an issue. By establishing the severity and probability of a consequence, one can identify which of the negative consequences should be mitigated first to avoid major problems. This also relates to considering risks, as by having an idea of which risks are related to a decision, one can make a pretty accurate estimate of which consequences are resulting from them. For example, if our risk is of financial nature, a consequence might be the inability to pay the contractors, which in turn might result in insolvency of the company.

Relevant stakeholders informed

This criterion relates to the fact that making a decision requires knowledge. If a decision is to be made, all people involved in the decision making process should be informed of the most recent data to be able to provide their input. Some types of risks can be predicted by experts in the given area. Also, if stakeholders are not involved, they might consider it not important to consider certain aspects or to share the data they possess with others. Informed stakeholders might also consider the debt more seriously and might be more committed to all identified measures to take. Yet, another aspect is the need to document the proceedings to convey the data to stakeholders that might be involved with the decision in the future, as teams might change during the project.

Established debt mitigation strategies

Each debt carries a certain risk to it. The important aspect to prudent debts is the identification of the risks and consequences to be able to establish mitigation strategies. The larger the risk, the larger mitigation measures to take. A debt that seems unbearable for the company, might in fact be beneficial thanks to the mitigation of its negative consequences. When considering taking a debt, it is important to consider the mitigation strategies when evaluating the debt. This allows to truly see, which of those strategies are available and which are possible in the context of a particular debt.

Deliberate, informed decision

The decision to take the debt should be taken deliberately with consideration of the available data. This includes preparing measures and strategies meant to manage the debt in the future. Lack of such preparation might result in a situation where a prudent deliberate debt, with time, causes problems. Such preparation requires also establishing thresholds and observation of the debt with time. Thresholds need to consider acceptable levels of risks and determination of the usual behaviour of the data, to be able to report eventual divergence. Additionally, norms and protocols should be introduced to prepare the stakeholders to deal with various situations related to the debt.

Iterative process

With time, the data might change. With the data change, the evaluation of a decision might also change. Given new information, the debt should be re-evaluated. The estimation of debt should be iterative with consideration of previously established thresholds. The change of context might also influence the evaluation. Not only a prudent debt might become reckless, but also a reckless one might turn out to be prudent given new data. One important consequence of this is that re-using previous solutions might not always be prudent, even if the decision was considered prudent in the past.

Risk-aware decisions

It is especially important for Decision Makers to be aware of potential risks. They need to take the debt consciously to manage it confidently in the future. A debt that is not managed might lead to various consequences. Unaware committed debt might result in consequences that remain unnoticed, which in turn will probably result in the increase of debt and other problems. Contrary, the debt taken consciously might be beneficial. Careful preparation and mitigation of identified risks reduce the probability of unwanted, negative consequences. This might go as far as presenting a risk-averse approach. However, it is important to remember that some risks might be unavoidable, so it is better to prepare for them and learn to manage them.

Goals consideration

When making a decision, it is important to consider the goals of the company and project. Identifying why is the decision being considered and what should the result be provide argumentation towards some of the more difficult decisions to be made. An example of that is the start-up approach to debts. Debts are taken seemingly recklessly with consideration of goals of for example becoming more competitive on the market. Such consideration might in the long run result in the prudence of the at the moment reckless approach. Each decision is taken with some goal in consideration, it is important to identify such goals and use them as a support when evaluating the prudence of a decision.

3.2.2. Recklessness

In the case of recklessness, there is less data on it, resulting in less definitions. This in turn means less aspects to identify. Based on the found literature, it seems that recklessness represents the inverse of prudence. Similarly to prudence, we identified five criteria for recklessness. This section focuses on those five criteria.

Consequences not considered

One of the criteria is not considering the consequences. If we do not consider the potential consequences and their probabilities, it increases the probability of unwanted consequences happening. Those are the consequences one never considered and as such never prepared for. This is a dangerous situation as such consequences also accumulate debt. This also means that the stakeholders do not try to understand the debt better, resulting in repeated mistakes, which just introduce new debt that could have had been prevented.

Stakeholders not informed

Another one is not informing the stakeholders. This results in a situation, where there the decision is made based on the limited data. This also means the unawareness of the committed debt, resulting in the decisions taken without the plan on its management in the future. A similar situation might happen when disregarding the data, including ignoring the warning signs that appear in the data. Another aspect is that if stakeholders are not informed, they might unconsciously contribute to the debt by performing actions that otherwise would be prevented.

Lack of strategy

This criterion references to the lack of a debt management plan. This causes multiple negative consequences that are a direct result of the lack of a strategy. If one does not analyze the decision and prepare a plan for it, it also means that there is no possibility of tracking such debt. This in turn means that it is relatively hard to understand such debt. Lack of mitigation of consequences might also result in incorrect rejection of a decision.

Uninformed decision making

Similar to the lack of plan, the lack of preparation concerns the unexpected consequences. Lack of consideration of data or not caring about consequences result in the inability to deal with some of the negative consequences. Even if there is a rough plan for the debt mitigation, without considering the consequences, one increases the possibility of unexpected, negative consequences. Incorrectly identified consequences might also lead to incorrect evaluation of the debt, meaning one can for example try to mitigate consequences that are not problematic for the considered debt.

Missing risk awareness

Contrary to the concept of prudence, recklessness is related to not considering the risks of a decision. This lack of regard towards risks might be due to a high tolerance or simply failure to recognize the risks. Not being aware of risks can result in unexpected difficulties in the project. Risks often result in negative consequences if not considered and managed. Being unaware of the risks or having a too high tolerance for them endangers the project.

3.3. Proposed definitions of prudence and recklessness

We believe that the two concepts should be treated as two ends of a scale. Almost no decision is fully reckless or fully prudent. The considered aspects can bring one closer to either of the ends and depending on the expected results either might prove to be beneficial to the company (here, the example of start-ups in *TD*) in the long run. However, prudent decisions might be required in the delicate systems of high importance or when considering crucial decisions.

3.3.1. Prudence

The problem of the identified definitions of prudence is that they usually consider one aspect, described in the particular context in which the authors wanted to use it. Such consideration also does not follow a thorough argumentation on how the definition was achieved. Following Fowler's intuitive representation of the four quadrants, the identified definitions do not agree on the crucial aspects of prudence. This means that without further processing those concepts are only partially applicable in the context of *EA Debt*. Some of the aspects do appear more often than others, but it is difficult to identify their actual contribution towards prudence. The criteria addressed in the previous Subsection 3.2.1 are the generalization of those aspects, while considering cross-referencing of the available definitions from various contexts. This in turn results in a meta-definition of prudence. This meta-definition of prudence does pertain to the general area of interest, however, it does not consider domain-specific needs. During our work we wanted to mitigate that by mapping the identified criteria to the context of *EA Debt*. This lead us to a proposed definition of prudence in the context of Enterprise Architecture Debt (EA Debt). We would like to propose that **prudence is a characteristic representing a cautious approach towards decision making, allowing to avoid unexpected, negative consequences of a decision made in the context of EA debt. Additionally, there are certain efforts to be done to exercise prudence. Namely:**

1. **E1: Consider the concerns represented by both the enterprise and project**
2. **E2: Seek the common agreement of involved stakeholders**
3. **E3: Consider all identified consequences and their mitigation strategies**

The most important aspect of prudence as identified in the literature review, is to consider risks and mitigate them, before they can result in hard to manage, negative consequences. This agrees with the definition provided by Fowler, who implicitly relates prudence with preparing for the consequences of the decision or being aware of how to improve the existing situation. We believe this definition is applicable in the context of *EA* debts as it pertains to the concerns and goals of the enterprise and project, meaning it considers bringing the company closer to the hypothetical ideal state as defined by Hacks et al. The involved stakeholders defined by the definition relate to stakeholders representing various areas of the enterprise, which can provide their perspective on the decision taken. The consequences, identified based on the available data and information from the stakeholders, then need to be evaluated with regards to the context of the company.

3.3.2. Recklessness

Just as with prudence, the identified definitions considered one aspect in a particular context. Recklessness is also not explained in detail. An aspect specific to recklessness is that it is considerably less defined in the literature. This might be due to the assumption of recklessness being the opposite of prudence. Limited number of definitions makes proposing a definition slightly more difficult. As presented we tried to map the identified aspects to criteria influencing recklessness of a debt. We noticed that four criteria identified for prudence, were not represented in literature. Based on literature, it is not considered whether the evaluation of recklessness is an iterative approach or not. Additionally, goals of the enterprise are not mentioned when considering recklessness. The reason for not considering goals might be due to the assumption that recklessness does not require considering goals or simply that the consideration of goals is not affecting recklessness in any way. Finally, the consideration of payoff vs. cost seems not to be connected to recklessness in literature. Based on the identified criteria, we wanted to introduce the concept of recklessness the context of *EA Debt*. We would like to propose that **recklessness is a characteristic representing an incautious approach towards decision making, increasing the risk of encountering unexpected, negative consequences of a decision made in the context of *EA* debt. Additionally, there are certain mistakes increasing recklessness. Namely:**

- 1. M1: Not considering the concerns represented by both the enterprise and project**
- 2. M2: Lack of information for involved stakeholders**
- 3. M3: Not considering the consequences and their mitigation strategies**

This definition relates in a natural way to the one of prudence. The proposed definition is also applicable in the context of *EA Debt* as it considers the to-be aspects of the enterprise. Additionally, it also discusses the aspect of the much needed cooperation in the context of *EA* - or in the case of recklessness - lack thereof. The lack of consequences

3.3. Proposed definitions of prudence and recklessness

consideration might affect the entire enterprise based on the unintended and not mitigated results of the taken debt.

4. Framework for evaluating the prudence of Enterprise Architecture Debt (EA Debt)

I don't know
 if it's what you want,
 but it's what you get. :-)

LARRY WALL

Contents

4.1. General requirements	32
4.2. EA requirements	32
4.2.1. Requirements relation	35
4.3. Building blocks	36
4.3.1. Debt Context Analysis	36
4.3.2. Debt Collective Assessment	38
4.3.3. Debt Prudence Evaluation	39
4.3.4. Re-evaluation	43
4.3.5. Debt Documentation and Communication	44
4.4. Demonstration	47
4.4.1. Example scenario	47

EA is increasingly used in large entities [Ber12]. Such large entities require additional focus and care provided to the definition of the processes to ensure the fluent work. In order to support and document the process, we need to establish some guidelines and activities that are to be performed in order to achieve the previously predestined goal. One approach is to provide a framework, which would combine various good practices in order to make the work more organised and focused towards accomplishing said goal.

The process of introducing a framework starts with the determination of a goal of the framework. This framework is meant to help EA stakeholders in the decision making process by evaluating prudence. One of the steps needed is the identification of relevant factors, which contribute towards the goal of the framework. In this chapter, a distinction of general and EA specific requirements was introduced to show how a framework can be adapted to the context of EA. Having determined the requirements, the Prudence Evaluation Framework (PEF) is introduced by explaining all framework steps separately, one by one to allow for in-depth description thereof. The steps consist of three main steps of the framework **Debt Context Requirements**, **Debt Collective Assessment**, **Debt Prudence Evaluation**, which all happen sequentially. Then the **Re-evaluation** iteration step and criteria are explained. Finally, the **Debt Documentation and**

Communication are discussed as a constant step, which is to be performed with all other steps always. After the introduction of the framework a brief example is introduced to allow for an additional understanding on how to apply the framework.

In this chapter, the framework and its components will be discussed in detail. Specifically, the focus will be on the requirements, both general [Section 4.1] and EA specific [Section 4.2], which define the characteristics of an *EA* framework; the building blocks [Section 4.3], determining the stages of the framework, the relations between them, as well as factors, data, and methods needed to evaluate prudence; finishing with a demonstration of the framework [Section 4.4].

4.1. General requirements

In the case of evaluating prudence, what is required is a use of framework that would regulate the evaluation process. Specifically, one should adapt an architecture evaluation framework into the context of enterprise architectures. As per ISO standard [B], an architecture evaluation framework should contain the following information:

1. correlation between concerns and stakeholders to determine the context
2. prioritization of each concern
3. identification of compliance documents in order to determine if a risk of non-compliance exists
4. specified form and format of the informational inputs required by the framework
5. mechanism for time estimation of related activities
6. specified form and format of the outputs provided by the framework
7. mechanism to correlate the inputs information with the resulting outputs

All of the above listed criteria are also applicable in the context of *EA*. The benefit of said framework is the preparation of all required documents needed to perform the evaluation, gathering stakeholders and their concerns to facilitate discussion and increase awareness of the *EA* debts, and prudence evaluation leading to the assessment of the future strategy.

4.2. EA requirements

There are multiple aspects, in which the framework should support the enterprise in the process of decision making. We identify four major requirements that need to be considered when working with *EA Debt*:

1. debts need to be considered in the context of the project and company (R1)
2. debt consideration needs to involve all relevant stakeholders (R2)

3. debts need to be quantified and re-assessed given new data (R3)
4. debt information needs to be gathered and documented (R4)

In this section, we will discuss them in detail.

The repeatedly mentioned problem is the awareness of the debt existing in the system in the first place. Even though the concept of debts is defined in the context of technical debts longer than in the context of enterprise architecture debts, even there, the awareness is one of the leading issues. Awareness of a debt is a very important aspect as it might lead to earlier repayment of the debt or even preventing the existence of a debt in the first place [WRS21]. Kruchten et al. [KNO12] mentions that the first step towards working with the technical debt is the awareness, understood as the identification of the debt and its corresponding causes. The authors notice however that most of the technical debt is invisible, hence rendering such debt almost impossible to notice and be aware of. This is also by extension the case for *EA* debt. Being a debt recognized and defined more recently [Hac+19] the issue of awareness will be more prominent simply due to less time spent on making stakeholders aware of it. Even if the debt might be recognized intuitively, the lack of in-depth understanding and classification of it, renders it very difficult to prevent or work with.

The framework should also allow to understand the causes of the debt appearing in the first place. This would not only support the in-depth understanding of the situation in the enterprise, but also will provide information for future decisions, in order to take them more consciously. Making a decision is often hard and requires the consideration of multiple factors, "*adjusting the decision making strategy to best meet the current needs of the company*" [PKP13]. Plataniotis et al. mention that the decision is often not limited to choosing the best alternative, but requires an in-depth understanding and adapting to the current situation. Naturally, the more data is available to the decision makers, the more confident can they be in their decision. Using previous data, allows one to alleviate the burden by providing information on how the decision will affect the project and the debt in the future [LLA15]. This will also influence the confidence in a decision made. Similarly, an important aspect of the framework is to help see the 'big picture'. As mentioned by Lankhorst et al. [Lan13] the decision makers need to work with multiple overviews from various domains discussing one project. The idea would be to provide a method that would gather the information in one place, allowing the decision makers to consider the context of the entire enterprise and entire project, resulting in a more confident decision made [vGv13]. As the method would require cooperation of stakeholders representing various viewpoints and also having a diverse technical or enterprise level of understanding, it needs to be simple to avoid creating additional problems, which in turn could increase the debt. The process of making a decision should be applicable in various contexts, and consider that multiple stakeholders may represent multiple interests [PKP13]. Additionally, such method should organise and facilitate the cooperation of stakeholders representing various viewpoints [vv08], who otherwise have difficulty in working together. This is the second requirement to consider, namely **debts need to be considered in the context of the project and company**

(R1).

Another important issue that often results from the lack of awareness is the lack of communication needed amongst various stakeholders. Especially in large enterprises the issue intensifies as given the amount of stakeholders involved, it is difficult to keep the appropriate communication flow, which might result in an increase of the errors or debt [Ock+19]. Communication is also important due to the fact that the debt is perceived in various ways amongst the stakeholders, who are representing different viewpoints. Zazworka et al. describe the situation in detail making a relation between communication and successful identification of TD [Zaz+13]. Further, the issue is complicated as one often needs to work with both technical and non-technical stakeholders resulting in different approaches and vocabularies [Kli+11]. This is important to work through, as the non-technical stakeholders often have influence on the technical stakeholders (e.g. client on a programmer), yet often lack the understanding of the severity of consequences of committing a debt [Bre19]. Also in the context of *EA*, the lack of communication is problematic and might be the source of many issues [BS19]. Kaisler et al. note that large number of challenges in the context of *EA* are non-technical as the *EA* itself is largely conceptual [KAV05], which in turn makes communication a crucial tool in identifying and resolving *EA Debt*. Recognizing this Banaeianjahromi and Hekkala [BH19] propose a number of factors to take into account to avoid problems with communication. As such, the first requirement to consider is that the **debt consideration needs to involve all relevant stakeholders (R2)**.

Further important aspect is the ability to measure the debt and assess it. Quantification of debt allows to observe the severity and magnitude of it. Quantification also supports determining thresholds based on the previously assessed values, which in turn help identify debts that require further consideration. Categorized data allows to, if needed, determine the required mitigation strategies, which allow to prevent or minimize the unintended, negative consequences of a decision. To be able to determine them, one first needs to determine methods supporting the assessment of debt with respect to the previously established criteria for evaluation. They need to be chosen to the context of the company and the decision to be made [Reg+01]. Often, this is simply not possible [Lan13] and as such it is important to provide the decision makers with a set of integrated methods, which can support them. An important aspect when considering the assessment of debt is the need to re-assess the debt. This might result from for example new information being available, due to context change, or due to a discovery of previously not visible debt [Kli+11]. With the data change, the debt assessment might change as well. As such, it is crucial to perform the assessment regularly. Given new information, it might also be important to reconsider the chosen methods to better suit the needs of the company. The third requirement is that the **debts need to be quantified and re-assessed given new information (R3)**.

Such a framework should help process the obtained information, often first selecting relevant information in the context of a particular case. After facilitating the communication, one needs to realize that every of the stakeholders possesses some information that can help in the process [Zaz+13]. Due to the time and budget constrains, it can often be

difficult to find the information needed [KR97]. In the case of a framework, one needs to consider methods that would help organize this data for further processing, which would include recognizing both inputs and outputs required to use the framework efficiently. As the decision making is highly context-dependent, we need to first consider the current situation. For this, documents helping determine requirements set by the project or the company, as well as any constraints or other information providing contextual information. This data is used to identify the existing and future problems in the project, such as debts. Another set of documents to consider are lists of viewpoints, concerns, and consequences resulting from them. This can then be used to determine aspects one should consider carefully in order to make an informed decision. Those aspects then represent concerns as defined by various stakeholders. One can then perform evaluation of this data with the help of documentation determining acceptable levels, possible risks and exemplary measures to combat them. This information then allows to prepare for the future situations, often allowing to avoid negative consequences. Naturally, such considerations need to be recorded for future reference and to be able to make decisions related to them faster [Dan+18]. This allows us to identify the fourth requirement, namely **debt information needs to be gathered and documented (R4)**.

4.2.1. Requirements relation

The four identified requirements (R1, R2, R3, R4) (please refer to List 4.2) were chosen as they not only support the decision making process, but also represent the previously identified efforts to evaluate prudence. The aspect of considering the context discussed by the first requirement (R1) considers the first effort (E 1) to achieve prudence, namely the *Consider the concerns represented by both the enterprise and project*. Similarly, the second requirement (R2) covers the second effort (E 2), namely the *Seek the common agreement of involved stakeholders*. Finally, the requirement three (R3) and four (R4) relate to the third effort (E 3), namely the *Consider all identified consequences and their mitigation strategies*. As such, the framework allows to follow a natural structure in order to determine prudence of a decision taken. A framework based on the four requirements will provide means to support the decision makers in the evaluation of the decision and in raising its confidence.

It is important though to remember that the prerequisite of such assessment is the awareness of the debt in the first place. Additionally, it is worth noticing that the requirements are inter-related between each other. The quantification of the debt is impossible without first identifying the context. Similarly, the stakeholders cannot discuss the debt without being recognized and learning the context in which the decision is to be made. As such, the first step is the identification of context and stakeholders, which supports requirements one (R1) and two (R2). Having identified the stakeholders and the context of the decision, the stakeholders need to discuss the debt. They each might provide valuable data for the assessment. This means that the second step is the consideration of the debt by the identified stakeholders as addressed by requirement two (R2). The third requirement (R3) allows to quantify and assess the gathered data, providing means to evaluate the prudence of the decision. As such, this results in the

4. Framework for evaluating the prudence of Enterprise Architecture Debt (EA Debt)

third and last step, namely the assessment of debt and its prudence. It is worth observing, that the debt might require re-evaluation of it. In the case of data change, it is important to inform the stakeholders and gather their input on the new information. This results in a re-evaluation step taken from the third to the second step of the framework. As the fourth requirement (R4) focuses on the documentation of the proceedings and gathering information, it needs to be performed simultaneously with the other steps.

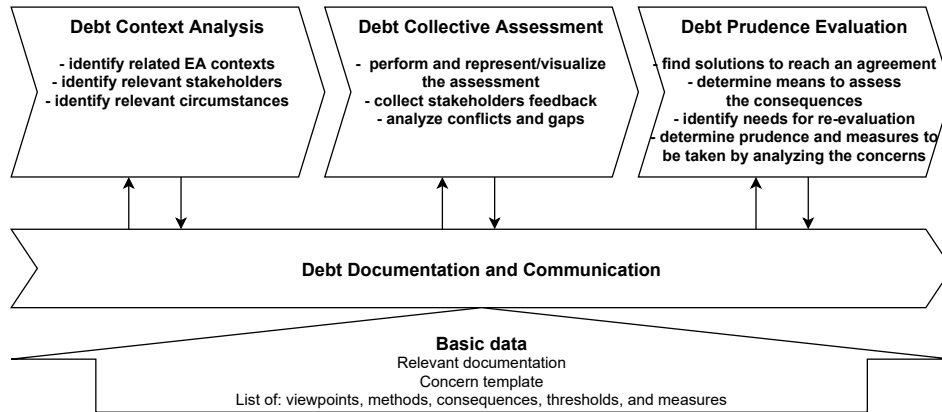


Figure 4.1.: The framework for evaluating prudence. It represents the steps and the data used by the framework. The up and down arrows represent input and output documents respectively.

4.3. Building blocks

To fulfill the requirements mentioned above, a framework can be proposed composed of 4 equally important parts as presented on Figure 4.1. Such framework would consider the decisions that might introduce a debt or ones that already resulted in a debt. The result of using said framework would be an evaluation of the considered debt and suggested means to work with it.

In the framework, there are multiple aspects that are dependant on each other. As such there are relations/assumptions that need to be considered. It is important to identify the dependencies to be able to determine if one has all necessary information to move to another stage of the framework. When considering prudence evaluation, there are several factors contributing towards prudence. Many of them are required by the proposed framework. There are numerous methods that could be adapted towards the assessment of prudence. To propose the initial ones, we will focus on simple cost-benefit analysis, analytic hierarchy process, portfolio approach, and options.

4.3.1. Debt Context Analysis

The first building block of the proposed framework is the Debt Context Analysis. This is the first step that will prepare the common ground for the evaluation. As mentioned by

Alenljung et al. [AP08], the behaviour and final choice of the decision makers is affected by the information and context they possess.

To categorize the debt correctly and select appropriate method to work with it, one should determine the context of the company and the project (R1) (please refer to List 4.2). Curtis et al. [CSS12] argue that without the analysis of what the "organization intends to fix", one cannot measure the debt. As such, it is important to use all available documents, especially ones indicating the requirements for the project and related to the decision evaluated, the strategy of the company or the goals to be realized [Sea+12]. One also needs to consider the constraints that might limit the possibility to work with the debt in the preferable way. It is noteworthy that every enterprise, similar to different people representing it, will have varying goals and methods used to achieve them. As a following step, it is useful to determine decisions or projects, which can be affected by this debt. This will allow to have a look not only on the project, but also on how the project affects the other parts of the enterprise.

As the field of *EA* debts is relatively new [Hac+19], it is also advisable to establish an *EA* dictionary to ensure that every involved stakeholder understands the underlying meaning of every of *EA* debt concepts [Hol14]. This will in turn make the discussion on relevant aspects less error-prone by ensuring a common understanding. Such dictionary will also speed up the process, as it will reduce the time needed to explain or discuss already known aspects, especially when working with non-technical stakeholders [Bre19].

From such documentation, one can not only gather the information on the context of the decision, but also determine stakeholders whose opinion and input is relevant to the project (R2) (please refer to List 4.2). This too is important, because of the information that is otherwise undocumented, which can though be provided by specific stakeholders [Sea+12]. In the beginning of a project one of the documents introduced is a Scope of Work, which describes who should perform what work in the project. This and similar documents can in turn be used to determine who to ask for their input when considering a decision. For those stakeholders it is important to determine their personal scope of work - what are they responsible for? what are they experts in?; their use cases - what do they care about? what do they do in the project?; and their related stakeholders - who do they work with? what kind of information do they need for their analysis? This is necessary as all stakeholders will differ considerably on their approach towards the debt [Hol14]. Such considerations allow to determine whether the stakeholders that are being gathered are sufficient to cover all relevant aspects, as for a successful *EA* implementation we need the cooperation of stakeholders of various *EA* levels and responsibilities [HM06]. Having gathered the relevant information, one can finally invite all stakeholders to the meeting considering the decision in the context of *EA* and move to the next step of the framework.

Relation towards prudence

Such consideration of stakeholders also represents one of the links of the first step towards prudence. Prudence ensures that all relevant stakeholders are informed, however that cannot happen without first identifying them. The first framework step is a prerequisite

to the link formed in the second framework step.

Another relation is that it is important to identify the context [vv16] of the decision made (R1) (please refer to List 4.2), as consideration of prudence is relative to the situation. To make an informed decision, the context needs to be identified. One difficulty could lay in the fact that context information can be distributed amongst various sources. Context can be related to the laws in a given country, guidelines provided by the company, co-operations formed between multiple projects or even information on the project itself. It is hence important to gather any information that can influence the project. This also addresses the aspect of considering the goals of the company, which are often represented in guidelines or other company-wide documentation.

4.3.2. Debt Collective Assessment

The second step of the framework is debt collective assessment. The pre-requisite for this step is the description of the debt itself, obtained in the first step of the framework. It is important to gather all relevant information to better understand the reasons and causes of the discussed debt [YHL19]. Such information also allows to identify the background situation that lead to the debt in the first place. Possibly the debt has to be considered with respect to specific legal constraints, which cannot be modified by the company. Another pre-requisite is the identification of relevant stakeholders, as performed in the first step, as they can influence the perspective under which said decision will be considered [SH10]. If any of the relevant stakeholders are omitted, due to the consideration of stakeholder feedback in the second stage of the framework, one could indirectly influence the assessment of prudence of a decision. This could prove to be dangerous as the confidence in the decision would be high, although incorrectly so. Another aspect is that the decision could be biased towards one result by not inviting the stakeholders with an approach apposed to ones own. This would result in a lower number of much needed discussions, but again would result in a misjudgement of the situation. Final pre-requisite is the identification of EA context allowing the stakeholders to focus on the important aspects of the decision. This too is an output of the first step of the framework. The context also provides information for the consideration of the debt with respect to the needs of the company. Additionally, determining context allows to use a common vocabulary when discussing related issues, allowing for a better understanding.

The second step is dedicated to identification of the consequences that need further processing. For this, first the topic of discussion needs to be introduced to the gathered stakeholders (R2) (please refer to List 4.2). This will allow to focus on one task at a time. Then one needs to identify which viewpoints [LLA16] can be represented by the stakeholders based on their responsibilities in the project and the list correlating responsibilities area to the viewpoints. Thanks to this, each of the stakeholders will be aware of the area represented by the stakeholder discussing their point. Afterwards, all stakeholders should focus on the concerns they identify in the proposed decision that need to be discussed. They should describe their concerns in as simple terms as possible to allow inclusion of other stakeholders opinion into the consideration. To ensure simplicity, one can use a pre-prepared template to make sure the stakeholders describe aspects relevant

to the discussion and possibly limiting the length of such description. Additionally, for each of the concerns they should provide the evidence showing why this particular issue could be problematic for this decision at a given time. To support their claims, they should identify the assessment approaches, such as KPIs [Cru+20], that according to them represents their view the best. Such gathered input is to be presented to all gathered. The stakeholders need to present their feedback to the presented assessment. Presenting feedback is an important step as it allows to identify relevant aspects to consider, raising the confidence in the decision taken. Additionally, based on the disagreements that might appear at this point, one can identify gaps and contradictions in the opinions. Those need to be discussed and resolved based on the available data. Reaching an agreement might require the consideration of context, so resolving the disagreements can be temporarily postponed to the next step, but such postponement needs to be documented immediately, for example with the help of a backlog. As the next activity, the stakeholders need to identify possible consequences resulting from the points of concern. This can be achieved with the help of a consequences list, either created based on the company's history or gathered independently.

Relation towards prudence

As with each consideration of any assessment, depending on the understanding of the concept, its use and interpretation differ amongst users. With prudence, the stakeholders can represent various levels of understanding and agreement with the evaluation. A prudent decision is one where all stakeholders are informed of the classification and process used to achieve it. This in turn allows to reach agreement about a prudence of a decision. Given the number of participating stakeholders, and the common understanding of prudence, one could expect the assessment being easy and complete. However, prudence requires the consideration of the viewpoints represented by each of the stakeholders. Even if there are two stakeholders agreeing on the definition, this does not immediately result in the same assessment of prudence as each of them will be representing a different viewpoint. There are various viewpoints considered in the context of *EA* and all viewpoints represented by the relevant stakeholders need to be considered to make a prudent decision [Zal17].

Another aspect relating this step to the consideration of prudence is the identification of consequences. Considering consequences allows the stakeholders to obtain a first view of what the decision might result in in the long run. To make a prudent decision all consequences need to be identified and considered. This does not only mean the negative consequences, but it also includes the positive ones. To make an accurate assessment of whether a decision is prudent or not, one needs to realize what the decision could result in. This can be evaluated with the help of consequences.

4.3.3. Debt Prudence Evaluation

This allows to move to the third and final stage of the framework, namely the debt prudence evaluation. One of the pre-requisites is the context identified in the first step

4. Framework for evaluating the prudence of Enterprise Architecture Debt (EA Debt)

of the framework is used at the Debt Prudence Evaluation step as the context needs to be considered when reaching an agreement, evaluating prudence, and when making a decision, including the determination of the measures to take for a given decision. Context allows to determine, which solutions are applicable in the particular situation and which should not be considered at all. The context is identified from various documents in the first step of the framework. The identified context then needs to be used for the assessment step to identify whether the decision should be made at a given time for a given project considering the current situation of the company. All decisions that affect the working of the entire enterprise should be made with consideration of the available resources and other projects. It might be the case that even though a decision is made to take the debt and for example create a new product, it might well be so that the context of the company will render such decision a bad one by for example already producing a new product and moving all resources towards it. Such a situation could lead to for example both products competing with each other, in spite belonging to one company. Hence, not only information relevant to the project should be considered but also one placing the project in the enterprise hierarchy. Naturally, the internal context of the decision needs to be considered as well. It is possible that for example a decision is considered prudent, but the legislative regulations block the decision from being pursued. For such situations, the context should be part of considerations as such decision might require a different approach to be proposed.

Another one is the identification of stakeholders from the first step and the consideration of criteria from the second one, as they greatly affect the results provided by this step. By the design of the framework, the consequences considered in the assessment of prudence are those identified and following from the gaps between the feedback provided by the stakeholders. Having noted down the criteria to consider when making a decision, stakeholders can either agree on them, making it natural to consider in the assessment of prudence, or they can disagree, making it difficult to achieve a high level of confidence on the prudence assessment. Prudence is verified with the help of identified consequences [EAR13] and an assessment strategy. If there are gaps that are not solved before the assessment is performed, then the result without the support and confidence of all relevant stakeholders will not be implemented to its fullest. This step needs to be completed before one can move to evaluating prudence, as every evaluation method will base on the assessment of the consequences in order to determine the prudence of the decision. Another important aspect is that the agreement that needs to be reached before taking the next step of the framework. If the stakeholders do not agree on the assessment of consequences and their importance to the decision, it is impossible to agree on the assessment method, which needs to be adapted to the chosen consequences. This is the main reason, why agreement needs to be reached latest at the beginning of the third step of the framework. Another aspect to consider is that even if prudence assessment would not be affected, omitting the criteria, that could only be determined by the missing stakeholders, could result in an unexpectedly high *EA* debt, resulting from the lack of mitigation strategy meant for the (from the meeting point of view) unidentified criteria. Additionally, time otherwise spent on improving the decision, will have to be used to

convince the opposed stakeholders, possibly resulting in another iteration of all stages of the framework. Another aspect is that by identifying gaps, one can consider aspects that are specific to a certain viewpoint, which even though important for the assessment, would be omitted otherwise. Facilitating discussion is one of the main goals of the framework as it results in information used to later make a confident and secure decision [ST85].

Before proceeding with this step, the stakeholders need to ensure that they all agree on all aspects determined in second step of the framework. If anything remains in the documentation as not resolved, it needs to be discussed before proceeding further. The main purpose of this step is to evaluate prudence, propose mitigation strategies for the risks and making a final decision. To achieve this, one needs to determine a unified measure for all of the concerns (R3) (please refer to List 4.2). If the strategy to evaluate prudence has been chosen, the unit can be adapted. For example, identifying the consequences in terms of cost required to avoid/mitigate them. One also needs to determine the acceptable thresholds [RK14] for all of the consequences and also a total acceptable threshold for all of the consequences together, based on the context data [SG11]. As context can change with time, it is important to set iteration conditions allowing to monitor the situation and react at an appropriate time to re-evaluate the assessment of the decision. This creates an additional link between the third step of the framework and the second one. The trigger for such a re-evaluation can come from various directions. Re-evaluation can be temporal, meaning that it is dependant on the time that elapses. Another way is through observing the change in data, meaning that either there was a change in already existing documentation or new information appeared. The sensitivity of such a change recognition system should also be set in the third step, to ensure twofold: one, the re-evaluation will not happen too often, wasting time and resources unnecessarily; two, when it is crucial, the re-evaluation will be called, in order to correctly assess the situation at every step. This could be supported by a list of previously determined thresholds to make the re-evaluation simpler to perform. As each decision comes with certain risks, one ought to identify those in order to determine corresponding consequences and the relation between the two. For example, if one of the consequences is related to significantly increased spending, one should consider the probability of such decision resulting in the risk of going over the set budget. The risks can be reused from a list of example risks. In relation to the identified risks, one should consider the mitigation possibility and the probability of risk happening. It might be that the decision is worth taking in spite of the risk, due to the risk being easily mitigated or not probable to happen. Combining the information about the risks and the consequences with their thresholds, one should use one of the assessment strategies to evaluate the prudence of the decision. This can be done by for example the means of a simple cost-benefit analysis, analytic hierarchy process, portfolio approach, and options as defined by Seaman et al. [Sea+12].

Simple cost-benefit analysis is a technique that takes into account two aspects of TD, namely impact and effort. Both are represented on each of the axes on the matrix, specifically one should look at the first quadrant. On the y-axis, the higher the positioning,

the higher the impact. Similarly, on the x-axis, the further right, the higher the effort. Effort to complete the task can be treated in the context of EA as risk taken when a specific decision is selected. As impact, one could determine the positive consequences resulting from a decision to use in the EA context. In such a way, various decisions, their gains, and risks could be compared against each other, allowing an easier identification of a decision to be taken. Similarly to the example presented by Seaman et al., one approach would be to start from the left top corner, first selecting decisions with high impact/gain and low effort/risk. In general, when considering prudence of a decision, one of the important aspects is to minimize the risk or establish methods that allow to mitigate said risk, as a prudent approach is a cautious one. Similarly, other methods can be adapted, the important aspect is to tailor the method to the needs of the company and project, while still considering all relevant consequences during the evaluation.

Due to the focus on the risk reduction, another method worth considering is the portfolio method. The portfolio method was considered in the context of EA debts by Yeong, Hacks and Lichter [YHL19]. The portfolio method focuses on the prioritization of the debts, considering the minimization of risks and maximizing the gain. One could consider applying the portfolio method in order to determine the priority of the possible decisions to be taken. Each decision consists of various debts resulting from it. One could use the portfolio method to prioritize the decisions that are considered. An important aspect is, as mentioned by the authors, the high-level operation of this method and the need for an expert EA practitioner.

The results should be then discussed by the stakeholders to identify potential conflicts before discussing the measures to be taken with respect to the decision discussed. In the process of resolving the conflict, the data determined at the earlier stages of the framework should be applied as arguments. After all conflicts are resolved, one can move towards determining the measures to be taken with regards to the decision. There are four approaches towards a decision, namely it can:

1. accepted as is, without much additional work;
2. accepted, yet require additional measures, such as risks mitigation, to be taken to make the decision acceptable;
3. delayed;
4. rejected.

Detailed measures can be chosen from the supporting list of example measures. Finally, the measures need to be verified with respect to the strategy chosen whether the company can apply the proposed strategy. This is the strategy deliberateness consideration. This will help put the decision and steps related to it in the context of the company and the goals to be achieved. Such consideration is an important step as one might identify the strategy to be used, but despite it, decide to apply it only after a certain criterion is met. For example, the strategy will be accepted if the budget for the project is increased, otherwise it will be rejected.

Relation towards prudence

The third step of the framework has the strongest relation to the prudence, as the step that helps in the assessment of prudence of a decision. In order to assess the decision, one needs to understand its context and the decision itself. In the third step all necessary information is already gathered and interpreted allowing to make an informed decision. One part of making an informed decision is the consideration of consequences. As there can be negative and positive consequences, differing especially from the point of various viewpoints, reaching a consensus is very important to proceed. After agreeing on the consequences and their assessment, it is important to consider the relation of the payoff to the cost. Each decision taken should not provide less than it costs to be made. A prudent decision will have a higher payoff than cost. As risks are consequences with the probability of them happening considered, all stakeholders should be aware of the potential risks related to the decision and consciously can make a decision on how to work with them in mind. As such, one can assess which risks require a mitigation strategy and which can be ignored for the time being. Mitigation strategies can influence the decision, especially in the case of steps with high risk and high gain. Mitigation of a risk, which can reduce the risk, can be a decisive factor when considering the payoff and cost.

4.3.4. Re-evaluation

Re-evaluation is the seemingly smallest step, yet it should not be considered less important than the others. Depending on the type of the trigger, this step might require to select and pass on information to enable the re-evaluation starting from the second step of the framework. If re-evaluation was triggered due to the data change appearing in the system, the information that was changed or appeared needs to be recognized, documented and passed to the second step in order to re-evaluate the now different consequences and as a result prudence of the decision given new information. The goal of the re-evaluation is to re-assess the decision given new/changed information without necessarily going over all framework steps from the beginning. This step is one adding an iteration step connecting the third step of the framework back to the second one. The re-evaluation can be triggered twofold:

temporal dependant on the amount of time that has passed,

data change triggered by the data change in the system.

The temporal re-evaluation would mean dependency on the amount of time that has passed. This poses multiple advantages and disadvantages. One of the advantages is that one does not have to consider the conditions needed for re-evaluation, allowing to spare a bit of time and resources otherwise used to agree on the thresholds. Another is the simplicity of such approach, as it is easily understandable and applicable by any stakeholder. This method also has certain downsides one has to consider. One major downside is a potential loss of time and resources upon an unnecessary re-evaluation. If the time period is too far, it might also happen that there will be a need for re-evaluation

which will go unnoticed, wasting the time-frame for a new decision to be taken. The second of the triggers, the data change, has an advantage of being reliable in such a situation, as the stakeholders will be notified as soon as a new information, one that could affect the decision, appears. Another benefit is that time and resources will only be spent in valid change scenarios. One of the disadvantages is the need for an expert to estimate the thresholds and the dependency on them. If for example the thresholds are not adjusted correctly, even being slightly off, the decision not to re-evaluate might result in the missed opportunity. Another aspect is the increased complexity in comparison to the temporal approach. However, one could adapt the both approaches to suit the needs of the company best possible. A mix of the two approaches to obtain a personalized approach. For example, one could temporally verify if the data changed significantly enough to perform the re-evaluation step. This would provide the benefit of simplicity given by the temporal solution, while maintaining the benefit of time and resources being spent only in relevant cases. One could treat the both approaches as a range for the re-evaluation, which can be personalized to both project and company needs.

The aspect worth considering is how to ensure that all the involved stakeholders are informed of the change. One possible approach would be to introduce a new routine of all involved stakeholders checking the information periodically. This would though introduce the waste of resources as the information might only change after a long time. A partial solution derived from it, would be to select a dedicated stakeholder, who would observe the data and inform other stakeholders upon noticing a relevant change thereof. Finally, one can introduce an automated system, which informs the stakeholders by broadcasting the data change by for example sending an e-mail. A similar solution could be an internal system managing the information, which would have a functionality dedicated to inform of data change. An additional benefit of such solution would be the gathering of data in one place, meaning reduced time of searching for any kind of information. Such system could also be developed to map the relations between the information or allow for processing of the data according to company needs.

Relation towards prudence

As the consideration of prudence can change, the evaluation of prudence needs to be an iterative process. The re-evaluation step takes into account the possibility of the evaluation changing with new data or with a change in the data, allowing to iterate over the decision taking, possibly updating the strategy towards it in the process. This is important, because with the data change, the balance between payoff and cost might be broken, making the decision more costly than needed. Another aspect is that based on the data update, the consequences might change, either by new ones appearing or old ones becoming invalidated. This all can influence the prudence evaluation.

4.3.5. Debt Documentation and Communication

All of the aforementioned stages of the framework need to be documented [LLA16] for future reference (R4) (please refer to List 4.2), which is enclosed in the Debt Documenta-

tion stage. Such documentation can then be used for backtracking previous consideration, for debt identification purposes or for future reference. Another benefit of such documentation is traceability that allows to hold stakeholders accountable. As this is a formal step, it should be adapted to the usual company approach towards documentation. After each iteration/sprint one can verify how much of the established strategy was applied and with which results, which is another benefit.

Understanding the factors is not the only prerequisite in assessing prudence. We need data to support our claims, in order to determine a decision prudent. The first relation is that between the documentation and the first step. The input documents like business analysis, scope of work or others help determine the context of the decision made and stakeholders relevant to the consideration. Any documents containing information on the project or company can be used to define the context in higher detail. The output documents are information that needs to be stored after performing the step. In the case of the first framework step, one should consider documenting the defined context, the identified stakeholders, and optionally the EA dictionary, Such a dictionary can be used to ensure all stakeholders, including those non-technical, understand all EA concepts in the same way.

The second step of the framework requires not only the documentation of all three outputs of the first step, but also measurement methods and a concern template. The measurement methods document should present an example on how a consequence could be quantified and measured, allowing the stakeholders to quickly select most suitable measuring method and present its results to the council. Concern template on the other hand should support the stakeholders in presenting their idea in a coherent and relatively short and concise way. The outputs will revolve around the assessments and consequences. First is the documentation of the assessment results of the concerns presented by the stakeholders. This data will then be needed during the assessment of prudence for a given decision. Second one, the consequences, focuses on gaps and contradictions found in the feedback provided by the stakeholders.

The third step takes the consequences and uses them to identify risks, which are to be documented along with their probability of happening. From the assessment, one can for example identify the thresholds for the re-evaluation step. The assessments are also used to find the risks and an evaluation method for the prudence assessment. After performing the third step, one should document the prudence, and the measurement strategy proposed for a given decision. This helps in improving the gathered data, allowing to make decisions faster in the future. Documenting the process also allows one to be more accountable for the decision and implementation of all conditions.

The important aspect to consider is how to convey the information in a way that supports the stakeholders in performing the activities required by the framework. To be able to perform efficiently, one needs to realize what kind of information one would like to convey, how and to whom. The main goal of the documentation is to support stakeholders in using the framework and gathering information. There is a need for both existing information to be documented as well as expected information to be indicated. The distinction between the two has to be made clear. To support identification of the

goals of documenting, one could consider the use of keywords, showing whether the document is finished or work-in-progress, or which framework activity does it correspond to. As such, it is important to identify whether there exist company style guidelines similar to the guidelines used by the USA government [Pla11]. For this, a determination of a supporting tool might be useful. Similarly, one should consider the validity period of documents to be considered - "how long are the documents to be considered by the stakeholders" and "when to update them" are just two examples to consider. As this proves to be much to consider, one could identify a common structure to follow when documenting information.

First, one needs to consider the representation of content. This can be considered from two perspectives. The first one is to consider the form of documentation. It is important as various problems might arise if documentation is not treated with much care. As stakeholders might represent various company departments, often going as far as representing different international units, it is important to consider the potential blockers, such as language barrier or time zone, before proceeding [Kur+20]. It is also important to consider a common vocabulary including the determination of all measuring units. One famous example, of why that could be crucial, would be the crash of a NASA spacecraft due to the lack of units conversion between its two pieces. Similarly, in EA one could encounter a situation where one team considers yen and another euro, leading to the lack of funds earlier than expected or a false evaluation of the debt. As a result, all assumptions in communication need to be identified, discussed, written down and resolved. Documentation should support the process by ensuring all relevant data is included in the report without omitting the seemingly obvious information.

When discussing the representation, one approach to consider would be to represent the data visually. Dos Santos et al. [dos+13] proposed a use of a high level debt board meant to represent the existing debt with colors ranging from green (indicating acceptable debt) to red (representing debt needed to be payed back). This method showed the benefit of improving the awareness and communication of involved teams. Such boards also proved beneficial for the interdepartmental exchange of information as they sparked curiosity of by-passers while being displayed on the common corridor. This also meant increased motivation for the teams to improve as they compared their results to those of other teams. Another approach is to create debt reports, either with the help with a reporting tool (like SonarQube for TD) or by creating documentation according to pre-discussed guidelines. What could prove to be beneficial, would be to consider using a documentation template, like a pre-prepared LaTeX file. Such a template could also include a user friendly formatting of various data chunks, including a brief overview of its functionalities. To support the ease of use further, one could provide a navigation mechanism that would speed up the search of important aspects - that could be done by including an outline and the well-defined use of sub-headers. Such reports could then be sent through the company intranet or distributed in a printed form.

Another perspective is to consider the quality of the documentation. To help with ensuring quality, one could use the 30/60/90 framework for feedback. The main idea of this rule is to first propose a draft (roughly 30%), which is evaluated by others. Then

the core is submitted (roughly 60%) and evaluated. Finally, an almost finished product (roughly 90%) is presented to be evaluated. This would ensure that the participants are all agreeing on the way, in which the documentation progresses. This can also be combined with three stages of the framework, meaning that each stage could end in a documentation review. This would in turn result in a more natural progress, where participants still are aware of aspects that need to be documented, limiting the loss of information.

Relation towards prudence

The documentation step supports the prudence of the decision taken by ensuring all important information is documented and communicated, allowing to easily find relevant information at any given time. This naturally involves discussing the data with the stakeholders, which increases the information flow. Additionally, this step is providing information for all other steps and documents the proceedings of the framework. Another aspect is that documenting the process allows to hold stakeholders accountable for the changes everyone agreed to. This is especially important for documenting actions to be taken, like mitigation strategies. One reason for it is that if the team changes during the process of working with a given decision, new stakeholders can, thanks to the documentation, learn what was done, what was decided and what remains to be done to keep the working of the process independent of the changes in the team.

4.4. Demonstration

To demonstrate the application of the proposed framework, we would like to present a simplified toy example.

Following the example of Hacks et al. [Hac+19], an insurance company has services using on-premise data storage. With the new established guidelines, a decision is made to migrate the applications to cloud. Due to the large quantity of applications, it is impossible to move them at once. Hence, it is decided that the migration will be performed iteratively. The company manages to complete the migration of some of the services, but some dependencies still remain on-premise. The company is now faced with a new project. Due to time limitation, an idea arises that the new product be developed on-premise as it will require access to the services that remained not migrated. The divergence from the guidelines leads to discussions whether it is worth to prioritize quick product delivery over conformance with guidelines. This conflict has been recognized as *EA* debt.

4.4.1. Example scenario

In this section, we will present a toy-example to bring closer the concept of the framework and its usage. The general overview of the example can be seen on Figure 4.2. The detailed overview of the presented scenario was presented on Figure 4.3.

The business is interested in developing a new product. It is a product, which contains a crucial functionality. As such, it needs to be developed as soon as possible. Waiting

4. Framework for evaluating the prudence of Enterprise Architecture Debt (EA Debt)

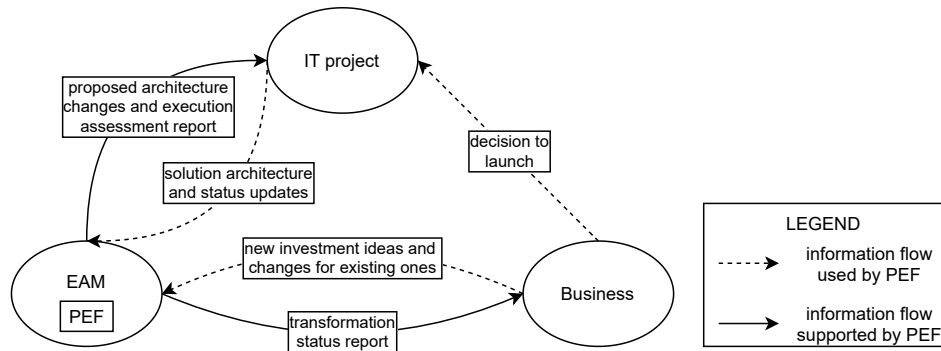


Figure 4.2.: The scenario, in which the *PEF* can be used to support the decision making

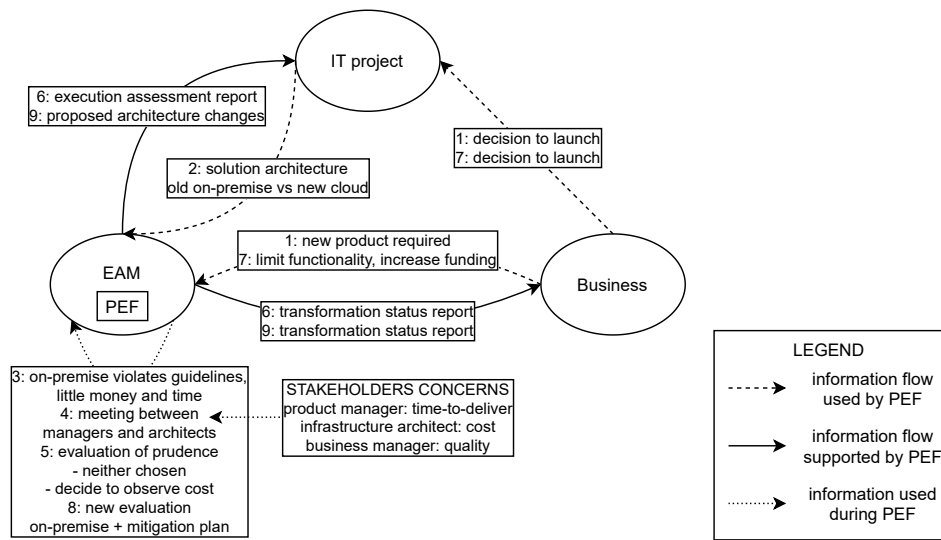


Figure 4.3.: The detailed image of the toy example scenario, in which the *PEF* can be used to support the decision making

for the next quarter is not possible. The business prepares their idea of the product and requests that the company works on it. After considering the funding, they present the new idea to the Enterprise Architecture Management (EAM), as they are aware that such last-minute projects might be introducing new debt upon development. They also forward the decision to launch to the IT project. They also provide them with all requirements for the product, awaiting a preparation of a development plan. IT project upon receiving such a request prepares a solution architecture. They identify that the new product can be developed either using the old on-premise approach or using the cloud. Given the short time and need for a decision beneficial to the company, they forward the proposed solution architecture to the EAM for evaluation. EAM, having received information from both IT project and business, decides to evaluate the prudence of the both approaches.

As the EAM uses the framework to help them evaluate prudence, the first step they focus on is gathering all product, project, and company related documentation. The three main documents they consider relevant is the previously mentioned set of guidelines, the requirements for the new product as obtained from the business, and the proposed solution and scope of work for the project as obtained from the IT project. From the gathered documents they learn that this is the only project currently developed in the enterprise. As it is almost time to change the quarter from the fourth to first, most projects are already finished. This means that the remaining resources can be freely used on this product. From the requirements, they learn that the product contains a crucial functionality, which means that the need to develop it is high. From the proposed solution architecture and corresponding EA standards, they learn that not only do they have to consider the migration, but also that the project will soon enter another phase. This means that the budget that can be allocated towards the new product is relatively small. Another aspect that they learn is that in the next phase the new product will be obsolete as there are plans to prepare a bigger product, which will encompass the functionality of the new product and will have other, additional functionality. However, the business needs to use the new product as soon as possible, making it impossible to wait for the development of the bigger product, which will probably take around a year or two. This means that they are interested in an early, yet cheap solution, while the development has to consider the resources management and the possibility of repeating a task. The documentation also helps identify the relevant stakeholders. One of them is the product manager, as they represent the needs of the business and the go-to standard of the product. Another identified stakeholder is an infrastructure architect, responsible for the migration plan. Finally, the business manager is invited to consider the financial aspect of the decision to be taken. Having identified the EA context, the stakeholders and the relevant circumstances, they document all identified information and proceed to the second step of the framework. Finally, they invite all relevant stakeholders to a meeting.

After a short introduction of the EA debt that needs to be considered, the viewpoints represented by the stakeholders need to be determined. For simplicity of the example, each stakeholder will only represent one viewpoint. This does not necessarily have to be the case in the real world situation. The project manager will represent the Project Viewpoint. The product manager is to focus on the Service Realization Viewpoint, while the infrastructure architect will consider the Implementation and Migration Viewpoint. The business manager's main aspect is the Strategy Viewpoint. Now, each of the stakeholders needs to present their concerns. To simplify the discussion, they use the concern template to note down only the important aspects, such as short name, description, measurement method, and estimation. The estimation is performed after they each identify measurement methods suitable for their respective concerns. Again, for simplicity, only one concern will be raised by every stakeholder. As such, the project manager's concern is the cost of the chosen solution, as there are not many resources left for this quarter. Product manager is interested in the time-to-deliver, measured with the date of the release of the new product. The infrastructure architect is concerned that the

implementation of the new product in the current phase would only result in the loss of resources, as the product would have to be planned, implemented and integrated, only to be exchanged in the future. They calculate the approximate cost of the implementation that they consider lost. Business manager focuses on the aspect of quality worrying that even though the product would be delivered on time, it would not be of appropriate quality due to time limitation, resulting in an overall loss for the company. Each of the stakeholders presents their concern. Product manager assures the business manager that the requirements are achievable in the limited amount of time, also adding that the risks related to the speedy development of a new product are considered in the assessment. They also disagree with the infrastructure architect pointing out that some of the features of the new product can be re-used in the development of the bigger product if carefully planned with this in mind. Infrastructure architect raises the issue of a limited budget in response to that. Not being able to solve the issue immediately, they decide to document the issue and move to the next step of the framework.

In the third step of the framework, the stakeholders recognize that the additional funding should be provided by the business if the product is to be developed in the current quarter. They also observe that the business could limit the product description further, in a way that would still allow to execute the needed crucial functionality, allowing to use the funds more efficiently to mitigate the risk of the work turning obsolete. As such all stakeholders decide that the conflicts and gaps to be evaluated are resolved. They decide to begin the assessment of the two approaches and for that, they gather the data on the cost, time-to-deliver, how soon will the solution be obsolete, and the available resources. To evaluate the prudence of the both approaches they decide to perform a side by side comparison of the two. Considering the cost, the on-premise solution seems cheaper. The time-to-deliver is far shorter for the on-premise solution. The point for the cloud solution is the longevity of it. The available resources however do not allow to move on with the development in a way that would not endanger the project at the given time. As such, the stakeholders decide that they need to observe the changes in the data concerning the resources and that neither of the two approaches is prudent now as there is a risk of company not being able to fund the new product development to the end. All information is documented.

After obtaining the results of the evaluation, the EAM forwards the transformation status report to the business. They also provide the IT project with execution assessment report. The business understanding the consequences of the new debt, recognizes that a financial loss in the case of not developing the new product is higher than the assessed additional cost of the product. As such, they decide to increase funding for the project and they limit the needed functionality to the bare necessary one. As such the resources data changes. The business forwards new data to the EAM and again informs the IT project about the expected launch. The EAM recognizes the data change as one sufficient to affect the evaluation of the debt. Hence, the re-evaluation step is activated and the stakeholders meet again.

The stakeholders do not have new concerns, so they immediately move towards the evaluation. From the two solutions, it is now decided that the on-premise is more prudent

as it is cheaper and can be delivered earlier. Even though this solution will soon become obsolete, given the context of the business being interested in a quick delivery and the overall benefit for the company, the concern is deemed irrelevant for the given situation. To mitigate the risks related to the potential waste of resources by developing an obsolete solution, the stakeholders agree to develop the new product with the bigger product in mind, allowing for a re-use of some components later. The on-premise solution is chosen and it is documented along with the mitigation strategies. The stakeholders need to now ensure the application of the agreed upon solutions. For this, the EAM sends another transformation status report to the business and proposed architecture changes to the IT project.

5. Evaluation

It's not a bug - it's an
undocumented feature.

AUTHOR UNKNOWN

Contents

5.1. Methods for evaluation	53
5.2. Results	54
5.2.1. Background	56
5.2.2. Definition	56
5.2.3. Framework	59

In order to determine, whether our results are applicable in the industry, it was decided to perform an evaluation of both the definition and the framework. To prepare the evaluation, a set of interesting questions divided into background information, definition, and framework sections was determined. In this chapter, we will first discuss the preparation of evaluation and then focus on the answers provided in order to analyze and summarize them.

5.1. Methods for evaluation

The first question when preparing for the evaluation was the style of evaluation. Two approaches were considered. One, a questionnaire, which could provide more information in a shorter period of time, but would require special preparation of questions and could limit the scope of the answers. The other, an interview, which would be more focused on obtaining detailed answers, but would take a lot to prepare for as it would require allotting time from the participants. As it was important to obtain as much information as possible, it was decided to use the interview as an evaluation method.

First, the questions we would like to ask to each of the presented results were gathered. For the definition part, it was important to learn whether the definition is understandable, whether it contains all necessary information, and whether it can be applicable in science/industry environments. For the framework, the questions were asked to learn, whether the steps are well designed, whether they are applicable in a company, and whether it is possible to accomplish the goals of the framework. In the preparation, a pilot study with the supervisor of the thesis was performed. This was done in order to identify points in the need of improvement. Given a limited time period, which was established to be one hour, it was decided to keep the interview on a more general level,

as the detailed approach was not feasible in the span of an hour. It was also decided to introduce the participants to the concepts before entering the interview.

To support the participants in the process, where they evaluate newly presented data, two sets of slides were prepared. One set was sent along with the invitation to participate in the study, while the second one was presented during the evaluation. In the two presentations the introduction to the topic containing foundation of the research, such as *EA Debt* definition or the TD Quadrant was first presented. As next, the focus was on the goals and motivation behind the study. Finally, this then lead to the interview parts, separately for definition and for the framework. Additionally, the invitation slides contained a recording describing the data presented on the slides in a more detailed manor.

The participants were invited and asked to choose a preferable date with the help of a previously prepared Doodle. The authors got three positive responses in return. As the field of *EA Debt* is relatively new, it was hard to gather more participants. Especially that for this evaluation it was important to invite people knowledgeable in the field, either scientifically or through the experience gathered in the industry. Although it limited the possibility of obtaining much input, the quality of the obtained feedback was deemed crucial, especially when proposing a definition and a concept of a framework.

After the participants selected their preferred date, they were invited to a Zoom meeting to evaluate this work. In the beginning of the evaluation, the participants were asked if they would agree to being recorded for scientific purposes. Only sound was recorded, as it would allow to analyze the answers at a much slower pace than just during the interview. All of the participants agreed to it. They were also asked whether they read and listened to the invitation slides, and if they need a reminder. During the evaluation, the relevant information was presented on slides, to which corresponding questions were asked (please refer to Table 5.1). In addition to recording the answers, short notes were made during the interview, to support the process of asking more detailed questions with regards to the feedback presented by the participant. After each participant, questions were reviewed for correctness and improved to be more understandable.

Having performed the evaluations, the authors listened to the recordings. This allowed to remove the gaps in the notes prepared during the interview and understand better the intention of the participants. This was performed a total of three times. First, the recordings were used to evaluate whether the questions are asked in a clear way or whether they need to be adapted to better convey the intention behind them. Second, they were listened to better understand the intentions of the participants focusing on identification of important aspects. Third, they were used to transcribe the answers to the posed questions. The results of this evaluation are presented in the next part of this chapter.

5.2. Results

This section focuses on presenting the results of evaluation, performed as described above. This section will revolve around the summary of gathered information and conclusions

General questions
What is your current position?
How do you understand EA (and EA Debt)?
How do you perceive recklessness and prudence in the context of EA Debt?
Definition questions
Is being risk-aware enough to define prudence?
How to identify context of the EA debt?
Does reaching an agreement of all stakeholders make a decision prudent?
Can prudence be exercised through a poll among stakeholders?
What would be a stakeholder agreement threshold for such a decision to be prudent?
Would an EA Debt without a mitigation strategy be prudent or reckless?
Are prudence and recklessness like true/false or are they rather on a scale?
Is such definition usable to communicate information about a decision?
Should anything be added/changed in this definition?
Framework questions
Can evaluation of prudence support a company/decision making?
Who can perform those activities in a company?
Can this framework be used collaboratively?
Which data/documents can be used to determine the context of a debt?
How can the stakeholders relevant to making a decision be identified?
Can comprehensive concerns be determined from the gathering of the stakeholders?
How can it be verified if all relevant concerns were identified?
How to manage potential disagreements?
Can comprehensive consequences be determined from the gathered concerns?
Given the consequences and based on the provided definition, can the prudence of the debt be determined?
Would a re-evaluation require stakeholders involved previously or only those related to the concern, whose information got updated?
Who and how can document the activities performed?
Can any challenges or difficulties in applying the framework be identified?
Is anything missing in the presented activities of the framework?

Table 5.1.: The questions asked during the evaluation of the definitions and framework

taken from each of the parts separately. Background part focuses on the participants and their approach to EA and by extension *EA Debt*, as well as the intuitive understanding of prudence and recklessness. Definition part focuses on the questions asked with regards to the presented proposed definitions. Framework part is used for the questions related to the framework and its goals specifically.

5.2.1. Background

This part focuses on the participants. Three questions were asked to establish the experience in the topic. First, the participants were asked about the position that they hold. This allowed us to see how experienced the participants are in the field. In no particular order, our participants were a Lead Information Architect at a Company C, an Associate Professor at University U1, and a Professor at University U2. This means that the participants were taken both from industry and scientific backgrounds. An important information is also that neither of the Universities U1 and U2 is RWTH Aachen University, with which the authors are affiliated.

The second question related to the understanding of EA represented by the participants. Each of the participants agreed that the concept of EA represents a *holistic consideration of the organization, meant to align IT and business needs*. Another aspect mentioned, was the need to *use the EA models, structure and visualize* in order to obtain an overview of the entire organization.

The third question was deemed harder to answer and it was related to the intuitive understanding of prudence and recklessness. One of the participants referred to the *gap between the holistic perspective and the reality* and the *delta describing it*. With this, the concept of prudence would be *trying to reduce the gap*, while the concept of recklessness would represent *allowing the gap*. The participant mentioned using EA as a tool to make a decision. The prudence would allow for the tool to be adapted to better fit the purpose with which it is used. Recklessness on the other hand would be shown in allowing the tool to not fit perfectly. Another participant related the two concepts to *consciousness*, indicating that prudence is about *making an informed decision*. The concept of recklessness would then mean *not being aware or not caring about doing wrong*. The third participant did not make up their mind on the two concepts. When asked about the TD Quadrant, they placed the *EA Debt* rather on the recklessness side, indicating that to shift towards prudence, one would need some common understanding, which can be achieved by having definitions, examples, and best practices. They also indicated a strong need for purpose of the term.

The intuitive understanding of the first and second participant align with the proposed definition, while the third participants answer further strengthens the motivation and need for this work.

5.2.2. Definition

The definition part main focus was on the understanding and completeness of the proposed definition. To evaluate that, several open questions were asked to establish if the means to

increase prudence/recklessness are accurate and whether the definition itself encompasses all important aspects.

During this stage the definition was presented iteratively, first showing the main part, then going over the means one by one. The two definitions were presented side by side to underline the close relation of the two. The questions asked were split accordingly into questions to the definition and its specific parts, and the general questions.

First, let us consider the questions to specific parts of the definition. Asked iteratively, the following questions were posed:

1. Is being risk-aware enough to define prudence?
2. How to identify context of the EA debt?
3. Does reaching an agreement of all stakeholders make a decision prudent?
4. Can prudence be exercised through a poll among stakeholders?
5. What would be a stakeholder agreement threshold for such a decision to be prudent?
6. Would an EA Debt without a mitigation strategy be prudent or reckless?

Is being risk-aware enough to define prudence?

Initially, the proposed definition focused around *cautiousness* of the debt and its consequences. This was soon clarified as being *risk-aware*, and the necessary changes were applied. Despite the initial incorrect usage of the word, the participants agreed with the association of prudence to the concept of risk-awareness. This was further strengthened by Participant 2 discussing the fact that being aware of the risk does not necessarily indicate avoiding the risk. This agrees with the intended definition and use of prudence, as an example of prudent decision might be one with high risk, which is easily mitigated or avoided.

How to identify context of the EA debt?

During the interview, it was underlined by the participants that identifying context is crucial for decision making. To answer the question, participants mentioned both looking at documents, such as requirements or strategies, and using methods, such as stakeholder analysis and root cause analysis.

Does reaching an agreement of all stakeholders make a decision prudent?

To this question, the participants mentioned it is dependant on how the agreement is defined. One participant argued it is more about the understanding of debt than agreement. Another mentioned that agreement is too general of a term in this context. Finally, Participant 2 pointed that it might be impossible to reach an agreement of all stakeholders, due to personal differences and various goals that the stakeholders want to achieve.

Can prudence be exercised through a poll among stakeholders?

According to the participants a poll could be used to learn what the stakeholders would consider important for reaching an agreement. It was indicated that it is one of the possible methods.

What would be a stakeholder agreement threshold for such a decision to be prudent?

To this question, all participants answered similarly indicating that such a threshold would be extremely context dependent and would have to be defined for each company separately. Additionally, Participants 2 and 3 discussed the difficulty of defining such a threshold. Participant 3 mentioned that it might theoretically be possible to define the method general enough to provide support to the companies. However, they also indicated that it would be considerably hard, due to sheer amount of parameters that one would have to take into account when providing such a method.

Would an EA Debt without a mitigation strategy be prudent or reckless?

The participants agreed that it is important to consider the mitigation strategies in order to consider the decision prudence, as it is part of being aware of risks. Participant 2 indicated that considering the mitigation strategies does not necessarily involve implementing them in order to consider it prudent. Participant 3 however, mentioned that it depends on the impact and probability of a given risk. They considered the case of risks that are of small probability and small impact, determining them to be acceptable to take even without the mitigation strategy. Additionally, they expressed that obtaining a full set of consequences is improbable, due to the aspect of consequences considering future.

The second part was dedicated to general questions mostly concerning usability of the definition. For that, three questions were prepared:

1. Are prudence and recklessness like true/false or are they rather on a scale?
2. Is such definition usable to communicate information about a decision?
3. Should anything be added/changed in this definition?

Are prudence and recklessness like true/false or are they rather on a scale?

To this question, the participants definitely answered that a scale.

Is such definition usable to communicate information about a decision?

Here, the participants opinion differed considerably. Participant 1 indicated that they can imagine using it when comparing two different scenarios. They clarified that it could be that the result is prudent vs reckless or even prudent vs even more prudent. Participant 2 mentioned it might work if using the positive communication, so when discussing prudence of a decision. They indicated that recklessness as a term is usually perceived negatively and as such might be avoided in application. Participant 3 underlined that it might be hard to apply, as it is highly context-dependent. They provided an example, saying that one could use it, if it were defined previously what exactly contributes to the prudence, such as a completeness being over a certain threshold.

Should anything be added/changed in this definition?

To this question, there were several suggestions, which will be discussed now. Participant 1 indicated the incorrect naming of risk-awareness as cautiousness. This was clarified during remaining interviews. They also proposed to indicate that being reckless might mean being aware of the risks, but having too high of a threshold for accepting them.

They also indicated that the usage of *negative consequences* is quite general. Contrary to this, Participant 3 expressed that they like the distinction between cautious and incautious, indicating that the underlying meaning makes sense. They understood them as follows *Cautious meaning I am assessing the situation and try to understand the consequences of my decision. Incautious not being aware or not caring for them..* They did in turn indicate that *allowing to avoid unexpected, negative consequences* part is not feasible as unexpected consequences are ones that were not predicted and were omitted in consideration. Upon the authors proposing the word *reducing*, they agreed to such a change. Similarly, for the recklessness instead of using *increasing the risk(...)*, they propose *accepting or not reducing* as the risk will not change in itself, especially not for unexpected consequences. They also indicated that the last aspect of each definition are two extremes. In the case of prudence, it would require *considering relevant consequences* instead. Recklessness would then be adapted to *not considering relevant consequences*. Finally, they expressed no need to add anything, explaining that a definition should be *compact and easy to memorize* and that the current ones fit into this category. Participant 2 did not want to change anything in the definitions, saying they reflect the participants understanding of them.

5.2.3. Framework

The evaluation of framework was performed in order to assess if it accomplishes its intended goals, as well as its applicability in the context of EA. Additionally, we wanted to verify its usability in the industry.

During this stage, we first briefly presented the framework and then moved to the presentation of the detailed view. The detailed view was the consideration of each of the activities of the framework separately, meant to identify the correctness of the process.

The initial questions asked after briefly introducing the framework were meant to identify usability of the framework. Specifically, the following questions were asked:

1. Can evaluation of prudence support a company/decision making?
2. Who can perform those activities in a company?
3. Can this framework be used collaboratively?

Can evaluation of prudence support a company/decision making?

One of the participants agreed that the evaluation of prudence can help in the process of making a decision. Participant 2 considered the similarity of evaluation of prudence to the utility theory used in finance and indicated that at least in theory it could work if the common understanding of values behind it could be established. Finally, the remaining participant indicated that to answer the question it is necessary to define the context in higher detail. They mentioned that they can imagine a situation where a measure for prudence would be the impact of disobeying a regulation, which would be accepted if prudence is above a certain threshold, and rejected otherwise.

Who can perform those activities in a company?

Asked about the people who could perform those activities, the participants underlined that it should be ones somehow working with models, also closer to the enterprise architecture. To provide more concrete examples, the participants mentioned various architects, project board, and other stakeholders involved due to the context. An example of a context dependant stakeholder would be application owners or business process owners, when discussing the interaction between the application and business. All in all, the scope is large and context-dependant.

Can this framework be used collaboratively?

The framework was deemed as possible to be used collaboratively. Two of the participants indicated the need for an expert to guide the process, especially in the beginning of using the framework. One of the participants indicated also that it would be good to standardize the process as much as possible. Participant 3 provided an even stronger answer, saying it is necessary for it to be collaborative, as all stakeholders are needed for the presented activities.

After this, the interview moved towards activities specific questions. Below are the questions asked to the activities corresponding to them:

Debt Context Analysis

1. Which data/documents can be used to determine the context of a debt?
2. How can the stakeholders relevant to making a decision be identified?

Debt Collective Assessment

3. Can comprehensive concerns be determined from the gathering of the stakeholders?
4. How can it be verified if all relevant concerns were identified?
5. How to manage potential disagreements?

Debt Prudence Evaluation

6. Can comprehensive consequences be determined from the gathered concerns?
7. Given the consequences and based on the provided definition, can the prudence of the debt be determined?

Re-evaluation step

8. Would a re-evaluation require stakeholders involved previously or only those related to the concern, whose information got updated?

Debt Documentation and Communication

9. Who and how can document the activities performed?

Which data/documents can be used to determine the context of a debt?

One of the straightforward answers was that EA models, if available. As next, the participant mentioned process descriptions, project documentation, guidelines, IT repositories, configuration management database, IT and business documentation. Another approach was to interview the stakeholders to obtain the required information. Participant 1 mentioned additionally that it is usually rare for an organization to have a high quality EA model.

How can the stakeholders relevant to making a decision be identified?

To answer this question, the participants agreed that the first step would be to inspect the documentation, for example the project documentation. Another proposed approach was to use a tool that would contain such information, including the relation of stakeholders to the corresponding responsibilities. Such process would result in identifying the person, who could be knowledgeable in which stakeholders to include. This in turn would be an iterative process, leading eventually to the identification of all relevant stakeholders.

Can comprehensive concerns be determined from the gathering of the stakeholders?

The participants agreed that even though a gathering of stakeholders could provide many relevant concerns to consider, it is improbable to identify all concerns. This is mainly due to the human aspect of this process. For example, some people might be missing, resulting in their concerns not being covered. Additionally, it would have to be performed iteratively with the help of pre-prepared discussion points, in order to avoid chaos during discussion. Another aspect is that stakeholders might be reminded of additional aspect as they gain more knowledge during the meeting.

How can it be verified if all relevant concerns were identified?

Although deemed impossible, the participants proposed multiple approaches to ensuring as high amount of relevant concerns as possible. The first approach would be the documentation, which would allow to easier understand what happened and to perform further analysis. Another approach would be to find a dedicated person, who would understand the company and the relations between stakeholders. Such person would then have to judge whether it is possible to obtain further data or not. Finally, it would be possible to perform a screening test - also try to apply it and observe if anyone raises a complaint. If not, then it means all relevant concerns were identified.

How to manage potential disagreements?

To manage potential disagreements, the participants proposed various approaches. Participant 1 mentioned the calculation of the impact and likelihoods of the consequences to establish which are the ones to be taken care of initially. They also mentioned that for it, the common understanding of the issue would be crucial. Participant 2 proposed two approaches. The first one revolves around a method to reach an agreement by convincing others to ones own concerns, such as Planning Poker. Another approach would be something like the Pareto approach, allowing the stakeholders to keep their personal rating, in order to use it as a variable in the evaluation of prudence. Participant 3 proposes the use of methods used in conflict management. They also indicate that it is something that one can learn only through experience, despite many books on the

topic. They also point out that it is needed to personally possess some qualities like being understanding of others, in order to resolve the potential conflicts.

Can comprehensive consequences be determined from the gathered concerns?

The answer to this question is similar to the one about comprehensive concerns. It is further complicated by the aspect of having to consider the future, when considering consequences. One approach would be to run some scenarios to simulate them. The issue is that this could only work for a limited amount of scenarios. As the scenarios get larger, the more difficult it gets to assess them. The participants agreed that having a list indicating the correlation between the concerns and their consequences could help. This might though result in having to generalize it considerably for it to be adaptable to the context of the organization.

Given the consequences and based on the provided definition, can the prudence of the debt be determined?

To this question, the answers varied considerably. One of the participants answered it should be possible with regards to documentation, if we focused on the rough estimates. Another participant indicated that it depends on the way it is measured in. They also mentioned such assessment will carry an uncertainty due to the possibility of not all gaps being identified. The third stakeholder answered that if we consider prudence as a reliability of information measure, then it would not be possible due to the two being too different. They pointed out that the decision to make the debt is an issue of the past, while the consequences are related to the future.

Would a re-evaluation require stakeholders involved previously or only those related to the concern, whose information got updated?

For this question Participant 1 and Participant 2 agreed that a re-evaluation should preferably involve as few people as possible to make the step easier to execute. This of course depends on the relations in the company. One proposed approach was to perform a two-step process. The first step would involve the core group, whose focus would be on the impact consideration. The second step would be that of verification, involving a larger group with the help of reviews. Allowing to, if needed, consult a larger group of interest. Participant 3 on the other hand proposed re-starting the framework, pointing out that the re-evaluation of a decision already made is not helpful, as it was already applied and the new consideration would lead to a new decision. This would result in a possible overlap of relevant stakeholders, but would still require the identification of new ones.

Who and how can document the activities performed?

The participants indicated that it is more important to consider how the documentation should be performed, rather than by whom. One aspect to consider would be the standardization of the documents. Such tool could be then used by a person governing the process, however they should have more responsibilities than just documentation preparation. An initial tool could be a wiki, confluence, a share-point server or even a shared network, and similar.

Finally, the questions about the difficulties related to the framework were asked, followed

by a question about activities requiring adaptation. This resulted in the following two questions:

1. Can any challenges or difficulties in applying the framework be identified?
2. Is anything missing in the presented activities of the framework?

Can any challenges or difficulties in applying the framework be identified?

One aspect to consider is the governance and standardization of the framework. The improvement of the two should allow for the framework to be used in an easier manner. The proposed framework was considered lightweight. Another challenge is the clarification of terminology to ensure people can work with it. This is especially important given that if the framework is considered too high level, no one will consider using it.

Is anything missing in the presented activities of the framework?

The first remark considers explaining the difference between assessment and evaluation, as they are sometimes used interchangeably in the industry. The second remark discusses the necessity for a *Control measures* step. It would be used to ensure that the agreed upon measures are implemented and that it is performed correctly. The third proposition is to merge the first two steps, as they need to be performed iteratively, instead of in a sequence. As an example, similar issue can be observed in the waterfall model. Fourth proposition is to make the identification of debts a prerequisite for the framework instead of an activity of the first step. As mentioned before, another proposition is to remove the re-evaluation step as mentioned previously, and re-start the framework on every new decision. This would make the framework easier as some of the documents will already be known and identified. Sixth is the change of Debt Documentation and Communication to the EA Debt Repository, whose purpose would be to store all information. This would be intended to allow for the outside data to be included in the considerations. It would also be updated by the person performing all the steps of the framework. Other than the mentioned aspects, the framework was deemed complete and high level. To allow for an easier understanding, the framework should be defined as much as possible, especially before being used in industry.

6. Discussion

Don't write better error messages,
write code that doesn't need
them.

JASON C. McDONALD

Contents

6.1. Research questions findings	65
6.2. Evaluation results	66
6.3. Implications of results to practitioners and researchers	69
6.4. Threats to validity	71
6.4.1. Internal validity	71
6.4.2. External validity	71

This chapter is dedicated to the remaining points of consideration. Having performed the evaluation with experts in the field, a lot of valuable input was identified. The section *Evaluation results* is meant to propose an improvement of the results based on the feedback received. Next, the implications of the results of this work will be considered in order to underline the usability of the proposed definition and framework. Finally, we will discuss the threats to validity concerning this work.

6.1. Research questions findings

In our work to evaluate the prudence of *EA* Debts, we tried to answer one main and three supporting questions. The main question to consider was:

RQ1 How to evaluate *EA* Debts prudence in large-scale enterprise environment?

The entirety of the results of this thesis is meant to answer this question. To evaluate prudence of *EA* Debts in large-scale enterprise environment it is important to define the prudence and recklessness to be able to distinguish between the two and to establish a common understanding when discussing the prudence of an *EA* Debt. During the work, we learned it is also important to establish a culture of working with the debts in the industry. This includes the identification of debts, which is a pre-requisite for such an assessment. The industry also requires a concrete methodology with a defined use, in order to change the existing approach. To help with those aspects, we devised additional, supporting questions.

The first of the three supporting questions revolved around a definition of recklessness and prudence.

RQ1.1 What are the existing definitions of recklessness and prudence?

To answer this question, we performed a literature review search (please refer to Chapter 3) to gather the existing definitions in order to establish how prudence and recklessness have been defined in related fields. This allowed us to get an insight into the current understanding of the two.

In order to propose a definition in the context of *EA Debts*, we devised a question meant to identify criteria relevant to the evaluation of the *EA Debts*.

RQ1.2 Which criteria contribute to debt being reckless or prudent?

To answer this question, we generalized them and identified criteria (please refer to Section 3.2) used to propose a definition applicable in the context of *EA*. Such definitions (please refer to Section 3.3) can help to understand the debts better and allow for the differentiation between prudent and reckless debts in the context of *EA*. They also are meant to improve the communication between the various stakeholders.

Finally, the third question was meant to help the decision makers make an informed decision on the prudence of an *EA Debt*.

RQ1.3 Which steps should be taken to create a sound judgement?

To answer this question, we proposed a framework, based on the identified requirements (please refer to Section 4.2) for an *EA* framework. The requirements support the efforts to evaluate prudence in a straightforward way (please refer to Subsection 4.2.1) and as such, we believe the framework defines the steps one should take to make a sound judgement on prudence of a debt.

6.2. Evaluation results

During the evaluation, we obtained various, valuable feedback both with regards to the definition, and the framework itself. We would like to convert the feedback into a proposition of an improved definition and framework to improve their usability and quality. First, we will consider the results of the evaluation of the definition. For this, we would like to include the aspects mentioned by the participants during the evaluation.

Focusing initially on the main part of the definition, we identified a need to improve the *misleading* wording from the first proposed version of the definition. As described before, it is important to underline the risk-awareness aspect as opposed to focusing on the characteristic of being cautious. This is mainly due to the aspect mentioned by one of the practitioners that *incautious means like one would not care, like one would ignore the facts*. This is far from our understanding of the recklessness. We believe it might be necessary to take the reckless debt in some cases. One example would be in the case of start-ups, where mitigation possibilities are not as big, and it is important to make the initial breakthrough by committing a reckless debt due to for example the limited time or resources. This is far from not caring or wanting to ignore the facts. One might be aware, but regardless be forced to take the reckless debt. As such, after a brief discussion on the matter with the participants, we would like to propose the *risk-aware* for prudence and *risk-unaware or having a too high of a threshold for risks* for recklessness. The second aspect to consider in the main part of the definition is that of *allowing to avoid* in the

definition of prudence. As we are considering consequences, whose existence is related to the future, we should not confidently discuss being able to fully avoid them. The first issue is that we might not be able to predict all consequences. The second is that the future is uncertain. Even being extremely cautious, one can encounter unexpected problems in the future. This would require a more flexible approach. We would like to propose *reduce* as the improved description. This is due to the fact that, being risk-aware and preparing a mitigation plan, one can remove or reduce the impact of many risks. Similar to risk management, we can actively work towards the mitigation of the identified risk and preparing for the unexpected. This does not mean though that the unexpected will not happen, but some risks will be predicted and mitigated. Simultaneously, one should consider the corresponding part in the definition of recklessness. For this, considering the aspect of *increasing the risk*, we would like to propose *not reducing*, as the new formulation does not indicate that the risk will change based on our unawareness of it. The risk in fact will remain same, and only the decision to work towards its mitigation can be considered an influencing factor. Another aspect is the broad definition of negative consequences. Even though one could provide examples, we believe that for the purpose of the definition, it is better to keep the definition of consequences general, as the consequences might be context dependent. Additionally, such definition might require additional work to identify and generalize the consequences relevant to the concept of prudence and recklessness. Even though this is outside the scope of this thesis, it still poses an interesting future research question.

To the second part of the definition there were two main concerns. The first concern related to the aspect of reaching an agreement among various stakeholders. One of the participants pointed out, and the others confirmed that implicitly, that an agreement might not be as informative as it should. Additionally, it is more about understanding the debt taken, than agreeing to it. As such, we would propose the change of the second part, second paragraph to one considering the understanding, rather than the aspect of agreement. During the evaluation period, one of the participants mentioned that when gathering any agreement in a company environment might be difficult due to interrelations between various stakeholders. As such, we would like to propose the aspect of *understanding* the debt in place of the agreement of stakeholders. Another concern was about the two last points related to the definition. First aspect is that it is near impossible to mitigate all of the risks, while at the same time, even identified risks are not always worth mitigating. If we identify risks related to some system, that will soon be abandoned, it would be considered a waste to invest resources and time to mitigate them. Even if some work will be completed in such environments, the entirety of such work and the existing debt will still be discarded along with the abandoned project. This means that in such systems it is better to allow the debt to grow if needed. The important aspect is to keep balance between mitigation strategies and the understanding of the consequences. This results in the proposal of *considering relevant consequences* and *not considering relevant consequences*. The relevance of the consequences would then be defined from the context of the company, which would intend to use such strategy.

We would like to propose that **prudence is a characteristic representing a *risk-***

aware approach towards decision making, allowing to *reduce* unexpected, negative consequences of a decision made in the context of *EA* debt. Additionally, there are certain efforts to be done to exercise prudence. Namely:

1. **E1:** Consider the concerns represented by both the enterprise and project
2. **E2:** Seek the common *understanding* of involved stakeholders
3. **E3:** Consider *relevant* consequences and their mitigation strategies

Simultaneously, we would like to propose that *recklessness* is a characteristic representing a *risk-unaware or having too high of a risk threshold* approach towards decision making, *not reducing* the risk of encountering unexpected, negative consequences of a decision made in the context of *EA* debt. Additionally, there are certain mistakes increasing recklessness. Namely:

1. **M1:** Not considering the concerns represented by both the enterprise and project
2. **M2:** Lack of *understanding from* involved stakeholders
3. **M3:** Not considering *relevant* consequences and their mitigation strategies

We believe that those changes do not affect the results of the SLR in any manor that could be interpreted as modification requiring further inspection. Most of the changes applied revolved around the different formulation, which might be the result of the authors not being native in the English language. Both the initial version and the improved version of prudence definitions adhere to identified concerns and require further evaluation and research.

With regards to the framework, we also got important feedback. We will provide its summary and the resulting proposed framework as visible on Figure 6.1.

The participants discussed the need to clarify the difference between assessment and evaluation. Assessment is a process of gathering and analyzing the data for the purpose of describing the performance in order to improve it. Evaluation describes a judgement based on a certain set of criteria. As such, assessment will tend towards mathematical estimation, functions, data, and visualization, while evaluation is an activity performed by the evaluator based on the pre-defined criteria. Another aspect to consider was the indication that the debt identification is a prerequisite for the framework. The prerequisite can still concern an existing or a potential debt, one still needs to identify. This is not the only change in the first step of the framework. One of the participants indicated that the framework would be more realistic if the first two steps were to be merged. They argued that the activities presented in both will be performed iteratively in a company environment. For this we propose to still logically distinguish between the two, but to treat them as sub-parts of the same step, to map the iterative relation of

the two. Another change is the removal of the re-evaluation step. As mentioned during the evaluation, one participant indicated that the evaluation of debt should not change. This should be due to the fact that the decision was already made and consequences happened, so evaluation of the debt at a new point in time is rather an analysis of a new decision. The scope would change enough to consider all aspects in the decision making process. This does not mean there will not be any benefit from previously performed activities. Contrary, some documents and stakeholders will overlap and be already identified, allowing for the decision to be taken with higher understanding of the debt, which is beneficial as well. Next, one of the participants proposed adding a Debt Control Measures step, meant to supervise the application of the identified measures and also ensure the correctness thereof. This would lead to a step focused on the implementation of the proposed solutions, allowing to also gather the data in an easier manner. Finally, one of the participants proposed to rename the Debt Documentation and Communication step to EA Debt Repository, allowing for it to store data related to more than one project. This could allow to easier observe the relations between various strategies and debts. It would still be required to document the data from the proceedings and also to use the data for all of the framework steps. Contrary to the improved definitions, we believe that the framework should be re-evaluated in terms of its clarity and applicability under the changes applied. Additionally, an important aspect might be to consider performing an additional set of interviews with practitioners to identify more accurately the activities required, and their relation, for such a framework.

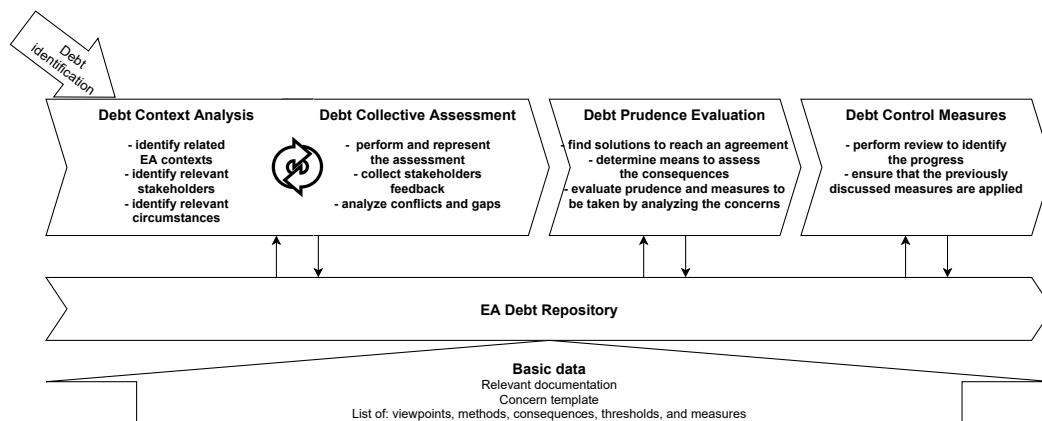


Figure 6.1.: The framework for evaluating prudence after evaluation. It represents the steps and the data used by the framework. The up and down arrows represent input and output documents respectively.

6.3. Implications of results to practitioners and researchers

During the SLR, we found no other studies defining neither prudence nor recklessness, which adds to the novelty of our research. The concept of prudence can prove to be

beneficial in the context of *EA Debt*, similar to how prudence is used in the context of *TD*.

We will focus now on the applicability of the proposed framework. According to Zachman [Zac99], a framework for the architecture of information systems is beneficiary, because it helps to:

1. improve communication,
2. understand the reasons (causes) and risks,
3. place tools in relation to each other, and
4. develop improved approaches.

Another point of view is represented by Intel [TB19], where they observed a contribution to the following fields:

1. Business outcome-driven Enterprise Architecture (EA) across the business, data, application, and technology domains;
2. Governance and accountability;
3. Prioritization of investments;
4. Operational efficiency and shifting budget into innovation, new capabilities and enhancements;
5. Awareness and ownership of technical debt.

From this, one can gather that a framework is often used to improve communication, especially one amongst various domains to obtain satisfactory results. We can abstract the benefits away to the context of *EA*, as many of the mentioned benefits would be well suited for decision making related to debts. Another benefit is that the existing operations need to be easily expandable and adaptable to support the process. Additionally, one should be able to identify risks and by extension to recognize the urgent cases to prioritize the points of focus. Such a framework is meant to increase the awareness of the enterprise architecture debt, while increasing the understanding and confidence in future decisions. Finally, such framework has to allow to react appropriately to the existing or future debt, for example by developing new methods to work with the debts, which were previously difficult to manage.

As described previously in Section 3.3, to achieve prudence, there are some efforts to be made, namely to:

1. consider the concerns represented by both the enterprise and project,
2. seek the common agreement of involved stakeholders, and
3. consider all identified consequences and their mitigation strategies.

This aligns with the requirements set upon a framework. By increasing the communication between stakeholders from all involved domains, the possibility to voice concerns is increased. Additionally, the consideration of the available documents allows to obtain a more broad overview of not only the concerns related to the project itself, but also those linked to the enterprise. Introducing a framework that facilitates information exchange allows in turn to seek common agreement. This is further supported by the increased awareness and understanding of the *EA* debt, as the evaluation highlights the reasoning *why* taking action is necessary, while considering *by whom*, *how*, and *when exactly* a debt should be taken. The framework also allows to understand what could be the result if the situation is left unattended. Identifying consequences and their respective mitigation strategies is also one of the goals of the framework as mentioned by the identification of risks and ownership of the debt, resulting in the ability to prioritize the investments made as a result.

6.4. Threats to validity

To determine the threats to the validity, we will follow the definitions by Wohlin et al. [Woh00]. One of the aspects to consider is the possible bias of the researchers, which one should consider when considering the results of their work. As such, we will consider the internal and external threats to validity for the SLR and framework.

6.4.1. Internal validity

We would like to consider the internal validity in relation to the entirety of the thesis results, meaning both the SLR and framework. As the internal validity considers the how trustworthy the relationship established between the study and its results, it requires an objective approach to assessing the gathered data. To mitigate the bias, all results were reported and consulted with the supervisor of the thesis. Additionally, we performed an evaluation, during which we consulted the results with the experts in the field. This was meant to minimize the impact of subjective consideration of data.

6.4.2. External validity

We would like to consider the external validity in relation to the entirety of the thesis results, meaning both the SLR and framework. The external validity considers the generalizability of results to other settings. As such, we described the entire procedure to allow for the study to be replicable. Additionally, we performed the snowballing during the SLR to include other relevant papers. In relation to the framework, we did not consider the specific case or context, other than that of *EA*, when defining the framework. As this work presents a proposition of a structure of a framework, it still requires further work on the more detailed aspects. As such the resulting framework is generalizable to any context. Another aspect to consider in relation to the external validity is the limited amount of resources used for this work due to the relative novelty of the topic. To mitigate that, we considered as many as possible papers that resulted from the SLR.

6. Discussion

With relation to the framework, we also tried to gather data supporting our approach, in order to make it as generalizable as possible.

7. Conclusion and future work

If debugging is the process of removing bugs, then programming must be the process of putting them in.

EDSGER DIJKSTRA

Contents

7.1. Summary	73
7.2. Future Work	74
7.2.1. Definitions	74
7.2.2. Framework	75
7.2.3. Others	76

During our work, we wanted to support the decision makers in their work in the context of *EA*. This lead us to propose the definition of the concepts of prudence and recklessness, to allow to make decisions with respect to the consideration of the risks and the impact on the entire enterprise. Additionally, we propose a framework to support the decision makers in the process of making a decision, identifying the activities, which help in the evaluation of prudence of an *EA Debt*.

7.1. Summary

In this work, we wanted to focus on the concept of prudence and recklessness in the context of Enterprise Architecture (*EA*). In order to do this we devised one main and three supporting research questions meant to guide us in the process. The main question focused on the evaluation of prudence in the context of large-scale enterprise environment. To better understand the goal, we identified three supporting questions (please refer to Subsection 3.1.2). First, focusing on the search for existing definitions of prudence and recklessness in the existing scientific literature, was used to assess the current understanding of the two. Second, trying to identify criteria contributing to the debt being either prudent or reckless, was used with the goal of differentiating the prudent debt from a reckless one. Finally, the third question, focusing on steps needed to be taken to soundly assess the prudence or recklessness of the debt, was meant as a support for the decision makers, identifying what to do in order to correctly assess the debt.

To help answer the first question, we decided to perform a Scientific Literature Review (SLR) (please refer to Chapter 3). The process allowed us to find and select papers that could help us define prudence and recklessness in the context of *EA Debt*.

Having performed the *SLR*, we identified the criteria that were appearing in the existing definitions, focusing on ones that could be applied in the context of *EA*. Those criteria helped us provide an answer to the second *RQ*. Based on the results of the performed *SLR*, we proposed two definitions (please refer to the Section 3.3), one for prudence and one for recklessness. To answer the third *RQ*, we proposed a framework as described in Chapter 4. To ensure correctness, we identified the requirements for an *EA* Framework (please refer to Sections 4.1 and 4.2) and based on them proposed a framework composed of four main blocks (please refer to Section 4.3). The proposed application of the *PEF* was presented in Section 4.4. We believe that the answer to the presented three *RQ* amounts to answering the main Research Question (RQ).

We then performed the evaluation of the results proposed by performing a series of interviews (please refer to Chapter 5). We asked the participants predefined questions to the definitions and framework separately (please refer to Table 5.1). The evaluation allowed us to identify some critical aspects to consider. This included changes in the wording of the proposed definitions, and also the consideration of the framework in the context of practical application thereof. Based on the the results of the work and the evaluation performed, we proposed some modifications and aspects to consider, when working with prudence and recklessness in the context of *EA* (please refer to Chapter 6).

One of the main implications of this work (please refer to Section 6.3) is cultivating the culture of recognizing and considering the debt, in order to prepare against the negative consequences of the decisions made, both expected and unexpected. We believe the results of this work will improve the communication in the enterprise by providing the common understanding of relevant terms, such as that of prudence and recklessness. Additionally, we consider this work a step towards raising the awareness about both the existence and severity of *EA Debt*. To aid in that we propose the definitions and framework as initial means to help understand the debt and assess its prudence. We do, however, identify that this process requires further focus and work, as it requires additional, iterative steps meant to correlate the needs of practice with the results of the theoretical work.

7.2. Future Work

We believe this thesis can be used as a starting point for the further work required in the field of *EA Debts* evaluation. To structure the future work, we propose the division of the future work into the work to be performed with respect to the definitions, work needed to consider the framework, and other remaining work.

7.2.1. Definitions

As we had limited time to perform a thorough evaluation, it is important to perform additional evaluations of the proposed definitions, possibly including performing a workshop in various companies, to help understand the concept of prudence better. We provided a detailed report of the evaluation, in order to make additional evaluations possible. Such

work could consider additional questions that were not considered by the authors of this thesis. This would make the results presented more reliable, allowing to use them with higher confidence. Additionally, one could compare the responses given towards the initially proposed definition, to those given to the definition proposed after the evaluation. When dealing with theory, it is worth to consider as much feedback as possible to obtain a valid and reliable final result.

It is also important to identify the need for an additional study of prudence. This should especially be prepared and performed with the industry in mind. This thesis was meant to gather the theoretical background on the concept of prudence. However, as we intend to use the concept of prudence also in the context of industry, it is necessary to gather inputs from various stakeholders representing various companies. This would help to assess the applicability of the concept in an industrial setting and provide accurate definition of prudence in a way that can be used in practice.

7.2.2. Framework

With regards to the framework, there are various aspects to consider in the future work. One of them is to further define the framework, by providing more concrete examples, methods, inputs, and outputs. Even though the presented work provides initial examples thereof, it is important to consider them in detail, especially considering their applicability in the given context. The evaluation of the framework showed that as much as there is a need to define such a framework, there are many aspects left to consider. One example is the consideration of the methods used in the financial and project management sector, that would be applicable to the assessment or evaluation steps of the framework. Based on the results of the evaluation of the framework, it is also worth considering the division of the activities with the point of interest being the applicability of the framework in industry. Additionally, it is important to identify any potential overlaps, so that the processes performed can be optimized, in a way that would reduce the required time and resources used to apply the framework in practice.

As it is, the proposed framework is still too general to really be applied in practice. However, it is important to remember that the framework should retain some generalizable aspects in order to be applicable to various contexts represented by various companies. As such, one should find the fine line between the framework being too general to use, and being too detailed to be applicable in various companies. To help with the identification of the more detailed view of the framework, we believe it important to consider performing a series of workshops with various companies. Using the general framework, one should ask detailed questions, meant to identify the unclear, but needed aspects of the framework. We believe that our work can support future research in establishing the initial common understanding needed to perform such work.

Having established the methods used, one can go further identifying methods, used to help adapt the framework to the context of the specific company. One aspect would be how to identify the consequences and when to consider a debt prudent given the specific context. Two interesting points to consider would be whether a dedicated expert is necessary for such adaptation of the framework, and whether the framework needs to

be adapted once or periodically.

7.2.3. Others

As the remaining future work, we identify the need to establish a culture to consider the debts in the industry, allowing researchers to gather more hands-on data on the evaluation of debts. The more people recognize the importance of debts, the more research will be performed in the field and the easier it will be to gather relevant data. Similar to the consideration of establishing a culture, it is important to ensure the common understanding of concepts related to the context of *EA*. One should ensure that all the aspects, covered by the definitions, framework, and other *EA* concepts, are commonly understood in the same way. Similarly, theory and practice should both rely on the same understanding.

For this, one could consider providing a uniform tool meant to gather *EA* Debts with the necessary information present in one place. Such a documentation tool could then support any decision making framework, including the Prudence Evaluation Framework proposed by this work. Similarly, one could consider creating a tool meant to classify the debts automatically based on the provided parameters. This could simplify the decision making and the potential frameworks meant to support it.

A. Mindmaps

A.1. Prudence

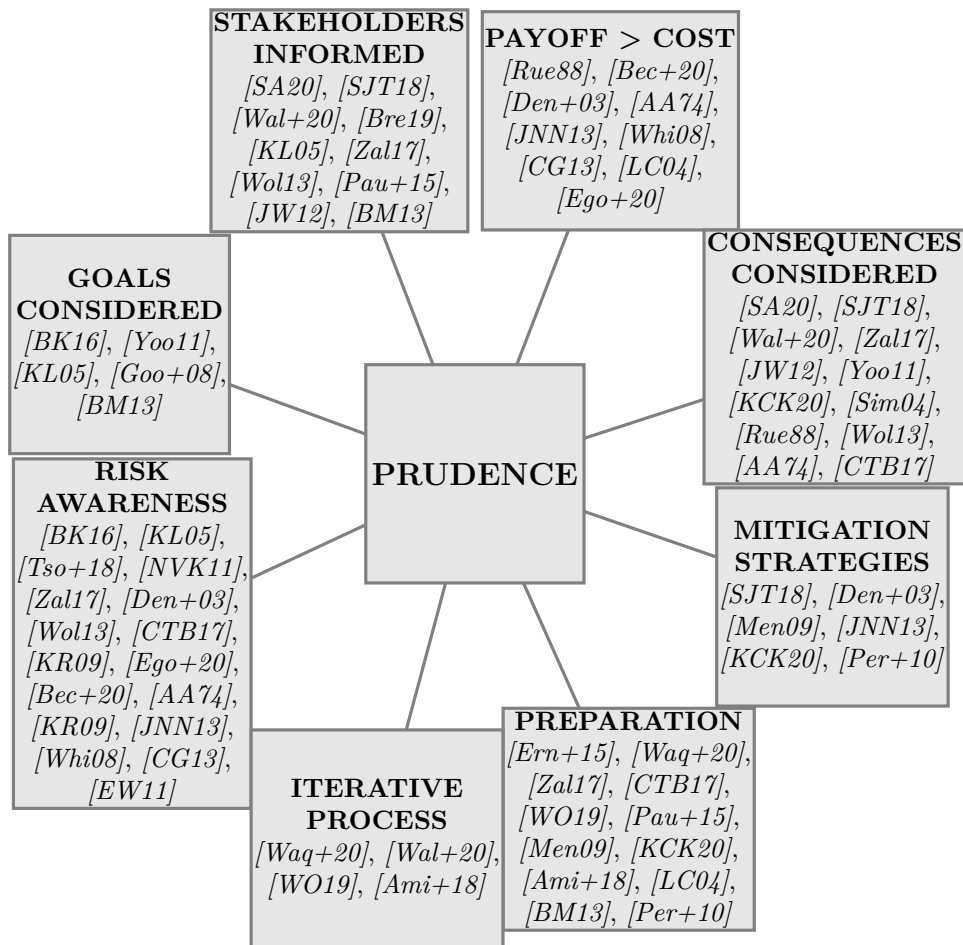


Figure A.1.: The mindmap representation of the criteria related to prudence

A.2. Recklessness

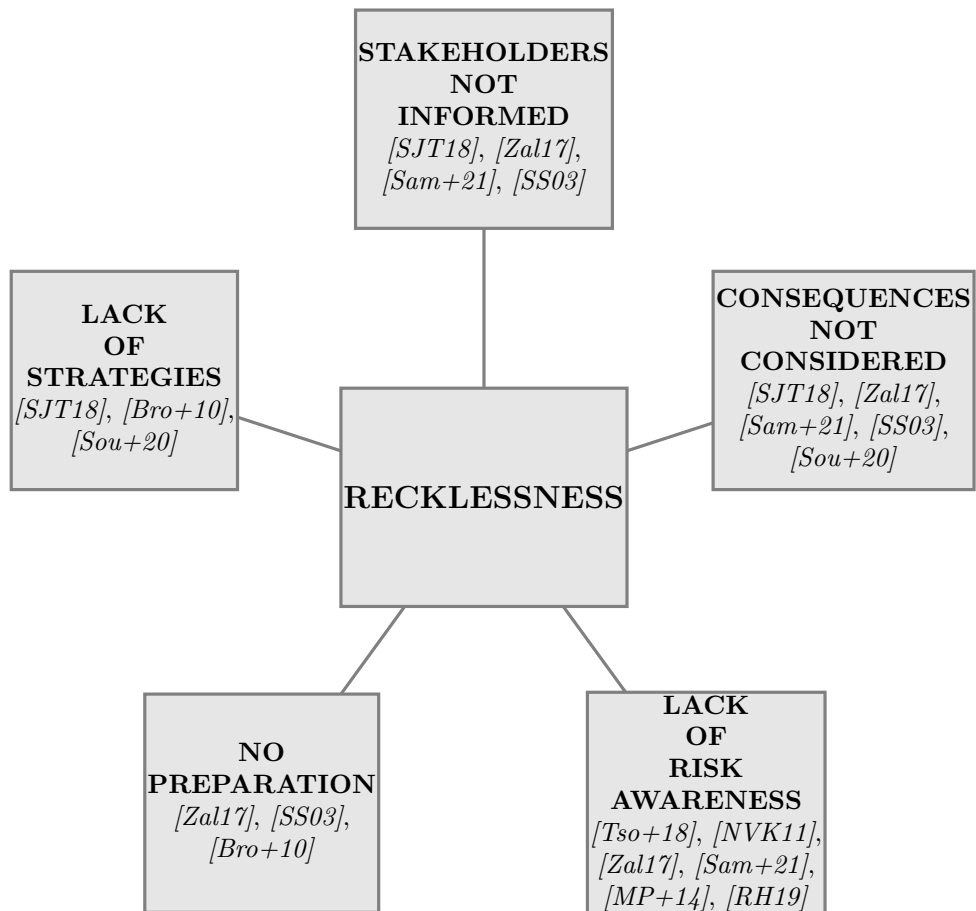


Figure A.2.: The mindmap representation of the criteria related to recklessness

Criteria	References
payoff > cost	<ul style="list-style-type: none"> - prudent as of high quality - cost vs quality [Rue88] - in doubt classify as bad credit rather than a good credit [Bec+20] - assessment of risks and costs to mitigate them [Den+03] - prudent risk-taking approach [AA74] - larger risk requires larger preventive measures [JNN13] - larger risk, makes more patient [Whi08] - prudent - save more in face of risk [CG13] - inappropriate attributes waste valuable evaluation resources [LC04] - considering risks in the face of not paying of [Ego+20]
consequences considered	<ul style="list-style-type: none"> - foresee little interest probability on the rushed parts [SA20] - after analyzing the benefits and when to repay it - action plan to repay, and eventually, eliminate it [SJT18] - reusing implementation is not always prudent [Wal+20] - consequences are analyzed especially wrt risks [Zal17] - prudent person hypothesis [JW12] - prudent egoism [Yoo11] - preventive focus to reduce vulnerability [KCK20] - prudent compromise - opportunity, competition and deadline to be considered [Sim04]
long-term consequences	<ul style="list-style-type: none"> - prudent as of high quality - cost vs quality [Rue88] - risk reduction adds value to stakeholders [Wol13] - prudent risk-taking approach [AA74] - considering risks with relation to the impact and future uncertainties [CTB17]
mitigation strategies	<ul style="list-style-type: none"> - after analyzing the benefits and when to repay it - action plan to repay, and eventually, eliminate it [SJT18] - assessment of risks and costs to mitigate them [Den+03] - prevention of risk should be bound by optimal threshold [Men09] - larger risk requires larger preventive measures [JNN13] - preventive focus to reduce vulnerability [KCK20] - avoid exchange when threshold crossed [Per+10]
preparation	<ul style="list-style-type: none"> - most debt occurs in the "inadvertent/prudent" quadrant [Ern+15] - impact and threshold of the risks should be identified and quantified periodically [Waq+20] - consequences are analyzed especially wrt risks [Zal17] - considering risks with relation to the impact and future uncertainties [CTB17] - establishing norms and processes for assessing risks [WO19] - prudent decisions require knowledge and understanding [Pau+15] - prevention of risk should be bound by optimal threshold [Men09] - preventive focus to reduce vulnerability [KCK20] - warning on unusual behavior [Ami+18] - inappropriate attributes waste valuable evaluation resources [LC04] - prudence as informed and context dep. [BM13] - avoid exchange when threshold crossed [Per+10]
stakeholders informed	<ul style="list-style-type: none"> - foresee little interest probability on the rushed parts [SA20] - after analyzing the benefits and when to repay it - action plan to repay, and eventually, eliminate it [SJT18] - reusing implementation is not always prudent [Wal+20] - documentation of TD is important as the teams can change [Bre19] - project manager optimism in risk taking [KL05] - consequences are analyzed especially wrt risks [Zal17] - risk reduction adds value to stakeholders [Wol13] - prudent decisions require knowledge and understanding [Pau+15] - prudent person hypothesis [JW12] - prudence as informed and context dep. [BM13]
goals considered	<ul style="list-style-type: none"> - prudent person principle [BK16] - prudent egoism [Yoo11] - project manager optimism in risk taking [KL05] - prudent predator [Goo+08] - prudence as informed and context dep. [BM13]
risk awareness	<ul style="list-style-type: none"> - prudent person principle [BK16] - project manager optimism in risk taking [KL05] - crucial to analyze awareness (reckless or prudent) and intention [Tso+18] - awareness (reckless or prudent) 2 [NVK11] - consequences are analyzed especially wrt risks [Zal17] - assessment of risks and costs to mitigate them [Den+03] - risk reduction adds value to stakeholders [Wol13] - considering risks with relation to the impact and future uncertainties [CTB17] - metric of sensitivity to changes in risk [KR09] - considering risks in the face of not paying of [Ego+20]
risk-averse	<ul style="list-style-type: none"> - in doubt classify as bad credit rather than a good credit [Bec+20] - prudent risk-taking approach [AA74] - conservatism in decision making [KR09] - larger risk requires larger preventive measures [JNN13] - larger risk, makes more patient [Whi08] - prudent - save more in face of risk [CG13] - prudence as downside risk aversion [EW11]
iterative process	<ul style="list-style-type: none"> - impact and threshold of the risks should be identified and quantified periodically [Waq+20] - reusing implementation is not always prudent [Wal+20] - establishing norms and processes for assessing risks [WO19] - warning on unusual behavior [Ami+18]

Table A.1.: Criteria describing prudence along with the corresponding list of citations and their short descriptions

Criteria	References		
stakeholders not informed	<ul style="list-style-type: none"> - without plans to be managed and repaid - no attempt to learn TD and eliminate it [SJT18] - no care for consequences including risks [Zal17] - unawareness of debt trade-offs [Sam+21] - disregarding the data, model does not match context [SS03] 		
consequences not considered	<ul style="list-style-type: none"> - without plans to be managed and repaid - no attempt to learn TD and eliminate it [SJT18] - no care for consequences including risks [Zal17] - unawareness of debt trade-offs [Sam+21] - disregarding the data, model does not match context [SS03] - introducing problems, with a negative impact, consequences of recklessness [Sou+20] 		
lack of risk awareness	<ul style="list-style-type: none"> - crucial to analyze [lack of] awareness (reckless or prudent) and intention [Tso+18] - lack of awareness (reckless or prudent) 2 [NVK11] - no care for consequences including risks [Zal17] - unawareness of debt trade-offs [Sam+21] 		
	<table border="0" style="width: 100%;"> <tr> <td style="vertical-align: top;">high risk accepted</td> <td style="padding-left: 20px;"> <ul style="list-style-type: none"> - failing to recognize danger [MP+14] - acceptance of unacceptably high risk, tolerance [RH19] </td> </tr> </table>	high risk accepted	<ul style="list-style-type: none"> - failing to recognize danger [MP+14] - acceptance of unacceptably high risk, tolerance [RH19]
high risk accepted	<ul style="list-style-type: none"> - failing to recognize danger [MP+14] - acceptance of unacceptably high risk, tolerance [RH19] 		
lack of strategies	<ul style="list-style-type: none"> - without plans to be managed and repaid - no attempt to learn TD and eliminate it [SJT18] - decision made without strategy/plan [Bro+10] - introducing problems, with a negative impact, consequences of recklessness [Sou+20] 		
no preparation	<ul style="list-style-type: none"> - no care for consequences including risks [Zal17] - disregarding the data, model does not match context [SS03] - decision made without strategy/plan [Bro+10] 		

Table A.2.: Criteria describing recklessness along with the corresponding list of citations and their short descriptions

B. Transcription of evaluation

On the following pages, we would like to present the shortened transcript of evaluation.

B. Transcription of evaluation

	Participant 1	Participant 2	Participant 3
Position	Lead Information Architect	Assistant Professor	Professor
EA understanding	<ul style="list-style-type: none"> Hollistic consideration over organization, includes business aspects (processes, strategies, roles) and systems perspective (technology, network), all of this is connected by data defined on a business level and more detailed when nearing the technical level, a lot about using models and visualization, and trying to structure the organization using a particular framework. 	<ul style="list-style-type: none"> Underlying structure of organization, having processes, software, people and how they relate to each other OR <ul style="list-style-type: none"> management of the previously mentioned aspects, principles steering the EA and also the models of it, EA Debts are the underlying reason why the actual state is not equal the ideal state you want to go to. 	<ul style="list-style-type: none"> Hollistic approach to align IT according to business needs and strategy, bridge between IT and business.
Perception of prudence and recklessness	Consider the delta between the hollistic and reality view: <ul style="list-style-type: none"> recklessness - to allow a gap between the hollistic perspective and the reality. prudence - the intention of reducing the data (making the steps smaller) Ideally, EA is a tool to make decision: <ul style="list-style-type: none"> recklessness allows the tool to not perfectly fit prudence allows to modify or update the tool to fit the purpose better. 	Both relate to conciousness. <ul style="list-style-type: none"> prudent - making an informed decision recklessness (in the context of creating new debts) - not being aware of doing wrong/not caring because of own goals/ignoring other peoples goals 	I did not make up my mind around them so far. Based on TD quadrant: <ul style="list-style-type: none"> I would place EA debts rather on the left hand side (authors note: reckless), as we have a strict framework and broad understanding what it means and how to measure it. To move it to the right hand side (authors note: prudent), we would need common understanding, some definition, examples, or best practices, so that you can communicate with other people and all of them understand the same.
Is being risk-aware enough to define prudence?	The more cautious you are the more it should reduce the amount of negative consequences.	<ul style="list-style-type: none"> Awareness does not mean you do not take the risk If people are aware of risks and they have assessed them properly, then making a decision (even taking the risk), is nothing against business rules. Maybe the risks are very low, and even if its costs are very high if the risk realizes, the probability is so low that people might still consider taking it. 	So far I would not add additional aspects.
How to identify context of the EA debt?	Typically, when a change would be made, one would have to look at the context: requirements, impact, involved parts, to find out what is close to whether decision makes and how can a change spread and have an impact on organization. What is close and what is distant. Typically, not considering the consequences is almost always reckless.	<ul style="list-style-type: none"> Classically, I would do some kind of a stakeholder analysis, to identify what are the stakeholders of my enterprise/project (management, customers, both from technical and business side) and look what are their demands. When I refer to management, I mean things like you have a strategy, which describes where you want to go as an organization. 	Most crucial - get aware of the debt <ul style="list-style-type: none"> using for example the root cause analysis not only understanding that a debt is there, but also why is it there workshop together with the experts, to understand the debt and its background, to later understand why it is there To identify reasons for issues: <ul style="list-style-type: none"> fish bowl diagram, pain point analysis

Figure B.1.: Evaluation transcript page 1 of 8

<p>Does reaching an agreement of all stakeholders make a decision prudent?</p>	<p>A decision made without an agreement would be reckless. Understanding is important.</p> <ul style="list-style-type: none"> Without an agreement, one needs to consider consequences. People might agree on things they don't understand. 	<p>Doubtful about reaching an agreement.</p> <ul style="list-style-type: none"> stakeholders usually have different, sometimes contradicting goals trade-off of different goals might be possible and the process to achieve it would be some kind of prudent. 	<p>If agreement refers to:</p> <ul style="list-style-type: none"> existence of the debt, it is one step. driving towards solving the debt, then even more yes. all participants reaching an agreement that the step should not exist, then even a bigger yes. <p>But it really depends on what is the agreement about. Just agreement is too contextless.</p>
<p>Can prudence be exercised through a poll among stakeholders?</p>	<p>-</p>	<p>For example, yes. There are different ways to get goals from them.</p>	<p>Typically, have an agreement and document it.</p> <ul style="list-style-type: none"> If you refer a poll and then having documentation of the buy-in or the agreement of stakeholders, then yes. Should support prudence, as all stakeholders are forced to really consider what they are agreeing to.
<p>What would be a stakeholder agreement threshold for such a decision to be prudent?</p>	<ul style="list-style-type: none"> Considering the threshold is very context dependant. In some cases, where the company is very mature, 60% might be enough. Usually, in the general case, it would be reckless. 	<ul style="list-style-type: none"> Yes and no. There might be a line, which when crossed could be called reckless or not. However, it might be event harder to identify this line than to get the agreement of all stakeholders. 	<ul style="list-style-type: none"> There is no general threshold. This cannot exist, because each company is different. In an individual situation or in one company, I think it is possible to agree on something. How to measure the influence people have on each other? How to measure the popularity of people? Having a general definition "how should it be defined/measured" is even harder, as there are so many parameters, that you cannot put them in one equation.
<p>Would an EA Debt without a mitigation strategy be prudent or reckless?</p>	<ul style="list-style-type: none"> The first step of working with EA debts is to create awareness and basic understanding, so having something like this is already good. Otherwise, there might still be things not considered going wrong, which would be rather reckless. 	<ul style="list-style-type: none"> If you are aware of the debt and you decide to take it, then it is not necessarily reckless. You should think about mitigation strategies, but you do not have to implement them. 	<ul style="list-style-type: none"> Depends on the context. Refer to risk management here. If you consider it a small risk, you do not need to consider the mitigation strategies. Sometimes the impact is so low that you just expect it to happen. The potential consequences set will never be complete, so a good mitigation plan includes a plan for consequences, we cannot foresee at the moment., We need to also assess each debt and each consequence that we are aware of. Then one needs to focus on relevant consequences, in the end we never consider all of them.
<p>Are prudence and recklessness like true/false or are they rather on a scale?</p>	<p>-</p>	<p>A continuum, so a scale.</p>	<p>On a scale. There is no binary value for prudence and recklessness, there are a lot of values in between.</p>

Figure B.2.: Evaluation transcript page 2 of 8

B. Transcription of evaluation

<p>Is such definition usable to communicate information about a decision?</p>	<ul style="list-style-type: none"> • Yes, I think especially when comparing different scenarios. • Considering A vs B, A could be more prudent and B more reckless. They could be considered as A being prudent, and B being more prudent than A. 	<p>If you communicate that the decision is:</p> <ul style="list-style-type: none"> • prudent, it will work. • reckless, people might be not very happy about it due to the negative annotation. 	<ul style="list-style-type: none"> • Hard to apply it in general, because it really depends on the context. • For example, you can identify what are the KPI for measuring quality or completeness of information. Then you can define that if completeness is over 80%, we might consider it as prudent and otherwise reckless. • The concrete values strongly depend on the context, so it might vary a lot.
<p>Should anything be added/changed in this definition?</p>	<ul style="list-style-type: none"> • Negative consequences is quite general. • Incautious sounds like one would not care, like you ignore facts. I think recklessness can be that you know the consequences, but you accept them. That you are cautious about potential negative impact. • Add to the definitions that recklessness is about having too high of a threshold to accepting the risks. 	<p>No, I do not think so. I think it reflects what I think about them.</p>	<ul style="list-style-type: none"> • Good distinction between cautious and incautious. Cautious meaning I am assessing the situation and try to understand the consequences of my decision. Incautious not being aware or not caring for them. • In the prudence part, "allowing to avoid (...)" - this is not possible. The consequences are unexpected and as such, you might not be aware of them when making a decision. Reducing would be fine. • In the recklessness, on the right hand side instead of "increasing", just accepting the risk or not reducing the risk would be more appropriate, because the risk would be the same, especially the risk of unexpected. If you are cautious of it, you might get aware of it, but it will not increase. • The two last points are two extremes. Instead of all, consider relevant consequences, as of course considering all will never happen. It would be prudent to not focus on consequences that aren't impactful. And then on the right hand side - not considering relevant consequences. • I would not add anything, because the definition should be rather compact and easy to memorize. The more details you add, the less intuitive it will be. So it is perfectly fine.

Figure B.3.: Evaluation transcript page 3 of 8

<p>Can evaluation of prudence support a company/decision making?</p>	<p>Yes, I think so.</p>	<ul style="list-style-type: none"> • Might be, at least in theory. • Did you have a look at utility theory in finance? So prudence and recklessness are like the volatility of something, which is usually referred to risk in finance, and the debt is then the return. The decision making would be based on utility function, which describes how risk-averse you are. • As this was already used for decision making in finance, so yes, why not? If you are able to have common understanding of the values behind it, it could work in EA. 	<ul style="list-style-type: none"> • To understand the concept of prudence, we have to identify the purpose of prudence, what is completely new about it. It is a matter of how to communicate it to the company. • It is needed to define more context for the framework. • We cannot talk about debt if the decision was not made yet. • Impact of a decision about disobeying could be a measure for prudence. Then at the end of the framework one would consider prudence. If the level of prudence is high, the framework would help to accept the debt, and if that level is below a certain threshold, then it would mean one should not make the decision.
<p>Who can perform those activities in a company?</p>	<ul style="list-style-type: none"> • Different architects (enterprise architects, solution architects, domain architects, information architects, business architects) • Anyone who has an impact on the organization, if they were trained to have an open eye could be doing the identification. Of course, then it would have to be someone who works with models, closer to enterprise architecture work. • In general, group who can give input is fairly large. It depends on the part of organization. For example, if development would be involved, this could be product owner. 	<ul style="list-style-type: none"> • Generally, often when we talk about the scenarios, then, at least for the bigger projects, you have some kind of project board, which decides about project and which direction it should go. • You could apply this, so the project would just need to assess it somehow and have it checked by the board members. 	
<p>Can this framework be used collaboratively?</p>	<ul style="list-style-type: none"> • It would be important to make the process structured, repeatable, and provide guidance. So I think it would need to be mature. For it to be governed, it would have to be standardized. • If we could make things repeatable it could be done, but would require some safe-guarding, especially in the beginning. 	<p>This project would require an expert dedicated to working on the framework.</p>	<p>One cannot do such an exercise without all of the various stakeholders, so it has to be collaborative.</p>
<p>Which data/documents can be used to determine the context of a debt?</p>	<p>Everything from:</p> <ul style="list-style-type: none"> • EA models, process descriptions, information flow diagrams, or more abstract things like: • minutes of meetings • mismatch between the UI and the application data that it works with, can be a gap. 	<ul style="list-style-type: none"> • EA model, if you have one. • Regulatory guidelines that would be the strategies. Architecture guidelines. • Some vision of the organization. • Interviewing stakeholders involved. 	<ul style="list-style-type: none"> • Project documentation, any IT documentation or business documentation that includes IT information can be used. • IT repositories, configuration management database.

Figure B.4.: Evaluation transcript page 4 of 8

B. Transcription of evaluation

<p>How can the stakeholders relevant to making a decision be identified?</p>	<ul style="list-style-type: none"> • In my organization most things have an owner and a data cataloging tool with dataflows, definitions, assets, responsibilities, and owners. • Looking at dataflows in such a tool would be a good first step to see. Iteratively, you would identify all people. 	<ul style="list-style-type: none"> • I think that the easiest way would be to do that based on the documents. • Ideally, there is a person in the company involved in this that already knows, which people would be influenced by the debt somehow. • It could partially be done by a tool. The model and similar are quite easy. But, if you have documentation, it is usually in plain text, so it would require natural language processing. • Conducting the interviews with stakeholders via a questionnaire, but they are limited in what you can ask for. I do not think it is completely possible to map everything. 	<ul style="list-style-type: none"> • Deduct them from the documents. • Project documentation usually has a lot of names, like project manager, quality manager, perhaps steering committee.
<p>Can comprehensive concerns be determined from the gathering of the stakeholders?</p>	<ul style="list-style-type: none"> • If you manage to identify the right stakeholders, you should identify quite a lot of what is needed. • It's a discussion on how much and what quality data do you have. • Have you identified everything? It is likely, but not 100% certain. 	<p>Comprehensive? Working with humans, there is always a lag to get anything.</p>	<ul style="list-style-type: none"> • No. It is hard to get people into one room for a discussion, given they work in a company. • One should prepare before such a meeting to use the stakeholders time efficiently. Even if you are well and carefully prepared, chances are, that during the discussion new data appears, because someone in the room understood more and has new information. Prepare decisions and questions before to make the proceedings easier. • There will always be people who will be missing for whatever reason. Comprehensive and complete results are not possible as they will take a lot of time and resources. • That is why the facilitator or the Enterprise Architect need to identify relevant concerns. Major concerns can be discussed, minor might be dismissed by participants.
<p>How can it be verified if all relevant concerns were identified?</p>	<ul style="list-style-type: none"> • Documentation in a standardised way, so its comparable and structured. Having documentation makes it easier to understand what actually happened and perform impact analysis. • It helps to ensure that the understanding is enough, so that the stakeholders have the basis to speak about what they want. • Process models can be used to identify dependencies. And application architecture if it ends with documentation of it. 	<p>No, not really. The only thing I can come up with is the screening test - you go for what you have and if nobody complains, it seems to be ok.</p>	<ul style="list-style-type: none"> • That is impossible. • There are no general stop conditions for the iterations. The decision maker should make a decision in between. • It starts with getting written documentation. It always depends on the context when to stop. There is so many factors that you need to consider to know when to stop. • The best advice is - the person doing the analysis and assessment, needs to be established and have a good network in the organization. It requires an expert, for the company to make the call.

Figure B.5.: Evaluation transcript page 5 of 8

<p>How to manage potential disagreements?</p>	<ul style="list-style-type: none"> • Identify likelihoods of consequences and if some are more likely and more stakeholders identified them, they are probably what needs to be dealt with. Identify what is most "burning" and the mitigation solution to it. • Common understanding is challenging, but it is the key. Moderating techniques can help ensure the common understanding. • Having a list of concerns, you would need to prioritize them based on the probability and their impact and solve them one by one. 	<p>You can go two ways.</p> <ul style="list-style-type: none"> • One way would be to do what in planning poker for example, so you try to reach an agreement and then exchange opinions. • The stakeholders might be so different that maybe some Pareto approach would be more suitable saying like you have a rating from each stakeholder and they give some kind of continuum of rating. • It is not to try to hold it down to one number, but keep the different numbers. So again going back to utility theory. 	<ul style="list-style-type: none"> • There is a lot of literature about conflict management. It is so, as it is hard to put it into recommendation list or an algorithm. • People need to have emotional intelligence, be capable of understanding the feelings and thoughts of others, as well as adapt their own behaviour towards the perception of other people. It is something you learn from practice.
<p>Can comprehensive consequences be determined from the gathered concerns?</p>	<ul style="list-style-type: none"> • It is difficult, as you would want to see the future and its impact. • You would need to derive to-be scenarios and try to see how they perform - thanks to a model analysis during the second step. A concern would then have a certain score or several of them. Based on an impact analysis, one could simulate different to-be scenarios to see how the score changes based on the implementation of the changes. • As it would require a lot of data collection, it might not be doable. In some scenarios you would need some reference values, might need to reuse the data, and involve probabilistic reasoning to cater eventualities. It probably can be done in limited cases, if the scenario at hand is not too complex. The larger the scenarios get and the context that you want to investigate, the more difficult it would be. • Lists correlating the two could theoretically help, but it depends, as you would want some that exactly fit your situation/organization/etc. It would be preferable, but it might not be doable without generalizing quite a lot. 	<ul style="list-style-type: none"> • You can think of some of them, but comprehensive - I do not think so. You will always have overseen some, so there will be always some kind of uncertainty. • Having a list mapping the two could help. 	

Figure B.6.: Evaluation transcript page 6 of 8

B. *Transcription of evaluation*

<p>Given the consequences and based on the provided definition, can the prudence of the debt be determined?</p>	<p>When thinking about the documentation, it should be possible. At least as a rough estimate, similar to t-shirt sizes.</p>	<ul style="list-style-type: none"> • To some degree. Depends how you want to measure it. • If from the previous step it is clear ok, there are some gaps, then it is quite easy, but maybe they did not come up with any gaps, because they were not creative. Then you could say ok, there is one gap, which they found, and a lot of other ones, that they are not aware of, which would indicate recklessness. • Again, there is some kind of uncertainty in the assessment. 	<ul style="list-style-type: none"> • No, because the two are two completely different things. • I understand prudence as the degree of reliability of the information that the initial information was based on. Even if we are trying to make a decision on creating a debt now or ex-post evaluate how reliable was the information, when we made the decision on making the debt, back when it was made - it is something focusing on the past. • The consequences are in the future and they do not depend on the quality of the decision making process. Especially in corporate environment, the consequences are measured by money.
<p>Would a re-evaluation require stakeholders involved previously or only those related to the concern, whose information got updated?</p>	<ul style="list-style-type: none"> • It would be preferable to involve as few as possible to keep them easier. People's time is expensive and it is a time consuming endeavour. • When you have various opinions, it is easier to do the overall impact analysis and discuss consequences. So from that perspective, we would need a full picture. • Maybe a two-step process could be taken, where the core group focuses on discussing the impact, and you have a larger group that rather reviews or is informed. But still you have the possibility to involve a larger group if needed. 	<ul style="list-style-type: none"> • Realistically, the less people, the better. If you always involve all, then some will be sitting there, thinking why am I here. And it costs a lot of money. • People whose concerns information got updated, together with the person governing the process. 	<ul style="list-style-type: none"> • I do not think the decision on prudence might change. It should be decided at the time of the decision. When it is made, it is not helpful to re-evaluate the decision that was made after a year, given more information. • We might re-assess prudence on how well-justified the debt is right now, but it still implies we are again in the decision process, which after a year is a new decision. • Instead, stop the framework and upon a new information/decision, start the framework again. It would make the framework simpler. • Some data will overlap. On second time many documents have already been analysed for the first step, even if new documents will need to be identified. There also will be an overlap in stakeholders needed, but there will also be changes, requiring to identify some new stakeholders.
<p>Who and how can document the activities performed?</p>	<ul style="list-style-type: none"> • It should be a person involved in the execution. Maybe a dedicated resource or several people, in particular when gathering the information. • It would be good to have a standardized template, which could be re-used and searchable, like a wiki or a confluence or something like that. 	<ul style="list-style-type: none"> • The person governing the process. • All decisions would have to be documented, so it is clear how you got there. • For first try you can use some kind of wiki and from that you can see if anything more special is needed. You can use some ticketing tools with information documented on the ticket. 	<ul style="list-style-type: none"> • People performing the framework should do the documentation. It should not be a person dedicated just to making the documentation. • It is more important to focus on how it should look like. • It can be a tool, a sharepoint server, confluence, a shared network.

Figure B.7.: Evaluation transcript page 7 of 8

<p>Can any challenges or difficulties in applying the framework be identified?</p>	<ul style="list-style-type: none"> • The good thing is that it's lightweight, not having many process steps. • The stronger the governance of it and the more it can be standardized, the easier it will be. 	<p>-</p>	<ul style="list-style-type: none"> • Yes, if it is too high level, no one will apply it. • Concerning terminology, make sure people can work with it, either because they know it or there is an excellent explanation.
<p>Is anything missing in the presented activities of the framework?</p>	<p>Clarify the difference between evaluation and assessment. In the industry they are sometimes used as synonyms.</p>	<p>Classically, you would need something titled "Control measures" later. Using a plan-develop-perform-review, a little bit of acting is missing. Currently, there is no "ok, we do something" - a step to remove the debt or whatever the decision is.</p>	<ul style="list-style-type: none"> • Merge together the first two steps - they cannot be done in sequence. In the industry you would identify the context, move towards analysing it and realize that you missed something, so you would get back to the context. They are rather iterative. • Remove identification of debt from the first step - should be known before. It should be input for the framework - an event/trigger, prerequisite for the framework. • I would change the "Debt Documentation and Communication" to EA Debt Repository, where all information is stored. No matter what is done, the person performing it could update the repository. There could also be data from outside. • It is still high-level, I would not say anything is missing. Describing details is important, especially if it is to be used in corporate environment.

Figure B.8.: Evaluation transcript page 8 of 8

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Glossary

EA Enterprise Architecture

EA Debt Enterprise Architecture Debt

PEF Prudence Evaluation Framework

RQ Research Question

SLR Scientific Literature Review

TD Technical Debt

