Ontological Foundations of Competition

Tiago Prince SALES [a,b,1], Daniele PORELLO [c], Nicola GUARINO [b], Giancarlo GUIZZARDI [c] and John MYLOPOULOS [a]

[a] *University of Trento, Italy*
[b] *ISTC-CNR Laboratory for Applied Ontology, Trento, Italy*
[c] *Free University of Bozen-Bolzano, Italy*

Abstract. It is widely recognized that accurately identifying and classifying competitors is a challenge for many companies and entrepreneurs. Nonetheless, it is a paramount activity which provide valuable insights that affect a wide range of strategic decisions. One of the main challenges in competitor identification lies in the complex nature of the competitive relationships that arise in business environments. These have been extensively investigate over the years, which lead to a plethora of competition theories and frameworks. Still, the concept of competition remains conceptually complex, as none of these approaches properly formalized their assumptions. In this paper, we address this issue by means of an ontological analysis on the notion of competition in general, and of business competition, in particular, leveraging theories from various fields, including Marketing, Strategic Management, Ecology, Psychology and Cognitive Sciences. Our analysis, the first of its kind in the literature, is grounded on the Unified Foundational Ontology (UFO) and allows us to formally characterize why competition arises, as well as to distinguish between three types of business competitive relationships, namely market-level, firm-level and potential competition.

Keywords. Competition, Business Ontologies, Enterprise Modeling, Ontological Analysis, Unified Foundational Ontology, OntoUML

1. Introduction

Dealing with competition is an important aspect of companies' management and strategy [20], as it impacts a wide range of important decisions, from where to expand to how to protect a company's position within a market. Still, it has been long recognized that companies recurrently fail to accurately identify and classify their competitors [25], an issue that affects both established organizations and startups [24]. This is such a well-known problem that it has even received its own name, *competitive blindspot* [29].

Identifying and understanding business competition is a challenging task for many reasons. Market boundaries keep changing, there is no default "place" to look for competitors and it is not up to a company to choose their competitors. Still, the issue is that, ultimately, competition is a complex socially-constructed concept that one needs to properly grasp to accurately identify competitors.

Given the importance and complexity of dealing with competition, a significant amount of effort has been employed in understanding the nature and types of competitive

[1] Corresponding Author: *tiago.princesales@unitn.it*

relationships [10,21,31,34], as well as in the development of automated tools to identify competitors (e.g. [26]). Despite these efforts, competition theories have not been properly investigated from an ontological perspective, which hinders their expressiveness and clarity, and in turn, impairs their application and integration with one another [20]. In this paper, we extend our previous work [36] to address this issue by using the Unified Foundational Ontology (UFO) (via the modeling language OntoUML) [17,16] to conduct an ontological analysis of competition, a domain that, so far, received little attention from business ontologies and enterprise modeling approaches. Our main goal is to unveil and formally characterize the ontological nature of *competitive relationships*, including when and why they occur and who is involved in them.

We stress that it is not the aim of this paper to model the dynamics of competition. We do not want to explain how the actions of a competitor affect those of their opponents or what is the best strategy to win a competition. These questions are far better answered by models based on, for example, Game Theory (see [28], for instance). Instead, we focus on creating a model that can answer questions such as whether or not Google competes with Amazon and why.

The remainder of this paper is organized as follows. In Section 2, we briefly introduce the reader to UFO and OntoUML. We continue, in Section 3, with a discussion on the general principles of competition and formalize them in a concise OntoUML model. Next, in Section 4, we exploit this analysis to conceptualize business competition, while distinguishing between three types of business competitive relationships, namely market-level, firm-level and potential competition. We then finalize this paper with a discussion of related work in Section 5 and some final remarks in Section 6.

2. The Unified Foundational Ontology (UFO)

The aim of this paper is to provide ontological foundations for the domain of competition. Since we build these foundations on top of the Unified Foundational Ontology (UFO), we provide below a brief description of the approach (see [17] for details). UFO is an axiomatic domain independent formal theory based on theories from Analytic Metaphysics, Philosophical Logics, Cognitive Psychology and Linguistics, which is a result of an integration and re-visitation of previous foundational approaches such as OntoClean [15], DOLCE [4] and GFO [22]. UFO is the theoretical basis of OntoUML, a language for Ontology-driven Conceptual Modeling that has been successfully employed in a number of academic and industrial projects in several domains, such as services, value, petroleum and gas, media asset management, telecommunications, and government [18].

In our analysis of competition, we shall rely on a recent re-visitation of the notion of *relationship* [14]. In UFO, most relationships (the so-called *descriptive* ones) are *reified*, that is, they are considered as elements of the domain of discourse. These relationships (termed *relators* in UFO) are conceived as clusters of relational qualities. Moreover, they are considered as truth-makers of the corresponding relations, i.e., a relation holds because a relationship exists. Take for instance the relation between a student and a university. Why is it true that a particular students studies at a particular university? Because there is an enrollment relationship (a relator) that sustains this relation. An important consequence of relationship reification in an ontology is the possibility to describe how they can change through time. Reified relationships have been shown to be fundamental for modeling social and enterprise phenomena such as services and contracts [18].

3. The General Ontology of Competition

In this paper, we take the widespread position on the nature of competition defended by Henderson [21], which assumes that the principles of competition are universal. This means that a general account of competition should be able to explain competitive relationships that arise in any kind of scenario, whether involving animals cohabiting in an ecosystem or companies operating in the same market. Thus, before elaborating on the ontological nature of *business* competition, let us first analyze it on a more general level.

3.1. Conflicts and Competition

Our primary assumption on competition is that it emerges from *conflicts*, a position in line with Deutsch's pioneering Theory of Cooperation and Competition [11]. A conflict is a situation characterized by a set of goals whose satisfaction are negatively interdependent, i.e., the more one such goal is satisfied, the less its interdependent goals are. A simple example of a conflict is a situation in which two applicants, John and Mary, apply for the same position in a company. If they did so, it is safe to assume that each of them has the goal of getting the position. However, since there is only one, John's and Mary's goals cannot be satisfied at the same time, for if Mary gets hired, John does not, and if John gets hired, Mary does not. Thus, John is in conflict with Mary. In an alternative scenario, if the company was to be hiring two new employees and John and Mary were the only two applicants, there would be no conflict, as it would have been possible for both their goals to be simultaneously realized.

Note that the very definition of negative interdependence between goals implies symmetry. Meaning that g_1 and g_2 are interdependent if and only if g_1 negatively depends on g_2 and g_2 negatively depends on g_1. Still, the degree of such an interdependency does not need to be either maximal nor symmetrical. By degree of dependency, we mean how much the satisfaction of one goal hinders the satisfaction of another. In the maximal case, two goals are negatively interdependent to such an extent that the satisfaction of one implies the negation of the other (e.g. the John and Mary example we have previously discussed). Still, note that the degree of dependency between two goals, g_1 and g_2, can be asymmetric, being so when the satisfaction of g_1 negatively impacts the satisfaction of g_2 more than the other way around. For instance, consider two ice cream shops operating side by side. One has the goal of selling a hundred ice creams per day, whilst the other has the goal of selling a thousand. If the maximum number of customers they can reach is a thousand, both goals cannot be simultaneously satisfied. Nonetheless, if the *hundred-ice-creams* goal is satisfied, the *thousand-ice-creams* can still be partially satisfied. Conversely, if the *thousand-ice-creams* goal is satisfied, the *hundred-ice-creams* will not be satisfied in any extent.

As discussed by Castelfranchi [6], the nature of conflicts might be *logical* or *practical*. Two goals are said to be *logically* conflicting when the satisfaction of one logically entails the negation of the other. An example would be wanting to win the lottery and not wanting to play it. Alternatively, two goals are said to be *practically* conflicting when the satisfaction of one entails the negation of (or has a negative impact on) the other only because of the current state of the world. For instance, in our John and Mary example, a conflict will exist only as long as there is a single position available. This distinction between logical and practical conflicts evinces that the conflict relation *necessarily* holds

between goals if it is logical, and *contingently* holds if it is practical. In other words, if a logical conflict exists, it does so regardless of how the world is or how it changes, whilst if a practical conflict exists, it is exactly because of how the world currently is and it may cease to exist depending on how the world unfolds. As it shall become clear later on this paper, practical conflicts are what grounds competition.

By using conflicts to ground competition, it follows that those involved, i.e. the competitors, must necessarily be agents. This conclusion holds if we assume that intentionality can only be ascribed to agents and not objects [19]. Note, however, that the interpretation of agents we adopt here is not limited to physical agents, such as a person, a robot, or a dog, but also includes collective (e.g. a group of people) and social or group agents (e.g. a company) [19,33]. Therefore, if competitors are always agents, statements such as "the iPhone competes with Google Pixel" or "the Fiat 500 is facing tough competition" cannot be interpreted at face value. In the latter case, it is Fiat, the company who produces the Fiat 500, who is facing tough competition. An alternative interpretation for such statements is that they actually refer to functional equivalence. Whenever we say that two products are competitors, what we intuitively mean is that the they can be used to achieve the same goals. In fact, functional equivalence is what underlies the definition of substitutes in Porter's five-forces framework [34].

The number of agents involved in a conflict allows us to further distinguish them in two groups, namely *internal* and *external* conflicts [6]. *Internal conflicts* occur in situations in which a single agent has two negatively interdependent goals (e.g. one wanting to have a baby and also wanting to sleep eight hours a day). Conversely, *external conflicts* are characterized by situations in which the conflicting goals belong to different agents (e.g. our John and Mary example). Our claim is that competition only emerges from external conflicts, and thus, we explicitly rule out the possibility of one competing with one-self. Thus, expressions such as "my biggest competition is myself" should be simply interpreted as metaphors.

It is important to stress that even though competition is grounded on conflicts, and these involve agents, awareness is not a requirement for conflicts. For instance, in our previous John and Mary example, the conflict exists regardless of whether one knows about the application of the other. Thus, if competition emerges from conflicts, competition is also a matter of *objective reality*[2]. Naturally, it is possible that a conflict occurs and those involved are unaware of it, but it is just as possible that no conflict exists and one believes it does. By not requiring awareness for the characterization of conflicts (and thus, competition), we are not denying the cognitive process associated to perceiving competitive situations and the impact it has on one's actions. This phenomenon, however, is more closely associated to rivalry than competition, as explained by Mead [27]: *"competition is behavior oriented towards a goal, in which the other competitors for the goal are secondary; rivalry is behavior oriented towards another human being, whose worsting is the primary goal"*. Thus, within this paper, whenever we refer to competition, we mean objective competition, not perceived competition.

[2]Given that intentional states of agents are necessarily involved in our definition of competition, we could say that it is a matter of *inter-subjective reality*, which may be ontologically relative but epistemically absolute.

3.2. Resources, Scarcity and Competition

External conflicts are necessary, but not sufficient to characterize competitive situations. To illustrate why, consider the following example. Dylan wants to date Hailey, but Hailey's mother, Claire, is against it. There is a clear conflict between them, but still, we would not say that Claire and Dylan are competing. Alternatively, if both Dylan and Andy wanted to date Hailey, we would not only say that they are in a conflict, but also that they are competing against each other. The reason why it feels natural to say that there is a competition in the latter case, but not in the former, is the presence of a *scarce resource* that both agents desire, namely the position of being Hayley's boyfriend.

Grounding competition on the presence of mutually desired scarce resources is our second core assumption on the nature of this relationship. This assumption, which is in line with competition theories in Ecology [1], helps us filter out which kinds of external conflicts lead to competition, namely those that arise from the collective pursue of scarce resources. To explain scarce resources and how they are related to competition, we first need to elaborate on what we mean by resource. Note that it is not our goal here to provide a complete ontological analysis of resources, as such an endeavor is still an open research problem in itself. Thus, we shall rely on a working definition of resources, as it suffices for our goal of explaining the nature of competition.

The term resource spans throughout various fields with varying definitions. In Ecology, resources are intuitively understood as "things" animals need to survive, such as food, water or territory [1]. From a manufacturing point of view, resources are objects that play a role in manufacturing processes [12], including raw materials that will be processed, machines required to do so, but also human skills and information necessary to execute these processes. In Strategic Management, the resources of a firm include "*all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc, controlled by a firm that enable the firm to conceive and implement strategies that improve its efficiency and effectiveness*" [3]. What emerges from these different views, implicitly or explicitly, is that being a resource is:

- a *contingent property*, as it is not essential for any individual to be a resource;
- a *relational property*, as an individual x is a resource for agent y if y needs to control x to achieve her goals; and
- an *all-embracing* property, as it is ascribed a wide range of things, including objects (either physical and immaterial), agents, qualities and relationships.

The specification of which resources an agent desires may be more or less precise. In the simplest case, an agent wants a determinate resource, such as a company who wants to acquire a particular customer. Alternatively, an agent might have a generic desire for resources of a given group or type. This second case describes, for instance, the desire of smartphone vendors like Apple and Samsung. It is not the case that either company wants to sell to a particular customer, such as you and I; instead, they want to acquire customers in the smartphone market. Note that generic desires might include a restriction w.r.t. to how many resources are demanded, as in a company who wants to hire five developers.

Note, however, that resources must be both mutually desired and scarce to give rise to competition. By being *mutually desired*, we mean that multiple agents must simultaneously seek to control the same resources. By being *scarce*, we mean that the number of available resources should be inferior to the collective demand for them. We emphasize

that one should not confuse scarcity with rareness. A resource is rare if it is not found in abundance in comparison with other resources (e.g. diamonds are rarer than coal), regardless of how many people want them. A resource is scarce if there is less of it than people need, regardless of how many exist. Thus, it is possible that an abundant resource is scarce, while a rare resource is not.

3.3. Representing the Ontology of Competition in OntoUML

Given the characterization of competition we have given so far, we define it as *a practical external conflict that arises from the collective pursue of scarce resources*. We represent this definition with its embedded concepts and relations in the OntoUML model depicted in Figure 1. This model leverages two concepts from UFO-C (an ontology of social entities [19]), namely AGENT and INTENTION. An AGENT is an individual who bears intentional moments, such as beliefs, desires and intentions and is able to perform actions. An INTENTION is an internal commitment of an AGENT to bring about a desired state of affairs. Two INTENTIONS are conflicting if they cannot be satisfied simultaneously.

In the domain of competition, we are concerned with a particular type of intention, namely those that are about acquiring or keeping control (or ownership, possession..) of resources. We label these as RESOURCE DEMAND and represent them as being externally dependent on (symbolized in Figure 1 as EXT.DEP.ON) a RESOURCE. Demands for resources have a particular quality inhering in them[3], labeled as QUANTITY and that accounts for how many resources an agent is seeking (e.g. a company who wants to hire *two* developers). RESOURCES, instead are characterized by another quality, AVAILABILITY, which refers to how many of it are available (e.g. *five* positions available in a company). Notice that we use the term resource in a very broad sense, being the generalization of SINGLE RESOURCE, RESOURCE TYPE, and RESOURCE STOCK. The first refers to particulars, the second to types (e.g. fast food customers), and the third to a collection of particulars (e.g. the collection of fast food customers in Italy). The relation CATEGORIZES, holding between SINGLE RESOURCE and RESOURCE TYPE, represents that instances of the latter are instantiated by instances of the former, as defined in [5]. Lastly, note that the availability of a SINGLE RESOURCES is naturally always one. Mutatis mutandis, the same for the QUANTITY of RESOURCE DEMANDS that refer to them.

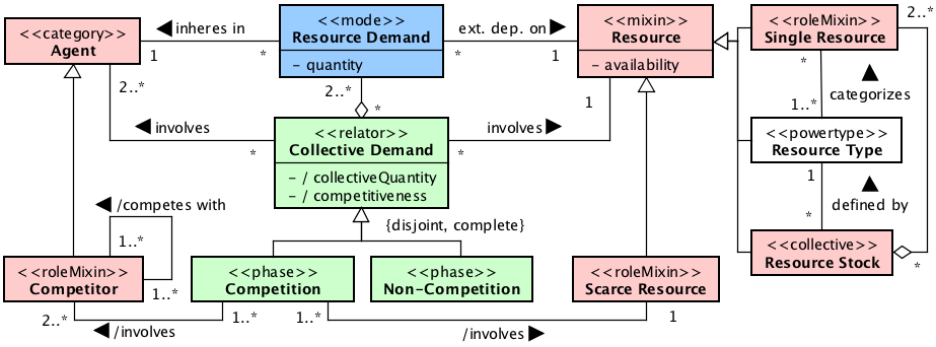

Figure 1. A fragment of the general ontology of competition in OntoUML.[4]

[3]For the sake of conciseness, we represent qualities as attributes in this diagram.

The sum of demands for a common resource gives rise to an external and descriptive [14] relationship we name COLLECTIVE DEMAND, which involves at least two AGENTS and exactly one RESOURCE. It is a descriptive relation because it holds in virtue of some individual aspects (modes) of its relata, namely the agents' resource demands. Moreover, since these demands are externally dependent on resources, the relationship is external. A COLLECTIVE DEMAND relationship is characterized by two derived qualities, COLLECTIVEQUANTITY and COMPETITIVENESS. The former equals to the sum of the individual demands for resources that form the relationship, whilst the latter equals to the ratio between the former and the AVAILABILITY of the commonly desired RESOURCE.

A COLLECTIVE DEMAND relationship becomes a COMPETITION whenever its composing RESOURCE DEMANDS cannot be simultaneously satisfied. Practically, this occurs whenever the AVAILABILITY of a RESOURCE is lower than the demanded COLLECTIVEQUANTITY, which makes the resource scarce and the AGENTS who seek it COMPETITORS. From the COMPETITION relationship, we derive the COMPETES-WITH relation that holds between COMPETITORS. This relation is irreflexive, symmetric and non-transitive. It is irreflexive because competition emerges from external conflicts. It is symmetric because competition arises from mutually desired resources, thus, if John demands the same resource as Mary, the opposite claim is also true. Lastly, it is non-transitive because agents might be engaged in multiple COMPETITION relationships for different RESOURCES at the same time. For instance, Facebook competes with Google for online advertising customers and Google competes with Spotify for music streaming customers, still Facebook does not compete with Spotify (so far!).

4. The Case of Business Competition

Companies need a wide range of limitedly available resources to survive. These include capital, customers, employees, infrastructure, information, technology, partners, and many others. It is often the case that various companies seek the same resources, thus, they end up competing in many dimensions, often against a significant number of opponents. In this paper, however, we limit our analysis of business competition to those arising for arguably the most valuable resource for a company – customers[5].

Given the inherently competitive nature of business, identifying and coping with competition is a fundamental aspect of firms' management and strategy [20]. Competitor identification, in particular, may seem to be a straightforward task at a first glance – a firm competes with every other firm that wants the same scarce resources as it does – however, it is in fact a much harder task than it seems. The big challenge comes from a simple, yet powerful barrier, namely the lack of access to what other firms really want. This barrier led academics to investigate a range of proxies that would indicate such intentions, which given the complex ontological nature of competition, gave rise to various frameworks and classification schemas for competition [7,9,13,31,34].

From the analysis of this plethora of competition theories, we extracted three recurring types of relationships that they directly or indirectly discuss. We refer to them

[4]We adopt the following color coding in this paper: substantials are represented in pink, relators in green, intrinsic aspects in blue, and powertypes in white.

[5]We are aware that labeling customers as resources is a simplification of the phenomena. What companies want, in fact, are the resources controlled by these customers, such as their money, time and attention.

as *market-level* competition, *firm-level* competition, and *potential* competition. In the following sections, we shall discuss each of them in detail.

4.1. Market-level Competition

Whenever we say that two companies compete, the intuition we most likely have in mind is that they offer similar products and services. This intuition makes it natural to claim that McDonald's competes with Burger King, as both companies are specialized in selling fast food hamburgers. It also makes it reasonable to claim that McDonald's competes with Subway and Pizza Hut, as they all offer low-priced quick meals, even if of different types. But what about companies that sell frozen meals? Could we still claim that they compete with McDonald's? To answer such a question, we need to elaborate on what we call *market-level competition*, the most basic competitive relationship in business. This type of relationship is characterized by conflicts between companies arising from the collective pursue of a common group of customers, a limited pool of resources commonly referred to as a *market segment*. Using product/service similarity works well as a proxy for identifying such relationships because functionally equivalent products and services help customers to fulfill equivalent needs. If you are hungry and on a budget, either a hamburger, a pizza or a frozen lasagna will suffice to fulfill that need.

A natural way to identify market-level competition, thus, is to look at the value propositions companies make, as argued in the theory of *Jobs to be Done* [8]. As we discussed in a previous work [35], value propositions are "promises" companies make towards a group of customers to fulfill a set of customer goals by means of an offering they make. When a company makes a value proposition to a group, it is straightforward to assume it wants to acquire customers from that group. Thus, any other company making a value proposition build upon the same goals of these customers would also want to acquire them, leading to a conflict over a scarce resource, and thus, competition.

Note, however, that customer goals can be defined in various levels of abstraction (or levels of saturation), which means that, depending how they are defined, the question of who competes with whom may have different answers. If we define, for instance, a customer need as "eating a hamburger", we would identify McDonald's and Burger King as competitors. Instead, if we define it as "eating a fast and cheap meal" we would identify all fast-food companies as competitors, but also all of those who sell frozen meals, bakeries and deli shops. If we were to define the need simply as "having a meal", virtually all companies in the food industry would be identified, from those selling frozen pizzas to high-scale sushi restaurants.

This variation w.r.t the level of abstraction in which we define goals is not arbitrary. We can find an explanation for them in the goal modeling literature (e.g. [23]), in which goals are usually organized by means of OR- and AND-refinements. If a goal is decomposed by an OR-refinement, the satisfaction of any of the subgoals entails the satisfaction of the original goal, whilst in AND-refinements, only with the satisfaction of all subgoals the original goal is satisfied. In our previous example, "eating a hamburger" is a *mean to achieve* (therein called an OR-refinement) "eating a fast and cheap meal", which in turn is a means of "having a meal". These goal hierarchies help us to distinguish between two types of market-level competition:

- *direct market-level competition*, which arises when companies create value for customers by fulfilling a common low-level goal. Examples include the compe-

tition between McDonald's and Burger King, who satisfy the goal of "eating a fast and cheap hamburger", and that between Netflix and Amazon, who satisfy the goal of "watching movies on-demand"

- *indirect market-level competition*, which arises when companies create value for customers by fulfilling common higher-level goals by means of different lower-level goals. Examples include McDonald's and local bakeries, and Netflix and broadcasting companies like BBC and RAI.

This characterization of direct and indirect competition integrates various distinctions made in competition theories. For instance, in Porter's five forces models [34], they would be equivalent to rivals and substitutors, whilst in Peteraf and Berger's framework [31], they would capture the distinction between direct rivals and vertical differentiators.

Notice that leveraging on goals to define market segments is not sufficient to fully characterize market-level competition. We also need to account for a market's geographical boundaries, as they define exactly which group of customers a company is pursuing. For instance, let us consider the need of "watching movies online on-demand". If we look into the European market, we identify Amazon and Netflix as direct competitors. Instead, if we consider the Japanese market, we would additionally identify Hulu as competitor. In the Chinese market, however, we would not identify any of the former three, but iQiyi and Youku instead.

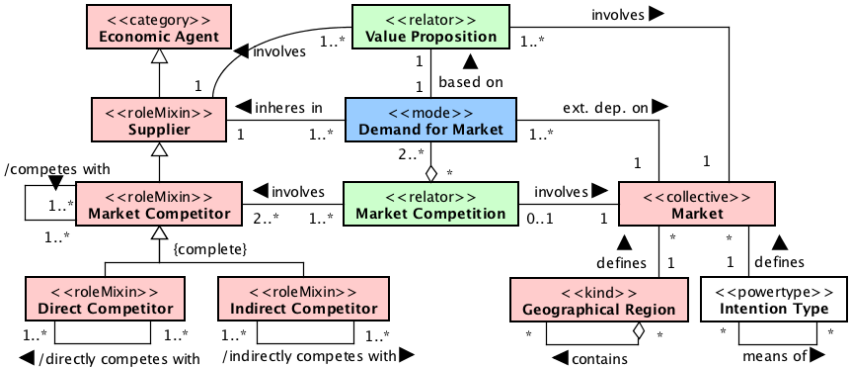

Figure 2. A model fragment on market-level competition.

Note that just as goals, geographical regions may be defined in multiple levels of granularity. The Japanese market of on-demand video is part of the Asian market, which in turn is part of the Global market. Differently from goals, however, companies competing in submarkets of a common broader market are not necessarily indirect competitors. For instance, both the Japanese and Chinese markets are part of the Asian market. Still, companies operating in these submarkets are not currently competing.

We represent market-level competition, in its direct and indirect form, in the model of Figure 2. Following the general case, MARKET COMPETITION is a descriptive extrinsic relationship [14]. It is composed by the intention of competitors to acquire customers of the same market segment. Such intentions can be identified by the VALUE PROPOSITIONS made by COMPETITORS towards a MARKET SEGMENT. These, in turn, are individuated by specific descriptions of customer needs (represented in the ontology as INTENTION TYPE) and GEOGRAPHICAL REGIONS. The part-whole relation between

MARKETS captures the varying level of abstraction in which these can be defined. More precisely, a market A is direct part of a market B (a sort of *unity criterion* for B) if:

- A is defined by a customer need that is a means for that which defines B; and A and B are defined by the same geographical region; or
- A and B are defined by the same customer need; and the geographical region that defines A is contained by that of B.

4.2. Firm-level Competition

Competitive relationships at the market level are crucial to identify interdependence between companies w.r.t. specific customer segments. However, it is often the case that companies compete against each other in multiple markets, a phenomenon which has a direct impact in strategic decision making. To explain this competitive tension between a given pair of companies that spans throughout various markets, M.J. Chen proposed [7] to distinguish two "levels" of competition: market-level competition, which we have just discussed, and firm-level competition.

The difference between market-level and firm-level competition regards the chosen unit of analysis. In the former, we fix a set of customer needs and identify, as competitors, all firms aiming to fulfill them. In firm-level competition, however, we fix the actual firms as the unit of analysis, and search for all market-level competitive relationships involving them. This characterization implies that, while market-level competition is a relationship involving at least two, but potentially multiple parties, firm-level competition is a relationship involving exactly two parties. It also follows that competitors in the firm-level are necessarily competitors in the market-level. In sum, firm-level competition can be understood as a complex conflict between two companies that emerges from multiple pursues of different types of scarce resources.

We also borrow from M.J. Chen [7] two properties to characterize firm-level competition, namely market commonality and capability similarity (originally dubbed *resource similarity* in [7]). *Market commonality* is a derived property calculated from the number of markets the two companies compete in divided by the number of markets each individual company competes in. These markets can be defined by different customer needs in the same geographical region (e.g. Unilever and P&G selling personal care and food products in Italy), by the same needs in different regions (e.g. Spotify and Deezer who offer the music streaming services in various countries), or by a mix of the two.

Capability similarity, on the other hand, refers to how similar companies are in terms of what they can achieve, what kind of strategy they can adopt and what kind of offerings they can make. To clarify on what we mean by capability similarity, we make use of follow definition of capability [2]: "*capabilities are intrinsic dispositional properties of agents that endow them with the power of exhibiting some behavior or bringing about certain effects in the world*". Examples include the Netflix's capability of streaming videos to a large number of users worldwide, as well as Amazon's logistics capability of quickly delivering orders. Capability similarity, then, refers to a relation between capabilities of different agents that enable them to achieve similar enough outcomes.

We formalize firm-level competition in the OntoUML model in Figure 3. Starting from top to bottom, we represent again the basic "building blocks" of market competition: SUPPLIERS' demands to acquire customers in MARKETS. We use these demands to represent FIRM-TO-FIRM MARKET COMPETITION, a binary relationship that

arises between every pair of competitors in a given MARKET. The sum of the firm-to-firm relationships is then used to compose the more complex relationship called FIRM COMPETITION, which always involves two competitors and all the markets they compete in. A FIRM COMPETITION is also formed by the COMPETITORS' CAPABILITIES. Note that we explicitly introduce *relational qua-individuals* (please refer to [17]) for the FIRM COMPETITION relationship, labeled as QUA-COMPETITORS. This allows us to account for the qualities that characterize this relation, namely CAPABILITYSIMILARITY and MARKETCOMMONALITY (represented as attributes for conciseness). At the instance level, in a FIRM COMPETITION between Amazon and Google, the QUA-COMPETITOR class would be instantiated by *Amazon-qua-competitor-of-Google* and *Google-qua-competitor-of-Amazon*.

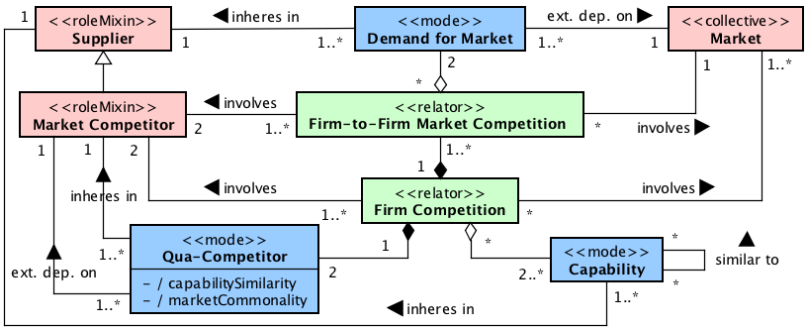

Figure 3. A model fragment on firm-level competition.

4.3. Potential Competition

The third recurrent type of competitive relationship found in the literature is the *potential competition* [31,34]. In general, the potential competitors of a given agent are those who are prone to be interested in the resources this agent currently desires. This suggests that potential competition is grounded on external conflicts over resources that are *expected* to happen, but that have not happened yet. Since many factors influence which resources an agent might desire in the future, a proxy suggested by Peteraf and Bergen [31] for identifying potential competitors is *capability similarity*. The assumption underlying this idea is that the potential competitors of an agent are those who have the proper *means* to compete for the resources the agent desires.

To exemplify this intuition, consider the following illustrative example. Jamie and Gordon are two chefs with an expertise on Italian cuisine, i.e. they are able to create and cook Italian dishes. Only Gordon, however, is an expert on French cuisine. Jamie owns an Italian restaurant and Gordon owns a French one, thus, they are not in a direct competition, for they serve two different market segments. Still Gordon poses a threat to Jamie, as he has the *means* to open his own Italian restaurant – Gordon's expertise on Italian cuisine. Jamie, however, does not pose an equivalent threat to Gordon, as he does not have the expertise in French cuisine. In this case Gordon is said to be a potential competitor of Jamie for the Italian restaurant market.

In this paper, we limit our analysis to potential competition between companies for market segments. Thus, we model it (see Figure 4) as a relationship involving three re-

lata: (i) a (reference) SUPPLIER, defined as a company that already makes a value proposition towards a MARKET; (ii) a POTENTIAL COMPETITOR, defined as a company who does not make a value proposition towards the same MARKET, but has CAPABILITIES that are equivalent to those that the reference SUPPLIER needs in order to deliver its value proposition; and (iii) a MARKET, the reason for the potential conflict. Note that potential competition involves exactly two companies and is always defined from the perspective of one of them. As an external descriptive relationship [14], potential competition "deserves" reification. We represent it as the sum of the reference SUPPLIER's CAPABILITIES required to deliver value for a particular market segment and the POTENTIAL COMPETITOR's CAPABILITIES that would allow them to make an equivalent value proposition to the same segment.

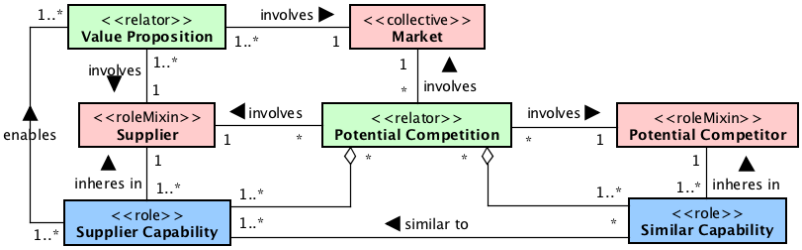

Figure 4. A model fragment on potential competition.

5. Related Work

To the best of our knowledge, no in depth ontological account of competition has been proposed in the literature, despite its clear relevance in strategic analysis. Thus, in this section, we compare the ontological analysis we propose with enterprise and business modeling contributions that use the concept of competition or a closely related notion.

One of such contributions is *c3value* [38], an extension of *e3value* designed to support competition, customer and capability analysis. Although the authors do not explicitly define competition, the underlying intuition is that the competitors of a company are those who offer the same primary value object to customers. Competitors can also be classified according to the secondary values they offer (e.g. convenience, reliability). This allows companies to identify their competitors and represent how they distinguish themselves from the competition. In *c3value*'s account of competition, one can represent direct and indirect competition between multiple companies.

Another extension of *e3value* that is related to this research is the *e3forces* model [32]. In this extension, the authors leverage on Porter's five-forces framework [34], a well-known strategic tool to analyze the competitiveness of industries, to describe how environmental factors impact a business value model. Three of such forces regard competitive relationships in the sense we have used in this paper, namely the rivalry between competitors, the threat of substitution, and the threat of new entrants. The first two refer to direct and indirect competition, respectively, whilst the third refers to potential competition. Although *e3forces* accounts for the same three relationships we discuss in this paper, it does not provide a precise characterization of why they hold and how to

systematically identify them, relying solely on the intuitions put forth by Porter. Still in the domain of Enterprise Modeling, Pant and Yu [30] propose to model competition and cooperation using the i* goal modeling language. In their approach, competition is represented by means of resource dependencies: two actors compete if they depended on an external common actor for a particular resource. By doing so, however, their approach does not distinguish between the three types of competition we discussed in this paper, and neither on the different types of resource demand companies may have (single resources, resource types and resource stocks).

A last related work is the Enterprise Ontology (EO) [37], a broad ontology about enterprises that marginally touches the notion of competition. EO defines a competitor as *"a role of a vendor in a relationship with another vendor whereby one offers one or more products for sale that could limit the sales of one or more products of the other vendor"*. With this definition, however, EO only describes binary direct competition, which, as we discussed, is just a particular case of one type of business competitive relationships.

6. Final Remarks

In this paper, we presented an ontological analysis of competition in general, and of business competition in particular. We first defined the general concept of competition as a *practical external conflict that arises from the collective demand for a common scarce resource* and formalized it in a concise OntoUML model. Then, we applied this conceptualization to investigate the ontological nature of business competition, which lead to the formal characterization of three types of business competitive relationships, namely market-level, firm-level, and potential competition.

The ontology presented in this paper can serve as a basis for future business ontologies and as a conceptual foundation for the development of several types of competitor analysis tools. These include modeling languages to support competitor identification and classification, machine learning algorithms that autonomously search for competitors, and linked open data repositories of competition information that could be fruitfully explored by entrepreneurs and researchers.

References

[1] Alley, T.R.: Competition theory, evolution, and the concept of an ecological niche. Acta Biotheoretica 31(3), 165–179 (1982)
[2] Azevedo, C.L., Iacob, M.E., Almeida, J.P.A., van Sinderen, M., Pires, L.F., Guizzardi, G.: Modeling resources and capabilities in enterprise architecture. Information Systems 54, 235–262 (2015)
[3] Barney, J.: Firm resources and sustained competitive advantage. J Manag 17(1), 99–120 (1991)
[4] Borgo, S., Masolo, C.: Foundational choices in DOLCE. In: Staab, S., Staab, S., Studer, R. (eds.) Handbook on Ontologies, pp. 361–381. Springer Verlag, Berlin, Germany (2009)
[5] Carvalho, V.A., Almeida, J.P.A., Fonseca, C.M., Guizzardi, G.: Multi-level ontology-based conceptual modeling. Data & Knowledge Engineering 109, 3–24 (2017)
[6] Castelfranchi, C.: The cognition of conflict: ontology, dynamics, and ideology. In: Conflict and Multimodal Communication, pp. 3–32. Springer (2015)
[7] Chen, M.J.: Competitor analysis and interfirm rivalry: Toward a theoretical integration. Academy of management review 21(1), 100–134 (1996)
[8] Christensen, C.M., Hall, T., Dillon, K., Duncan, D.S.: Know your customers' "jobs to be done". Harvard Business Review 94(9), 14 (2016)

[9] Czepiel, J.A., Kerin, R.A.: Competitor analysis. In: Shankar, V., Carpenter, G.S. (eds.) Handbook of marketing strategy, pp. 41–57. Edward Elgar Publishing, Northampton, MA (2012)
[10] DeSarbo, W.S., Grewal, R., Wind, J.: Who competes with whom? a demand-based perspective for identifying and representing asymmetric competition. Strategic Management Journal 27(2), 101–129 (2006)
[11] Deutsch, M.: Cooperation, competition, and conflict. In: Morton Deutsch: A Pioneer in Developing Peace Psychology, pp. 47–70. Springer (2015)
[12] Fadel, F.G., Fox, M.S., Gruninger, M.: A generic enterprise resource ontology. In: 3rd Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises. pp. 117–128. IEEE (1994)
[13] Ferrell, O.C., Hartline, M.: Marketing strategy, text and cases. Nelson Education (2012)
[14] Guarino, N., Guizzardi, G.: Relationships and events: towards a general theory of reification and truthmaking. In: AI*IA 2016 Advances in Artificial Intelligence, pp. 237–249. Springer (2016)
[15] Guarino, N., Welty, C.: An Overview of OntoClean (revised version). In: Staab, S., Studer, R. (eds.) Handbook on Ontologies, pp. 201–220. Springer, Berlin, Heidelberg (2009)
[16] Guizzardi, G., Fonseca, C., Benevides, A.B., Almeida, J., Porello, D., Sales, T.: Endurant types in ontology-driven conceptual modeling: Towards OntoUML 2.0. In: 37th International Conference on Conceptual Modeling (ER) (2018)
[17] Guizzardi, G.: Ontological foundations for structural conceptual models (2005)
[18] Guizzardi, G., Wagner, G., Almeida, J.P., Guizzardi, R.: Towards ontological foundations for conceptual modeling: the Unified Foundational Ontology (UFO) story. Applied ontology 10(3-4), 259–271 (2015)
[19] Guizzardi, R., Guizzardi, G.: Ontology-Based Transformation Framework from Tropos to AORML, in Social Modeling for Requirements Engineering. MIT Press (2010)
[20] Gur, F.A., Greckhamer, T.: Know thy enemy: A review and agenda for research on competitor identification. Journal of Management (2018)
[21] Henderson, B.D.: The anatomy of competition. The Journal of Marketing pp. 7–11 (1983)
[22] Herre, H.: General Formal Ontology (GFO): A foundational ontology for conceptual modelling. In: Theory and applications of ontology: computer applications, pp. 297–345. Springer (2010)
[23] Horkoff et al.: Goal-oriented requirements engineering: an extended systematic mapping study. Requirements Engineering pp. 1–28 (2017)
[24] Krzyżanowska, M., Tkaczyk, J.: Identifying competitors: challenges for start-up firms. International Journal of Management Cases 15(4), 234–247 (2013)
[25] Levitt, T.: Marketing myopia. Harvard business review 38(4), 24–47 (1960)
[26] Ma, Z., Pant, G., Sheng, O.R.: Mining competitor relationships from online news: A network-based approach. Electronic Commerce Research and Applications 10(4), 418–427 (2011)
[27] Mead, M.: Cooperation and competition among primitive peoples. Transaction Publishers (2002)
[28] Myerson, R.: Game Theory. Harvard University Press (1997)
[29] Ng, D., Westgren, R., Sonka, S.: Competitive blind spots in an institutional field. Strategic Management Journal 30(4), 349–369 (2009)
[30] Pant, V., Yu, E.: Modeling simultaneous cooperation and competition among enterprises. Business & Information Systems Engineering pp. 1–16 (2018)
[31] Peteraf, M.A., Bergen, M.E.: Scanning dynamic competitive landscapes: a market-based and resource-based framework. Strategic management journal 24(10), 1027–1041 (2003)
[32] Pijpers, V., Gordijn, J.: e3forces: understanding strategies of networked e3value constellations by analyzing environmental forces. In: International Conference on Advanced Information Systems Engineering. pp. 188–202. Springer (2007)
[33] Porello, D., Bottazzi, E., Ferrario, R.: The ontology of group agency. In: 8th International Conference on Formal Ontology in Information Systems (FOIS). pp. 183–196 (2014)
[34] Porter, M.E.: Competitive strategy: Techniques for analyzing industries and competitors. Simon and Schuster (2008)
[35] Sales, T.P., Guarino, N., Guizzardi, G., Mylopoulos, J.: An ontological analysis of value propositions. In: 21st International Enterprise Distributed Object Computing Conference. pp. 184–193. IEEE (2017)
[36] Sales, T.P., Guarino, N., Guizzardi, G., Mylopoulos, J.: Towards an ontology of competition. In: 12th International Workshop on Value Modeling and Business Ontologies (VMBO) (2018)
[37] Uschold, M., King, M., Moralee, S., Zorgios, Y.: The Enterprise Ontology. Knowl Eng Rev 13(1) (1998)
[38] Weigand, H., Johannesson, P., Andersson, B., Bergholtz, M., Edirisuriya, A., Ilayperuma, T.: Strategic analysis using value modeling–the c3-value approach. In: Hawaii Int. Conf. on System Sciences (2007)