Measuring and Managing the Design Restriction of Enterprise Architecture (EA) Principles on EA Models

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***Abstract*—Implementation and formalisation, alongside with creation, adoption and usage of Enterprise Architecture (EA) principles are hot topics of the current years of EA research. However, the EA community, both academic and professional, misses a consensus on the definitions and use of principles. Furthermore, not much research is done in the direction of measuring the impact (e.g. design restriction) of EA principles. We aim to create a formal framework for measuring and managing this impact manifested by the EA principles on the EA models.**

Studying the current literature, we noticed there are similarities and differences between EA principles and regulations. The two concepts resemble each other given first, the purpose (both providing a normative guidance on the evolution of the enterprise) and second, the natural language representation and the structural definition (even if most of the time the principles are company specific, they all seem to have common fields in their definition). Principles behave mostly like soft-laws and being non-compliant with them results in fewer penalties and consequences compared to non-compliance with regulations. To that end, we investigate and adapt methods similar to the ones that can be found in requirements engineering for checking and managing regulatory compliance.

***Index Terms*—Enterprise architecture (EA), EA principles, EA models, formalism, compliance**

I. Introduction

In practice, enterprises are confronted with frequent changes and challenges and the alignment between the constantly changing business objective and organisation's landscape (e.g. business processes, IT infrastructure and applications) has to be managed. In order to do so, the organisations use Enterprise Architecture (EA), as a method to represent a holistic view of the company and to guide and steer its evolution. Thus, EA encompass all levels of the organisation, including business processes and IT, aligning them with external regulations and requirements of the stakeholders.

In order to define the means by which technology and services are managed, acquired, designed or configured, architects use what it is called "enterprise architecture principles". In our understanding, the architecture principles are soft-laws that are used to steer modellers (architects) in their effort to create EA models (specifically, IT and business layers).

An observed issue in the current state-of-the-art is the lack of a consensus on both the definitions for EA and EA principles and the lack of common practices for the usage of EA principles [9], [29], [1], [33], [16]. Furthermore, there are issues regarding the interpretation and formalism of principles, as well as ranking and applying principles based on priorities and trade-off analysis.

Similar to regulations, EA principles are used to set boundaries on design of enterprises and provide guidelines and limits for the enterprise's evolution. EA principles can be viewed as soft-laws as opposed to regulations. Non-compliance with them does not directly cause legal sanction, however, it can add cost or cause financial losses to the enterprise due to making bad design decisions. Principles are written in natural language and similar to regulations can be vague and ambiguous. Also, most of the time principles are written by enterprise architects (based on stakeholders' goals and preferences) with limited knowledge about regulations. This can result in conflicts with the regulations as well as conflicts in the set of resulting EA principles.

Given the resemblance between the EA principles and the regulations, we aim to study the existing formal methods present in the fields of requirements engineering and regulatory compliance, enhance and adapt them for the enterprise architecture domain. To our knowledge, in EA there is no formal method to capture principles and to analyse their impacts on the enterprise, whereas in other disciplines, such as requirements engineering, there exist some methodologies (e.g. Nómos3 [20], Legal-URN [11] for analysing regulatory compliance between business rules, laws, regulations and business processes). Even if companies and architects emphasize on the importance of principles [33], the real impact of EA principles on the creation of the EA models, their adoption process, their life cycle, etc., is not formally tackled in the current on-going research in the field of EA.

Our main concern is to understand how the EA principles are reflected into the resulted EA models. We aim to evaluate whether the design decisions made by architects are aligned (compliant) with the principles, calculate the degree of coverage of the EA principles by EA models and analyse the impact of (potential) misalignments. Moreover, we aim to provide means to align principles with external regulations and analyse what is the impact of non-compliance with either principles or laws.

The analysis is twofold. On one hand, changes in the set of principles (e.g. addition, deletion or modification of principles) triggers consistency checks on the models and revision of the current landscape. On the other hand, analysis of the current situation (e.g. current objectives or current environment of the organisation) can trigger changes in the set of principles, potentially makes the principles outdated and creates conflicts with the new goals, new situations and potential imposed regulations.

We aim to exploit and extend Goal-oriented Requirements Language (GRL) [24] to formalize EA principles. In addition to the representation and impact analysis provided by GRL, we choose logic-based methods for documenting and analysing the rationales (e.g. motivation, alternative decisions, impact of decisions) and for formalising the propagation rules mechanism (e.g. how each block of the model interacts with its connected components and implications of change).

The rest of the paper is structured as follows: in Section II, we briefly review the current state of the art regarding the definitions, adoptions and use of architecture principles, the regulatory compliance frameworks as well as requirements a for regulatory framework. In Section III, we position our work and present our proposed framework. We discuss the applicability of our framework in Section IV. We conclude and present directions for future work in Section V.

II. Related Work

A. EA Principles Definitions

In the current literature, there is not a consensus on the definition of EA principles, and furthermore on their impact. In this section we summarise the current state of the art, such that we can clarify what "principles" are in our understanding. We use the terms "EA principles", "principles", "EA design principles" for referring to the same entity.

- Principles are an organisation's basic philosophies that guide the development of the architecture. Principles provide guidelines and rationales for the constant re-evaluation of technology plans [28].
- Simple, direct statements of how an enterprise wants to use IT. These statements establish a context for architecture design decisions by translating business criteria into language and specifications that technology managers can understand and use. Architecture principles put boundaries around decisions about the system architecture [7].
- Architecture principles define the underlying general rules and guidelines for the use and deployment of all IT resources and assets across an enterprise [22].
- A design principle included in an architecture is a declarative statement that normatively prescribes a property of the design of an artifact, which is necessary to ensure that the artifact meets its essential requirements [14].

Design principles are declarative statements that normatively restrict the design freedom [14]. A normative principle is a declarative statement that prescribes a property of something (it can be seen as a "rule of conduct"). This is the focus of our work. *Design instructions* are instructive statements that describe the design of an artifact. They contain usually concepts used in the actual construction of the enterprise (e.g., value exchange, transactions, services, contracts, processes) and use a representation language (e.g., UML, ArchiMate, BPMN, DEMO) [14]. Design instructions provide a more operational and tangible refinement of the design principles. Due to their nature, design instructions allow an enterprise to simulate/analyse the effects of different options for the future, as well as analyse the current state and identify current problems [21]. In conclusion, *enterprise architecture principles*, in our understanding, focus on how the design of an enterprise meet its essential requirements. They are declarative statements that can be made more precise using design instructions (by modelling and formalising the design principles).

In recent years, some work have been done to define and represent EA principles. Fischer et al. [9] made efforts in creating a common definition of principles in their environment while the formal representation of principles is tackled by Chorus et al. [8] and Bommel et al. [32], [31]. Greefhorst et al. [14] and Haki et al. [16] collected and refined templates and meta principles. Fischer et al. created a meta-model of EA principles in their environment, based on the analysis, synthesis and extension of the previous contributions (e.g. [28], [7], [18], [22]). First part of their definition deals with the principle itself, and contains the statement, rationale, implications, key actions and measurement. The second part of their definition extends the definition such that it captures the use and the impact of the principles on the environment. We adopt their definition for EA principles in our work.

B. Formalising EA Principles

Formalising architecture principles comes from deep analysis of drivers (i.e., goals and objectives that stakeholders seek to meet) embedded in the strategy of the enterprise, the risks that may occur, potential opportunities and constraints. TOGAF lists five criteria that distinguish a good set of principles: a) Understandable: The underlying conviction can be quickly grasped and understood by individuals throughout the organisation. b) Robust: Each principle should be sufficiently definitive and precise to support consistent decision making in complex, potentially controversial situations. c) Complete: Every potentially important principle governing the management of information and technology for the organisation is defined. d) Consistent: Principles should not be contradictory to the point where adhering to one principle would violate the spirit of another. e) Stable: Principles should be enduring, yet able to accommodate changes.

In addition to formalism, creation process is supported and documented by frameworks such as the one proposed by Greefhorst and Plataniotis et al. [15], [27]. These frameworks/methods support the principles' life cycle and the decision process for adopting principles. They also capture the assumptions that form the basis of introducing principles in the organisation or alternatives of design decisions.

In another effort to formalise EA principles, Marosin et al. [24] establish the foundations of a principles-based GRL approach. Inspired by Ghanavati et al. [11] that models regulations with an extension of GRL called Legal-GRL, the authors model principles and rationales in EA by introducing a GRL Profile. Akhigbe et al. [3] introduce an adaptive EA framework (BI-EAEA [1]), that allows to proactively accommodate the changes that occur in evolving settings (e.g. how the enterprise responds to various changes, such as modification, deletion and addition of organisation's objectives). To that end, KPIs (Key Performance Indicators), integrated with the GRL model, are used to measure the performance level of the information systems with regards to the business goals. Furthermore, the authors identify and compare seven groups of decision making approaches that are suitable for modelling and evaluation with GRL [2]. Their work shows the feasibility of using qualitative values, supported by the tool [6].

C. Regulatory Compliance in Requirements Engineering and Logic Literature

In the field of legal compliance, Ghanavati et al. [10] identified 5 areas of research, as follows: 1) business process compliance frameworks (e.g. guidelines on how to extract and map legal requirements), 2) methodology for prioritizing the legal requirements (in terms of impact on the objectives and in respect with the law), 3) templates to create law-compliant business processes, 4) methods for improving the links between legal requirements and business processes (in terms of impact) and 5) overall improvement of the goal modelling notations and their analysis to capture the legal aspects. Our work follows partially this suggestions and adapts them to the field of enterprise architecture. We aim to work on defining guidelines and methods for formalising EA principles (similar to research stream 1 identified by Ghanavati et al.) and focus on the impact analysis of the EA principles on the EA models (research streams 3 and 4).

The work of Colombo-Tosatto et al. [30] tackles logic based approaches for compliance checking. The authors propose an abstract logic-based framework, in which business processes are represented by simplified petri nets whereas the obligations are represented in a language similar to the one developed by Governatori and Rotolo [13]. In this work, the obligations are defined as a set of conditions the business process has to comply with, that have a life cycle and a deadline (specific temporal moment when the obligation has to be in place). Colombo-Tosatto introduces the notion of compensation: if it is not possible to comply with a norm, then the compensation mechanism provides a new obligation to which the process must comply so that it is considered compliant. Furthermore, Marosin et al. [26], [25] defined an abstract reasoning framework and introduced algorithms for changing intentions (e.g. goals) and commitments (e.g. actions forming a plan) based on reasons and assumptions. In their work, the authors use case studies from the field of enterprise architecture. The reasons and assumptions are abstract entities and include changing goals or motivation, or changing the assumptions about the environment (e.g. assumptions about resources, time, risks, costs, etc.). The framework supports the introduction and analysis of new alternatives, in case the old commitments cannot fully satisfy the goals. The notions of compensation and the analysis of new alternatives are features we wish to tackle in our future work, when creating, adopting or changing a set of principles.

D. Synthesis

1) EA principles as regulations: Much work has been done to align software and business requirements with regulations, but we observed there is no research done in a similar way for the field of EA, and there are no insights about how the EA models are aligned with regulations, and in particular with EA principles. Similarly to business process compliance, which focuses on integrating business processes with (legal) requirements, the goal of our work is to integrate enterprise architecture models with architecture principles.

[1] Business Intelligence - Enabled Adaptive Enterprise Architecture

As seen above, there are similarities and differences between EA principles and regulations. First, we found similarities with regulations and laws, such as the vagueness given by the natural language representation and the structural definition (even if most of the time the principles are company specific, they all seem to have common fields into their definition). The creation of principles comes from deep analysis of the goals of the enterprise and they are created such that the goals are (partially) fulfilled. Second, we noticed the differences, most important that principles do not need to be blindly followed and have different degrees of adoption.

Given the similarities, we believe that a goal-oriented representation is suitable for principles. Using GRL, we aim to link the principles to the goals of the company, provide influence links and run analysis (e.g. see what happens if principles support conflicting goals, if principles conflict, if principles partially support multiple goals). GRL is our choice because it is part of a standard (i.e. User Requirements Notation (URN) [5]) and it includes quantitative and qualitative evaluation mechanism and KPIs. GRL tool-support, jUCMNav [6], which is an Eclipse-based plug-in, helps resolving the scalability issues of GRL. Furthermore, GRL can be extended by the help of Metadata and URN links concepts.

2) Requirements for a compliance framework: Given the variety of existing compliance analysis approaches and the different application domains, Thao Ly et al. [23] synthesize the current approaches and propose a list of ten functionalities over which compliance frameworks can be evaluated, as follow: 1) include constraints that refer to time; 2) include constraints that refer to data; 3) include constraints that refer to resources; 4) support both atomic and non-atomic activities; 5) support the activity life cycle; 6) support multiple instances of the same compliance rule in an activity trace; 7) reactively detect and manage compliance violations; 8) proactively detect and manage compliance violations; 9) explain the root cause of a violation; and 10) quantify the degree of compliance. Our aim is to tackle as many of these requirements in our framework. Architecture principles include constraints referring to time, data and resources, therefore, the first three requirements are mandatory to meet (e.g. requirements 1,2,3). Our main focus is on performing post factum analysis of the compliance/coverage and trigger changes both in the models and in the set of principles (e.g. requirement 7). We aim to trace back the source of non-compliance, in order to act upon (e.g. requirement 9). One of the end goals of our work is the identification of methods to quantify the degree of compliance (e.g. requirement 10).

III. Framework Presentation

In our work we adopt a design-oriented approach [17]: first, we conducted a systematic literature study identifying both the state of the art and the current gaps in the research, followed by defining the current framework. In the future steps we will develop further the framework, evaluate it via case studies and interviews, improve and re-evaluate. The current paper focuses on the framework definition.

By studying the literature and case study examples, our goal is to define KPIs or consistency indicators and to create a formal framework that can support and test the balance between the compliance and the impact of non-compliance on the EA models.

We divide our framework into two main interconnected parts, as represented in Figure 1: the formal models (left), for example ArchiMate [2] models [21], business rules and the formal representation of EA principles, and the informal models (right), such as documents and textual informal representation of models and principles.

In the space of enterprise architecture, the EA principles restrict the design freedom of the architect when creating EA models [14]. The block "regulatory intent" captures the regulatory intentions of the stakeholders involved in the formulation of the principles in the textual format. It contains the semi-informal representation of the EA principle. In our work, we do not investigate the real motivation behind the creation of the EA principles, but instead we aim to study the techniques to formalise and analyse them. The EA transformation (the block "To-be Enterprise" is out of the scope of this work, therefore, together with its transitions, it is greyed-out in Figure 1.

To check the consistency and to automatise the verification, we need to formally represent the EA principles in a way that they become machine understandable. The "regulatory model" block, which is the formal counter-part of the "regulatory intent", aims to serve this purpose. The regulatory intent represents principles in an informal way (such a textual representation), whereas the regulatory model contains the formal representation of principles (such as business rules and OCL rules). The "regulatory intent" is driving/changing the "To-be Enterprise". The "To-be Enterprise" represents a shared understanding between stakeholders on what needs to happen such that the organisation follows its strategies. This represents the expected behaviour/trajectory of the enterprise in case all of the rules/principles are fully enforced and plans are fully respected. This informal representation is transposed into a formal "EA model", designed by an architect (e.g. an ArchiMate model).

In order to bridge the formal and informal worlds, we propose the definition of four protocols, each specialised

[2] ArchiMate is an open and independent enterprise architecture modelling language to support the description, analysis and visualisation of architecture within and across business domains in an unambiguous way. ArchiMate is now a standard from The Open Group and it is based on the concepts of the IEEE 1471 standard.

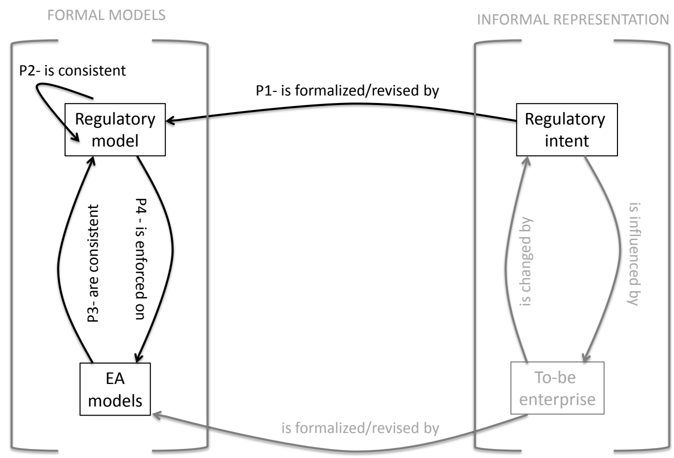

Fig. 1: Proposed framework

on a different side of the same problem. In Figure 1, we mark which protocol is responsible for each transitions and we define the scope of each protocol in the rest of this section. The role of the proposed protocols is two-folded: to provide guidelines on how to formalise the information from the real world and to provide consistency checks, define enforcement strategies, provide guidelines on how to avoid violations or evaluate the non-compliance cases. Protocol 1 deals with the formalism and methods of revision of the principles, Protocol 2 is responsible for keeping consistency of the set of principles, Protocol 3 is in charge of compliance checking between principles and EA models and Protocol 4 defines how the principles should be enforced.

a) Protocol 1 (P1): This protocol is responsible for the formalism of the regulatory intent. It links bi-directionally the regulatory intent with the regulatory models. The first role of Protocol 1 is to formalise the EA principles, so it should be designed in such a way that it supports and rationalise the elements of the real world. Thus, it should provide methods on how to handle the natural language modalities (e.g. "should", "would", etc.) exist in the definition of EA principles, how to handle vague and incomplete statements (for example a principle such as "One should not discriminate based on nationality" needs to be disambiguated by a set of measures), how to capture the motivation of principles and the design rationales when creating an EA model, correlated with the EA principles. The definition of this protocol will be the result of case studies, conducted as unstructured interviews. We, together with architects, aim to investigate how to minimize the uncertainties and how to formally represent the EA principles.

Chorus et al. [8] and Bommel et al. [32], [31] made efforts in formalising principles from TOGAF and industrial practice using ORC[3] rules and ORM[4] schemas. They use a template to represent EA principles, as follows: *statement* (from the original text), *rationale* (from the original text), *assumptions* (made by the authors while interpreting the original text), *ORM schema*, *verbalization* (semi-formalized natural language translation of the ORM schema) and *issues* (things that need to be clarified such that the principle is specific enough to be operational).

The previous efforts show that the main issue for formalising the principles is given by the natural language interpretation. We aim to create guidelines for interpretation and together with architects find out how the principles are supposed to be interpreted and applied. We wish to find out why their definition is so vague and why uncertainties are introduced. Furthermore, we wish to leverage GRL to model principles, link them to precise goals of the organisation as well as to operational actions for realisation.

b) Protocol 2 (P2): This protocol is defined over the formal set of principles. It represents a feedback loop in the set of principles with sole role of keeping the set consistent. Beside the formalisation in GRL, we aim to define principles as norms from deontic logic. When performing a change in the set of principles, by adding, modifying or deleting a principle, Protocol 2 should be triggered. The checking mechanism will be designed using a logic-based approach. First steps into creating revision algorithms and introducing alternatives were made by Marosin et al. in [26], [25]. In the future work we aim to further refine these norm revision algorithms, based on the goals of the organisation, new situation at hand or assumptions made. .

c) Protocol 3 (P3): This protocol has the role to check the consistency between the regulatory side and the models side (bottom-up analysis, as presented in Figure 1). It is important to align the regulatory intent (EA principles creation and adoption) with the organisational goals, mission and vision. We aim to define this protocol with the help of goal-oriented modelling approaches. By using GRL and its tool support, we can visualise and analyse if there is a correlation between the goals and the principles and analyse the influence relationships between them. First steps towards this directions were made by defining a Principle-based GRL [24]. By performing this analysis we can also capture if it is feasible to use a EA principle, or if an existing one is deprecated.

d) Protocol 4 (P4): This protocol is responsible for assuring that the principles are followed and that the created models are in line with them (in Figure 1 this relationship is represented top-down). This protocol contains enforcement strategies for the EA principles on

[3]Object-Role Calculus
[4]Object-Role Modelling

the EA models. Furthermore, Protocol 4 should support impact analysis, such that violations have clear, quantifiable consequences. Based on this analysis, EA models can be created compliant-by-design based on the regulatory model. Furthermore, we can check compliance if either the models or the regulatory framework is changing and provide compensation strategies or alternatives in cases of non-compliance. To do this, we aim to leverage and extend GRL analysis algorithms [4] to perform top-down (P4) and bottom-up (P3) evaluation.

IV. Discussion

A. Case Study Description: XBRL Assurance

In this section we describe the use of principles and the EA design decisions based on principles in the case of the XBRL Assurance [19], [12]. XBRL is a standard message representation format for exchanging financial informations, adopted in the Netherlands as part of a program called Standard Business Reporting (SBR). By law, from 2015, annual financial statements need to be filed in XBRL, through the SBR portal.

The architecture has to be compliant with 5 design principles, according to [19] as follows:

1) SBR assurance should be an integrated solution for creating, signing and publishing both assurance reports and annual accounts, or other types of financial statements.
2) Each filing consists of separate XBRL instances for assurance reports and for financial statements, but the approach should be able to create a solid link.
3) The structure should be flexible, to support future modifications in the structure of assurance reports.
4) The standard is applicable to all types of reports, and should in principle be applicable both within and outside of the Netherlands and the SBR framework.
5) The Dutch Taxonomy Architecture is followed as much as possible.

These design principles are created to satisfy some legal constraints, such as the Civil Code 2-210 or the reporting under the MIFID regulations. Furthermore, the governmental agency in charge of implementing the XBRL Assurance (Logius) is constrained by limited time to finish the implementation and storage space. The main issue is given by the signing and linking the auditor report to the financial statements process, which, in the initial design, uses of 5 XBRL message instances and requires performing 6 distinct steps.

B. Preliminaries

The Goal-oriented Requirement Language (GRL) [4] is a goal modelling notation, basing its syntax of the i* language. A GRL diagram shows the high-level business goals and non-functional requirements of interest to stakeholders and the alternative means for achieving these goals and requirements.

GRL intentional elements are connected to each other through different types of links, such as decomposition, contribution, correlation or dependency. A decomposition can be a type of *AND*, *IOR*, or *XOR*. Contribution links indicate the impact of one element's satisfaction on another element's satisfaction. A contribution link can have a qualitative contribution level ("make", "help", "some positive", "none", "some negative", "hurt" and "break"), or a quantitative contribution level (represented by an integer value between âĹŠ100 and 100). Correlation links are similar to contribution links, but describe side-effects rather than desired impacts. Finally, dependency links model relationships between actors (one actor depending on another actor for something specified with an intentional element).

GRL models can be evaluated several times based on different strategies, mainly for comparison. Satisfaction values can be qualitative ("denied", "weakly denied", "weakly satisfied", "satisfied", "conflict", "unknown", "none"), or quantitative (represented by an integer between âĹŠ100 and 100). The satisfaction values capture contextual or future situations as well as choices among alternative means of reaching various goals. The qualitative and quantitative evaluation attributes of the intentional elements in the strategy are initially set to 0 and "none" respectively. These values are then propagated to other intentional elements via the links between them (i.e., contributions, decompositions and dependencies), according to predefined algorithmic rules.

C. Interpreting and Modelling the EA Principles in GRL

We consider the second and the forth EA principle presented above and use GRL for modelling, as follows:

EA principle 2) "Each filing consists of *separate XBRL instances* for *assurance reports* and for *financial statements*, but the approach should be able to create a solid link". This principle introduces two different tasks to create the reports, as presented in Figure 2.

In this example, the interpretation problem is given by the statement "a solid link". The principle can be simplified and represented in GRL, however this statement is ignored due to its vagueness. We need to talk with architects or other stakeholders involved in formulating this principle in order to understand the goal and meaning of this statement. This will lead to introducing a new protocol in P1 set to help measuring and interpreting "solid link".

EA principle 4) "The standard is applicable to *all types of reports*, and should in principle be applicable both within and outside the Netherlands and the SBR framework".

This principle is not straight forward to follow and it introduces even more interpretation issues. It first requires to document the existing types of reports and

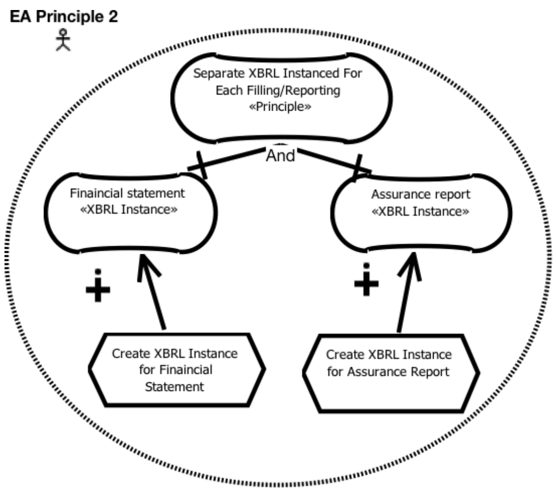

Fig. 2: EA principle 2

then document each report type's needs. Again, by adding a protocol in P1 set, we help resolving the ambiguities.

For simplicity, we model the compliance with the NBA (The Dutch Institute of Charted Accountants) reporting. The NBA has its own taxonomy for the SBR assurance and requires that both the manager's signature *and* the auditor's signature are encoded into the XBRL instances, regarding or complexity, bandwidth or storage space limitations. These tasks are presented in Figure 3.

In addition, to ensure that our set of 5 EA principles are consistent with each other and are not contradictory with each other, we introduce protocols from P2 set.

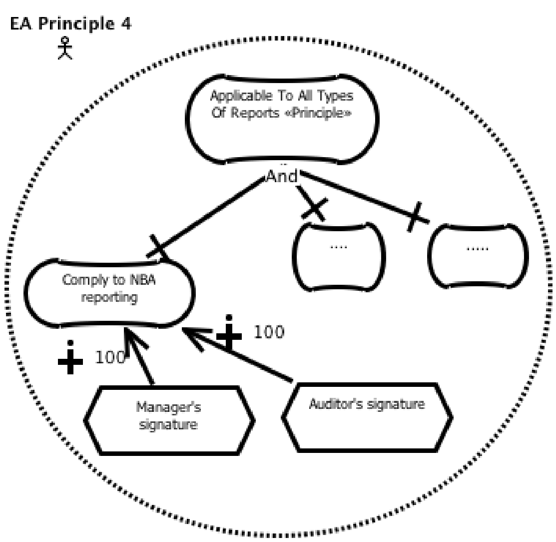

Fig. 3: EA principle 4

D. Interaction between EA Principles and XBRL assurance processes

One of the raised issues was the signing and the linking the auditor report to the financial statement. According to [19] this process requires 5 different XBRL Instances, as follows: 1) the annual financial statements; 2) the signature of the manager on the financial statements; 3) the assurance report; 4) the auditor's signature on the assurance report; 5) an instance with the role of container, adding the date and place of the report. This process, presented in Figure 4, in the current form is compliant with both EA principles detailed above.

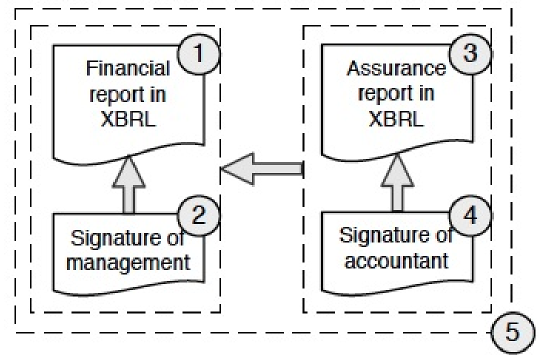

Fig. 4: Signing and linking the auditor's report to the financial statements, adopted from [19]

E. Modelling and Analysing the XBRL Assurance in GRL

Based on discussions and the effort to accommodate the constraints and principles in their architecture designs, the architects come up with two solutions: either 3 or 5 XBRL message instances. Both solutions partially satisfy the principles, laws or constraints. We model them in GRL.

In Figure 5 the concerns that need to be addressed by Logius are represented in the upper part, as goals: "Comply to Civil Code 2-210", "Comply to MIFID regulations" and "Limited time and storage". In our case all goals have two importance levels, 100-"high" for the "Limited time and storage", which makes this goal impossible to break and 50-"medium" for the rest. Furthermore, each design decision has a positive or negative contribution on the goals (represented as an integer a between -100-"hurt" and 100-"make"). The design decisions ("3 XBRL Instances" and "5 XBRL Instances") are represented with a "task"-block, with the stereotype ≪EA Decision≫.

In the lower part of the diagram we represent the EA principles the company wants to follow. The principles are modelled as soft-goals, with the stereotype ≪Principle≫. We choose to model principles as soft-goals because they are less strict than other types of regulations (e.g. the law). Also, we did not give importance levels to the principles.

Considering the decision to have an architecture with "3 XBRL Instances", as represented in Figure 6. This decision is non-compliant with the law, the goals "Comply to Civil Code 2-210" and "Comply to MIFID regulations" are marked red ("Denied"). The decision is

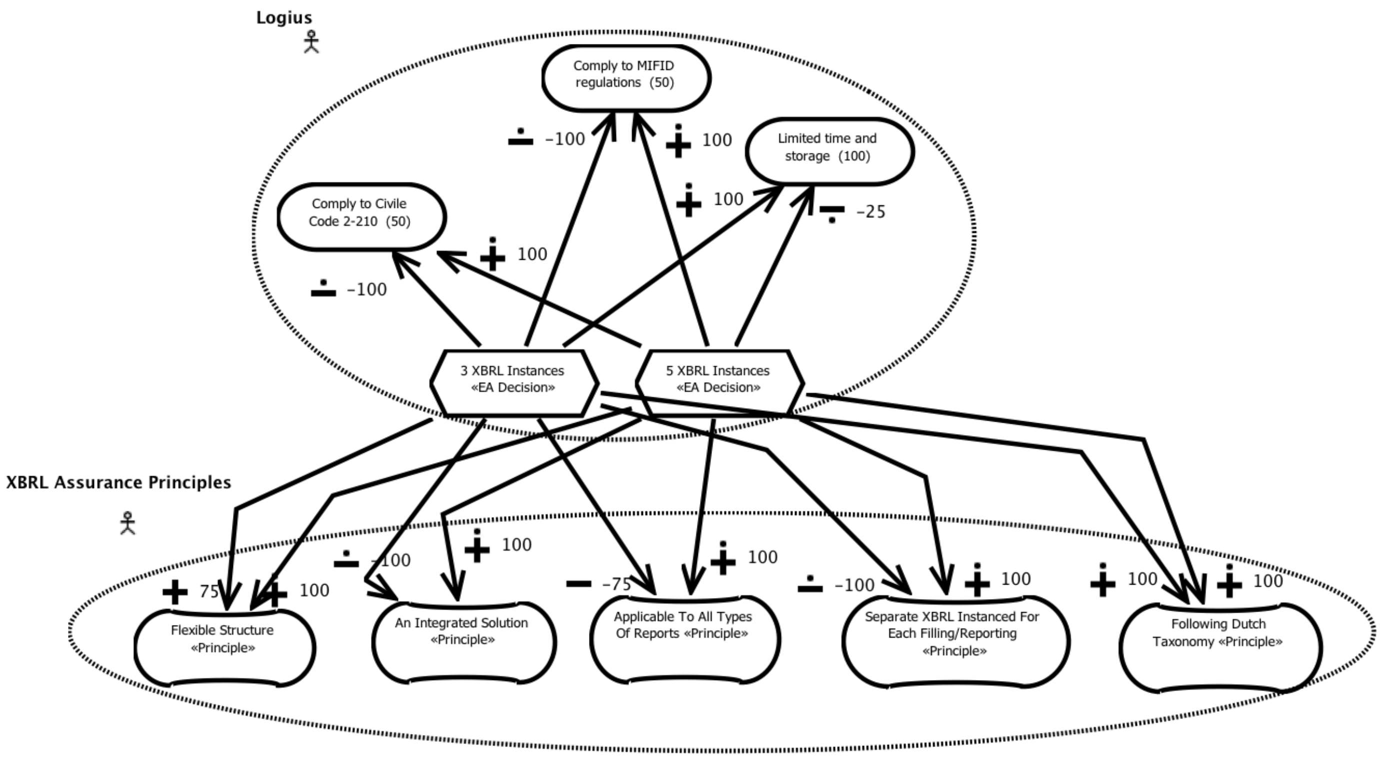

Fig. 5: XBRL Assurance Instances and EA principles

however fully in-line with the limitation given by time/storage, the goal "Limited time and storage" is marked green ("Satisfied"). Furthermore, this decision completely breaks three architecture principles: "An integrated Solution", "Separate XBRL Instances For Each Filling/Reporting" and"Applicable To All Types Of Reports", marked red ("Denied") and "Flexible Structure" is marked light-orange ("Weakly-Denied"). The principle to "Follow Dutch Taxonomy" does not receive any qualitative value after the evaluation and remains marked yellow.

On the other hand, choosing to have "5 XBRL Instances", as represented in Figure 7, is compliant with three EA principles: "An integrated Solution", "Separate XBRL Instances For Each Filling/Reporting" and"Applicable To All Types Of Reports" are marked green ("Satisfied"). Furthermore, this decision is in-line with the law: "Comply to Civil Code 2-210" and "Comply to MIFID regulations" are marked green ("Satisfied"). The main issue is that this decision breaks the critical limitations given by the time and storage: the goal "Limited time and storage" is marked red ("Denied"), making it impossible to be followed.

F. How to Apply the Protocols

In the previous section we proposed four protocols to support the analysis. Protocol 1 and Protocol 2 are responsible with the formalism of the EA principles and with checking if the set is consistent. We are currently working on the definition of these two protocols and the first steps for creating a Principle-Based GRL framework were made in [24]. On one hand, P1 should provide guidelines for interpretation and answer questions such as: *what is a "solid link"?* (EA principle 2), *what is "as much as possible?"* (EA principles 5), *how to define an acceptable level?*. This is part of our future work and requires interviews with stakeholders and architects. We expect that the resulted collection of guidelines will be company and case specific, however it will help acknowledge the importance of formulating EA principles as specific and detailed as possible. On the other hand, P2 will result from translating the EA principles in deontic logic and will provide algorithms to support the creation of a consistent set of principles. In our case study, with the help of P2, we can do the consistency check between the 5 EA principles.

Protocol 3 and 4 have the role to check the consistency between the regulatory side and the models side. By using GRL, we can visualise the goals of the organisation or the feasibility of adopting a set of EA principles. EA models are not fully represented using GRL, therefore, one goal for future research is first, to chose an EA modelling language and second, to connect the EA models with GRL, such that the analysis can highlight the problematic areas of the models. The GRL analysis shown in Figure 6 and Figure 7 can serve as P3 and P4.

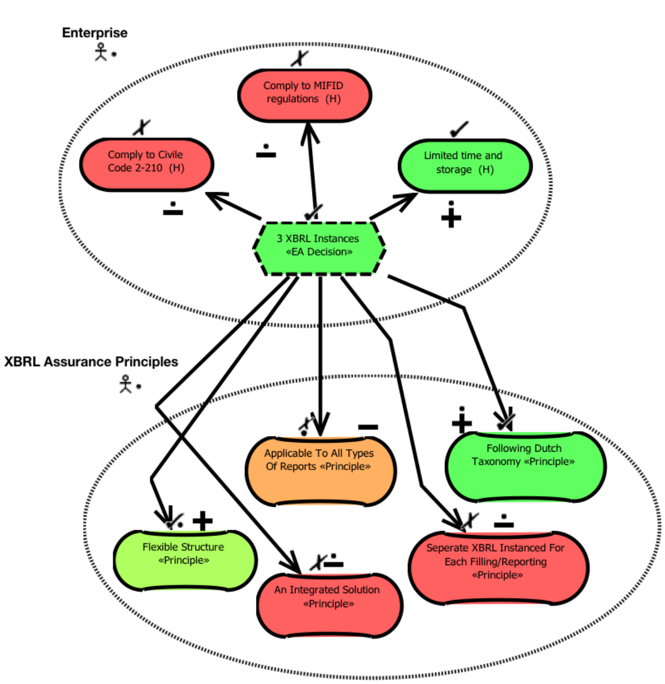

Fig. 6: Choosing 3 XBRL Instances

Fig. 7: Choosing 5 XBRL Instances

V. Conclusions and Future Work

The framework we presented is part of a PhD thesis. First, we presented the context and gave a succinct presentation of the state of the art regarding definitions, use and adoption of EA principles and compliance in the context of EA. We also draw lines for interdisciplinary research and applications in the field of RE and logics. Second, presented the building blocks of our proposed framework.

We conclude by presenting our end goal for this project, as follows:

- Formally define EA principles, based on synthesis/adoption of previous definitions
- Define the notion of compliance/consistency between EA principles and EA models invariants
- Define a measurement methodology for the impact, based on KPIs
- Define impact analysis algorithms for analysing the interactions between principle and other EA elements (e.g. goals, legal aspects)
- Run a-posteriori and design-time analysis to check the compliance degree between EA principles and EA models

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