Competences in Ontology-based Enterprise Architecture Modeling: Zooming In and Out

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Abstract

Competence-based approaches have received increased attention, as the demand for qualified people with the right combination of competences establishes itself as a major factor of organizational performance. This paper examines how competences can be incorporated into Enterprise Architecture modeling: (i) we identify a key set of competence-related concepts such as skills, knowledge, and attitudes, (ii) analyze and relate them using a reference ontology (grounded on the Unified Foundational Ontology), and (iii) propose a representation strategy for modeling competences and their constituent elements leveraging the ArchiMate language, discussing how the proposed models can fit in enterprise competence-based practices. Our approach is intended to cover two tasks relevant to the combined application of Enterprise Architecture and Competence Modeling: 'zooming in' on competences, revealing the relations between competences, knowledge, skills, attitudes and other personal characteristics that matter in organizational performance, and 'zooming out' of competences, placing them in the wider context of other personal competences and overall organizational capabilities.

Keywords: Competences, Ontologies, Competence Modeling, Enterprise Architecture

1 Introduction

Given the importance of human performance in business management and the transformation of socioeconomic systems in general, it is not surprising that human resource management, education, and training typically receive a considerable interest. The drive to human development has resulted in advancements in fields such as Vocational Education and Training (VET) and Human Resource Management (HRM). One of these advancements has been the gradual change from content-based to *competence-based* methods, which reflects a change in Vocational Education and Training from a supply-oriented to a demand-oriented model [1, 2].

A focus on competences promotes deeper integration of formal education, vocational training, and professional development, which is aligned with lifelong learning strategies [1]. Further, competence-based methods serve to link an organization's future requirements to its Human Resources (HR) programs [3]. Personnel selection, development, and performance monitoring, as well as corporate strategy planning, are all examples of competence-based activities in HR Management [4]. By reviewing staff competences, organizations can conduct self-assessment to improve

their HR programs, revisiting talent recruitment procedures, performance management systems, training and development tools, employee engagement initiatives, and institutional development plans [3].

The importance of competences to the enterprise has motivated past efforts in which key concepts of Competence Management (CM) were incorporated into Enterprise Architecture modeling [5]. In that work, personal competences were conceived of as "dispositions" of individual business actors that are manifested through their behaviour in organizational contexts. A number of patterns for competence representation in *ArchiMate* were proposed, leveraging on the capability construct. This paper builds up from that baseline and identifies and tackles challenges pursuant to "zooming in" on competences (which were considered black-boxes in [5]). We also tackle challenges pursuant to "zooming out" of competences. This requires relating competences among each other and also reveal their role in the make up of organizational capabilities.

The literature on Competence Management reveals that it is indispensable to examine the build up of competences in detail. Over the years, competence has been typically conceived of as the result of the interaction of specific *knowledge* and generic *skills* [6], mediated with *attitudes* [7]. Personal traits, mindset, patterns of thinking, and tacit knowledge are also considered by some authors to be part of competence [8]. While these terms are pervasive in the Competence Management literature, their precise definition has remained elusive. The terms are frequently used interchangeably and are sometimes confused with "competence" itself [7, 9].

We argue that conceptual analysis of these notions and their relations is key to their adequate representation in Enterprise Architecture (EA) models. Domain-adequate representations are, in turn, key to support the use of EA models in competence-based practices. We approach the representation of competence elements in this paper by positioning the notions of competence, skill, knowledge, attitude and other personal characteristics through a reference ontology. The reference ontology is then used as a starting point to the representation of competences alongside their constituent elements in *ArchiMate*.

We also argue that a conceptual analysis concerning competence relationships is fundamental to their adequate representation in Enterprise Architecture (EA) models. In this case, personal competences (and skills) can be related as a result of the collaborative relationship between professionals. Based on this, they can even give rise to new organizational capabilities in teams, departments, or other organizational structures. We address the conceptual problem by establishing the notions of *vertical* and *horizontal capability relationships* in a reference ontology, reflecting hierarchical and collaborative relationships based on theories of dispositions and property emergence in the literature. As a result, the reference ontology is used as a basis for the well-founded representation of the various types of competence relationships in ArchiMate.

This paper is further structured as follows: Section 2 briefly reviews the relevant literature on competences and competence management, stating the key conceptual challenges for "zooming in" and "zooming out" on competences, which involves the relations between competences, knowledge, skills, attitudes, other human characteristics, and also organizational capabilities. Section 3 quickly reviews the foundational baseline we adopt in this work, presenting elements of the Unified Foundational Ontology (UFO) [10] used to ground the ontological analysis of competence-related concepts. A reference ontology for these concepts is offered in Section 4 by specializing the notion of *disposition* in UFO and examining the various relations that dispositions can establish with each other. This forms a principled basis for the representation of competence elements in *ArchiMate* as discussed in Section 5. Section 6 applies the proposed representation in a real-life case study from the literature addressed originally by Bäcklander [11] concerning the Spotify company. Section 7 discusses related work. Finally, Section 8 summarizes our effort and proposes a research agenda, which includes the integration of competence management with other key architectural domains of Enterprise Architecture.

2 Competences

Competence[1] is the general ability to perform well a set of mastery tasks [7]. It is not enough for an individual to have a variety of specific skills for this. Mastery of skills or knowledge does not ensure success in complex and unpredictable environments [9]. In addition to skills, the individual must have a sufficient understanding of the domain in question (knowledge) as well as know how to act appropriately in the context (attitude) [7]. In order to be efficient and effective in such situations, the individual must be able to integrate the most appropriate skills and knowledge for

[1]We adopt in this work the term "competence" to refer to an individual's performative ability, and refrain from using the term "competency".

it [9]. As a consequence of this, various authors define competence as a combination of knowledge, skill, and attitude [6, 12, 13]. Competences, in other words, are highly valued qualifications that are accountable for the effective application of skills and knowledge in specific and complex contexts [9].

2.1 Skills and Competences

In general, *skills*, not unlike competences, allude to the capability to perform actions. The literature provides different definitions for skills emphasizing different aspects of it. For example, Rodriguez [4] defines a skill as the ability of an individual to perform a task (discrete unit of work) well. Esposto [14] defines it as a set of general procedures that underlies the application of knowledge in a domain. Paquette [6] defines skills as processes that act on knowledge in an application domain [6].

There is no agreement on the best criterion for distinguishing competences and skills [9]. One existing distinction is the level of ability awareness. Competences would be more "conscious", while skills would be more "automatic" [9]. However, this distinction is insufficient because conscious actions occur with skills as well [9].

The level of complexity is another criterion that is invoked to differentiate competences and skills. Competences are considered more complex in this case than skills. Indeed, authors argue that skills *structure* competences [6, 9]. Competences can be made up of sub-competences, forming an internal hierarchical structure inherent in the individual. In this sense, competence is a complex entity. That is, a competence can be formed by others, which can be formed by others, and so on. As a result, this internal hierarchical structure can be formed by many levels of sub-competences [9]. The *basis* of such an internal hierarchy, however, has not been well understood. Competence decomposition only occurs up to a certain level, where the "simple" competences are. Generally, these competences are divided into skills (and also attitudes and knowledge) after this level. In this regard, it is unclear where "simple" competences end and skills begin [9]. Even skills can also be divided into different levels, until reaching the "basic skills".

Some competence models allow sub-competences or skills that make up a competence to be represented. However, as previously stated, the line between "simple" competence and skill is not always evident. Due to their similarities, the concepts of competence and skill are frequently misunderstood in definitions and representations. As a result, an important goal of a reference ontology for this domain is to clarify the similarities and differences between the concepts of competence and skill, settling how to position those two notions for a certain context of usage.

2.2 Knowledge

Internal representations of facts, principles, or theories in a specific domain are typically associated with "knowledge" [9]. It is the cognitive outcome of assimilation of concepts, ideas, or figures related to a specific topic [7]. Knowledge is linked to a specific person, the bearer, then it is difficult to transfer and assimilate [15]. Knowledge is assimilated when it becomes a part of the bearer's internal structure. As new information or facts are added, the structure changes [16]. This internal structure is not distinctive to the bearer but is integrated into the internal structure of abilities [16]. Indeed, such internal structures (of knowledge and skill) interact in practical applications and problem-solving [17]. Despite the fact that it changes over time [17], knowledge is a static (passive) entity [9]. It is stored in memory and retrieved using cognitive skills (mental processes) [9].

Many knowledge definitions are similar to skill descriptions as a result of learning. Some authors even consider skills to be a sub-type of knowledge. According to [17], skills represent an individual's "practical knowledge" gained through experience. While an individual's interpretations and facts are known as declarative knowledge, the skills (what an individual knows how to do) are known as procedural knowledge [17]. Authors include that skills and knowledge are represented in a similar manner in the human mind, via an interconnected internal structure [17].

Understanding an individual's knowledge in the context of CM is important for better understanding their competence. This is particularly useful during the *gap analysis* and *competence assessment* steps. Competence models, which represent a professional's knowledge, can aid in this task. Despite the similarities described above, skills and knowledge have subtle differences that can interfere with modeling. As a result, a reference ontology for this domain should provide a solid definition of knowledge and clarify the distinction between knowledge and skill.

2.3 Attitudes

In some definitions, attitudes are generally associated with an individual's behavior [6, 13]. Others associate them with personality traits or the professional's psychological and emotional nature [7]. Attitude is a tendency to act (or feel) in a given situation [18]. It is based on assumptions, values, and beliefs, so they are non-neutral with respect to actions [18]. In general, definitions of attitude take into account the following characteristics: (i) mental state; (ii) values (beliefs, emotions); and (iii) predisposition to act or behave [19]. That is, it is a concept that is dependent on its context: a situation, an object, or a person. As a consequence, attitude is a disposition toward a specific phenomenon and can be considered a reaction to the context (whether positive or negative) [19] .

Attitudes are regarded as an important aspect of competences, and are included in many competence definitions as one of the key 'KSA' elements (Knowledge, Skills, and Attitudes). In contrast to skills and knowledge, attitude is a more general characteristic that is not tied to a specific task or domain [7]. Because they have a certain behavioral impact, attitudes are frequently confused with skills, particularly soft skills [13]. Again, as in the case of skills and knowledge, a reference ontology for this domain should clearly position attitudes with respect to the other elements of competence.

2.4 Other Characteristics

Although competence is commonly defined as a set of attitudes, skills, and knowledge, authors consider further types of elements to be components of competences. Personal traits, behavior, mindset, patterns of thinking, and tacit and explicit knowledge are considered by some authors to be part of competence [8]. This is recognized also by Westera [9], for whom competences have additional elements that are not clearly defined. According to Miranda et al. [13], competences are also formed by a set of personal characteristics required to perform tasks in a specific context, leading the authors to consider the 'KSAO' model, a variation of the KSA model that includes "Other Characteristics" as a fourth element to define competence.

According to Westera [9], task analysis is insufficient to establish competences; instead, the individual's characteristics and experience must be considered. Le Deist and Winterton [1] emphasize the importance of focusing on the individual rather than their conduct. The authors explain that, in addition to performance, it is critical to look at traits, motives, attitudes (or values), and knowledge, among other things. Some KSA elements (knowledge and attitude) are considered personal characteristics by the author. Messick [17] extends on this point by stating that the psychological, emotional, social (environmental) situation must all be considered.

All of these characteristics, as well as actual behavior (performance, tasks, and outcomes), can be used to assess an individual's competence. Hence, attention to these elements is critical to the Competence Assessment task, which is one of the most demanding in the CM context, because it entails evaluating (and even *measuring*) something that cannot be fully observed.

2.5 Organizational Capabilities

Competence management gains new dimensions when competences are considered in relation to other competences. First, competences of the same individual can be combined to form new competences [13]. An example is John's front-end development competence and his back-end development competences, which when combined form John's full-stack development competence. Such a composition forms an internal hierarchical structure in which a "super" competence is dependent on a "sub" competence [13, 20]. Similarly, the competences of different individuals can also be externally combined in the context of teams, groups, projects, or sectors of an organization [21]. In this case, instead of forming new competences, this combination of external competences contributes to the formation of organizational capabilities [21]. This is what happens when John's Front-end development competence and Karl's Back-end development competence are combined to form a team's Full-stack development capability. In this setting, it is important to realize that the combination of competences to generate other capabilities is not arbitrary. Generated capabilities are the results of the *ways* in which people, teams, and groups are organized [21]. In other words, just bringing together high-performance people is not enough to form a high-performance team. Individual competences must be properly combined to generate desired organization capabilities. This issue is fundamental in the context of CM, as it has as its objective the development of organizational capabilities. In this sense, development of individual competences is a means of developing the capabilities of the entire organization. Hence, it is critical to understand how competences can be composed for organizational capabilities to emerge.

3 Foundational Baseline

We build upon the work discussed in [5], which used the Unified Foundational Ontology (UFO) [10] to examine competences from an external perspective, not zooming in on a competence's constituent elements. Competences are considered "dispositions", which, in a nutshell, are objectified properties inherent in an object (or agent) that may manifest themselves in certain situations through events (or actions). (They are also called "powers" in the philosophical literature [22].)

The domain-independent elements we reuse from UFO are shown with a UML class diagram in Figure 1. Individuals are partitioned into perdurants (also called *events*), endurants, and situations. *Perdurants* are *individuals* that occur in time (i.e., activities, actions, tasks, processes). *Endurants* are individuals that persist in time changing qualitatively while retaining their identity (i.e., people, organizations, cars). *Endurants* include *substantials* and *moments*. A *Substantial* is an endurant that is considered existentially independent (like John, his car), while a *Moment* (also termed *Aspect*) is a reified property that *inheres in* another *endurant* (termed its bearer), on which it is existentially dependent. Moments (as full-fledge endurants) have a life-cycle of their own and can be created, destroyed, or otherwise change qualitatively in time. Examples include John's weight (a quality that inheres in him), his marriage to Mary (a relator that depends on John and on Mary) and John's fishing skill.

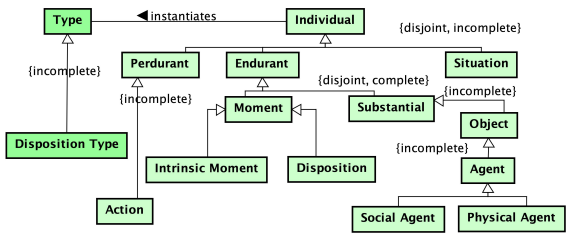

Fig. 1 Foundational fragment employed in this paper

Of special interest to us in this work are those moments called *dispositions*. *Dispositions* are intrinsic moments that can be manifested through the occurrence of *events* (possibly agents' actions, such as Anna's speaking English). In *situations* where *dispositions may manifest*, they are said to be "activated" (e.g., when a magnet is close to some ferrous material, or when Anna is prompted to introduce the topic of a meeting). The literature discusses a number of important features of dispositions; they may fail to manifest when enabled, they may be manifested in tandem with other dispositions in complex events, and they may reinforce or cancel each other [22, 23]. Reifying (i.e., objectifying) them puts them at the center of our efforts as first-class citizens. As endurants, they can themselves bear moments, and change qualitatively while retaining their identity through time [24].

Figure 1 also shows a few concepts from the UFO-C layer [25] which are relevant here. UFO-C is an extension of UFO addressing social aspects [25]. In UFO-C, *agents* are considered *objects* that perceive *events* and perform *actions* based on a background of *beliefs*, *desires* and *intentions* (special categories of *intrinsic moments* termed *intentional moments*, omitted from the figure for brevity). As depicted in the model, *agents* can be *physical* (e.g., humans and animals) or *social* (e.g., teams, organizations, communities, etc.), and all of these are considered potential bearers of *capabilities* and *intentional moments*.

4 Ontological Analysis of Competence-Related Elements

We explore the multi-faceted phenomenon of competence by proposing a reference ontology for competences concerning its constituent elements and the corresponding *organizational capabilities*. The issues discussed in Section 2 help us to identify focal points for this effort, and ultimately relate *competences*, *knowledge*, *skill*, *attitudes*, and other *human characteristics* to *organizational capabilities*, in a coherent overall representation, as required in Enterprise Architecture efforts.

Figure 2 shows a hierarchical perspective of the proposed competence ontology. The concepts in yellow were explored initially in [26] (of which this paper is an extension), and already incorporate the "zooming in" perspective on competences (from personal competence to its elements, revealing *knowledge*, *skills*, *attitudes* and other *human characteristics*). The concepts concerning the "zooming out" perspective—which are our focus in the sequel—are highlighted in red, and integrate the ontological analysis of capabilities proposed in [27] with the "zooming in" perspective. All elements are ultimately specializations of the UFO concepts (in green). In the following, each of the proposed concepts will be addressed, as well as the relationship between them.

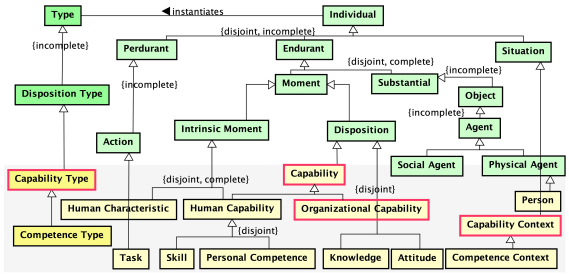

Fig. 2 The proposed *competence ontology* (hierarchical view) grounded on UFO concepts (in green)

4.1 Zooming out (from Competences to Organizational Capabilities)

The general notion of *capability* is key to place *personal competences* and *organizational capabilities* in the same conceptual framework, understood as dispositions [27].

Capabilities are changeable [28] and composable entities [29]. As a type of ability [21], a capability inheres in a bearer and depends on it to exist. As a potentiality [30], a capability has attributes that may only be observed through the capability's manifestation in an enabling situation (or context). Similarly to [30], a capability is considered here as a subtype of *disposition* that has a "utility", or a "benefit" for someone. Since it is a subtype of *disposition* (also following [27]), a capability is manifested by *events* (*perdurants*), is activated by a *situation* called *capability context*, and is inherent to a *substantial*, specifically an *object* (the bearer), as represented in Figure 3.

4.1.1 Capability's Vertical Relationships

Figure 3 also shows what we call here the "vertical relationships" between dispositions (capabilities included), encompassing *results from* and *emerges from*. These capability relations are called "vertical" as they relate capabilities of a complex object (at a higher level of composition) to capabilities of the object's parts (at a lower level). In addition, capabilities themselves can be subject to decomposition, and hence, a complex capability can have other capabilities as its parts (see "has part" in Figure 3). These vertical relationships are further explained in the sequel.

Capabilities of a whole and capabilities of the parts

In general, an organizational entity (e.g., team, department, company) is hierarchically structured as having other organizational entities or individuals as its parts.

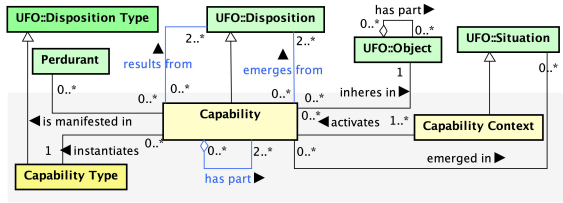

Fig. 3 The *capability concept* and its relations (vertical ones highlighted in blue)

As a result, the *capabilities* inherent to a complex organizational entity may be the accounted for in terms of the *capabilities* of its parts. This perspective concerning vertical relations is depicted in Figure 4(a) (left-hand side of the figure). Examples include (i) a team's collective *capability* that *emerges from* personal *competences* of team members, and (ii) the *capability* of a distributed computer cluster to serve a large number of customers that *results from* each individual computer system's capabilities.

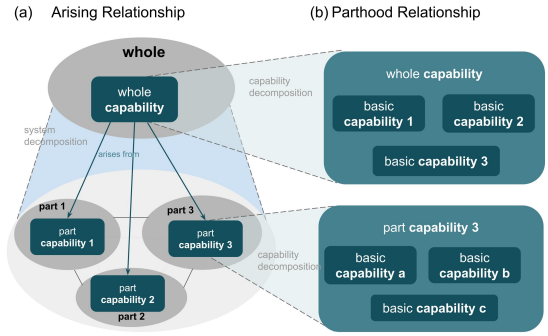

Fig. 4 Vertical relationships illustration

The distinction between *emerges from* and *results from* correspond to Bunge's notions of "emergent" and "resultant" properties [31, 32]. Bunge states that *resultant properties* are those that can be directly decomposed, explained, or reduced into properties of a system's parts. For example, the total mass of a car is directly defined by the simple sum of the masses of its components; or, the chair height is a result of the sum of the height of the leg, seat, and back. In contrast, *emergent properties* are those that, while related to the properties of parts, are not present in isolation in the separated parts. For example, the buoyancy of a ship cannot be reduced directly to the buoyancy of its parts (an arbitrary piece of a steel hull is typically not buoyant by itself). Hence, emergence is not directly explained by some simplification. Instead,

property emergence can be explained according to many aspects, such as (i) the part's properties "combination" [33]; (ii) the part's relationships [34] (e.g., the way in which carbon molecules are associated distinguishes diamond's and graphite's dispositions); and even (iii) system constraints [35, 36] (e.g. restrictions caused by the knee in the femur and tibia movements allow the emergence of the walking capability). In UFO terms, all these circumstances that allow for emergence can be explained as particular *situations*. Hence, in order to account for these situations broadly, an *emerges in* the relation between the concepts of capability and situation can be found in Figure 3. The identified *situation* expresses a combination of factors that account for the emergence of that capability. (In sum, a capability can emerge *from* other capabilities *in* a particular situation.)

Complex capabilities and their parts

The second perspective about vertical relationships concerns the complexity of capability, regardless of the hierarchical structure of the bearer, as shown in Figure 4(b) (right-hand side). Examples include (i) the capability of a boat to move in a body of water, which is formed by the boat's buoyancy, its propulsion capability, and its capability to be steered; (ii) the football-playing capability of a player, which is formed by his/her dribbling skill, attacking skill, defending skill, etc.; and (iii) the back-end development competence of a software developer, which is formed by his/her Java programming skill and SQL coding skill.

Differently from *emerge from* and *results from*, the parthood relation (*has part* in Figure 3) relates a complex capability to other capabilities that inhere in the same bearer, as shown in Figure 4(b). In this context, a similar notion is put forward by Bunge [31] when discussing "property conjunction". He explains that properties can be formed by a "*conjunction*" of others, i.e., basic properties forming complex ones. For example, the dimension of a box is a "conjunction" of its *width*, *length*, and *depth*. In this context, the complex property is a kind of bundle. Regarding *dispositions*, according to [37], they also have a compositional nature. As a result, a complex *disposition* can be composed of (or decomposed in) basic *dispositions*.

Organizational Capabilities and Human Capabilities

We apply *capability* and vertical relationship definitions to allow the "zooming out" on competence modeling, from *competences* to *organizational capabilities*. As a result, we address in the ontology the concepts of (i) *organizational capabilities* and (ii) *human capabilities*, as shown in Figure 5.

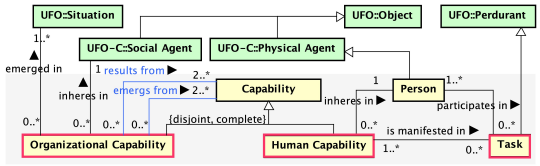

Fig. 5 Organizational and human capabilities concepts (in red) with correspondent vertical relationships (in blue)

Organizational capabilities are those that inhere in a *social agent* specifically formed by people (e.g., group, organization, team, department, etc.). In their turn, *human capabilities* are those that inhere in a *person* (*physical agent* in UFO). In this case, *human capability* encompasses all human abilities to perform some (human) *task*, from those that are innate (inherited) to those that can be learned (formally or not). In the context of *human capabilities*, we consider a *task* as an *action* with some intentional aspect (as a goal). A *task* is regarded as the smallest unit of labor. In other words, it is a discrete unit of work that contributes to the production of output or the achievement of a result [4].

Figure 6 shows a schematic view combining organizational capabilities and human capabilities, in which a "complex organizational capability 1" inheres in a group and has as part other basic *organizational capabilities*. In this case, as depicted, the "basic organizational capability 2", as a *capability* of the group as a whole, "emerges from" (or "results from") the *human capabilities* (of members of the group). Figure 6 shows this distinction, in which the "complex human capability 1" inheres in a person *P*2 and is constituted by other basic *human capabilities*.

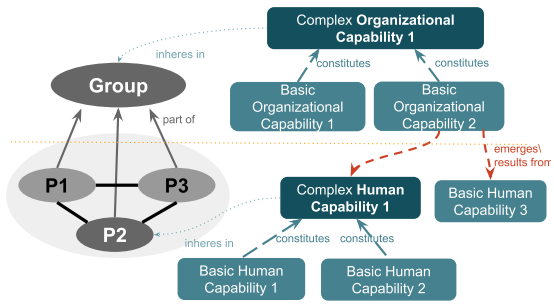

Fig. 6 Complex and basic organizational and human capabilities (illustration)

4.1.2 Capability's Horizontal Relationships

Differently from vertical ones, horizontal relationships do not account for a new (complex or whole's) *capability* based on other (basic or part's) *capabilities*, in spite of being relevant in the conditions of emergence. Figure 7 depicts the horizontal relations we consider here, including *reciprocal to*, *additional to*, *enabled by*, *disabled by* and *changed by*.

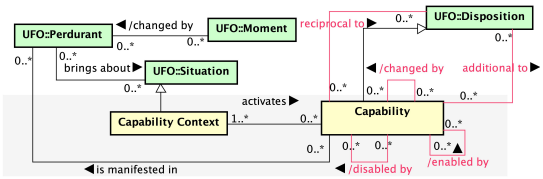

Fig. 7 Capability's horizontal relationships (in red)

Reciprocal Horizontal Relationship

Based on Galton et al. [38], *dispositions* can be *reciprocal* when they mutually depend on each other to be manifested (not existentially or historically dependent). For example, the magnetic's attraction *disposition* is circumstantially conditional to the iron's *disposition* of being attracted (and vice versa). As a consequence, their activation *situations* and manifestations should be the same (or be closely related). For example, the *dispositions* of the magnet and the iron share a related *situation* (related to their proximity to each other) and a related manifestation (to attract or be attracted together). In this context, the reciprocity between two *dispositions* corresponds to the complementary opposite aspect (e.g., to sell or to buy, to send or to receive, to attract or to be attracted, to push or to be pushed, to signal or to perceive) that inheres in them. As they generally are related to antagonistic roles (e.g., active and passive roles), they commonly are manifested through interactions between distinct bearers. Figure 8(a) illustrates this setting. As depicted, the reciprocal *dispositions* share a common activation *context* and also common manifestation events (*tasks* in the figure), being mutually conditioned to manifest together. We also consider that *capability types* are "reciprocal to" others (not shown in the model), as addressed in [39] with the "mutual activation partnership" relationship definition. Based on this, we can derive that a capability is potentially reciprocal to others according to their types.

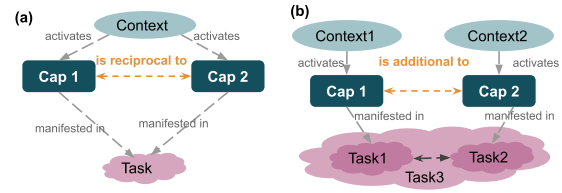

Fig. 8 Reciprocal Horizontal Relationship

Additional Horizontal Relationship

Otherwise, according to Barton et al. [37], one *disposition* can be *additive* to another if their effects (manifestation) can be "mixed" for some reason. In this sense, *dispositions* are "added" in order to manifest together. As a result, each disposition impacts the other changing qualitatively their manifestation (or forming a complex one). For example, the (i) attraction disposition of two or more magnets can be added, making their attraction stronger; (ii) a singer and a guitarist's capabilities can be added, allowing a distinct song presentation; (iii) the vibrating capabilities of two or more guitar strings can be added, forming new combined notes. As occurs in these examples, the additional relationship can cause a vertical relationship to arise (but not necessarily). The addition of magnets' dispositions can result in a resultant capability, and the addition of the singer and guitar player's capabilities can make an emergent capability arise. Unlike reciprocal capabilities, an additional capability is not inevitably dependent on another to be manifested. Their relationship is not mandatory but optional. For example, in the case of the guitar strings' vibrating capabilities, they can be manifested independently. Otherwise, the reciprocal capabilities need each other to be manifested. In the example, the "attraction capability" of a magnet needs the " be attracted capability" of iron to manifest. Additional relationships can even depend on reciprocal ones. For example, "singing capability" and "guitar playing capability" can only be added (e.g., in a live performance) if the musicians have the "reciprocal" capability to listen to each other. Figure 8(b) illustrates this setting. While the reciprocal relationships share a common interdependent activation context, the additional *dispositions* have distinct activation *contexts* that can be (optionally) related, allowing an interrelated manifestation. We also consider that *capability types* are "additional to" others (not shown in the model). Based on this, we can derive that a capability is potentially additional to others according to their types.

Dynamic Horizontal Relationships

Capability's Enabling Relationships. Regarding the dynamic aspect between *dispositions*, they can also have interactive relationships with each other. As Barton et al. [37] state, *dispositions* can (potentially) trigger or be triggered by others, creating a "chain reaction". In this case, the manifestation of one *disposition* creates a "favorable" *situation* for the manifestation of another *disposition*, as it is shown in Figure 9(a). In UFO terms, a manifestation of a *capability* through a task (*perdurants*) can bring about a situation that activates another *capability*. Based on these distinctions, this work considers that a *capability* can "be enabled" (triggered) by others (in a past perspective). We also consider that *capability types* "enable" others (not shown in the model). Based on this, we can derive the relationship that a capability can (potentially) enable others based on their types.

Capability's Disabling Relationships. Otherwise, based on Galton et al. [38], an opposite phenomenon is also possible when a *disposition* blocks the manifestation of another *disposition*. In this case, a "blocker" *disposition* creates some *situations* that inhibit the manifestation of another *disposition*. This circumstance is also illustrated in Figure 9(a). In UFO terms, a manifestation of a *capability* through a *perdurants* (events) can bring about a situation that inhibits another *capability*. Based on these distinctions, this work considers that a *capability* can be "disabled" (blocked) by others. We also consider that *capability types* "disable" others (not shown in the model). Based on this, we can derive that a capability potentially disables others according to their types.

Capability's Changing Relationship. Another kind of "dynamic" between *dispositions* happens when one *disposition* changes another. In this context, the manifestation of the "changer" *disposition* modifies qualitatively another disposition, altering its properties (and also its manifestation).This changing relationship is illustrated in Figure 9(b). In UFO terms, a manifestation of a *capability* through a *perdurants* (events) can change the moments (i.e., *qualities* or *modes*) of another *capability*. Based on these distinctions, this work considers that a *capability* can be "changed" by others (from a past perspective). We also consider that *capability types* "change" others (not shown in the model). Based on this, we can derive that a capability potentially enables others according to their types.

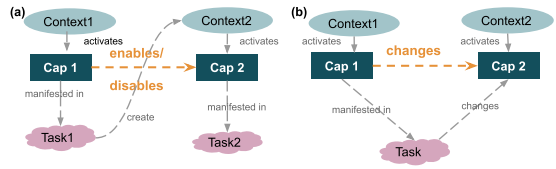

Fig. 9 Disposition relationship (dynamic aspects)

4.2 Zooming in on Competence

So far, we have considered only *human capabilities* in a general perspective, in their roles in the makeup of organizational capabilities. Here we zoom in on the makeup of human capabilities, whose descriptions have been expressed often in terms of human *skills* and *competences*.

4.2.1 Skill and Competence Definition

Regarding the *skill* concept, there are some parallels between it and the definitions of *competence* [7]. Some authors even argue that such concepts have the same meaning in essence. Competence is conceptually considered a skill sub-type in some cases [9]. Even among those who believe that competence and skill are distinct concepts, there are many similarities between them. In this sense, both are regarded as human abilities that enable satisfactory task performance [7]. Thus, both skill and competence are inherent abilities in a person, the bearer, that enables the performance of specific action types. That is, they represent an individual's "know-how". Aside from this fundamental similarity, there are other comparable features in the definitions of these concepts. Both are abilities that can be learned (formally or informally) and developed through practice [16, 17]. In this sense, skill and competence can be used to learn new abilities via the transfer mechanism [7, 16, 17]. In terms of structure, there are also some similarities between skills and competences. Both have a hierarchical structure, according to some authors [7, 9]. As a result, they can be aggregated or combined at various levels. Thus, simpler skill/competence forms more complex skill/competence. As a consequence, the complexity of skill and competence can also vary. Another similarity between these concepts is their relationship with the context. Both are associated with a context, environment, area, or domain [7,9]. In this regard, competence and skill can be more generic (domain-independent) or more specific (domain-dependent) [7, 9].

Skills and Competences as Human Capabilities

Skills and *competences* frequently rely on favorable conditions to manifest. That is, *skills* and *competences* depend on other properties (internal or external) to manifest themselves more effectively. Knowledge, mental states, attitudes, feelings, and so on can all aid in the proper manifestation of a *skill* or *competence*, for instance. Finally, in addition to the aforementioned similarities, some authors argue that *skills* and *competences* involve similar domains of an individual. According to them, both are related to the bearer's affective, social, physical (or operational), cognitive, and meta-cognitive domains [1, 7]. In order to capture the common features of *skills* and *competences*, we adopt the notion of *human capability* defined early, in Figure 5. Based on this, in this work, *skills* and *competences* are considered sub-types of the more general notion of *human capability*, as shown in Figure 10, which also reveals a number of relations between personal competences, knowledge, skills, attitudes and other human characteristics (beyond human capabilities).

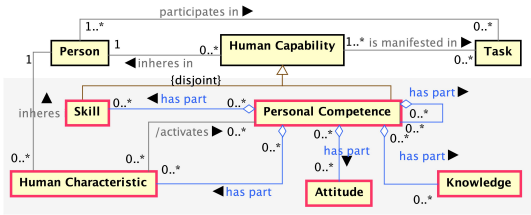

Fig. 10 Competence-related concepts (in red) with correspondent vertical relationships (in blue)

Skills and Competences Distinctions

In this current work, the main distinction between *skills* and *competences* is the structural aspect as revealed by the specialized whole part relations in Figure 10. So, *competences* are considered here a complex capability since they can be composed of other capabilities (and dispositions). As a result, competence is constituted by *knowledge*, *skills*, *attitudes*, and also other *human characteristics*, whereas *skills* are formed only by other simpler *skills*. In this work, *competence* is made up of at least one *skill* that is (horizontally) related to one or more other *competence* elements (e.g., a skill that is additional to an attitude and to a specific knowledge). As a complex *capability*, *competences* can also be composed of others, forming a hierarchical structure. (The distinction between basic and complex competences, presented in [26], is no longer required here, since in this work the complex *capability* concept was addressed at a more general level.) Likewise, *skills* can also be a type of *complex capability*, being also structured hierarchically, in this case. Based on [7], another adopted criterion to distinguish *skill* from *competence* is the mode of manifestation. *Competence* is associated with one or more complex (and contextualized) *tasks*, whereas *skill* is associated with a simple *task* (basic unit of work), as in [7].

4.2.2 Knowledge, Attitude, and Human Characteristic Definition

Knowledge Definition

In this context, *knowledge* is defined as a justified true belief [40]. *Knowledge*, while assisting in the realization of *skills*, differs from *skills* in that it is a static entity registered in the individual's memory. It is related to the person's *knowledge* of information, facts, and concepts. It is produced as a result of internal (mental) information processing. *Skills*, on the other hand, manifest themselves through "external" *tasks* and are developed through practical experiences. In this way, *knowledge*, despite representing external facts or concepts, is existentially dependent on the bearer. Individual *knowledge*, as a type of belief, can be considered a subjective entity that is difficult to measure or quantify, despite the fact that it may have attributes. Furthermore, *knowledge* is a mental property that is inherent in the individual that can lead to action (e.g., reflections, reasoning, inference). It is manifested alongside other forms of *dispositions* such as *skills* to manifest itself in tasks, forming *reciprocal* or *mutual* activation partners [23]. Indeed, *knowledge*, as a *disposition* type, can have all the relationship types presented above, such as emergence and resulting (i.e., organizational *knowledge* from individual's *knowledge*), constitutive (i.e., forming *knowledge* "bundles"), reciprocal, additional, enabling, disabling, and changing.

Attitudes Definition

Despite the fact that it is manifested through actions, gestures, postures, and so on, *attitude* differs from *skills* in that it is not manifested through *tasks* but by behaviors. *Attitude*, on the other hand, can be task-related. For example, a responsible *attitude* can be present during a developer's completion of the *task* of fixing a bug in software; an empathetic *attitude* can be present during the *task* of negotiating project scope with the

client. *Attitude* in the context of this work is considered a sub-type of *Disposition*, because it is a proclivity to act and behave. Again, like *knowledge*, it is manifested alongside other forms of *dispositions*, forming *reciprocal* or *mutual* activation partners [23] with skills and knowledge. As *knowledge*, *attitudes* are subtypes of *disposition* and can have all the relationship types presented above.

"Other" Human Characteristics Definition

Other *human characteristics* include objective (or measurable) attributes (e.g., height, sex, age), while others are subjective (non-measurable), such as the individual's traits, character, motivations, worldviews, values, and beliefs. As previously stated, such *human characteristics* are regarded in this work as a subtype of the *intrinsic moment*. As an *intrinsic moment*, *human characteristics* can be categorical (e.g. age, gender, etc.) or dispositional (e.g. personality traits). Based on the categorical base of the *disposition* [41] and UFO distinctions, the former contributes to competence activation since is considered part of the competence context (*situation*), as illustrated in Figure 10, as the derived relationship "activates". And, the latter can even be a proper part of the *competence*. Furthermore, some *human characteristics* can be included in the competence context, activating the competence manifestation. We also consider that *human characteristic types* "activate" *competence types* (not shown in the model). Based on this, we can derive that a *human characteristic* potentially activates a *personal competence* according to their types

4.3 Summary

Figure 11 depicts a summary of the proposed ontology, embracing both the zooming-in and zooming-out perspectives presented above. The model focuses on presenting the vertical relationships (in blue) and the horizontal ones (in red) between the proposed concepts, including the UFO concepts (in green). As shown, *capabilities* (*dispositions*) are activated by *capability context* (*situation*) and manifested through *tasks* (*perdurants*). In the vertical perspective, (emergent) capabilities can be "emerges from" others (including *dispositions*) and "emerges in" a *situation* (e.g., the relationship between the parts); (resultant) *capabilities* can be "results from" others (including *dispositions*); (complex) *capabilities* can have other *capabilities* as parts; *organizational capabilities* (those inherent to a *social agent*), as a whole *capability*, can be "emerges from" or "results from" (human or other organizational) *capabilities*; and *personal competences* (those inherent to a *person*), as complex human capabilities, can have other *personal competences*, *skills*, *attitudes*, and *knowledge* as parts, besides depending on *human characteristics*. In the horizontal perspective, capabilities can be "reciprocal to", "additional to" others (including *dispositions*), besides being "enabled by", "disabled by", and "changed by" other *capabilities*.

5 Well-Founded Competence Representation

Based on the ontological analysis presented in the previous section, we define in this section an ArchiMate language pattern, proposed as a conceptual extension of the ArchiMate metamodel, with no changes to it. This well-founded representation is proposed to allow modeling of competence, its elements (knowledge, skill, attitude), and organizational capabilities in the EA context, supplementing the representation proposed in [5, 26]. We performed three main steps: (i) *conceptual mapping*, linking concepts from the ontology to ArchiMate constructs, (ii) *relational mapping*, linking relationships from the ontology to ArchiMate relations, and (iii) *viewpoints definition*, offering distinct perspectives on the competence models.

5.1 Conceptual Mapping

The following correspondences between ontology concepts and ArchiMate constructs are established: **(a)** the ***person*** concept from the ontology is mapped to the *business actor* construct (as in Calhau et al. [5, 26]) representing a human being, and related (optionally) to a *business role* representing the job positions or occupations played by the person; **(b)** ***human capability*** concept (*skill* and *competence*) is mapped to the *capability* construct, related to (i) a *business role* construct (representing a *person*, the bearer) using the ("normal") association relationship, as proposed in [5, 26], or to (ii) another *human capability* construct; **(c)** ***organizational capability*** is mapped in the same way as human capability, but is related to business actor representing an organizational entity (team, department, group, company, etc.); **(d)** ***knowledge*** is represented by a *meaning* construct that is related to a: (i) *capability* construct that represents a *human capability*, or (ii) *business actor* that represents a *person* (the knowledge bearer); **(e)** ***attitude*** is represented by

the *value* construct related to (i) *capability* construct, which represents a *human capability*, or (ii) *business actor*, which represents a *person* (the attitude bearer); **(f)** ***human characteristic***, as an *intrinsic moment*, is mapped to the more general *note* construct "labeling" (i) a *person*, or (ii) a *human capability* ; **(g)** ***task*** concept is mapped to *behavioral elements* (e.g., *business process* or *business event*) related to a *capability* construct representing a (i) *human capability*, or (ii) *organizational capability*, as in [5, 26] ; **(h)** ***capability context*** is mapped to the *plateau* or *location* constructs, composed of business roles and business objects related to the (human or organizational) **capability** manifestation.

5.2 Relational Mapping

Relations in the ontology are represented as follows: **(a) horizontal relationships**: (i) the *reciprocal* relationship is represented using an *association* relation labeled with "recriprocal" (with heavy line width) between the reciprocal elements (*capabilities* or *competence*'s elements); (ii) *additional* relationship is represented in the same way, using the *association* relation with a light line width and without label; (iii) *enabling* relationship is represented using *triggering* relation labeled with "enable", between the enabler and enabled element; (iv) *disabling* relationship is represented using triggering relation labeled with "disable", between the disabler and disabled element; and (v) *changing* relationship is represented using flow relation labeled with "change", between the changer and changed element (in the case of horizontal relationships that involve knowledge and attitude, it is used a directed *association* relation, labeled with "enable", "disable" or "change", since ArchiMate's triggering and flow relationships are not allowed between motivational elements). **(b) vertical relationships**: (i) *conjunction* relationship is represented using *composition* and *aggregation* relation between *capability* constructs (possibly represented by nesting); (ii) *emergence* is represented using the *serving* relation with heavy line width and labeled with "emerge", between the emergent *capability* and the part's *capabilities*; (iii) the *resulting* relationship is represented using *serving* relation with heavy line width and labeled with "result", between the resultant *capability* and the part's *capabilities* (the *grouping construct* of ArchiMate may be used to distinguish the level of the whole and the level of the parts).

5.3 Representation Viewpoints

The following viewpoints are defined based on the different relations that competences establish: (1) the *competence manifestation* viewpoint, focusing on a single competence (as a black box) in its context of manifestation; (2) 'zooming-in' viewpoints, including (a) the *competence elements* view and (b) the *competence element relationships* view, and; (3) 'zooming-out' viewpoints, including (a) the *competence interaction* view and (b) the *capability grounding* view.

1. Competence Manifestation View

The competence manifestation view aims to represent how personal competence is manifested in its context. Figure 12 depicts an example of competence's manifestation view, focusing on the manifestation of "John's Front-end Competence". As shown, this *personal competence* is inherent in the developer John

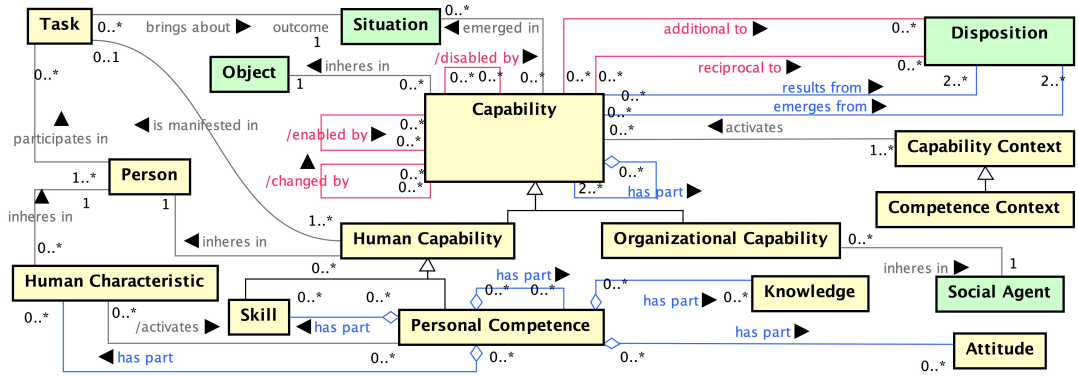

Fig. 11 An overview of the proposed ontology, with UFO concepts in green, horizontal relationships in red and vertical ones in blue

(*person*). In this case, John's *competence* is activated when, while playing the "front-end developer" *business role*, he receives the "client web form prototype" and the "requirement #33" *artifacts* in his workplace. As shown, it is composed of an Integrated Development Environment (IDE), for coding, which represents the *competence context* that activates his *competence*. In this scenario, the manifestation happens through the *task* "implement client web form", performed by him "focusedly" and with "four hours of duration". As depicted in the figure, this *task* has as input the "client web form prototype" and the "requirement #33" *artifacts* and is formed by other *tasks*: (i) code CSS; (ii) code JS; (iii) code HTML. As an output, this *task* leads to a "client web form", part of the "SinCap system", with "field validation", "responsiveness", "stylishness" and "accuracy".

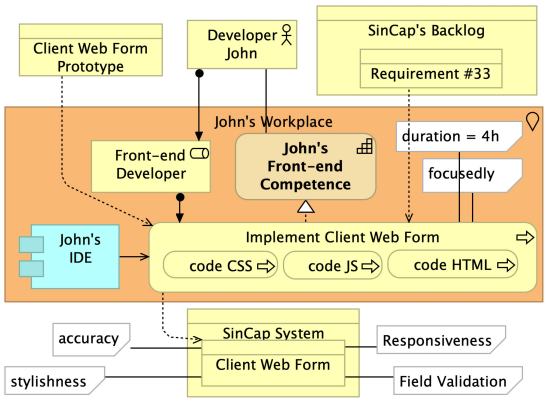

Fig. 12 Example of competence manifestation view

2. *Zooming-in Viewpoints*

(a) Competence Elements View. The competence elements view aims to represent the parts of personal competence. Figure 13 reveals the elements of "John's Front-end Competence". As depicted, his competence is formed by (i) skills such as "requirements understanding", "understanding back-end (BE) code", "explaining front-end (FE) code ", and "front-end (FE) coding"; (ii) attitude as "effectiveness" and; (ii) knowledge as "user interface (UI) heuristics" and "requirement types". Especially "front-end (FE) coding" is a complex skill composed of other (basic) skills: (i) "CSS coding", (ii) "HTML coding", and "Javascript (JS) coding". One important aspect is that competence parthood can reveal the elements' context of manifestation. In this case, the competence manifestation (tasks, artifacts, and their characteristics) can be represented following a similar structure and vice-versa. For example, in this context, the "front-end (FE) coding" (sub) skills are related to the "implement client web form" (sub) tasks.

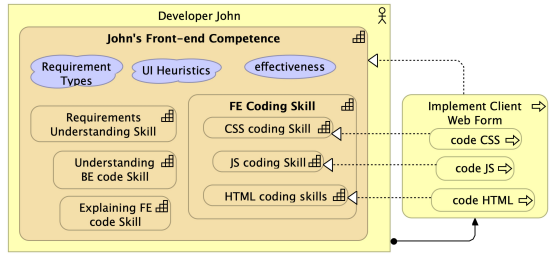

Fig. 13 Example of competence elements view

(b) Competence Element Relationships View. Further detailing can be provided in the competence element relationships viewpoint, revealing how the elements are "integrated" through their horizontal relationships. Figure 14 illustrates the use of this viewpoint by focusing on the relationships between "John's Front-end Competence" elements.

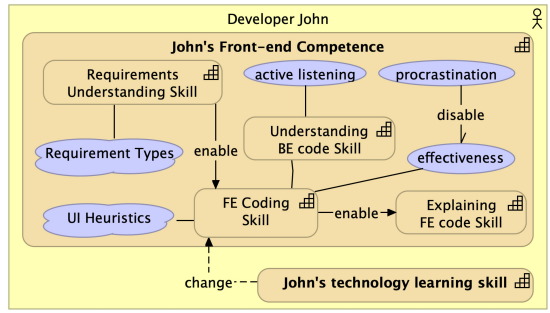

Fig. 14 Example of competence element relationships view

As shown, (i) "John's technology learning skill" changes the "front-end (FE) coding skill" since it can modify some qualities of this skill such as its proficiency level; (ii) John's "requirements understanding skill" enables his "front-end (FE) coding skill" since by understanding the requirements he can perform the latter skill; (iii) "front-end (FE) coding skill" enables "explaining front-end (FE) code skill" since just after coding the developer can explain his code; (iv) "front-end (FE) coding skill" is additional to "understanding back-end (BE) code skill", since this allows the development of front-end code connected with the back-end; (v) "front-end (FE) coding skill" is additional to "user

interface (UI) Heuristics" and "effectiveness" attitudes, since their manifestations can be combined; (vi) "understanding back-end (BE) code skill" is additional to 'active listening" attitude, since their manifestations can be combined; and finally (vii) "procrastination" attitude can disable the "effectiveness" one, since the manifestation of the former can harm the manifestation of the latter.

3. Zooming-out Viewpoints

(a) Competence Interaction View. The following view concerns the representation of the *competence* relationships in an organizational context; in this view, the focus is on the ways that competences of different individuals interrelate. As illustrated in Figure 15, Karl and John work together as members of a software development team. As represented by the association between them, they have a collaborative relationship in the software development context. In this case, this collaboration is a consequence of the relationships between their *competences* that allow them to collaborate. As depicted in Figure 15, they have additive *skills*, such as "front-end (FE) coding skill" and "back-end (BE) coding skills", and also reciprocal *skills*, such as "understanding back-end (BE) code skill" and "explaining back-end (BE) code skill"; and explaining "front-end (FE) coding skill" and "understanding front-end (FE) code skill".

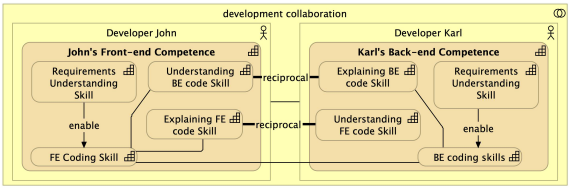

Fig. 15 Example of capability interaction view

(b) Capability Grounding View. The last view concerns the representation of emergent and resultant *capabilities* and reveals how they are *grounded* on other capabilities (by *emerging from* or *resulting from* these capabilities). Figure 16 illustrates this view showing the Software Development Team capabilities that are grounded on team member competences and skills. In this example, the "team's full-stack capability" of the team emerges as a consequence of "John's front-end competence" and "Karl's back-end competence" interrelationships. This emergent capability inheres in the software development team. Besides the emergent capability, there is also a resultant capability that inheres in the software development team, named "team's technology learning capability", that arises from the "sum" of John's and Karl's technology learning skills. As depicted, differently from the emergence representation, in this case, the resultant *capability* is not based on interrelated *capabilities*.

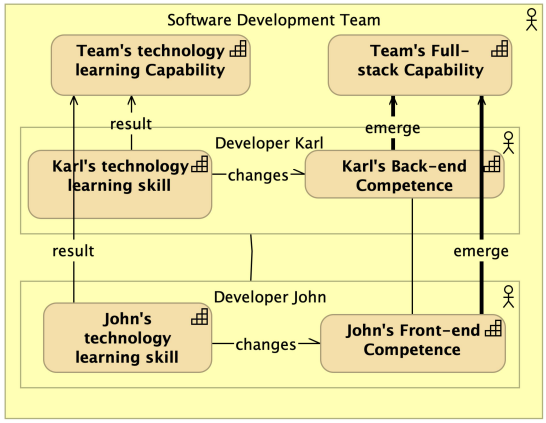

Fig. 16 Example of capability grounding view

6 Capabilities in Spotify

To show the benefits of the pattern language, we have applied it to a real-life case study from the literature addressed originally by Bäcklander [11]. This case study concerns the Spotify company, a well-known Swedish audio streaming (music and podcasts) and media services provider. This study focuses specifically on understanding (1) how adaptability and related capabilities (e.g., self-organization, learning, collaboration, etc.) emerge in the company, and (2) how the agile coach position contributes to these capabilities. The author of that work performed an ethnographic study inside the company, observing and interviewing the agile coaches. The interviews were conducted using a theory-based code, with codes based on complexity leadership theory (CLT). After the interviews, the author identified the main characteristics, practices, interactions, and motivations of the agile coaches that contribute to the emergence of these organizational capabilities.

Spotify's Structure

The Spotify company is well-known for having a unique structure, which distinct authors describe [11,

42–44]. Its general structure is depicted in Figure 17. It is composed of guilds ("testing guild" and "web technology guild") and tribes (e.g., "music player tribe", and "back-end infrastructure tribe"). Guilds represent cross-cutting study groups focused on employee development and which anyone can join. On the other hand, tribes are focused on the development of solutions.

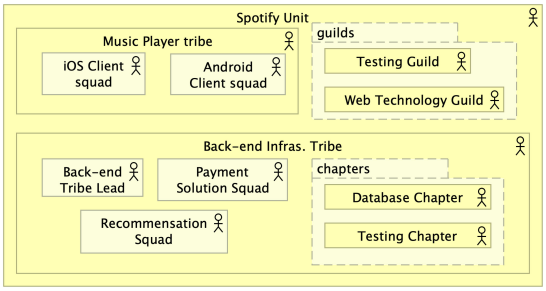

Fig. 17 Spotify Organizational Structure Representation

Tribes are also formed by chapters, as illustrated in Figure 17. They are "local" study groups (e.g., database chapter, testing chapter) that anyone can join, similar to guilds. In this case, while tribes and squads are result-oriented and highly coupled groups, guilds and chapters are learning-oriented and loosely coupled groups. Each tribe is formed by a tribe leads (e.g., "music player tribe lead") and by squads, or teams, (e.g., "android client squad" and "IOS client squad" in the "music player tribe"; "recommendation squad" and "payment solution squad" in the "back-end infrastructure tribe"). This is detailed in Figure 18. As depicted, each squad has members (e.g., the developers) and is related to a product owner (PO). Besides this, in the case of Spotify, each tribe has its own agile coach (e.g., the "music player agile coach" of the "music player tribe") supporting the developers of each squad.

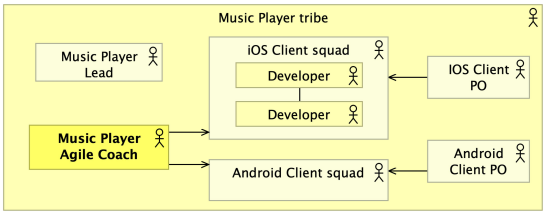

Fig. 18 Spotify Tribe's structure

Agile Coach Role

In the Spotify company, agile coaches are an evolution of the scrum master position. They do not function as managers, but, as the author reports, they have a kind of enabling leadership that balances formal and non-formal practices to create an adaptative space in the company. Agile coaches have two main goal outcomes [11]: (i) to help the squads and keep improving them and (ii) to enable their productivity. According to the author, these goal outcomes are the result of some "team states indicating adaptative systems": (i) sense of ownership, (ii) focus on values (not solution); (iii) action orientation ("team is biased to action"); (iv) frequent and open communication, and; (v) fun and friendly atmosphere. Based on the agile coach's goals, Bäcklander [11] identified what she termed as the main "practices" of agile coaches in Spotify. A description of these "practices" is detailed in Table 1. For each practice of the agile coach (AC), the author exemplifies and also mentions attitudes and quotes from distinct agile coaches, representing real situations they passed through. For example, as the table shows, regarding the practice of "increase sensitivity to context", one agile coach experienced this by "encouraging paying attention to context and considering what others understand", another by "encouraging considering consequences on others", and another by "getting people to understand each other's different perspectives better".

"Agile Coaching Competence" Manifestation View

Based on this description of goals and practices, we represented the competence manifestation view. This is illustrated in Figure 19. Besides the representation of the competence manifestation, we also consider the agile coach's goals. As shown, John (a generic persona) is an agile coach that has as drivers: (i) help the squads keep improving, and (ii) increase the squad's productivity. He also has goals such as: (i) improving the squad's communication (i.e., making it frequent, open, etc.); (ii) improving the squad's atmosphere (i.e., making it friendly and fun); and (iii) improving the squad's values (e.g., the ownership sense, the practical experimental culture, etc.). In this case, as illustrated, these goals are achieved by "John's agile coaching competence". As depicted, these drivers and goals motivate John's "agile coaching competence". This competence is a synthesis of all competences and skills behind all the agile coach's practices and their manifestations presented in Table 1. One of these manifestations of the

Table 1 Agile Coach's (AC) main practices descriptions based on Bäcklander [11]

PRACTICES	EXAMPLES	ILLUSTRATIONS
(a) Increase sensitivity to context	1-on-1 coaching about how to think, what to consider; at any time it seems prudent, encourage to consider the consequences of one's actions as individual and team, their impact on others, consider that others may not know what you know, and vice versa.	1) [AC] encouraging paying attention to context and considering what others understand; 2) [AC] encouraging considering consequences on others; 3) [AC] getting people to understand each other's different perspectives better; 4) [AC] describing a conflict episode; increasing sensitivity through guided individual reflection, increase empathy
(b) Boost and support other leaders in the team, particularly the PO	Work with PO; Coach PO how to lead, how to be a PO; How to lead in the Swedish setting; Helping CL prepare for difficult conversations	1) [AC] working with a part of the organization deemed as troubled, with no teams, no teamwork, and many interpersonal conflicts; 2) [AC] helping Chapter Leader conflict resolve
(c) Establish and remind of simple principles, interpreted locally	Some of the principles: "Value first"; "Function over form"; 12 principles of agile manifesto; Action bias; How people interact –higher band width is better, i.e. face to face. Interact with respect and receptiveness.	1) [AC] reinforcing the focus on value and function over form as "simple rules"; 2) [AC] reinforcing the simple rule of action bias by prompting team to distil their thoughts to something doable; 3) [AC] reinforcing an agile manifesto principle; 4) [AC] talking about the value of fostering a respectful culture through how you interact
(d) Observe team, pay attention to dynamics, and monitor	What is observed: Mood of team; Helping behaviours; Smiling; Talking; Being civil towards each other; What is not said; Team members mentally present; Patterns, like failing to deliver using certain planning method.	1) [AC] mentions observation as important and common/What is observed (mood, things going well); 2) [AC] describing observing negative team dynamic; 3) [AC] talking about when to engage and when not to engage; 4) [AC] on deciding more time for observation was necessary;
(e) Make the unseen more visible and tangible (surfacing conflict) through mirroring and questioning	Visualizations of work and work process, e.g. using boards, sticky notes, digital visualizations. The retrospective meeting itself. Various agile games.	1) [AC] on surfacing through questions; 2) [AC] on helping lower the bar for action, surfacing paths for action; 3) [AC] on getting commitment to act by surfacing and questioning; 4) [AC] on surfacing unique information and views within the group, facilitating team reflexivity and learning; 5) [AC] questioning to surface paths for action;
(f) Facilitate and encourage constructive dialogue as the generator of new forms	Setting a format; "Tossing" an open question; Live directing (calling on people); Acting as a surrogate (asking"stupid questions"); 1-on-1 coaching to instil civil and constructive ways of interacting.	1) [AC] describing the constructive dialogue dynamics they are looking for; 2) [AC] describing that when teams are really good at constructive dialogue, they themselves do not even have to be there anymore;

"agile coaching competence" is illustrated in Figure 19. As depicted, the "agile coaching competence" is manifested through the event "make an open question about stakeholder relationship", made by the agile coach to the android client squad's members (Karl and Paul).

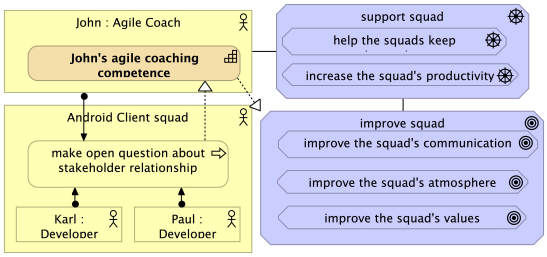

Fig. 19 Agile Coach's manifestation view with motivational aspects

6.1 Zooming in on the Agile Coaching Competence

After the competence manifestation viewpoint, in this section we will focus on the zooming-in viewpoint, representing the elements of "agile coaching competence" based on the agile coach's practices identified by Bäcklander [11] and described in Table 1. The textual representation of the agile coach's competences in the case study was used as input for the zooming-in modeling; however, the application of the patterns in an explicit EA model has several benefits when contrasted to the original textual description. For example, some elements described in this model had not been explicitly mentioned in the text, but surface here as the EA model serves as a frame of reference for details to be added. Besides this, in the original study, the agile coach competences were not aggregated explicitly into complex capabilities. The relationships between competences and their elements were not described either. We highlighted all these hidden elements and relationships in red for emphasis and highlighted in blue the elements that were considered and mentioned in the case study but were not detailed.

"Agile Coaching Competence" Element Relationships (General) View

Figure 20 depicts the "zooming in" perspective of the "agile coaching competence" based on the proposed language pattern, clarifying its elements' relationships.

Based on the agile coach's practices identified in the case study, we established the agile coach's competences that form the "agile coaching competence". To facilitate and improve the representation of the practices presented in Table 1, the agile coach's abilities were "organized" into three main complex capabilities, as shown in Figure 20: (i) "cultural development competence"; (ii) "communication skill"; and, (iii) "squad supporting competence". In this case, the intent of this summary is to increase the abstraction level of the representation and improve understanding of the agile coach's capabilities. As Figure 20 depicts, one of the main distinctions between the case study description and this representation is the relationship between the competences. As shown, the competences and skills that form the complex competence "agile coaching competence" are related as "additional". In this case, this means that their manifestation can be added in distinct circumstances.

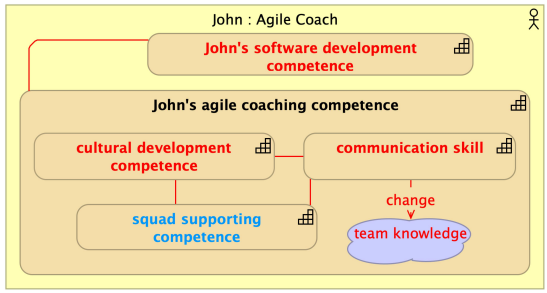

Fig. 20 General representation of "agile coaching competence"

"Agile Coaching Competence" Elements Relationship (Detailed) View

Figure 21 shows how these presented elements of the "agile coaching competence" can be decomposed.

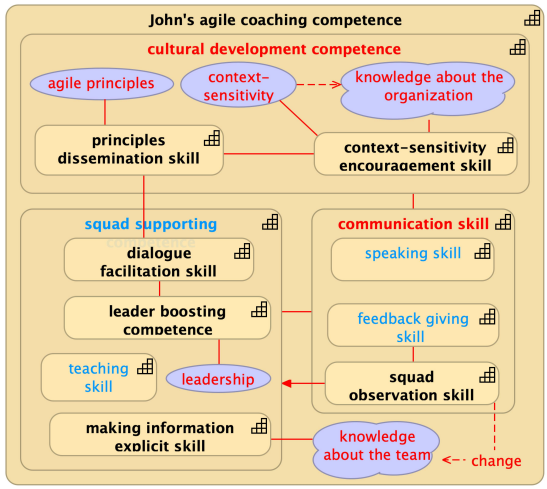

Fig. 21 Detailed representation of "agile coaching competence"

As depicted, (a) "cultural development competence" is formed by *(i) "principles dissemination skill"* (practice *c* in Table 1), *(ii) "context-sensitivity encouragement skill"* (practice *a* in Table 1), (iii) "agile principles attitude", (iv) "context-sensitivity attitude", and (v) "knowledge about the organization"; (b) "squad supporting competence" is formed by *(i) "dialogue facilitation skill"* (practice *f* in Table 1) , *(ii) "leader boosting competence"* (practice *b* in Table 1), (iii) "leadership attitude", (iv) "teaching skill", and *(v) "making information explicit"* (practice *e* in Table 1); (c) "communication skill" is formed by (i) "speaking skill", (ii)"feedback giving skill", and *(iii) "squad observation skill"* (practice *d* in Table 1). As depicted, for this model some attitudes such as "agile principles", "context sensitivity", "leadership" (in red), not considered in the case study, were represented here since they are key to account for some competences. We considered "knowledge about the team" and "knowledge about organizational" for the same reason. Concerning the relationships, (i) "principles dissemination skill" *is additional to* "context-sensitivity encouragement skill" and to "agile principles attitude"; (ii) "context-sensitivity encouragement skill" *is additional to* "context-sensitivity attitude" and "knowledge about the organization", since the manifestation of these attitudes and knowledge potencialize the manifestation of the skills; (iii) "dialogue facilitation skill" *is additional to* "leader boosting competence" since they can be manifested together; (iv) "leader boosting competence" *is additional to* "leadership attitude" since this attitude potencialize that skill; (v) "making information explicit skill" *is additional to* "knowledge about the team"; (vi) "squad observation skill" can change the "knowledge about the team"; and (vii) "John's agile coaching competence" *is additional to* "John's software development competence", since the agile coach came from the development area his technical competences help in the agile coaching competence, as the case study explains.

"Context-Sensitivity Encouragement skill" Elements Relationship View

Figure 22 illustrates further "zooming-in", focusing on "John's context-sensitivity encouragement skill". As described in the case study, this skill concerns practices such as (i) "whole perspective dissemination skill"; (ii) "organizational mission sensitizing skill"; (iii) "self-reflection stimulation skill"; and (iv) "empathy encouragement skill". As shown in the figure, these practices were considered skills that form "John's context sensitivity encouragement competence" and some of these skills are considered additional to others and on some attitudes. In this context, the "whole perspective dissemination skill" *is additional to* "John's holistic values" and the "empathy encouragement skill" *is additional to* "John's empathy" attitude, since these attitudes potentialize the manifestation of those skills.

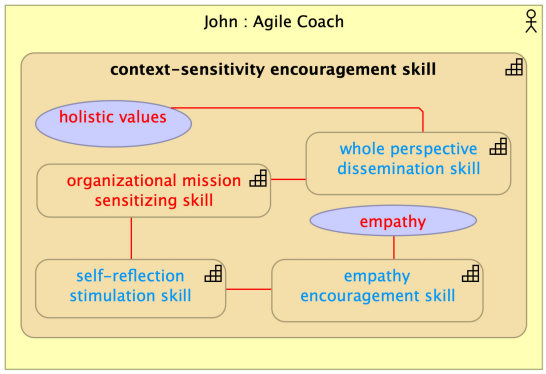

Fig. 22 Zooming-in on "context-sensitivity encouragement skill"

6.2 Zooming out on Agile Coaching Competence

6.2.1 "Agile Coaching Competence" Interaction View

The interaction view is important to understand how people (or social agents) collaborate. Figure 23 illustrates this interaction perspective between the agile coach, developer, and product owner (PO). As the case study analysis the agile coach role in Spotify, it seems as an enabling leadership. This aspect can be observed in the interaction view through the enabling relationships. As depicted, (i) John's "cultural development competence" enables Karl's "self-reflection skill" (since it creates conditions for to Karl reflect), which enables Karl's "learning skill"; (ii) John's "teaching skill" and Karl's "learning skill" are reciprocal (since they can manifest together, sharing a same context); (iii) John's "making information explicit skill" enables "Karl's learning skill" (since it creates conditions that stimulate the learning); (iv) John's "making information explicit skill" are reciprocal to Karl's "perception skill", which enables the "self-reflection skill"; (v) "John's dialogue facilitation skill" enables "Karl's communication skill" (since it creates conditions that stimulate Karl's communication), which

enables “John’s squad observation skill”; and, (v) “John’s leader boosting competence” enables “Bob’s leadership skill”. As the case study highlights, the agile coach is an enabling leader that allows the developers and PO to learn and improve. This is expressed explicitly in the figure since the interactions presented between the agile coach and developer competences are mostly focused on the reciprocal and enabling relationship.

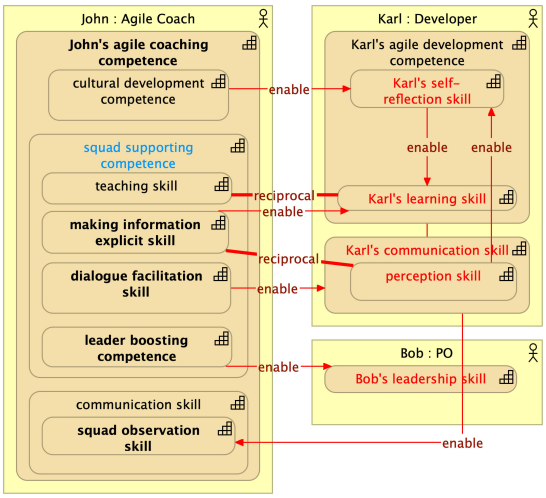

Fig. 23 Agile coach, developer, and PO’s capabilities interaction view

“Context-Sensitivity Encouragement Skill” Interaction View

As shown in Figure 24, when necessary, it is possible to detail the interaction of a specific human capability from the interaction view. In the figure, it is applied to understand better “John’s context-sensitivity encouragement competence” interaction. As depicted, “John’s context-sensitivity encouragement competence” enables “Karl’s context-sensitivity attitude” since it creates conditions to activate this attitude in Karl, through different kinds of acts such as conversation, examples, etc. Besides this, the same occurs between (i) John’s “self-reflection stimulation skill” and “Karl’s self-reflection skill”, and; (ii) “empathy encouragement skill” and “Karl’s empathy”. As also shown, “Karl’s self-reflection skill” can change their attitudes. The model elements make explicit the author’s conclusions that the agile coach serves as an enabling leader, showing specifically *how* the agile coach enables development competences.

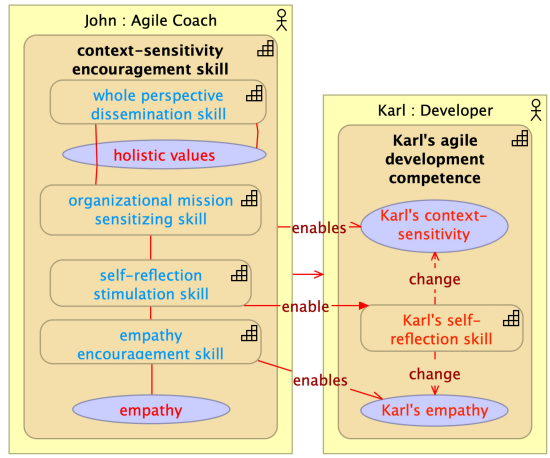

Fig. 24 Context-sensitivity encouragement skill Interaction view

Agile Coach’s “Communication Skill” and “Dialogue Facilitation Competence” Interaction View

As the study case explains, one of the most important competences of the agile coach is (constructive) “dialogue facilitation”. This includes: (i) open question asking; (ii) live direction (making all team members participate in a conversation equally); (iii) surrogate acting (asking “stupid questions”); (iv) dialogue format setting; and (v) opinion sharing stimulation. Another important competence is “team observation”. As the case study details, this competence includes (i) dynamic noticing; (ii) team monitoring; (iii) listening; and, (iv) noticing. These two competences are partially represented in Figure 25. As shown, John’s “open question asking skill” enables Karl’s “answering skill”, and John’s “opinion sharing stimulation skill” enables Karl’s “opinion sharing skill”. Otherwise, in this case, the interaction between their capabilities also includes reciprocal relationships. As shown, John’s “listening skill” is reciprocal to Karl’s “answering skill” and John’s “open question asking skill” is also reciprocal to Karl’s “listening skill”. This reciprocal relationship is present between other capabilities too, besides those not being represented (e.g., the agile coach’s teaching skill and the developer’s learning skill). As in the previous model, this figure also reinforces that the interaction between the agile coaches and developers is based on reciprocity and enabling relationships. As it will be shown in the next subsection, these factors are the base for the emergence phenomenon.

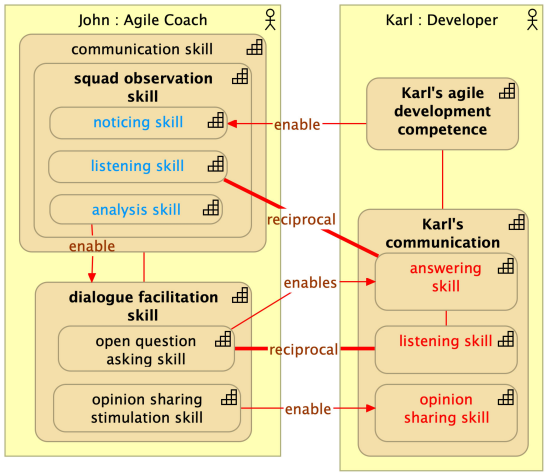

Fig. 25 Communication and dialogue facilitation skills interaction

6.2.2 The Emergence Phenomenon in Spotify

Besides Bäcklander [11] analyzes the emergence of non-technical capabilities in Spotify (i.e., adaptability and innovation) based on the agile coach's participation, the author does not focus on the emergence in a technical aspect. Otherwise, based on other authors [42–44], it is possible to identify the emergence relationships based on the description of the company structure and related capabilities. In this case, concerning the technical capabilities of a tribe, they emerge from additional technical capabilities from the squads, which emerge from additional competences from the squad members.

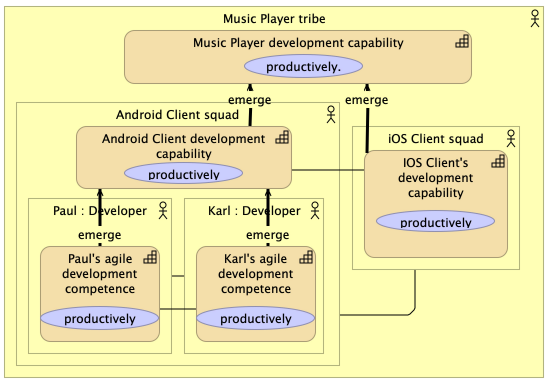

Fig. 26 Emergence of technical capabilities in a tribe

Figure 26 illustrates this. As shown, the "Music Player development capability" of the Music Player tribe emerges from the "Android Client squad's development capability" and "iOS Client's development capability" (additional ones); and, "iOS Client's development capability" emerges from "Karl's agile development competence" and "Paul's agile development competence" (additional ones). As a result of the emergence of development capability in each tribe, the development capability of Spotify emerges too, as shown in Figure 27. Two important aspects regarding this case are: (i) the emergence is a result of the interaction between the actors and their capabilities since in this case they are additional; (ii) as a result of the agile coach support, the development capabilities emerged with productivity value, as illustrated.

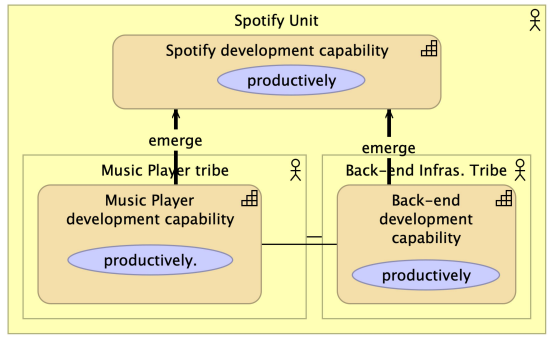

Fig. 27 Emergence of technical capabilities in Spotify

Resultant Technical Capabilities Relationships

Based on the same authors [42–44], it is also possible to identify the resulting vertical relationships between technical capabilities in the company. This happens especially in Spotify's guilds. As the authors explain, they are learning communities composed of professionals with similar capabilities. As a result, their capabilities "result from" the personal competences of their members. Figure 28 illustrates this relationship. As shown, the Testing guild has the "testing capability" as a resultant one. This capability, as depicted, results from "Paul's testing skill", and "Karl's testing skill", among others. In this case, the individual "testing skills" are not related as they were in the case of the squads and tribes, resulting in the emergence phenomenon. As a consequence, in this case, the resultant "testing capability" of the Testing guild is just a kind of "simple sum" of the "testing skill" of individuals. As [44] states, some guilds are not just focused on learning, the called "book club", but also on the development of components and standards proposition. In this case, with the individual testing competences interacting, the testing capability could emerge. Even in

guilds that work as "book clubs", the interaction of learning, reflection, presentation, discussion, and questioning skills could allow the emergence of the "guild collective learning" capability.

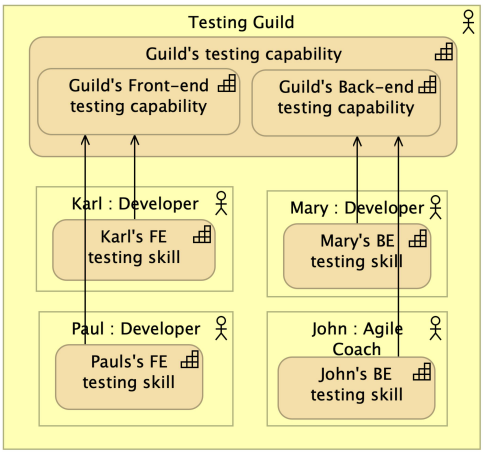

Fig. 28 Technical capabilities as resulting capabilities in the guilds

Spotify's Adaptability Emergence

The emergence phenomenon in Spotify is one of the main aspects explained in this case study, even because Bäcklander [11] considers complex and adaptive system (CAS) theory as a foundation. As a result, Spotify is seen by the author as a complex system that belongs to a changeable environment. In this case, the work explains how agile coaches play a special position since they contribute to the emergence of some capabilities, especially the adaptability and evolution of Spotify. As an outcome of the study, the author concludes that the adaptability capability emerges due to two main leverage point: increasing the context sensitivity (that improve the quality of communication and solutions) and the relevance of information in the context (that stimulate learning and reflection). The author also associates adaptation and evolution capabilities with learning, open dialogue, and creativity capabilities. According to the study case, these capabilities in Spotify are a result of the agile coaches acting as enabling leaders and creating adaptation spaces in the company.

Squad's Improvement Emergence

However, besides explaining the influence of the agile coach in this case, the author does not explain how

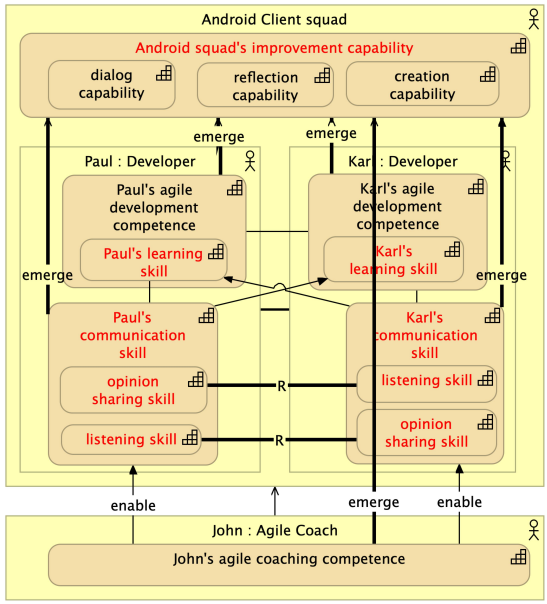

Fig. 29 Squad's improvement capability emergence

emergence happens. Figure 29 aims to illustrate better how the agile coach contributes practically to the emergence phenomenon in a squad. As depicted, in this case, one of the main contributions of the agile coaches is enabling better communication between the squad members. As a result, the developers can share more of their opinions, among other communication skills, as illustrated. As it is shown, the more the (reciprocal) communication skills of the developers are enabled by agile coaches, the more their learning and reflection skills are enabled through these interactions, allowing them to create new solutions. In summary, as a result of this dynamics, the improvement capability of the squad emerges, as illustrated in the figure. As depicted, this capability is formed by the squad's dialogue, reflection, and creation capabilities.

Tribe's Adaptability Emergence

As a result of the emergence of the improvement capability in each squad, stimulated by the agile coach, the improvement capability of the tribe also emerges. This is illustrated in Figure 30. As depicted, the improvement capabilities of squads are additional (since they can be manifested together to propose improved solutions). Likewise, the improvement capabilities of the tribes are also "additional" to each other for the same reason. As a consequence of this, the adaptability of the whole company emerges, as illustrated in the figure. Besides these capabilities, the learning capabilities of

the guilds also contribute to the emergence of adaptability in Spotify. As explained by the authors, guilds are learning communities where the members share knowledge, have discussions, and promote events as workshops. They also have a practical approach since they also try to solve common problems and establish patterns for the organization. As a result, one of the capabilities that emerge from these interactions is the guild's learning, as shown in the figure.

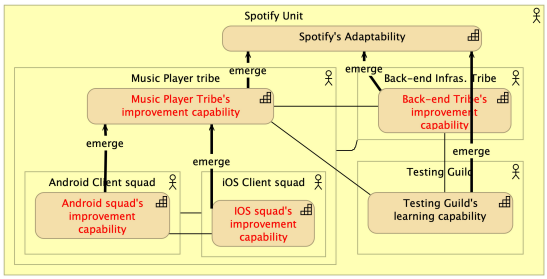

Fig. 30 Tribes's adaptability emergence

7 Related Works

Competence models range from simple competence representations to more semantically rich and sophisticated representations [45]. Competence management approaches began to use standardized models, such as XML-based ones, to support specific technological tasks such as data integration and exchange. These models then evolved into more complete conceptual models. Recently, ontology-based models have become more prevalent in CM approaches, incorporating more semantics into competence models [46]. They have been used for a variety of purposes, the majority of which are related to business and education. Some of these works are discussed below.

In the ontology of Zaouga et al.'s [47], knowledge and skill are considered sub-types of competence rather than elements. The ontology does not cover attitudes. In its place, the authors use the behavior concept with similar meaning. Paquette's ontology [6] also includes skill and knowledge, but not attitude. In this case, knowledge and skill are components of competence. Paquette [6] also relates the concepts of skill and knowledge concerning parthood and applicability. According to this work, skills are "applied to" knowledge entities. Skills are classified in the ontology based on taxonomies and complexity levels, and they are also measured using indicators. Miranda et al.'s [13] also incorporate knowledge, skill, and attitude into their model. In its structure, competence consists of these elements. As stated in [13], knowledge, and skill are also related concepts. This ontology takes into account not only skill classification but also knowledge and attitude.

In contrast to those works, here we treat skills as constituent elements of competences. As a result, competences can be represented at various levels of abstraction. They are dispositional concepts, and types of Human Capability, that can manifest themselves through tasks. Knowledge and attitudes share this dispositional nature and can manifest together with tasks through actions, posture, and so on. Aside from the detailed and well-founded representation of competences, supporting Competence Management tasks in Enterprise Architecture is another distinguishing feature of this work.

Concerning vertical relationships, they are not addressed by most of the other efforts reported in the literature. Only [13, 48] consider this aspect in a simple way, by allowing solely parthood between competences. The composition of other human capabilities (as skills) in a general sense is not considered. The only vertical relationship considered in the related works was the parthood one. These works do not consider the emergence (or resulting) of organizational capabilities from individual competences. Concerning the horizontal relationships, only [48,49] consider them in a very generic way. In this sense, these works do not regard the specific relationship types addressed here, but rather a kind of generic relationship between competences, that could be used vaguely to model some horizontal relationships.

Still concerning this aspect, one of the most relevant related works is not focused on competences (or capability) but on prevention and risk modeling [39, 50]. These works also consider foundational ontologies and disposition theories to propose relationships between disposition types. Besides focusing on other domains, these works also focus on disposition types relationships, differently from this work that also considers relationships between (individual) *dispositions*. In this case, similar relationships are addressed in these related works such as "mutual activation partnership" (similar to "reciprocal to"), prevent (similar to "disables"), and triggering (similar to "enables"). Otherwise, other important relationships considered here are not addressed there, such as "additional to" and "changes". Another similarity of this work is that is also

applied in the EA context, also proposing well-founded representations but in the risk area [51] area.

Some other works such as [52, 53] have also explored foundational ontologies in EA modeling. Both employ UFO to conduct ontological analyses of two concepts closely related to competence: capability and service. [53], for example, views service delivery as the manifestation of competences. [52], on the other hand, conducts an ontological analysis of Capability and is also related to the concept of Competence. [52] briefly discusses the definition of competence based on capability; in the current work, we adopt and expand on that analysis. As discussed here, competences can be placed in the so-called capability bundles [52], connecting individual-level capabilities (competences) with organizational capabilities.

8 Final Remarks and Discussion

The study presented in this paper aimed to improve competence modeling in the context of Enterprise Architecture by using a reference ontology as a semantic foundation. The understanding of skills, knowledge, attitudes, and other characteristics allowed us to zoom in on individual competence, allowing for a detailed competence representation in the context of Enterprise Modeling. In addition, the comprehension of organizational capabilities and the horizontal and vertical relationship distinctions allowed us to zoom out on individual competences, enabling a general representation of them. The reference ontology has provided us with a semantic foundation that accounts for the relation between organizational capabilities and individual competences, and this is reflected in the representation strategy.

We investigated the support of Competence Management activities with Enterprise Architecture models with the goal of improving personal competence and organizational capability understanding. From the standpoint of competence composition and decomposition, the proposed competence representation strategies make it easier to implement Competence Management in EA at distinct abstraction levels, from individual skills to capabilities of the whole organization. The model representation using *ArchiMate*, on the other hand, contributes a set of possibilities to enhancing the Competence Management practice. This distinguishes the current work from other ontology-based competence works in the literature.

As a result, the proposed representation can aid in essential Competence Management (CM) activities such as competence mapping, identification, and gap analysis. In this sense, the proposed representation patterns facilitate CM activities by visualizing modeling competences from various perspectives. It enables the detailing of individual competences in these various representations, assisting with a deeper comprehension of the individual skills, knowledge, and attitudes that comprise these competences, and how they can be related giving rise to organizational capabilities. This combination of detailed and general vision aids in many CM activities such as competence comparison, planning, and assessment, to name a few.

The focus of this work was to represent the competence-related concepts at individual levels (similar to [5, 26]). The models can be used to represent: (i) real situations from the present or past related to one or more professionals (to support the *competence identification*); (ii) desired situations from the future, related to one or more professionals (to support the *gap analysis*); and (iii) hypothetical scenarios related to a persona, using storytelling to validate the models, as [54] propose, and understand better the CM requirements.

Based on the case study application, the language pattern brought some benefits to the understanding of how individual competences and skills can impact the capabilities of the whole organization. Through the proposed representation, it was possible to account for how the agile coach's competences impact the squad, the tribe, and consequently the whole organization, thereby increasing Spotify's adaptability. As presented in Section 6, the case study addressed by Bäcklander [11] provided a textual description of the individual and organizational capabilities. This description is very complete since it was a result of interviews and based on suitable theoretical background. We have rendered the description using EA models. This is conducive to producing hierarchical structures (revealing the content in different levels of detail) and to fill in certain gaps in the original textual rendering. A noticeable difference is that this description was not capability-oriented. As a consequence, the focus of the descriptions was not the capabilities themselves but the adopted practices (by the agile coaches, specifically). However, in other to achieve this, the descriptions basically detailed the agile coaches' capabilities (competences and skills) behind the performance of those practices. This description also included implicitly other elements related to the agile coaches' capabilities, such as attitudes and knowledge. Another aspect is the case study is the understanding

of the relationships. In this sense, Spotify's case tried to understand how the individual practices of the agile coaches impacted other tribe members and how they contributed to the emergent process of new capabilities (especially adaptability and innovation). That is, the *implicit* focus of the study was to analyze the horizontal relationships between agile coaches and tribe member competences and the vertical relationships between their capabilities and Spotify's emergent capabilities.

Even though its main focus was to understand the emergence and enabling relationships between agile coaches and other tribe members, how these phenomena happened in the organization was not so accurate. We believe that our use of a conceptual framework about competence-related concepts sheds further light into the observed phenomena. More specifically, the different kinds of human capabilities (competence and skill) and their elements (e.g., knowledge and attitude) can now be more clearly identified. The same could happen with the relationships among these competence-related concepts. In other words, with the proposed language pattern, the case study's understanding of horizontal and vertical relationships and respective analyzes of the context can be better supported.

In addition, it was noticed that, through the language pattern adoption, many implicit (tacit) relevant details of the scenario have surfaced while the model was constructed. In this sense, the language pattern worked as a guide, favoring the representation of hidden elements and relations during competence modeling. In this case, the reference ontology provided well-founded distinctions that served as archetypes in competence modeling. In practice, these archetypes as patterns helped to increase the level of abstraction of the representation. In summary, these archetypes worked as lenses, allowing a more precise view of this competence domain. As a result, (i) more human capabilities and correspondent elements (knowledge and attitude) were identified; (ii) how agile coaches impact other tribe members through enabling relationships was explicitly captured; and finally, (iii) how adaptability emergence happens was precisely described. In addition to these points, other important aspects to be concerned about in the proposed language pattern are: (i) the visual representation works as a complementary resource to facilitate communication and understanding; (ii) the vertical relationships allows us to work in distinct abstraction levels, enabling to manage the complexity of the competence representations; and (iii) the reference ontology allows a structured representation of competence information, which may serve as the basis to improve the quality of queries, reasoning, inferences, and technological solutions in general.

Future works

Future research could open up the concept of competence by investigating how the competences of different individuals can be combined to form organizational and collective capabilities from a systemic perspective, based on *General System Theory* (GST). This study would delve deeper into how organizational capabilities emerge from personal competences according to the system (organization) structure and how its parts are connected. In this case, capabilities are not created by simply combining competences. The combination of high proficiency and competence does not guarantee the formation of a high-performance team. In this regard, we see an opportunity to incorporate GST concepts (e.g., system, component, connection, function) into the ontological foundation in order to better represent the phenomena of evolution, emergence, and composition in the context of Enterprise Architecture. We see an opportunity to combine GST notions with theories of dispositions in order to improve understand how competences can be related and combined.

We also see the need to develop case studies to further validate the proposed competence representation patterns. Although ontological analysis provides the foundation for a well-founded representation (as used here, the foundation incorporates advances in Formal Ontology, Philosophical Logics, Philosophy of Language, Linguistics, and Cognitive Psychology [24]), the pragmatics of a representation in its usage context should be thoroughly assessed. Efforts in this sense have already been made for other UFO-based representation schemes, such as [55], [53].

Another area of future research concerns the relationship between competences and other *ArchiMate* perspectives, such as Motivation Elements. In this case, the ontological analysis could include other UFO concepts related to intentions, such as Goal and Proposition, which are related to the organization's strategic goals [56].

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References

[1] Le Deist FD, Winterton J. What Is Competence? Human Resource Development International. 2005;8(1):27–46. https://doi.org/10.1080/1367886042000338227.

[2] Sampson D, Fytros D. Competence Models in Technology-Enhanced Competence-Based Learning. In: Handbook on Information Technologies for Education and Training. Springer Berlin Heidelberg; 2008. p. 155–177.

[3] Gangani N, McLean GN, Braden RA. A competency-based human resource development strategy. Performance Improvement Quarterly. 2006;19(1):127–139.

[4] Rodriguez D, Patel R, Bright A, Gregory D, Gowing MK. Developing competency models to promote integrated human resource practices. Human Resource Management. 2002;41(3):309–324. https://doi.org/https://doi.org/10.1002/hrm.10043.

[5] Calhau RF, Azevedo CLB, Almeida JPA. Towards Ontology-based Competence Modeling in Enterprise Architecture. In: 25th IEEE Int. EDOC Conference (EDOC 2021). IEEE; 2021. .

[6] Paquette G. An Ontology and a Software Framework for Competency Modeling and Management. Educational Technology and Society. 2007;10(3):1–21.

[7] Rodrigues M, Fernández-Macías E, Sostero M. A unified conceptual framework of tasks, skills and competences. JRC Working Papers Series on Labour, Education and Technology; 2021.

[8] Draganidis F, Mentzas G. Competency based management: a review of systems and approaches. Inf Manag Comput Secur. 2006;14(1):51–64. https://doi.org/10.1108/09685220610648373.

[9] Westera W. Competences in education: A confusion of tongues. Journal of Curriculum Studies. 2001;33(1):75–88. https://doi.org/10.1080/00220270120625.

[10] Guizzardi G. Ontological Foundations for Structural Conceptual Models. No. 15 in Telematica Instituut Fundamental Research Series. The Netherlands: Telematica Instituut; 2005.

[11] Bäcklander G. Doing complexity leadership theory: How agile coaches at Spotify practise enabling leadership. Creativity and Innovation Management. 2019 Jan;28(1):42–60. https://doi.org/10.1111/caim.12303.

[12] Draganidis F, Chamopoulou P, Mentzas G. A semantic web architecture for integrating competence management and learning paths. Journal of Knowledge Management. 2008;12(6):121–136. https://doi.org/10.1108/13673270810913667.

[13] Miranda S, Orciuoli F, Loia V, Sampson D. An ontology-based model for competence management. Data & Knowledge Engineering. 2017 Jan;107:51–66. https://doi.org/10.1016/j.datak.2016.12.001.

[14] Esposto A. Skill: An Elusive and Ambiguous Concept in Labour Market Studies. Australian Bulletin of Labour. 2008;34(1):100–124.

[15] Brown JS. Learning in the digital age. In: The Internet and the university: Forum. vol. 71; 2001. p. 72.

[16] Wood R, Power C. Aspects of the competence-performance distinction: Educational, psychological and measurement issues. Journal of Curriculum Studies. 1987 Sep;19(5):409–424. https://doi.org/10.1080/0022027870190503.

[17] Messick S. The Psychology of Educational Measurement. Journal of Educational Measurement. 1984 Sep;21(3):215–237. https://doi.org/10.1111/j.1745-3984.1984.tb01030.x.

[18] Maze JR. The concept of attitude. Inquiry. 1973 Jan;16(1-4):168–205. https://doi.org/10.1080/00201747308601684.

[19] Altmann TK. Attitude: a concept analysis. In: Nursing forum. vol. 43. Wiley Online Library; 2008. p. 144–150.

[20] Acampora G, Gaeta M, Orciuoli F, Ritrovato P. Exploiting Semantic and Social Technologies for Competency Management. In: 10th IEEE Int Conf Advanced Learning Technologies. IEEE; 2010. p. 297–301.

[21] Pyster A, Olwell DH, Hutchison N, Enck S, Anthony Jr JF, Henry D, et al. Guide to the systems engineering body of knowledge (SEBoK) v. 1.0. 1. Guide to the Systems Engineering Body of Knowledge (SEBoK). 2012;.

[22] Molnar G, Bradley N. Powers: A study in metaphysics. Clarendon Press; 2003.

[23] Mumford S, Anjum RL. Getting Causes from Powers. Oxford University Press; 2011.

[24] Guizzardi G, Wagner G, Almeida JPA, Guizzardi RSS. Towards ontological foundations for conceptual modeling: The unified foundational ontology (UFO) story. Applied Ontology (Online). 2015;10:259–271. https://doi.org/10.3233/AO-150157.

[25] Guizzardi G, Wagner G. Towards Ontological Foundations for Agent Modelling Concepts Using the Unified Fundational Ontology (UFO). In: Agent-Oriented Information Systems II. Springer Berlin Heidelberg; 2005. p. 110–124.

[26] Calhau RF, Almeida JPA. Zooming in on Competences in Ontology-based Enterprise Architecture Modeling. In: 2022 IEEE 26st International Enterprise Distributed Object Computing Workshop (EDOCW); 2022. .

[27] Azevedo CLB, Iacob ME, Almeida JPA, van Sinderen M, Ferreira Pires L, Guizzardi G. An Ontology-Based Well-Founded Proposal for Modeling Resources and Capabilities in ArchiMate. In: 17th IEEE International EDOC Conference (EDOC 2013). IEEE Computer Society Press; 2013. p. 39–48.

[28] Dori D, Sillitto H. What is a System? An Ontological Framework. Systems Engineering. 2017 May;20(3):207–219. https://doi.org/10.1002/sys.21383.

[29] Sillitto HG. 10.2.1 "Composable Capability" - Principles, strategies and methods for capability systems engineering. INCOSE International Symposium. 2013 Jun;23(1):723–738. https://doi.org/10.1002/j.2334-5837.2013.tb03050.x.

[30] Merrell E, Limbaugh D, Koch P, Smith B. Capabilities; 2022.

[31] Bunge M. Treatise on Basic Philosophy: The Furniture of the World. Ontology I. Reidel Pub.; 1977.

[32] Bunge M. Treatise on Basic Philosophy. Ontology II: A World of Systems. Dordrecht, Netherlands: Springer Netherlands; 1979. Available from: https://doi.org/10.1007/978-94-009-9392-1.

[33] O'Connor T. Emergent properties. American Philosophical Quarterly. 1994;31(2):91–104.

[34] Spencer-Smith R. Reductionism and emergent properties. In: Proceedings of the Aristotelian Society. JSTOR; 1995. p. 113–129.

[35] Mossio M, Bich L, Moreno A. Emergence, Closure and Inter-level Causation in Biological Systems. Erkenntnis. 2013 Jul;78(S2):153–178. https://doi.org/10.1007/s10670-013-9507-7.

[36] Juarrero A. Dynamics in action: Intentional behavior as a complex system. Emergence. 2000;2(2):24–57.

[37] Barton A, Jansen L, Ethier JF. A taxonomy of disposition-parthood. In: Workshop on Foundational Ontology in Joint Ontology Workshops: JOWO 2017. vol. 2050. CEUR-WS: Workshop proceedings; 2017. p. 1–10.

[38] Galton A, Mizoguchi R. Dispositions and the infectious disease ontology. In: Formal Ontology in Information Systems: Proceedings of the Sixth International Conference (FOIS 2010). vol. 209. Ios Press; 2010. p. 400.

[39] Oliveira Í, Sales TP, Baratella R, Fumagalli M, Guizzardi G. An Ontology of Security from a Risk Treatment Perspective. In: Conceptual Modeling. Springer International Publishing; 2022. p. 365–379.

[40] Ichikawa JJ, Steup M. The Analysis of Knowledge. In: Zalta EN, editor. The Stanford Encyclopedia of Philosophy. Summer 2018 ed. Metaphysics Research Lab, Stanford University; 2018. .

[41] Choi S, Fara M. Dispositions. In: Zalta EN, editor. The Stanford Encyclopedia of Philosophy. Spring 2021 ed. Metaphysics Research Lab, Stanford University; 2021. .

[42] Kniberg H, Ivarsson A.: Scaling Agile Spotify. Available from: https://blog.crisp.se/wp-content/uploads/2012/11/SpotifyScaling.pdf.

[43] Kniberg H.: Spotify engineering culture (part 1). Available from: https://engineering.atspotify.com/2014/03/spotify-engineering-culture-part-1/.

[44] Smite D, Moe NB, Floryan M, Levinta G, Chatzipetrou P. Spotify guilds. Communications of the ACM. 2020 Feb;63(3):56–61. https://doi.org/10.1145/3343146.

[45] Rezgui K, Mhiri H. Modeling Competencies in Competency-Based Learning: Classification and Cartography. In: 2018 JCCO Joint Intl Conf ICT in Education and Training, Intl Conf Computing in Arabic, and Intl Conf Geocomputing (JCCO: TICET-ICCA-GECO). IEEE; 2018. .

[46] HR-XML Consortium.: Competencies 1.0 (Measurable Characteristics) Recommendation 2001-Oct-16. Available from: http://xml.coverpages.org/HR-XML-Competencies-1_0.pdf.

[47] Zaouga W, Rabai LBA, Alalyani WR. Towards an Ontology Based-Approach for Human Resource Management. vol. 151 of Procedia Computer Science. Elsevier; 2019. p. 417–424.

[48] Rezgui K, Mhiri H. Towards a Semantic Framework for Lifelong Integrated Competency Management and Development. Comput J. 2020;63(7):1004–1016. https://doi.org/10.1093/comjnl/bxz067.

[49] Sicilia MA. Ontology-based competency management: infrastructures for the knowledge intensive learning organization. In: Intelligent learning infrastructure for knowledge intensive organizations: A semantic Web Perspective. IGI Global; 2005. p. 302–324.

[50] Baratella R, Fumagalli M, Oliveira Í, Guizzardi G. Understanding and Modeling Prevention. In: Research Challenges in Information Science. Springer International Publishing; 2022. p. 389–405.

[51] Oliveira Í, Sales TP, Almeida JPA, Baratella R, Fumagalli M, Guizzardi G. Ontological Analysis and Redesign of Security Modeling in ArchiMate. In: Lecture Notes in Business Information Processing. Springer International Publishing; 2022. p. 82–98. Available from: https://doi.org/10.1007/978-3-031-21488-2_6.

[52] Azevedo CLB, Iacob M, Almeida JPA, van Sinderen M, Pires LF, Guizzardi G. Modeling resources and capabilities in enterprise architecture: A well-founded ontology-based proposal for ArchiMate. Information Systems. 2015;54:235–262. https://doi.org/10.1016/j.is.2015.04.008.

[53] Nardi JC. A Commitment-based Reference Ontology for Service: Harmonizing Service Perspectives [Ph.D. dissertation]. Federal Univ. of Espírito Santo. Brazil; 2014.

[54] Braga BFB, Almeida JPA. Modeling Stories for Conceptual Model Assessment. In: Lecture Notes in Computer Science. Springer International Publishing; 2015. p. 293–303.

[55] Griffo C, Almeida JPA, Guizzardi G. Conceptual Modeling of Legal Relations. In: 37th Int. Conf. Conceptual Modeling (ER 2018). vol. 11157 of Lecture Notes in Computer Science. Springer; 2018. p. 169–183.

[56] Azevedo CLB, Almeida JPA, van Sinderen M, Quartel D, Guizzardi G. An Ontology-Based Semantics for the Motivation Extension to ArchiMate. In: 15th IEEE Int. EDOC Conference. IEEE; 2011. p. 1–10.