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Modelling business Capabilities and their connection to Services

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Δημιουργία μοντέλων επιχειρηματικών δυνατοτήτων και η σύνδεση τους με τις υπηρεσίες

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ABSTRACT

In the constantly changing business environments experienced nowadays, researchers try to discover ways of modelling business architectures that are able to adapt to those changes, in order to avoid the reconstruction of the whole architecture after a few years. Furthermore, the development of new technologies leads to not only different Information Technology (IT) Architectures, the more prevalent being Service-Oriented Architecture (SOA), but also to new marketing strategies. One way to address this situation is by modelling a business not based on “How” the business works but on “What” the business does, thus creating more constant architectures, since in most cases only the business processes change while the what remains the same (e.g. when moving from regular sales to e-shopping, it is still sales but with different processes and resources). That approach is called Capability modelling or Capability mapping.

The goal of this dissertation is the introduction of a Capability modeling framework that can be used in order to analyze what a business does, offering a methodology of identifying business Capabilities and creating relative diagrams which also include Services so that the business view of a company can have a direct connection to its SOA. The proposed framework is utilized to analyze the use case of a Shipping Company in order to demonstrate the functionality and usefulness of such an analysis.

SUBJECT AREA: Strategic Management

KEYWORDS: Capability, Capability Modeling, Service, Enterprise Architecture

ΠΕΡΙΛΗΨΗ

Η διαρκής μεταβολή των σημερινών επιχειρησιακών περιβαλλόντων ωθεί τους ερευνητές σε αναζήτηση νέων τρόπων για τη μοντελοποίηση επιχειρησιακών αρχιτεκτονικών, με δυνατότητα προσαρμογής σε αυτές τις αλλαγές, με σκοπό την αποφυγή της επανασχεδίασης των αρχιτεκτονικών μετά από μερικά χρόνια. Επιπροσθέτως, η ανάπτυξη νέων τεχνολογιών οδηγεί όχι μόνο σε διαφορετικές αρχιτεκτονικές Τεχνολογίας της Πληροφορικής (IT architectures), με επικρατέστερη αυτή τη στιγμή την Υπηρεσιοστρεφή Αρχιτεκτονική που βασίζεται σε υπηρεσίες, αλλά και σε νέες στρατηγικές όσον αφορά στο marketing.

Ένας τρόπος αντιμετώπισης της παραπάνω κατάστασης είναι η μοντελοποίηση μιας επιχείρησης με βάση όχι το «Πώς» δουλεύει η επιχείρηση αλλά με βάση το «Τι» κάνει. Αυτή η προσέγγιση οδηγεί σε πιο σταθερές αρχιτεκτονικές, αφού στις περισσότερες περιπτώσεις αλλάζουν μόνο οι επιχειρησιακές διαδικασίες ενώ το τι κάνει η επιχείρηση παραμένει το ίδιο. Για παράδειγμα όταν ένα κατάστημα περνά από τις κανονικές πωλήσεις στις ηλεκτρονικές πωλήσεις, εξακολουθούν να υπάρχουν πωλήσεις οι οποίες όμως υλοποιούνται μέσω διαφορετικών διαδικασιών και πόρων. Η προσέγγιση αυτή καλείται «μοντελοποίηση βασισμένη στις Δυνατότητες» (Capability modelling ή Capability mapping).

Ο στόχος αυτής της διπλωματικής εργασίας είναι η εισαγωγή ενός πλαισίου μοντελοποίησης με βάση τις Δυνατότητες το οποίο να μπορεί να χρησιμοποιηθεί για την ανάλυση του τι κάνει μια επιχείρηση. Μέρος του στόχου είναι επίσης η εισαγωγή μιας μεθοδολογίας που υποστηρίζει το πλαίσιο μοντελοποίησης βοηθώντας στην αναγνώριση επιχειρησιακών δυνατοτήτων και υπηρεσιών και στη δημιουργία σχετικών διαγραμμάτων. Με αυτόν τον τρόπο η επιχειρησιακή όψη (Business View) μιας εταιρείας μπορεί να συνδεθεί άμεσα με την Υπηρεσιοστρεφή αρχιτεκτονική της. Επιπλέον, το πλαίσιο χρησιμοποιείται για την ανάλυση μίας μελέτης περίπτωσης που αφορά μία ναυτιλιακή εταιρία, με σκοπό την επίδειξη της λειτουργικότητας αλλά και της χρησιμότητας μιας τέτοιας ανάλυσης.

ΘΕΜΑΤΙΚΗ ΠΕΡΙΟΧΗ: Στρατηγική Διαχείριση

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CONTENTS

FIGURES

Prologue

The current dissertation was undertaken as part of the graduate program of Kapodistrian University of Athens. Any information concerning the Shipping Company which shall remain anonymous for reasons of confidentiality, was acquired during a research project related to the notion of Capability. Though the Shipping company was very generous, sharing a lot of information regarding its structure and its processes as well as its services, the whole Service Oriented Architecture (SOA) could not be revealed and that is one of the reasons our analysis related to Services is neither thorough nor related to the SOA but is rather confined on the connection of each Service to the relative Capabilities.

1 Introduction

The term Capability is linguistically well-defined, meaning “The ability to do something” [1]. Capability is a term that was introduced in strategic management with the Dynamic Capability theories back in 1997 [2] and which is now rekindled as more researchers and entrepreneurs realize that modeling an enterprise’s capabilities facilitate the understanding of what that enterprise does. According to the Dynamic Capability theories, the notion of capability scopes the resources and expertise that an enterprise needs to offer its function[2, 3]. More recent research considers Capability as the fundamental abstraction to describe what a core business does in the sense of the capacity to achieve a desired outcome [4] or as an ability or capacity for a company to deliver value [5]. The definition of capability that will be used is in simple words an abstraction that describes what someone (that someone is usually a business) does or is able to do. This definition is mostly inspired by Ulrich and Rosen[4].

Some may argue that Capability mapping is not important since business processes can describe how a Business works. Actually that is exactly why Capability mapping *is* necessary, since the *how* of a business’ functionality (business processes) constantly changes nowadays due to the new developments on many factors such as IT infrastructure, clients’ needs, new products etc. while the *what*, that is the Capabilities, have the tendency to remain constant [6]. That way, modelling a Business based only on its business processes will require the constant rebuilding of the models which will probably lead to a more difficult to adapt architecture, while an architecture based on Capabilities will require minimal changes, even if the IT infrastructure and services do change on a regular basis, since the Capabilities will remain the same and only their connections with the new services, which represent their implementations, should be changed making the architecture far more flexible. It is important to mention that Capability modeling is a complementary framework and does not replace any other frameworks such as business process management or organizational charts, but rather helps a business’ adaptation by providing a relatively constant view of the business on which the other models can be based.

Since there is a shift in the market from product centered economies to service centered ones [7] we will adopt Ulrich’s perspective on Capability in order to demonstrate how two important terms, namely Capability and Service, are connected and how they interact with one another. The term Service could refer to both business services and software services but we will concentrate our research on the latter, since that could provide a connection among Capabilities and IT systems that are nowadays of vital importance to the majority of enterprises.

Even though several approaches have been presented in the literature in order to model Capabilities by creating capability maps [4, 7, 8], none of them presents a methodology demonstrated on one or more specific use cases. That is due to the fact that the majority of those approaches are presented by enterprises, rather than by academic institutions, which do not want to reveal too much information to their competitors.

Based on the above, the goal of this dissertation is to introduce a Capability modeling framework that will simplify the analysis of an enterprise’s Capabilities and the development of Capability maps, by providing a methodology based on simple steps to be followed by an analyst. Those steps will in turn be supported by a variety of diagram or map templates that will also be introduced as part of the framework, in order to be used according to the analyst’s preferences. The creation of the diagrams will be quite simple

and there will be a connection between Capabilities and Services depicted on some of them. That will help the analyst to be able to provide a clear connection between *what* the enterprise does and *how* that is implemented by its IT systems, thus mapping specific Services to the Capabilities that make use of them. That connection is necessary in order to offer quick adaptation of new services to the business architecture, since by replacing services with new ones, only the above connection or connections will be affected, thus leaving the capability map unchanged. Finally, the aforementioned framework will be applied on a specific use case, in order to provide a better understanding of how the methodology is to be used.

As far as the structure of the Thesis is concerned, in *Chapter - 2.* Research Methodology, the Design Science Research Methodology (DSRM) [9] on which the writing of this thesis was based, is described. This part describes the methodology on which our research was based, and it has no relation to the methodologies we developed for modeling Capabilities. This section includes the reference to the six activities that are to be followed which are further explained in that chapter, along with the actual implementation of those activities during our research.

Following that is *Chapter - 3.State of the Art* . In order to address the first activity of DSRM, that is problem identification and Motivation, a state of the art on Capabilities and Services is presented, referring to other approaches on connecting capabilities with services and identifying the gaps that exist in the literature on this particular subject, and also some useful definitions of the term Capability.

In *Chapter - 4.Capability mapping and its connection to services* a new approach of modeling Capabilities and the relationships between them and Services is introduced. That approach is inspired by the literature that is presented in the State of the Art and introduces a new Capability Meta-model describing the notions related to Capabilities as well as the relationships that may exist among them. This chapter actually includes the second and third activities of DSRM which are the definition of the objectives of a solution and the design and development of this solution, respectively.

Chapter - *5.Use Case* presents a shipping company use case to demonstrate how the modelling components presented in the previous chapter, can be used in practical terms, to describe an enterprise’s capabilities and depict how these are connected to the associated software services.

In the last chapter, conclusions that derive from the research and the use case are presented, along with plans for future work.

2 Research Methodology

The methodology used for the development of this dissertation is the design science research methodology, which will henceforth be referred as DSRM [10]. DSRM was chosen over “natural science” research methodology, since the main focus of our research is to fill the gap that exists as far as the connection between Capabilities and Services is concerned. That requires the development of new models that describe this connection between those two very important modeling terms as well as a methodology that describes how the modeling takes place, both of which can be developed using DSRM since it focuses on the creation of artifacts. Relevance and novelty are also fulfilled since we address a problem that is important and we do that by introducing a new model which solves that exact problem.

The DSRM as described by Peffers et al. consists of a nominal sequence of the following six activities:

1. Problem identification and motivation
2. Definition of the objectives of a solution
3. Design and development
4. Demonstration
5. Evaluation
6. Communication

The above activities also include iteration, as far as the definition of the objectives and the design and development are concerned, and are further analyzed below.

The first activity described in DSRM is the problem identification and motivation. In this part of the methodology, the researcher shall define the research problem and justify the value of a solution. In order for that to be done, one should understand the problem’s relevance and its current solutions as well as their weaknesses.

The next step is the definition of the objectives of a solution. In this step, lies a description of how we plan to solve the problem at hand and includes the specification of criteria that should be met by a solution to the problem. Therefore the researcher should know what is possible and what is feasible and also know methods, technologies and theories that can help with defining the objectives of the proposed solution.

When the objectives are set, the design and development step follows, during which an artifact that solves the problem should be created. By the word artifact we mean constructs, models, methods or instantiations in which a research contribution is embedded.

The fourth step is the demonstration where we have to prove that the artifact works by solving one or more instances of the problem. In our case the demonstration will take place via the use case.

Next we have the evaluation. In this step we have to observe and measure how well the artifact supports a solution to a problem by comparing the objectives with observed results. For this step the knowledge of relevant metrics and evaluation techniques is of utmost importance. The evaluation can also provide useful feedback that might put the research back in the definition or design and development part.

Finally we have communication, which has to do with the dissemination of the problem and its solution and the utility, novelty, and effectiveness of the solution to researchers and other relevant audiences.

2.1 Application of the DSRM

The application of the DSR Methodology will be described in this part, i.e. how the methodology was applied in the context of the current dissertation. Some steps were omitted since they demanded a long period of time that could not be afforded, and are about to be performed in future work.

As described above, the first step of DSRM is the Problem identification and motivation. The identification of the problem had taken place by exploring the literature related to Capabilities and Capability Mapping, as well Services in order to identify the connection across those two notions. During that exploration, a State of the Art was written which is presented in the next chapter, which summarizes the more interesting papers that have been read and identifies the gaps of those papers, on which our case is made. The motivation also comes from exactly those gaps that are mentioned and elaborated on the State of the Art. The main problem identified was the lack of a complete Capability Mapping methodology presented on a specific Use Case, though other minor problems were also identified such as the complexity of some of the methodologies.

The second step is the definition of the objectives of a solution. Having identified that there is a lack of a complete and detailed methodology the following objectives were defined:

Objective 1: The creation of a Capability Mapping methodology

The methodology should fulfill the following criteria:

- Should be based on a Meta-model which depicts the relationships among the various notions used in the methodology, so that everything will be well-defined
- Should be simple and easy to implement. Some of the methodologies found in the literature are simply too complicated for an analyst to be able to follow and without specific instructions
- Should be derived by the literature, since many of the authors have practiced their methodologies on real world cases and thus have actual experience on the Capability mapping
- Should describe how Services are related to Capabilities, and that because Capability mapping is made in order to have a relative constant view of the company associated with the ever changing IT Services provided or used by the Enterprise.

Objective 2: The creation of templates on which the diagrams will be based

The templates should follow the criteria mentioned below:

- Should provide alternatives for the depiction of the Capability map. Even though it is a good thing to have one template for each type of diagram, every case has its unique features which might be depicted better with another template. Therefore a variety of templates for different depictions of the diagrams would be a good thing.
- Should be able to provide an overview of the Capabilities in a simple manner
- Should depict the connections between Capabilities and Services but also the connections between Capabilities.

Objective 3: The implementation of the methodology on a specific use case

The use case should be able to cover the following criteria:

- Should be about a large business so that at least three levels of Capabilities will be available during the analysis
- The business should have a lot of its functions performed by IT Services, in order to be able to show how Capabilities can connect to these Services.
- There should be access to a lot of information about the business, since in order to create the capability model a good understanding on *What* the Business does, should be made.

The next step includes the design and development. The artifacts created during that phase of DSRM are the methodology, along with the Meta-model and the templates for the implementation of the models. All of those artifacts are presented in detail in *Chapter - 4.Capability mapping and its connection to services.*

As mentioned above, the demonstration in this dissertation takes place with the use case in *Chapter - 5.Use Case*. After our artifacts were created we had to apply them on a specific use case to see if everything could be applied in reality and to gather valuable feedback to our methodology thus being able to reconstruct the artifacts as needed. Since the specific use case we worked on was an international shipping company, we had to narrow down the use case on only one specific first level Capability. That was mostly due to insufficient access to information about the other first level Capabilities but it did not gravely affect our research since we managed to develop all the artifacts produced in the previous step.

According to the DSRM, the next step is the evaluation. Since there were no specific metrics we could use, the evaluation was based on how much the artifacts we created as well as the use case were meeting the criteria established during the second step of our research methodology. Thus the evaluation took place as an iterating process where every artifact and model created was reevaluated to make sure it met the criteria. In case the criteria were not met, we went back to previous steps, redesigning the artifacts, until all of the criteria have been met. The same happened with the Use Case, where each model provided a lot of feedback on the initial methodology and templates and assisted their evolution to their final form, after several iterations. Therefore the evaluation phase was iterated throughout chapters 4 and 5.

The final step of dissemination was omitted and will take place in the future as referred to in *chapter - 6.Conclusions and future work*.

3 State of the Art

For years scientists were trying to figure out why firms are able to achieve and keep competitive advantage on the market. The theories developed to give an answer to that question go back to the beginning of the resource-based view of the firm (RBV) in 1959 [11] and continue with the competence-based view of strategic management [12]. Both theories agree that resources play a very important role in gaining a competitive advantage and according to Wade and Hulland capabilities are actually a subset of resources [13]. In today's enterprises, where seems to be a constant reallocation of resources due to the IT technologies used, the need arises for a framework that makes the identification of those changes easier and makes it possible to foresee the impact of any future changes in Capabilities. And that is none other than Capability driven architectures which in turn lead us to produce Capability maps.

That is one reason why Capability driven architectures seem to be gaining ground but another is the fact that service-oriented architectures (SOA) are the prevalent architectures for designing large scale software systems such as Enterprise Resource Planning (ERP) software solutions which are nowadays used in the majority of large enterprises. That is why there are several approaches that have been presented in order to model capabilities which help in the connection of the strategic planning of an Enterprise with the IT infrastructure and for that arises the need to find the relation between Capabilities and Services. As mentioned before the goal of this particular dissertation is to manage to provide a modeling framework for Capabilities and their connection to Services along with a methodology and proposed templates to create the models that are required for a Capability driven analysis of a business. In order to achieve that we summarize the most influential approaches, relative to capabilities and services so as to discuss and elaborate how they can be useful to our approach.

The importance of business capability mapping is stressed by D. Cook [6]. According to Cook, Business-capability mapping enables adaptive, sleek architectures that can respond quickly to changes in today's competitive business landscape. Business-capability mapping is the process of modeling what a business does to reach its objectives (its capabilities), instead of how it does it (its business processes). This kind of mapping is important because the basic capabilities of a business tend to remain constant and thus provides the advantage of longevity. Cook also describes the following methodology for the creation of a capability model; firstly, one has to determine the business architecture. In order to do that we have to (a) document the top-level capabilities of the business, (b) add next-level Capabilities and refine, (c) develop some common semantics for operational terms across the business and (d) document the relationships between the capabilities. Secondly we have to align the technical architecture to the business architecture by mapping the capability view to a technology architecture.

Another interesting feature of Capabilities that Cook highlights, is that like services, they too expose interfaces. Thus, in order to create a complete model of the business, relationships have to be considered between its capabilities. Connectors represent those relationships, and they consist of data exchanges, policies, and many other types of information.

The approach of Cook gives us a good understanding about what is generally meant with the term Capabiliy as well as why Capabilities are important for businesses nowadays. Also Cook introduced the idea that Capabilities should considered to have interfaces that inspired us in the definitions of the relations between Capabilities but does not provide any immediate connection with services.

Cook's approach is continued by Homman and Tobey [7] who describe a more analytical method to model a business in a capability-driven way and also provide guidelines for connecting capabilities with services. According to the authors a business architecture modeled as a network of Capabilities offers an architecture foundation that is ideally aligned with service-orientation. The methodology used for Capability modelling is called "Motion". Motion comprises of four phases. In phase one we have the development of a capability map, which is based on a generic module map and is then customized to fit the business at hand. In that phase the Capabilities are decomposed up to three levels. The second phase requires the collection of several data such as organizational charts, thus exploring whatever seems relevant to the capability map, in a deeper level and also exploring the relationships between how the business actually works, and the capabilities written down on the map. Phase three includes the assignment of capability connectors and attributes and then the building of a stack of views such as people, processes, technology and capability which are then related to the map from phase one. Finally, in phase four, the team discusses over what can be changed in the current way the business works and the impacts of those changes. After having concluded the creation of the capability map comes the question of how the discovered capabilities are connected to the services provided by the business, thus connecting capability modelling to Service-Orientation. According to the authors, using the Capability map, one could identify which connections are weak and which ones are strong, and we can also use it to tackle other issues such as (a) creating an interaction inventory that describes the interactions that are to be supported by the services (b) make an interface factorization which will help to identify and create the service interfaces on how they group, (c) make a service factorization to better understand how services will work and (d) identify the technical capabilities and constraints that are documented in the capability map.

As mentioned above, Motion also focuses on the connections between the capabilities, dividing them into the following three categories: (a) Input/Output connections which consider each capability as being either a supplier of a service or a consumer, (b) Supporting connections which describe information passed from one capability to another and (c) Control connections which describe how one capability may affect another by placing specific policies or performance requirements.

The next step in Mapping Capabilities to Services with the methodology proposed by Homman and Tobey, is the transformation of Motion Artifacts into Services. This is achieved by using the following table.

Motion Artifact/Property	Service-oriented Artifact/Property	Design Considerations
Capability—Higher-level	BPEL4WS structure—UDDI	
Capability—Lower-level	Service—Set of related services: WSDL, WS-Discovery, WS-Addressing	First, catalog all interactions for a capability, and then regroup interactions into services. Capability boundaries don't determine service boundaries, but once you develop a full catalog of interaction, their affinities drive service boundaries.
Connection	Operation—Schematized message	
Inputs and Outputs	Schematized messages (operation) or schematized private data	You need to determine what data is private to a service (not an interaction), by understanding all of the inputs and outputs for each interaction, and then seeing whether grouping interactions based on the shared input/output data works; if it does, the data is privatized.
Process flows (as in a capability relationship diagram)	BPEL4WS structure—WS-BusinessActivity rules	
SLE properties	Operation—Port bindings (because the transport may impact SLE levels) WS-BusinessActivity (because the SLE may be related to a cluster of operations)	
Capability operation frequency		This is important when designing the service implementation, because it sets a requirement for the service performance.
Capability variability	Operation—WS-Policy (if the variability is related to business policy settings)	This is important in considering the drivers of variability that might impact how the operations are defined (if variability is driven by input data), or how the service(s) that provide this capability are factored. For example, it may make sense to create multiple services, each with less variability. Mostly, this is an invitation to the designer to make sure that the sources and dimensions of the variability are well understood.
Agreement/contract-based capability, or one under regulatory control of some kind	WS-Policy and WS-Management might both play a part in capabilities that have this attribute	
Functional complexity		As with variability, this invites the designer to make sure that what makes this functionally complex is well understood. May trade-off message schema and operations (having more operations with simpler schemas, or fewer operations with more complex schemas) and may factor into multiple services (operation clusters).

Table 1: Transformation of Motion Artifacts into Services

The aforementioned transformation comprises of several other processes, such as the identification of the connections between the services at hand, which will help us determine not only the current but also the potential capabilities of the architecture. The connection between services in an SOA architecture are, according to the authors, as important to their design and factoring, as are the functions that these services provide. Some other processes that are required in order to connect capabilities with services are the establishment of a relationship between them, and then their assessment, in order to decide whether there should be any change in those relationships. The above processes should also take into account the SLE (Service-level expectation) information that is collected during Motion, since these are tied to the definition and understanding of the business capabilities.

The transformation of Motion artifacts into services is concluded by identifying the boundaries of the services. This is achieved (a) by understanding the affinity of the capabilities which might lead to their clustering and thus a refactoring of the architecture and (b) by better understanding the Operations and interactions between services. The latter leads to the conclusion that there are two service boundaries to be drawn, the first being an operational service design focused on implementation details such as common regulations, shared code, databases, and so on, in order to deliver upon the determined service level, and the second being an interaction service design focused on the implementation of the connections revealed during the business capability design.

The approach of Homman and Tobey is very interesting, presenting Motion as a way to model Capabilities and also providing a way to map Motion artifacts directly to Service-Oriented artifacts. Unfortunately, this approach lacks specific examples and use cases and is very technical concerning the mapping of Capabilities to Services, thus being difficult to implement by analysts.

Another interesting approach was presented by W. Ulrich and M. Rosen [4] who consider that the business Capability serves as an essential communication medium between a business and an organization’s ability to transform itself through the use of IT. In that same paper, they state that a capability defines what a business does and does not expose any sort of information concerning where, why or how something is done. The authors propose another methodology in order to map capabilities and services.

The first step is, as seen in the aforementioned methodologies, to create a capability map. The capabilities are added to the map in different levels of detail, thus using capabilities from levels one to three for planning purposes and those of levels four to six for purpose of detailed business/IT mapping. They also point out the importance of the relationships between capabilities and other business units, technologies, processes and information assets which can number to hundreds and can be quite complicated.

According to the authors, the identification of the capabilities is one of the most difficult part of a capability driven architecture. Therefore they present ten basic principles that should be taken into account during the process of capability identification. Those principles are in short; 1) Capabilities define what a business does, not how a business does something 2)Capabilities are nouns not verbs 3) Capabilities are defined in business terms not technical terms 4) Capabilities are stable, not volatile 5) Capabilities are not redundant, 6) There is only one capability map for a business 7) Capabilities map to but are not the same as an LOB (Line Of Business), business unit, business process, or value stream 8) Capabilities have relationships to IT deployments and future-state IT architecture 9) Automated capabilities are still business capabilities — not IT capabilities and 10) Capabilities are of most value when incorporated into a larger view of an enterprise’s ecosystem.

Ulrich and Rosen argue that a capability map should be viewed business-wide and not enterprise-wide, due to the fact that a business may extend beyond the bounds of an enterprise, when using external partners to outsource some of its operations. They also classify Level-1 capabilities in Strategic, Value-Add and Support capabilities. Strategic capabilities have to do with executive-level decision making, while Value-Add capabilities are related to who the organization is and how customers view organization. Support capabilities represent certain abilities that an organization should have to function as a business.

Beginning the building of the capability map, Ulrich and Rosen introduce two important rules that should be followed by the analysts. The first one is that there should be only on capability map for the whole business, and not different ones for each business section. The second is that every capability should be rationalized into a single occurrence. Keeping those rules in mind, the analyst should follow ten steps; (1) obtain an industry template if possible, (2) draft an organization-specific Level 1 capability map, (3) finalize Level 1 capability map, (4) publish the Level 1 capability map (5) Establish Level 2 capability decomposition priorities (6) Decompose Level 2 capabilities (7) establish Level 3 capability decomposition priorities (8) decompose level 3 capabilities (9) socialize and refine the capability map and finally (10) publish the capability map.

Once the building of the capability map has taken place, Capability should be incorporated into Business Architecture. That, according to the authors, includes the following mappings: (a) Organization unit decomposes into organization unit. (b) Organization unit is a business partner. (c) Organization unit has capability (Level 1 or Level 2) depending on level of organization unit. (d) Capability Level 1 decomposes into capability Level 2. (e) Capability Level 2 decomposes into capability Level 3. (f) Capability Level 3 decomposes into capability Levels 4, 5, and 6 as required. (g) Capability Level 3 maps to various stages within the value stream. (h) Value stream stage decomposes into business process. The information for the above is stored in a Business Architecture Knowledgebase.

To evaluate the importance of each capability, Ulrich and Rosen propose the use of a color-coded “heat map”, where capabilities that are considered to be underperforming are depicted in a yellow box and those that are in serious need of attention are depicted in red boxes. Any capabilities that function efficiently are in green boxes. Those “heat maps” are then used to determine why some capability lacks efficiency and what can be done to rectify it.

As soon as the aforementioned processes take place, what follows according to the authors’ methodology is the mapping of capabilities to IT architecture. In order for that to be achieved, a Business/IT Transformation Roadmap should be developed which will then be used in extending Capability mapping into IT Architecture Planning, Creation and Design. The most important concepts for the creation of the Roadmap are the following (a) Business vision for what should be accomplished, (b) business capabilities and value streams impacted by a given strategy or executive mandate, (c) Time frame requirements and related business priorities, (d) Analysis as to which aspects of a given strategy should come first based on business priorities, (e) IT vision that corresponds to the business vision, (f) Service, information, and technology infrastructure required to support the transition and (g) Governance requirements to enable a sustainable business/IT transformation initiative. Since IT implementations usually have a lot of overlapping and redundant applications, using Business capabilities as the fundamental concept is a good way to deal with all those overlaps and redundancies. Another way could be mapping business processes to the systems that implement them, but processes are also usually overlapping. Therefore Ulrich and Rosen propose a direct mapping of capabilities with

applications thus tackling three important issues, namely (a) Removal of Redundancies, (b) Reduction of Overlaps and (c) Filling of potential Gaps by enhancing existing systems or by acquiring new ones.

Another interesting research was presented by Beimborn et al. at IPSI conference [8]. In this research, the authors provide useful information concerning Capability mapping, while considering Capability mapping to be the first practical implementation of the RBV theories. The authors also believe that Capability mapping can add value to an Enterprise by supporting strategic decisions and provide key indicators for the evaluation of capabilities, namely (a) Inimitability, (b) Non-substitutability, (c) Interconnectedness and (d) Contribution to the perceived customer benefits of the end product.

Beimborn et al. suggest that Capability modeling does not aim at replacing other process improvement frameworks or diagrams such as IDEF etc. but is a new type of analytical framework that is *complimentary* to common process modeling and analysis approaches. Capability modeling delivers added value in many cases of optimization, by helping to easily identify the origin of problems in a Business Process modeled environment.

The definition of Capability given by Beimborn et al. is *a particular ability or capacity that a business may possess or exchange in order to enable a specific purpose or outcome*. Furthermore Capability abstracts and encapsulates involved people, workflow, technology information and service level expectations (SLEs), representing only the essential information needed to provide improvement of performance and to redesign analysis. A Capability map, referred by the authors as CM, is a nested hierarchy of capabilities and a taxonomic diagram that describes the interplay of capabilities while doing business. It exposes all capabilities across the business ecosystem. It allows displaying several business processes within a single map, thus giving valuable insights on how these processes are related with each other, by using the same capabilities. Viewing the business as a network of capabilities and connections may help to overcome complex organizational and procedural boundaries, which may hinder strategic analyses.

As far as Capability connectors are concerned, the authors consider that Capabilities are usually parts of business processes and thus provide some specific output that is an input for another process step, i.e. another Capability. Furthermore, connectors may exist among Capabilities of different levels. The existence of other types of connectors is mentioned in the paper (support and control connectors) but are not depicted in Capability maps.

Capability-oriented modeling of the firm also provides a use case, over a German bank which remain nameless for confidentiality reasons. The use case includes a couple Capability maps which not only map Capabilities but also their connections and also a Draft Capability GUI, named Capability Cockpit, which is suggested to be used in order to store and present information for each Capability. The information registered through that particular GUI is presented in four different areas; the upper left area represents basic information about the capability and its relations (description, connections to other capabilities and related inputs and outputs, superior capability, sub-capabilities etc.), while the upper right section provides the navigation through the capability hierarchy and gives information about the implementation. The lower part contains strategic and operational measures which help to determine the strategic value and the operational performance of the particular capability.

While this particular paper is the only one to present a real Use case, it lacks the analytical description of the methodology so that others could use it for Capability modeling, though it stresses out the importance and usefulness of Capability mapping. Furthermore, some very interesting ideas such as the Capability Cockpit are introduced and the fact that Capability mapping is considered by the authors as a complimentary framework is very

important for the dissemination of such methodologies, since it is very difficult to convince an enterprise to change its whole architecture.

There are other approaches on the matter such as Capability Driven Development (CDD) (Berzisa, Bravos et al. 2014) though they usually focus to other goals such as IT adaptability in the case of CDD and are generally more IT oriented than is our approach which focuses on the development of the Capability map.

The aforementioned methodologies are all well written and based on actual business analyses but do not provide any Meta-model to describe the relationship between Capabilities and every other business terms such as Services, Business Processes, Stakeholders etc. Furthermore, even though some diagrams are used to give examples, there are no proposed templates for the modeling of Capabilities but it is left to the reader to decide how to depict the diagrams and there are no use cases to demonstrate how the capability map is created. The only exception is the paper of Beimborn et al. where a use case is presented, which assists in the understanding of the importance of Capability modeling. Still, as mentioned above, it does not present any methodology on how the Capability mapping should be done and also there is no mention on how Capabilities can be connected to Services.

According to the gaps identified on the previous paragraph, the goal of this dissertation is to address all those omissions, by (a) presenting a solid Capability Meta-model so that there is a clear meaning of every notion related to Capabilities as well as the explanation of the connections between them, (b) by giving a solid definition of Capability as well as defining all the terms that are related to Capabilities, one of them being Software Services, (c) by providing a simple methodology and rules that should be followed in Capability modeling, (d) by providing modelling templates that can be used by the reader to do the Capability Mapping so that there is common understanding among researchers who are willing to use this methodology, and finally (e) by providing a use case, that can be used as a reference.

4 Capability mapping and its connection to services

In this chapter a meta-model that describes the relationships between Capabilities and Services, and other related entities will be presented. Along with the Meta-model, we will present some definitions and finally the proposed methodology and its components.

One of the most important terms in our approach is that of Capability. In the literature, one can find many different definitions of the term Capability and different interpretations as well. That is why we should provide a definition of what is meant in this approach with the word Capability which is actually similar to how Motion and Ulrich and Rosemann use it. We consider Capability as a term that describes what someone (that someone is usually a business) does or is able to do. When describing a business, it makes sense to use different levels for describing the various business Capabilities, ranging from high level capabilities that describe general things that a business can do, as Account Management, which will henceforth be referred to as *Planning Capabilities*, to lower level Capabilities that are more specific and usually describe more specific tasks, such as Employee Payout which will be referred as *Operational Capabilities*. The latter is closer to the technical level and will provide a link to the Services.

4.1 Capability Meta-model

In *Figure 1: Capability Meta-model (ORM)* a Capability Meta-model is presented to provide a more solid definition for Capability and its relations with other entities that are important to a business. The Meta-model is created using the Object Role Modelling (ORM) thus allowing us to be very precise in the definition of not only the relationships but also the cardinality of the entities. Please note that in ORM relationships are read from left to right, unless there is an arrow (depicted as a black triangle) indicating that the relationship is read from right to left.

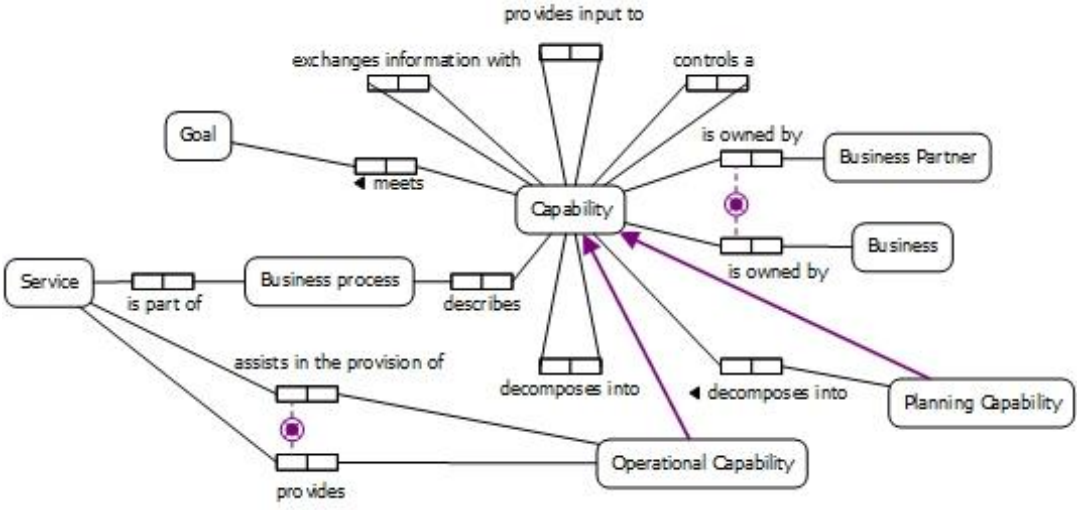

Figure 1: Capability Meta-model (ORM)

The interpretation of the Meta-model follows along with descriptions for each entity depicted in it.

4.1.1 Entity Definitions

Capability: A Capability is in the epicenter of the Meta-model. It describes what a business does.

Planning Capability: A Planning Capability is a Capability that is presented at a high level view of the business capabilities and can be decomposed into other capabilities. At

some point the capabilities into which a higher level capability is decomposed, will be Operational Capabilities.

Operational Capability: Operational Capabilities are lower level view capabilities that can be described by business processes (that is how the capability is provided) and are dependent on services. Operational Capabilities can be provided by services.

Goal: A business goal describes what a company expects to accomplish. The business goals are obviously related to capabilities and that is why the entity goal is placed in the Meta-model. Since this dissertation is not about goal modelling though, goals will be omitted from the methodology.

Business: A business is an organization or economic system where goods and services are exchanged for one another or for money. As an entity in the Meta-model, Business is used to indicate whether the Capability is owned by the business itself.

Business Partner: In several occasions businesses use Capabilities from third parties. In this case we consider that the Capability at hand is owned by a Business Partner.

Business Process: A series of logically related activities or tasks (such as planning, production, or sales) performed together to produce a defined set of results[14, 15][14, 15] [14, 15]. Business Processes are very important since they are letting us know how business activities work and *how* services are orchestrated to provide a Capability, but will be omitted from our methodology since our purpose is to discover the direct connections between Capabilities and Services.

Service: “A service is a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description. A service is provided by an entity – the service provider – for use by others, but the eventual consumers of the service may not be known to the service provider and may demonstrate uses of the service beyond the scope originally conceived by the provider.” [15]. This definition from the OASIS Reference Model for SOA did not probably take into account the definition of Capabilities that is used in this dissertation, but remains helpful as to indicate the connection that could be found between a Capability and a Service

Sub-Capability: Though this entity is not depicted in the Meta-model, we will consider as such, any capability into which another Capability has been decomposed.

4.1.2 Relationships between entities

The description of the relationships that are represented in Figure 1: Capability Meta-model (ORM) will follow.

A Capability meets one or more goals.

A Capability may exchange information with one or more Capabilities

A Capability may provide an input to one or more Capabilities

A Capability may control one or more Capabilities.

A Capability is owned by the Business itself or a Business Partner

A Planning Capability is a Capability

A Planning Capability decomposes into one or more Capabilities (Sub-Capabilities)

An Operational Capability is a Capability

A Business Process may describe a Capability

A Service provides or assists in the provision of one or more Operational Capabilities

A Service is part of a Business Process

4.2 Methodology

In this section the methodology for both Capability Mapping and the connection of Capabilities and Services will be discussed.

4.2.1 Capability Mapping

Every approach presented in the state of the art begun with the creation of a capability model. That is very reasonable since in order to map the Capabilities of a business to its IT implementations, one must already have recognized those Capabilities. Despite that common element, there are some differences in the steps that should be followed for the creation of the model in each approach. Following will be the methodology we propose for the creation of a capability model along with the rules that should be followed.

The first step of the methodology is to gather information relative to the organization of the business and to what the business does. It is possible to create a draft capability model just by knowing the field of operations of the business (e.g. Shipping or Logistics business), especially for the top levels that are the more general and are usually common across businesses of the same field of operations, but still it is much safer to first gather any information on exactly how that particular business operates and thus reduce any refinement processes in the next steps.

Now that every piece of information is gathered we can proceed to the development of the top levels (usually but not always levels 1-3) of the capability map which will be referred to as Planning Capabilities (see definition above). The first level will be comprised of the most general operations that the business can perform, such as accounting, HR management etc. The next two levels will be used to decompose the top level capabilities, into more specific capabilities but not adding too much detail, since that is the goal to be achieved by capabilities of the lower levels. The development of the map can be done in plain text or using one of the capability map templates provided below though the diagram should be preferred since it provides an overview of the Capabilities in an easier to read manner. We can then decompose our top level capabilities to lower level ones, thus proceeding deeper into the capability diagram and closer to the services and processes of the business. Once a Capability cannot be decomposed into other capabilities it will be considered to be an Operational Capability which can be described by a Business Process and is closely related to the IT implementation of the Business at hand. The diagram that will be used to depict the aforementioned analysis will be called a *Capability Overview Diagram* or *COD*. According to the literature we can go down to the sixth level of capabilities, but there is actually no restriction as to the level of the depth of our analysis.

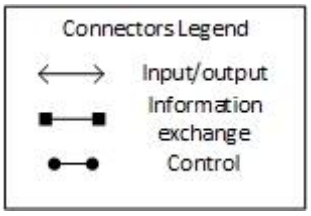

Figure 2: Capability Connectors

The third and final step in the creation of the Capability Map is the assignment of connectors between capabilities in order to portray their relationships. We will consider the three following connectors that can be used for connecting capabilities and which can be seen in *Figure 2: Capability Connectors;* (a) input and output connectors, in other

words the interface of a capability, which indicates that a capability might provide a service to another capability or be the recipient of a service from another capability, (b) information connectors to indicate that a capability exchanges information with another capability and (c) control connectors, which depict if a capability imposes any restrains on another capability. There are two important things that should be mentioned as far as the placement of connectors on capabilities is concerned. The first one is that during this process it is very probable that the need for revision of the initial capability model will arise, since overlaps and redundancies might be discovered. The second important observation is that the placement of connectors might lead to a very complicated diagram, especially in a large business where a lot of capabilities may be discovered with connectors across different levels. A way to make things simpler is to produce a number of diagrams, each of which will present a different capability level and the related connectors. The diagrams that will be used for the depiction of those relationships will be called *Capability Collaboration Diagrams* or *CCD*.

4.2.2 Connecting Capabilities to Services

Regarding the connection of Capabilities to Services, we suggest that services should be mapped directly to capabilities by assigning each service to the capability that is related to it. To be more precise and following the Meta-model presented earlier, a Service can be related to a Capability, either by directly providing that Capability or by assisting in the provision of that Capability. The latter could mean that the Service could be a part of a Business Process that ultimately provides the Capability or that the Capability is provided by more than one Services. It has to be stressed that Services are directly connected only to Operational Capabilities.

In order for an analyst to be able to connect Services to Capabilities, there must either be knowledge of the whole SOA of the business or at least of the services that exist and what they do. As mentioned before, Capability modeling is a complementary framework, thus preexisting knowledge of the services used in the business is considered to have been acquired or documented previously. If not a different study must take place for this exact reason, before starting to connect Capabilities to Services.

Following the above paragraph, the steps that should take place for connecting Capabilities to Services are the following:

1) The identification of Services. The number of services and what they do should be known to the analyst.
2) A draft grouping of services could take place next. All services that cooperate should be put in the same group. Though that does not necessarily mean that they will also provide or assist in the provision of the same Capabilities there is increased possibility that this will be the case. This step is optional and it is more appropriate when complicated service architectures are used.
3) The third step is the matching of Services to Capabilities. By knowing what a Service does, the analyst should find which Services match to each Capability in the Capability map. During that task, the draft created in the previous step could prove very useful.
4) The final step is to identify the connectors between Services and Capabilities. If a Capability is provided by only one Service the connector will be of the “provides” type. In any other case the connector will be of the “assists”

According to the goals set in *2.Research Methodology* the analysis should be exact and accurate, therefore the following rules should be followed:

1) A service could either **provide** a capability or **assist** in the provision of a capability. Higher level capabilities are more likely to be provided through the collaboration of

several services while lower level ones are more likely to be provided by a single service or an orchestration of services.

2) Since capabilities are mapped in a hierarchical manner, there is a relationship of inheritance among them. Thus a service that provides a 3rd level capability, also assists in the provision of the 2nd level capability that relates with that and also assists in the provision of the 1st level capability related with the previous one. Those *assist* connections are implied and do not need to be depicted in the diagram.
3) As a consequence of 2) a service should be connected to the lowest level capability that this service provides or assists, which according to the definitions above will be an Operational Capability.
4) A service may provide or assist in the provision of more than one Operational Capabilities.

4.2.3 Capability Mapping Diagrams

Now that we have defined the terms that will be used in the modelling of Capabilities and Services, some Templates will be presented, which will be used to create the diagrams. All diagrams were created using Microsoft Visio, but other similar software can be used, since only basic shapes are used to represent the entities. Let us now analyze the basic diagrams of our methodology.

4.2.3.1 Capability Overview Diagram (COD)

A Capability Overview Diagram (COD) is a diagram in which the Capabilities and their respective decomposition are depicted, based on the level they belong to. A COD can use one of the following three templates; the first template (Encapsulation Template) presents all the Capabilities in one diagram, by encapsulating the Capabilities of each level in the Capability they have decomposed, as seen in *Figure 3: Encapsulation Template*. This template is recommended only for small businesses because it can be really difficult to manage when having more than three or four levels of Capabilities and it requires a lot of effort to be drawn, constantly requiring the resizing of the rectangles and the allocation of space for the new Capabilities to be added. Despite the above, the Encapsulation Template has the benefit of providing us with a complete view of the Business Capabilities.

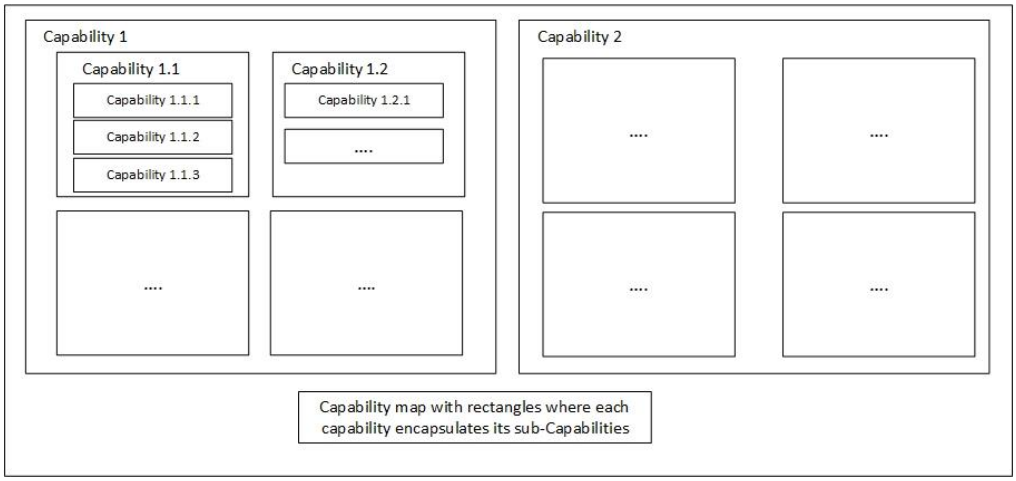

Figure 3: Encapsulation Template

Another template that can provide an overview of a Business' Capabilities, is the Tree Template, where the Capabilities and their sub-Capabilities are depicted as a tree where the root can be either the company (thus including every capability) or for simplicity

reasons the root can be any Planning Capability, in which case we will have multiple tree diagrams. The template is depicted in *Figure 4: Tree Template*.

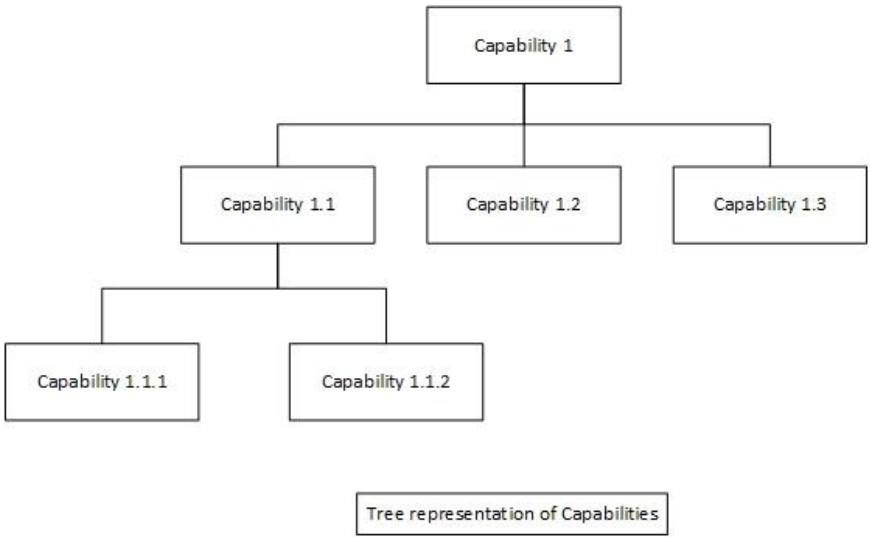

Figure 4: Tree Template

Finally the third template that can be used for the creation of a COD is the Decomposition Template as seen in *Figure 5: Decomposition Template*. This last template comprises of a diagram that contains all first level Capabilities, and a new diagram for each Capability that is decomposed into its sub-Capabilities (Capability Decomposition Template).

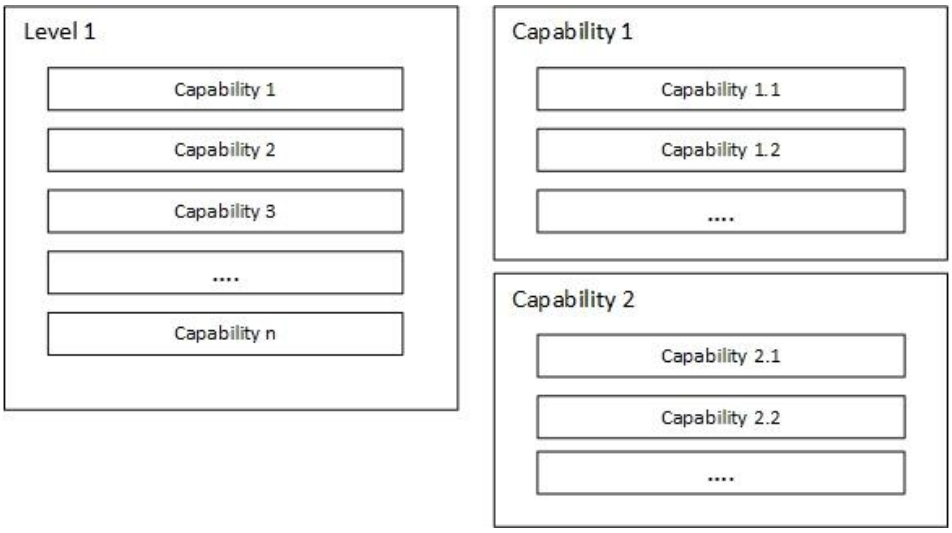

Figure 5: Decomposition Template

The template used in our use case is the Decomposition template though each analyst can choose to depict Capabilities using whichever template better fits his use case.

4.2.3.2 Capability Collaboration Diagram (CCD)

As described in the methodology, once we have an overview of the Capabilities that exist within the business, it is time to discover the underlying relationships that connect these Capabilities. In order to depict those relationships we create one or more Capability Collaboration Diagrams (CCD) depending on the complexity of the relationships. Following are the connectors that can be used, and some variants which can be useful to make the diagram easier to read.

4.2.3.2.1 Connectors

Connectors come in three different forms that represent the different relationships that can be found between capabilities.

Control connector: The control connector is depicted using a circle at the edge of the controlled Capability. Thus in *Figure 6: CCD example* Capability 3 controls (imposes restrictions on) Capability 1. This relationship, as any other mentioned here, can be bidirectional, in which case both connected Capabilities impose some restrains on each other and there should be a circle on each edge of the connector.

Input/output connector: Input and output are indicated as arrows at the edge of the connector. Therefore in the example, Capability 1 has some output to Capability 4 (meaning that it offers some service or item) and Capability 4 receives some input from Capability 1. In case we have an exchange of inputs and outputs, an arrow head would be placed on both edges.

Information exchange connector: An information exchange is indicated by placing squares at the edges of the connector. Usually this is a bidirectional process, thus having squares on both edges as seen in the example, between Capability 1 and Capability 2. In the exception of a Capability getting information from another Capability without sending back any information in exchange, a square should be placed on the edge of the connector in the side of the Capability that receives the information.

Any Capability can connect to another Capability with all three connectors, if that is the case. Furthermore, since the connector edge shapes are well-defined, the text would rather be omitted, so that there will be more space available in case of complex relationships across a multitude of Capabilities.

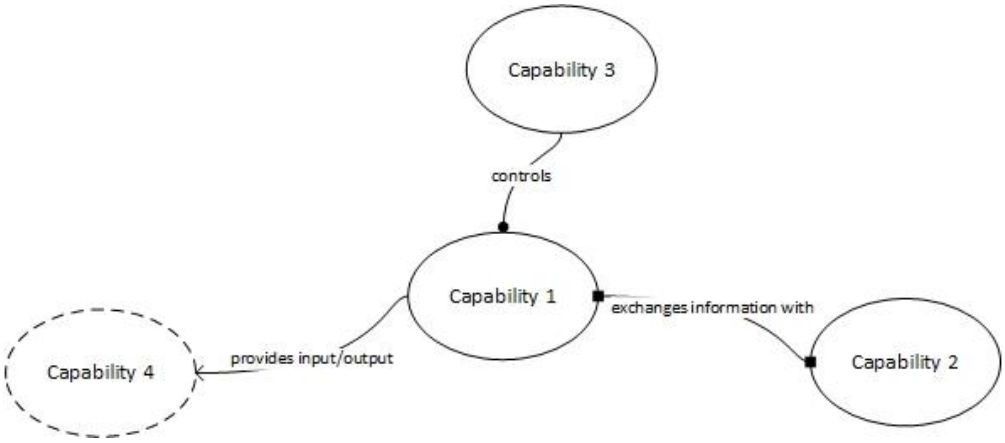

Figure 6: CCD example

4.2.3.2.2 Ownership

A CCD diagram also deals with ownership at a very basic level. Many times Capabilities are outsourced by third parties (for example the technical support of the IT infrastructure of a business) and that is something that should be reflected on the diagrams. In that case, a Capability that comes from a third party will be depicted with dashes, such as Capability 4 in *Figure 6: CCD example*.

4.2.3.2.3 Color Mapping

Another piece of information that is useful to be depicted in some cases, is the level in which a Capability belongs, since there may be a relationship between capabilities that belong to a different level of granularity. In this case a color could be assigned to each level, thus coloring each Capability of that level with the corresponding color. One such an example can be seen in *Figure 7: Color Mapping Example*. The colors are not binding,

each analyst can define the colors he prefers, as long as there is a legend that juxtaposes the levels to their respective colors, as seen in the example.

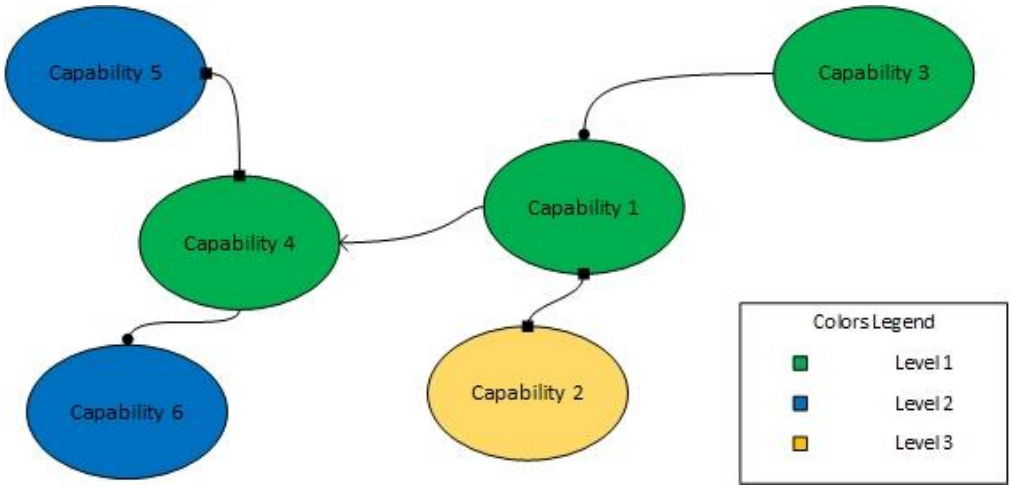

Figure 7: Color Mapping Example

4.2.4 Connecting Capabilities with Services

According to *Figure 1: Capability Meta-model (ORM)* a Service can either provide a Capability or assist in its provision. In addition, according to rule (3) of the methodology a Service can be connected to one or more Operational Capabilities and no Strategic Capabilities at all (it can only be implicitly connected to Strategic Capabilities).

Since Capability Collaboration Diagrams are very likely to omit Capabilities that are likely to be provided by one or more services but do not collaborate with other Capabilities, we will use Capability Overview Diagrams to depict the aforementioned connection, where all the Capabilities are depicted.

The encapsulation template is not very useful since it contains a lot of information put together too tightly and it could be very complex if a large number of services provide the Business' Capabilities.

On the other hand both the tree as well as the decomposition templates are very convenient; the first because the operational capabilities are clearly depicted as the leaves of the tree, where the services can connect (see *Figure 8: Tree Template used to depict Service relations*) and the latter because the information is actually presented as a column, therefore giving the analyst the potential of placing services on the left and right of the Capabilities (see *Figure 9: Decomposition Template used to depict Service relations*). In both Figure 8 and Figure 9 we have the representation of the same scenario.

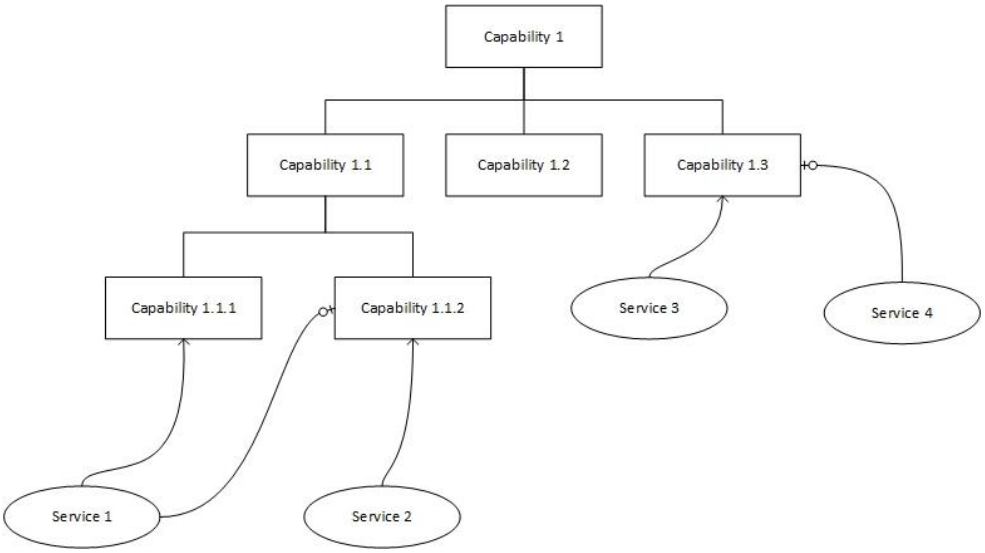

Figure 8: Tree Template used to depict Service relations

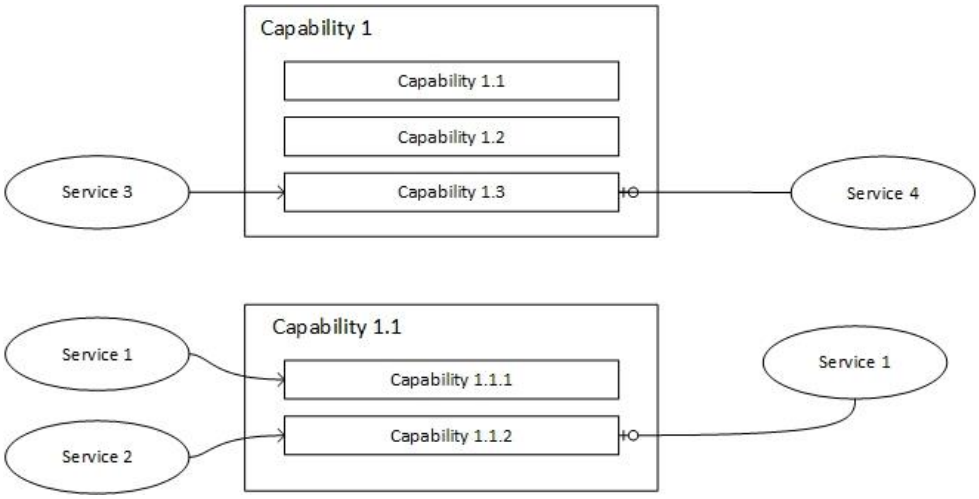

Figure 9: Decomposition Template used to depict Service relations

In both diagrams, Capabilities are represented by rectangles, while services with eclipses. One can observe that two kind of connectors are being used; the first one (the one with the arrow head) is used to depict that a service *provides* a Capability while the second one (having as an edge a closed plus) represents that a service *assists in the provision of* a Capability. As far as the Decomposition template is concerned, we may note that Service 1 appears twice, both on the left and on the right of the Capabilities. This is optional, as one could easily draw two different connectors from Service 1 to Capability 1.1.1 and 1.1.2 respectively.

5 Use Case

In order to demonstrate our methodology a use case will be presented. The use case will be about a shipping company which shall remain anonymous for confidentiality reasons. Since the higher levels of Capability models are quite general by nature, it is possible that the same capability model, with just slight modifications, may also describe the capabilities of other shipping companies.

5.1 The shipping company

The company presented is one of the leaders on International shipping and is divided into three companies; the first one dealing with shipping, the second company dealing with the creation of maritime software while the third one is creating the hardware to support the former two and other shipping companies.

As far as the shipping company is concerned, the company amasses a contracted revenue which amounts to over 5 billion dollars through long-term time charters. Its total fleet has risen to more than 60 vessels and its fleet capacity is more than 300 TEU[1] while the total fleet average age is about 6 years. They are amongst the largest containership charter owners in the world based on total TEU capacity. Their headquarters are in Piraeus, with Branch Offices in both Europe and Asia.

5.2 Capability Map

In order to create the capability map, the steps described in the methodology have been followed. Firstly, we came in contact with people that work for the shipping company. After having them interviewed, a first understanding of the company's organization and its Capabilities took place.

The second step comprises of the development of a Capability map. Based on the information gathered from the previous step, we were able to start creating our capability models but we have to stress that the Capability models presented in this section are the final ones and there were revisions for the majority of them, before they ended up in this form. The first model produced by the data we gathered in step 1 was the Capability Overview Diagram depicted in *Figure 10: Capability Overview Diagram (COD) Level 1*. This diagram depicts the top level capabilities (first level) without depicting the decomposition relationships, and it presents no other information about the connections that might exist among those capabilities, or their owners. It is the most general kind of diagram, which provides a general overview of the business' Capabilities. More specifically, the top level capabilities of the Shipping Company are as seen in the diagram:

[1] The twenty-foot equivalent unit (often TEU or teu) is an inexact unit of cargo capacity which is based on the volume of a 20-foot-long (6.1 m) intermodal container, a standard-sized metal box which can be easily transferred between different modes of transportation, such as ships, trains and trucks.

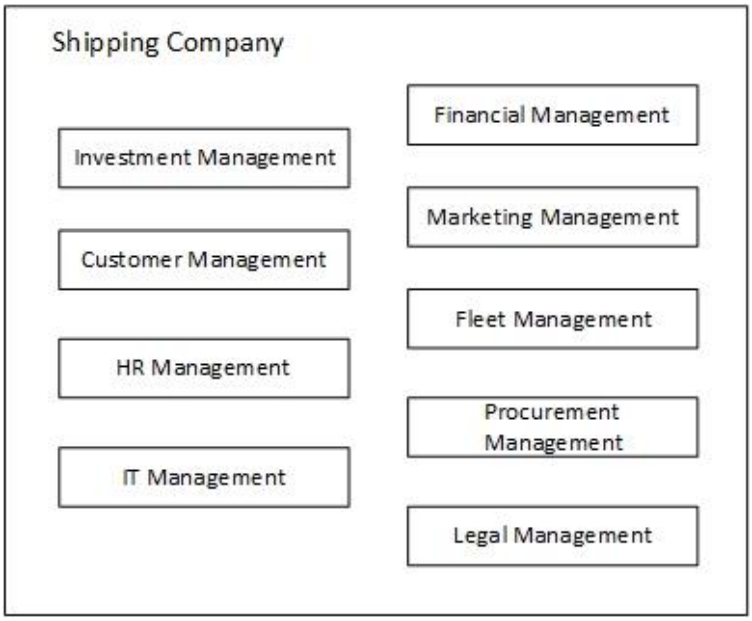

Figure 10: Capability Overview Diagram (COD) Level 1

(a) Investment Management. Every process and service that is related to the investments of the company is directly connected to this particular Capability.

(b) Customer Management. This is an essential Capability for every business and one of the more important ones, since it is related to the ability of a Business to treat its clients. Also note that in our case, there are a lot of different clients, since the Business consists of three different branches.

(c) HR Management. This is another generic Capability, meaning that every Business has this Capability, since it cannot operate without managing its stuff.

(d) IT Management. The management of the IT infrastructure of a Company is nowadays very important. In many cases the IT management can be outsourced in which case there might be no decomposition of that Capability into its Sub-Capabilities in the Business Capability map (that will be the business of the outsourcing company).

(e) Financial Management. The Financial Management Capability is also necessary to every company and is also one of the Capabilities that is expected to be connected with almost every other Capability.

(f) Marketing Management. Every Business have specific Marketing stuff and Strategies thus having the Marketing Capability.

(g) Fleet Management. This is the most distinctive Capability since it applies only to shipping Companies. It is reasonable that a shipping company is the owner of a fleet which should be managed using several processes and services. Due to this Capability being the one that characterizes a shipping company, it will be the one that will be further analyzed, or decomposed, in the next segment.

(h) Procurement Management. This Capability is about ordering and getting supplies from the suppliers. This does not concern the procurement related to ship supplies, since ships have a procurement Capability of their own (as can be seen in the analysis of Fleet management Capability), but is rather about getting supplies needed for the business itself.

(i) Legal Management. The final Capability identified is the Legal Management. It is very important for Businesses to be sure that everything works according to the international law. This Capability is usually outsourced in the maritime industry, since it is very complex

work. The reason for its complexity is that there is a series of laws that each ship must abide to, such as environmental laws or laws concerning the health level of the crew, and also the fact that there are different sets of laws that should be followed in every different harbor where each ships sails to. So the ship owner should make sure that the ship status is legal in every one of those harbors and that is a really difficult task, especially since some laws have the tendency to change under different governments.

Following, is the depiction of the second level capabilities. The Fleet Management Capability decomposes, into another three Capabilities. Since shipping is quite a complicated business example, we had to focus on just one first level capability and that is Fleet Management which is the most characteristic and diverse capability of a shipping company.

Figure 11: Fleet Management COD Level 2

As can be seen in *Figure 11: Fleet Management COD Level 2* the Fleet Management Capability is decomposed into three Sub-Capabilities. The first one, namely Ship Management, refers to the individual management of each ship and is the most important of the Capabilities, therefore the majority of services are supporting this Capability (this will be further discussed later on). Information Store & Management Capability is related to the infrastructure that is used for information but also with all the information that is exchanged during a ship's trip. Finally the Maritime Compliance Capability is related to the ability of the Business to be able to be compliant as far as the Maritime legal framework is concerned. One can easily observe that this Capability is very closely related to level 1 Capability Legal Management, and therefore it could be considered to be a Sub-Capability of Legal Management. The reason why it was finally considered to be a Sub-Capability of Fleet Management instead is unraveled through further decomposition of the Capability, where it is clear that its Sub-Capabilities are describing what the fleet or a ship does in order to be able to be compliant with the international or local maritime laws.

In order to complete the second step we also have to decompose Level 2 Capabilities to Level 3 capabilities, as seen in Figure 12.

As mentioned before, the Ship Management Capability is the more complex one and thus it comprises of seven Level 3 Capabilities; the first one is the Ship financial management Capability, which describes all the processes and infrastructures required to manage the financial aspects of a vessel. These include crew payments, crew taxations etc. International safety management Capability refers to the mechanisms and processes used within a ship, in order to be able to provide safety to both the crew and the cargo. Another necessary Capability is the ship technical management with which the crew can control any technical aspects such as communications or aspects related to the function of the engines of the ship. Despite the fact that on Level 1 there are Capabilities that are related to human resources and procurement, since the ship is by itself an ecosystem, those two aspects are considered as different kind of Capabilities (namely Ship

procurement management and Human resource management) on level 3 and are performed by different processes and services. Chartering is the process through which a ship is booked in order to carry specific cargo and thus the Chartering management Capability is of grave importance. Finally the operation management includes all the operational matters of the ship.

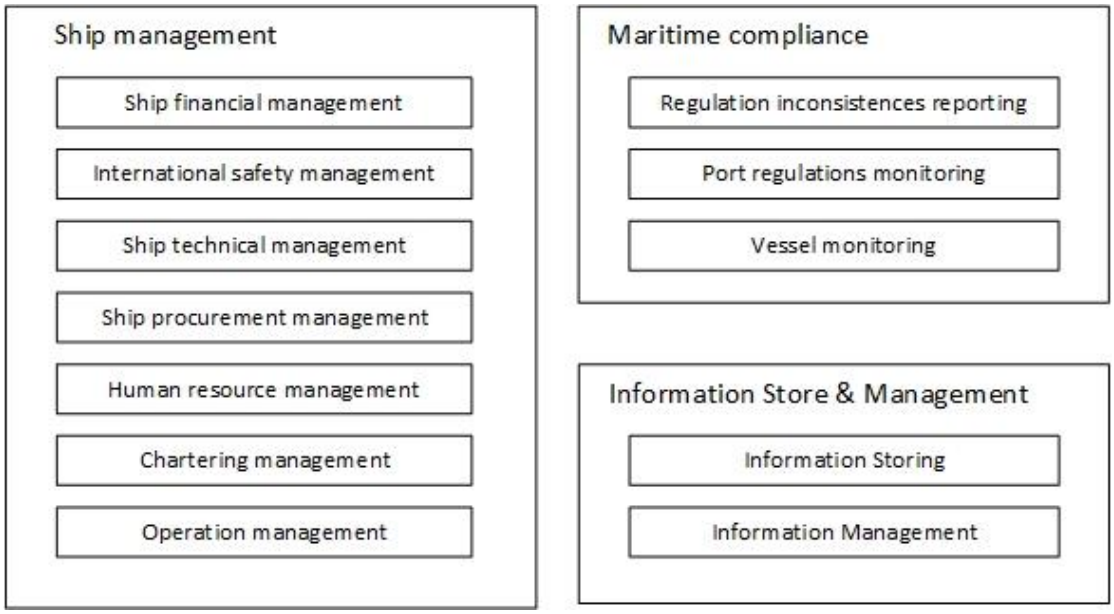

Figure 12: Ship management, Maritime compliance and Information Store & Management decomposition to level 3 capabilities

The Maritime compliance Capability consists of three Sub-Capabilities. The first one is the Regulation inconsistences reporting. As described by its name, this Capability relates to processes and services that have as a goal the reporting of any inconsistencies that may arise against the regulations. That Capability also collaborates with the port regulations monitoring Capability which is used to get data from different ports regarding any changes on the legislation and also Vessel monitoring which produces information regarding the ship's status.

The last level 2 Capability is the Information Store & Management Capability. This comprises of two level 3 Capabilities, namely Information Storing and Information Management. The first is related to any resources and processes required in order for the ERP of the ship to be able to store any information, while the latter has to do with the infrastructure and processes related to the management of the information that moves either from one part of the ship to another or from outside sources to the ship and vice versa.

The third and final step, requires the creation of a Capability Collaboration diagram in order to depict the connections that might exist between the Capabilities. In order to create such a diagram, we have consulted the data acquired during step one and investigated the relationships across the Capabilities in the COD. Once those relationships were clear, the Capability Collaboration Diagram *Figure 13: Capability Collaboration Diagram (CCD)* has been created.

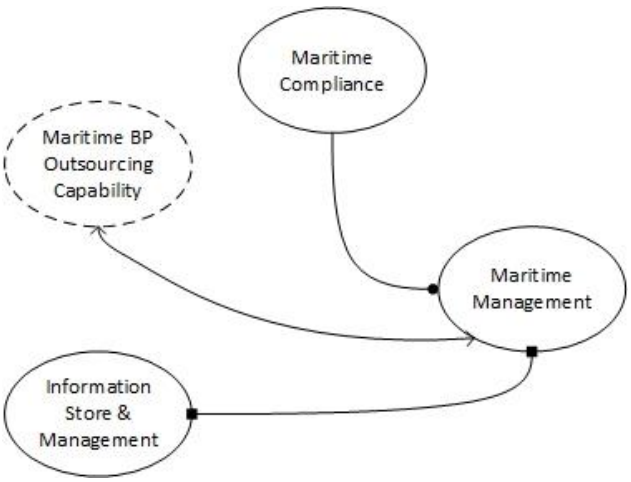

Figure 13: Capability Collaboration Diagram (CCD)

The relationships between the first level Capabilities depicted in Figure 10: Capability Overview Diagram (COD) Level 1 are the following:

The Maritime Management Capability is being controlled by the Maritime Compliance Capability, since in order for the company to be compliant, certain rules and regulations should be enforced.

The Maritime BP Outsourcing Capability is a “borrowed” Capability since it is provided by an outside company. The relationship between this Capability and Maritime Management Capability is that of input/output, namely the Maritime Management capability provides the specifications as an input for the outsourcing to the Outsource Company and receives the outsourced Business Processes as an input.

Finally, the Information Store & Management Capability exchanges information with the Maritime Management Capability in order to store and manage that information in an efficient manner.

Connections between Capabilities also exist in lower levels as implied above, and such relationships are depicted in *Figure 14: Capability Collaboration Diagram for level 3 Capabilities*, in our case being far more complicated than the higher levels.

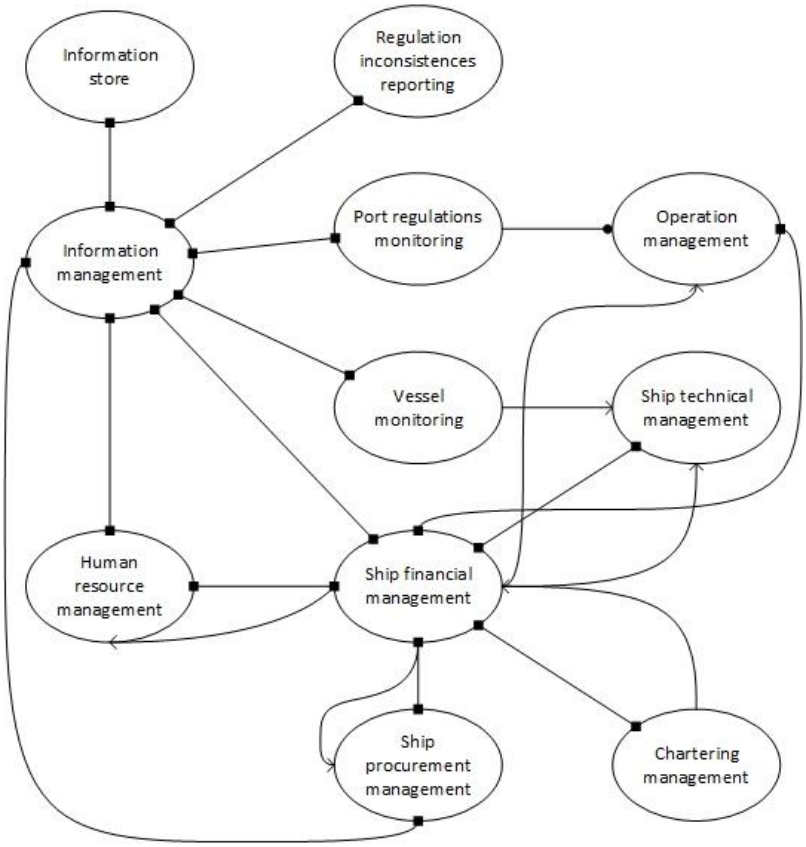

Figure 14: Capability Collaboration Diagram for level 3 Capabilities

As seen in this diagram, the Information management Capability receives information from Regulation inconsistencies reporting, Port regulations monitoring, Vessel monitoring, Human resource management, Ship financial management and Ship procurement management Capabilities. All of those Capabilities produce information, which should be passed over to Information management for further processing. There is also information exchange between Information management and Information store Capabilities, for the storage and retrieval of information provided by all the aforementioned Capabilities. Another Capability that has a central role for the Capabilities is the Ship financial management Capability. That Capability exchanges financial information with all those Capabilities that require funding or provide some income. Those Capabilities are Human resource Management, Ship procurement management, Chartering management, Ship technical management and Operation management. Furthermore Ship financial management can send funds as an output to Human resource management, Ship procurement management, Operation management and Ship technical management and can receive funds as an input from Chartering management. The Port regulations monitoring capability exercises control over Operation management, since a change in regulations can restrict ship operations. Finally, Vessel monitoring produces reports (output) which are passed on to Ship technical management Capability.

Note that the above two diagrams could have be integrated into one diagram where a color mapping could have been used. In this particular case though, that would not be very helpful since there are no interconnections between Capabilities of different levels.

5.3 Services connection

In order to connect the Services to the Capabilities modeled in the previous paragraph we will again follow the methodology presented in section *Connecting Capabilities to Services*.

The first step is to identify the services used by the business at the time of the analysis. Unfortunately the whole SOA could not be acquired but we managed to learn the majority of services used and what they do, and that will suffice for the demonstration of the methodology and diagrams.

Crewing service: Provides historical performance record for each seaman on the ship
Input: seamen personal data
Output: Filtered data

MGA service: The service is designed to automatically check Master's Accounts. It can produce the wages and tax statements for the crew
Input: Crew data
Output: Wage and tax statements

Tanker Management Self-Assessment Compliance service: This service makes sure that the ship complies with the TMSA rules.
Input: Various ship related data
Output: TMSA compliance verification

Planned Maintenance Service: It is the software which is designed for maintenance monitoring. Given the current status of the engines and other data that is acquired through various sensors it can alert the user to perform maintenance.
Input: Data related to the engines and sensors of the ship
Output: Alerts to perform maintenance when necessary

Dry-dock organizer service: Dry-docking service offers the creation of the dry-docking report, the sending to the various shipyards of the final order placement and the follow up of the jobs done during the dry-docking.
Input: Needs on replacement parts
Output: Dry-docking report

Provisions Control Service: This service is used in order to help in the provision of supplies, being able to provide automation of the complete supply cycle.
Input: Information related to provisions such as products, quantity, date of order etc.
Output: Provisions order

Stores Control Service: The Stores Control Service is used in order to keep track of the changes in the amounts of provisions of the ship it is cooperating with Provisions Control Service.
Input: Provisions thresholds
Output: Alerts when thresholds are reached

Risk Assessor Service: is a structured risk assessment service for ships operation covering operational, accident, security and environmental risks with a unified approach.
Input: Data concerning ship and crew status
Output: Potential Risks report

Optimal Routing Service: Calculates the optimal route depending on the parameters given as an input. The Optimal routing service takes into account parameters such as piracy areas, weather etc.
Input: Various Parameters (destination, goal etc.)
Output: The optimal route according to the parameters

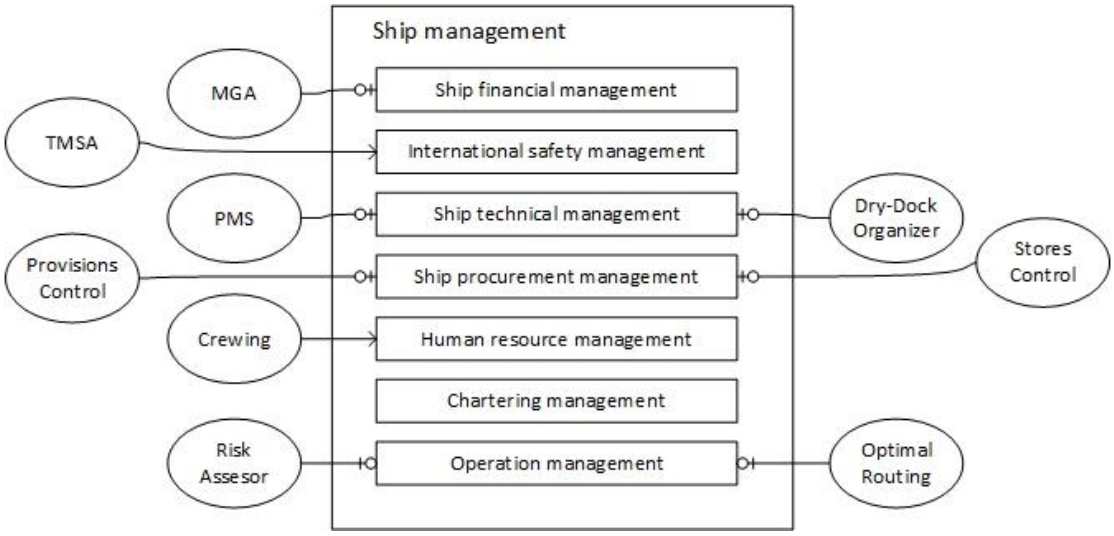

Figure 15: Connection of services to the Capabilities they provide

In *Figure 15: Connection of services to the Capabilities they provide* we can see the connection of Services of the shipping company to the Sub-capabilities of Ship management. One can easily observe that both kind of connectors, *provides* as well as *assists in the provision of*, appear on the diagram. It is a fact though that the general rule stated in the methodology, stating that a Service *provides* a Capability when it is the only Service related to the provision of that Capability is not always the case. Such an exception is presented in the case of the MGA service. As seen on *Figure 15* the Ship financial management Capability's provision is helped by the Master's general accounts Service (MGA) which enables the calculation of crew's salaries taxes etc. and is not *provided* exclusively by this service thus escaping the general rule. This is due to the fact that in truth Ship financial Capability also uses other services in order to manage not only crew accounts but any other financial activity of the ship. Unfortunately sufficient information about those services could not be obtained. The Tanker Management Self-Assessment Compliance (TMSA) Service provides the Capability of International safety management by making all the assessments necessary to calculate whether the ship is compliant with the TMSA rules or not. The Ship technical management capability is being provided by two Services, namely the Planned Maintenance Service (PMS) used to make sure that every engine component works properly and the Dry-dock organizer service which is an invaluable tool for communication with the Dry-dock where the ship will go to do any repairs, taking care various tasks that save a lot of time for the chief Engineer. Ship procurement management Capability is also provided by two Services, the first one being the Provisions control service which automatically performs a variety of procurement orders, in collaboration with the Stores Control Service which monitors the supplies and creates certain alerts when some thresholds have been reached. The crewing Service *provides* the Human resource management, since it can provide historical performance records and also the management of the crew. Finally the Risk Assessor and Optimal Routing services *assist in the provision of* Operation management, by offering risk assessment reports and calculating the optimal ship route respectively. As far as Chartering management is concerned, there was not enough information regarding the services that provide it.

6 Conclusions and future work

The current dissertation has presented a new approach for modeling enterprises using Capability mapping and connecting Capabilities with Services in order to have a more stable view of *what* an enterprise can do.

Specifically, the dissertation introduced:

(a) a Capability Meta-model, which depicts the connections of Capabilities to other important aspects of businesses and

(b) a methodology which in simple terms describes

i) the steps that should be followed in order to model Business Capabilities, that represent the high level architecture of an enterprise, and

ii) how to connect them with software services, which represent the IT infrastructure level of it.

In order to demonstrate the viability and usefulness of the proposed framework, it was applied on a shipping company; the analysis of the company's Capabilities was performed according to the methodology proposed in this dissertation and the analysis results were depicted in diagrams based on templates also introduced in this dissertation.

As mentioned in the *Prologue*, the amount of information received by the enterprise proved insufficient for the direct connection of a Capability model to an SOA. Despite that, the methodology presented in this dissertation can be used regardless of whether the SOA is known or not, since Capabilities connect directly to Services. The benefit of this type of connections is that even if the services that provide a certain Capability change, the Capability would, in the majority of cases, remain the same; thus, in such cases, there is no need for creating new Capability models from scratch but rather, one just has to assign the connectors to the new services that provide that Capability.

There are a number of suggestions some of which are outlined below as to how this research could move a step forward, which were not implemented due to a variety of reasons, the most important ones being the lack of time and information.

Regarding Capability modeling one suggestion is to also create a template used to connect Capabilities to Business Processes. Since the methodology was created by getting a lot of feedback from the use case that would require the acquisition of detailed business process models which in our case were not available. Also criteria could be established for evaluating the importance of Capabilities that could be very useful for identifying which Capabilities can be improved or even which ones might be omitted. Since Capabilities are the main notion of Capability modeling, more information could be obtained and recorded for each of them and that would also help in their evaluation. That could be done with the use of a GUI, as suggested by Beimborn et al [8].

Finally as far as the Use case is concerned, in the future there can be an evaluation of the different templates to identify which one is the more productive for different cases of enterprises. Furthermore an interesting aspect of a use case, would be to make a hypothetical model regarding future Capabilities, in order to study how new Capabilities would impact the Capability model and how useful that would be for expanding businesses.

List of Acronyms

BPEL4WS	Business Process Execution Language for Web Services
CCD	Capability Collaboration Diagram
CDD	Capability Driven Development
COD	Capability Overview Diagram
DSRM	Design Science Research Methodology
ERP	Enterprise Resource Planning
GUI	Graphical User Interface
IT	Information Technology
LOB	Line Of Business
MGA	Master's General Account
ORM	Object Role Modeling
PMS	Planned Maintenance Service
RBV	Resource Based view
SLE	Service Level Expectation
SOA	Service Oriented Architecture
TMSA	Tanker Management Self-Assessment
UDDI	Universal Description Discovery and Integration
WS	Web Service
WSDL	Web Service Definition Language

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