Towards Ontology-Based Information Systems and Performance Management for Collaborative Enterprises

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Abstract. Much of the research on Performance Management (PM) for collaborative enterprises (CE) is based on qualitative considerations and does not consider the impact of modern Information Systems both on the collaborative/competitive dimension of firms and on the PM process. The peculiarities of the different types of CEs are not clearly addressed and managed in literature, and the performance measurements are often oriented to specific aspects rather than to assess the overall quality of business. Moreover, in several proposals, the skills and the time required to the managers of CEs are far from those available in the largest part of existing SMEs. In this scenario the objective of the paper is to discuss how conceptual modeling techniques, and namely ontologies and performance modeling, can contribute to better manage collaborative enterprises.

Keywords: Information systems · Enterprise modelling · Performance evaluation · Collaborative enterprises · Ontologies

1 Introduction

Collaboration among enterprises is gaining ever more importance due to globalization, which has forced businesses to rearrange their organizational structures. In this work, we focus on collaboration from a systemic perspective [1,2]; in order to emphasize this view on collaboration and to abstract from the specific forms that it can assume (e.g., strategic alliances, networked organizations, etc.), we use the term collaborative enterprise (CE).

In the last twenty years, organizational relationships have moved from intra-organizational to inter-organizational ones (i.e., collaboration among enterprise, also defined as cross-organizational) and are moving towards trans-organizational relations (i.e., collaboration among collaborative enterprises), with a prediction of a speed for value creation never seen before [3]. Nonetheless, it is known that globally between 50 % and 70 % of CEs fails [4,5], often due to the lack of a comprehensive analysis that combine strategic goals and KPIs, whereas performance

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measurement is a key element in achieving business goals [6]. In fact, although, as outlined in a review of literature [7], several authors studied the role of management accounting in inter-organizational environments, to our knowledge no one applied these results in order to quantitatively analyze the performance of CEs, of involved firms and of their linkage [3,8,9] for governance purposes. Moreover, in several proposals, the skills required to managers are far from those available in the largest part of existing SMEs, which are the most numerous actors in CEs. In this context, organizations would benefit from methodologies and tools allowing them to better link desired objectives and achieved results in an inter-organizational environment. This requires a more structured and systematic approach to evaluate not only the individual organizations' performance but also how it compares with partners and competitors [10], even in different CEs. In practical cases, this kind of interrelated performance evaluation and comparison cannot be conceived and realized without a set of suitable IS elements and procedures, which becomes not neutral with respect to the measured performance and to type of collaboration, as well as a music instrument is not neutral with respect to the played music.

In this perspective, Information Systems (IS) have to face the new challenge offered by collaboration among enterprises [11,12] and Information Technology (IT) concepts, such as online databases, information modeling, ontologies and Semantic Web techniques, become relevant to CEs for their operational life.

The aim of this paper is (a) to identify the challenges for IS deriving from the collaboration among organizations and the existing gaps in literature, (b) to elicit a set of requirements, starting from the gaps in existing literature and (c) to propose a IS architecture for CEs that can satisfy these requirements.

The paper is organized as follows: in Sect. 2 the research method is defined as a foundation for the explorative research; in Sect. 3, the research problem is outlined and the high-level requirements for the architecture are elicited; in Sect. 4, the related works on the modeling of performance and collaborative enterprises are presented. In Sect. 5 the high-level architecture of the IS for collaborative enterprises is presented, while in Sect. 6 we discuss a use case. The last section is for concluding remarks.

2 Method

The research method here adopted is based on the Design Science Research methodology proposed in [13,14]. This methodology implies the identification and motivation of the problem, the definition of the possible solution (Relevance cycle), the adoption of grounding theories and methods at the state of the art (Rigor Cycle) and the design of the artefact and its evaluation (Design cycle). In particular, this work is concerned with the with the identification of the problem and with the proposition of a suitable architecture for an information system able to satisfy the characteristics and the need of collaborative enterprises and of the participating organizations.

As a first step, we outline the general problem in order to motivate our proposal. In order to follow a technology-enabled enterprise-driven approach, as recommended by [11], we elicited the requirements towards the IS architecture starting from the management literature on collaboration among organizations. As a second step we analyze and compare the existing literature and its compliance whit the above defined general requirements. Finally, we propose a set of guidelines and a high-level architecture and we discuss its compliance towards the requirements, in order to evaluate whether our proposition is suitable to face the challenges posed by the collaboration among enterprises.

3 Problem Definition

In this section, we analyze both the literature on performance management for CEs and on cross-organizational information systems, in order to outline which challenges arise from the collaboration among organizations and are still open. Furthermore, we elicit the high-level requirements related to performance measurement.

3.1 Domain Outline

Whilst we are going towards a network-SMEs-driven society, new challenges arise for performance measurement systems, since they have to be developed and used across the traditional organizational boundaries. Indeed, the key element in the future seems to be cooperation [12], thus IS should "enable new forms of participation and collaboration, catalyze further the formation of networked enterprises and business ecosystems [...] ushering in a new generation of enterprise systems" [11]. Indeed, according to contingency theory, a change in the organizational structure implies a change in the IS. In this sense, IS usually distinguish and oppose relations within a firm, from those across it, whilst in an inter-organizational setting it is necessary to broaden data sources so to include partners and to consider them as beneficiary of the information [15].

One of the roles of information systems is to allow performance measurement, which is a key function in the assessment of the collaborative enterprises and of how the CE is affecting the individual organizations. At the Enterprise System level, this can be achieved through shared databases, data warehouses, workflow management systems, web services, SOAs or cross-organizational ERP [16], which are used from several independent firms whom cooperate in an inter-organizational environment [17]. In particular, cross-organizational Information Systems can assure a flow of information among and within organizations [16], thus permitting the coordination among partners, which is essential in order to define and to achieve shared goals. However, the use of cross-organizational ERP systems can lead to a lost on flexibility because it implies processes standardization which is not easy to achieve in CEs, being the collaborative relations not always stable. Anyway, most of the IS adopted are not cross-organizational; thus, they focus on a single enterprise with some supports towards sharing performance information with external parties [3]. On the other hand, there are also non IS-based enforcement methods, such as Open Book Accounting (OBA), which allows firms to share accounting information. Nonetheless, they are sometimes seen as formal control mechanism that damages trust [18].

In this scenario, there is the need to manage both the performance of CEs and of organizations (SMEs or big enterprises) [3]: it is necessary to modify existing tools for inter-organizational settings, overcoming the clear-cut between external and internal environment. Indeed, whilst it is possible to use the same performance measurement frameworks used for firms, it is still necessary to structurally and operatively change the measurement system [19]. Therefore, the question is how to design and develop IS, allowing a monitoring at two levels of granularity (i.e., the collaborative enterprise level and the organizational level), with a guarantee of comparability between KPIs and perspectives of the two levels, providing also suggestions for KPIs and dashboards.

3.2 High Level Requirements for the IS Architecture

Research and empirical studies [4,5] suggest that collaborative enterprises need specialized tools to support performance management and decision-making processes, by enabling a clear linkage between strategic goals and Key Performance Indicators (KPIs). Indeed, the continuous monitoring of the fulfillment of goals is a critical factor in determining the success of CE [20,21]. This can be achieved by designing and implementing suitable information architectures, as defined in [22], based on appropriate models and right technologies. Staring from the papers on collaboration available in literature, it is possible to define some high-level requirements. In the following, we will outline the most relevant ones in connection to performance measurement issues.

When the performance measurement is related to inter-organizational aspects, interoperability issues need to be accounted for. Indeed, different organizations often use different terms to describe the same concept or the same term to refer to different concepts (semantic heterogeneity), use different data structures in their information systems [23] (structural heterogeneity) or apply diverse data formats (syntactic heterogeneity). This is sometimes due to different accounting standards and methods or to a different calculation and interpretation of KPIs.

Requirement 1. Interoperability issues should be accounted for.

Collaborative enterprises that differ for type, goals or other characteristics, require different KPIs [24] in order to measure the achievement of the business goals. However, the definition of relevant KPIs and dashboards is particularly difficult in CEs, due to the implicit complexity of the collaboration. This is even more difficult for SMEs, which often lack of the know-how needed to perform these kinds of analyses. Therefore, it can result particularly useful the automatic suggestion of relevant KPIs and dashboards, based on the context. In order to achieve this result, there is the need to also precisely define the context and the domain-specific KPIs.

Requirement 2. It should be possible to automatically suggest, based on the context, domain-specific KPIs and dashboards.

Requirement 2.1. It should be available a comprehensive analysis of the context, taking into account CEs type, organizational structures, roles and goals.

Requirement 2.2. It should be possible to derive domain-specific KPIs, i.e., KPIs specific for the specific context.

Furthermore, the organizations participating in a CE can establish some policies and governance rules that define their constraints on the behavior over time, which sometimes are embedded in contracts. Some of these policies can be easily re-used by others, creating general patterns (i.e., useful for all kinds of collaborations) or patterns specific to a particular type of collaboration (e.g., rules on the supply of raw materials).

Requirement 3. It should be possible to store the information on the contracts and on the specific type of CEs that used them and assist in the contract drawing and enactment by means of contractual patterns.

Finally, among the organizations of a CE, there is usually a certain degree of information asymmetry. On one hand, this is sometimes an unwanted effect of the difficulty to communicate (e.g., interoperability issues). On the other hands, it can also results from a choice of partners, who prefer to keep private the information concerning, for instance, revenues and costs, because they are afraid of potential opportunistic behaviors.

Requirement 4. The information disclosure should be balanced with the degree of privacy defined from each organization.

4 Related Works

Enterprise Modeling is a set of formal, semi-formal and non-formal languages able to model, represent and describe important aspects of the structure and of the operational life of an enterprise. The research on enterprise modelling has several topics. Some authors focus on the analysis of business processes [25–27], others on the information architecture [28] of firms, some others on the modeling of strategic an organizational aspects as well [29,30], of the collaboration between enterprises, or of performance indicators, by means of domain-specific modeling languages (DSML) and ontologies.

Performance Modeling. Domain specific modeling languages (DSML) have been used in order to offer models able to support the creation and the interpretation of performance measurement systems effectively and efficiently by providing differentiated semantics of dedicated modeling concepts and corresponding descriptive graphical symbols [29]. Some of these works model performance for business processes, describing, e.g., the meta-types `Indicator` and `Indicator Group` with the aim of aggregating different KPIs and to offer different views to the users [31]. In [29] other concepts, e.g., formula, unit of measurement, time horizon, and the inter-relation between KPIs are accounted for. Moreover, in [6] causal, correlation and aggregation relations are defined, as well as the high-level relation between the concepts of KPI, task, goal, process, role and agent. Another approach has been used with the Business Intelligence Model (BIM) [32,33], which provides high level concepts that can be used in order to model the strategy and the related goals, indicators and potential situations (Strengths, Weaknesses, Threats and Opportunities). In other works, the modeling of performance is achieved by means of ontologies, which can be very effective to represent shared conceptualizations of specific domains and to infer new knowledge, as outlined in [34]. In particular, some authors [35] focus on Process Performance Indicators (PPIs) and on the computation methods, such as the use of base measures, the use of aggregation functions (e.g., min, max) or of mathematical functions. An interesting work has been done in [36] where an ontology of KPIs with reasoning functionalities for Virtual Enterprises is presented. In more detail, the main reasoning functionalities concerns the formula manipulation, used to derive relation between indicators and to rewrite a formula; the equivalence checking, used in order to check for duplicates; the consistency checking and the extraction of common indicators. Both the works on DSML and on ontologies still lack of some characteristics which are particularly desirable when it comes to developing IS for collaborative enterprises. Even though the works on DSML and semi-formal frameworks offer a broad analysis of performance indicators and of their relations, it is not possible to add reasoning functionalities. On the other hand, these works offer high-level models; therefore, the concrete use of these models requires too much work for the users and it is seldom feasible in SMEs. Moreover, for what concerns ontologies, most of the works do not take properly into account reasoning functionalities, they are seldom available online, existing ontologies are rarely re-used and no pattern is presented, as discussed in [37]. In general, there are still few works that analyze ontologies of KPIs and a lack of works that simultaneously take into account KPIs, goals and CEs, which are entities far more complex than individual enterprises.

Collaborative Enterprise Modeling. Ontologies and taxonomies have been used as well to model the collaboration among enterprises. An ontology for Collaborative Networks has been proposed in [38], where the organizational structure and the domain specific knowledge of Virtual Breeding Environments (VBEs) are represented. In particular, each `VBE` has some assets and have some participants. Each VBE participant has a `VBE Role` and to each role some tasks are associated. Also, a VBE has some business opportunities related to the development and commercialization of products and services. VBEs are defined as organizations, to which are connected competencies and processes. In turn, each `Process` uses some resources and produce or use as inputs other products and services. Although this ontology provides a general representation of CNOs and VBEs and it is possible to analyze the roles of participants, it is not possible to understand CEs types, since the ontology is focused on VBE. Moreover, in [39,40], a taxonomy of Collaborative Networks (CNs) is provided. The authors start from a definition of CNs in order to classify 26 types of CNs, among which digital ecosystems. The study is quite interesting and takes into account criteria such as the time perspective, however, the analysis is not enough broad and deep and accounts for a limited subset of collaboration forms. Also, the lack of a formal language does not allow the semi-automatic classification of instances (CEs) nor the suggestion of relevant KPIs for the type of collaboration. In [41] the IDEON ontology is proposed in order to support the design and the management of collaborative and distributed enterprises. To this aim, the authors take into account four views of the collaboration, namely, (a) Enterprise Context View; (b) Enterprise Organizational View; (c) Process View; and (d) Resource/Product View. Finally, in [42] a model for supply chain is presented with the aim of enabling the semantic integration of Information Systems. In order to do so, some basic concepts, such as the supply chain structure (`SC_Structure`), the participants (`Party`), their roles (`Role`), the purpose of the alliance (`Purpose`), the `Activity`, the `Resource`, the `Performance` and the `Performance_Metric`. However, not even in these two cases there is a classification of the types of collaborative enterprises, although the basic concepts used in these ontology can be borrowed.

5 A High-Level Description of an Ontology-Based Information System for CEs

5.1 Functionalities of the Information System

From the requirements outlined in Sect. 3.2, it emerges that the Information System of a collaborative enterprise should have four aims, as outlined in the following. Conceptual models in general, and ontologies in particular, play a central role [43] both to understand the business and organizational domain of CEs (which is essential in the IS design phase) and to support a number of important services at runtime (data and information integration, knowledge sharing, reasoning), which represents the collaborative hearth of any good IS for CEs.

Performance Monitoring of Organizations and CEs and Benchmarking, through the creation of personalized dashboards, KPIs evaluation and information sharing. Through benchmarking it is possible to compare firms or CEs with similar ones, without the necessity to provide analytic data on costs and revenues and, thus, overcoming one of the main limits of management accounting solutions such as open book accounting (OBA). In this case, interoperability issues need to be accounted for. Indeed, different organizations often use different terms to describe the same concept or the same term to refer to different concepts (semantic heterogeneity), use different data structures in their information systems [23] (structural heterogeneity) or apply diverse data formats (syntactic heterogeneity). This is sometimes due to different accounting standards and methods.

Context-Aware Recommender System. In order to better link strategic goals to KPIs, a context-based recommender system for performance indicators could facilitate the decision of which performance to use, thus offering a more comprehensive perspective and, based on the achieved performance, help managers in taking strategic decisions. The recommender system should suggest relevant KPIs and possible dashboards starting from the information on the collaborative enterprise's and the participants' goal system and from the collaboration type. Indeed, each actor and CE has a goal system - explicitly or implicitly formulated - and can use a set of metrics to monitor the goal achievement. These metrics should also be linked with the role of each participant and to the resources used to perform the required activities. On the other hand, the performance measurement system cannot abstract from the peculiarities of collaborative enterprises and from the specific types of collaboration. The system should help organizations and collaborative enterprises to understand and manage the collaborative aspects. In this way, Requirement 1 and Requirement 3 of Sect. 3.2 should be satisfied. Examples of domain specific KPIs for a supply chain with an informal-technical based connection at the early stages of the CE and with the goal of cost reduction are the following:

1. Overall production costs variation, for a given firm, between t0 (before entering a given CE) and t1 (after entering the CE), since the comparison between two periods of time is an effective indicator [19];
2. Overall transportation costs variation, for a given firm, between t0 and t1;

This approach enables the representation of the linkage between the goals and KPIs of collaborative enterprises and individual organizations and makes it possible to track which KPIs are used from firms with specific goals of a specific type and with a certain maturity, so that this information is stored and used to suggest to not expert users which KPIs to choose (Requirements 1–5). The effective availability of this information for the above mentioned layers, and the creation of an online repository with a suitable set of access rights to preserve confidentiality, could facilitate the search for partners (individual organizations or CEs), thus supporting and simplifying the partner selection process (Requirement 6). In short, this approach can facilitate firms also in the choice of which KPIs to include in the dashboard, thus which KPIs are relevant for their specific goals, CE type and maturity. Indeed, through data visualization tools and KPIs ontologies it is possible to develop an interpretative framework able to understand KPIs and to offer information on relevant variables, depending on the typology of partnership. This is particularly useful for SMEs, who lack of the skills to develop and maintain adequate performance measurement systems.

Repository of Templates. Contracts or agreements and organizational structures, whereas available, can be furthermore processed, in order to make available an online repository of domain-specific templates for CEs, such as those provided by the Legal-IST project (http://cordis.europa.eu/project/rcn/71925_en.html), for organizations that decide to formalize or change the collaboration and organizational structures.

Information Sharing, in order to better collaborate with partners and to have more detailed benchmarks, with different level of privacy. This is coherent with the interest in techniques such as open-book accounting (OBA) [44], which allows for the exchange of financial information. In this case, it would be useful to have more information than the one on financial aspects. Indeed, organizations that cooperate need to exchange information (e.g., on their transactions, goals), since this can increase their performance [45]. Also, in case they decide to share more data not only with partners but also with other organizations, this can increase the effectiveness of benchmarking. In the collaborative IS firms should be able to share information, in order to better collaborate with partners and to have more detailed benchmarks, with different level of privacy. This means that each firm can decide to be a grey box, a white box or a black box for each other firm. In more detail, it is (a) a white box if choose to be completely transparent for other firms, e.g., disclosing its processes and organizational structures, (b) a black box if the firm choose to disclose to other firms only external parameters (e.g., financial statements, information on web sites); (c) a gray box if the firm choose to disclose only partial information.

These features can be offered through a collaborative, ontology-based Information System delivered online. As stated in [3], IS are essential for the development and use of Performance Measurement Systems. In order for the information system to operate in an inter-organizational setting, it has to be Interned-based, thus being easily accessible by all firms. In this scenario, as we will discuss in Sect. 5.2, ontologies are particularly useful due to both the reasoning functionalities that they enable and for their ability to offer a shared conceptualization of both performance measurement and collaborative enterprises.

In order to exploit these functionalities, it is useful to see a collaborative enterprise as a system [24] composed by three layers: the *CE structural layer*, the *organization structural layer* and the *dynamic layer*. The CE structural layer is about information on the CE (e.g., objectives, activities, program) and on its performance (e.g. results achieved) as described in financial statements, web sites and other available sources. The organizational structural layer is for information on firms participating in CEs, such as firm objectives, activities, business sector, characteristics, organizational structure and performance. Finally, the dynamic layer is for information on formal and informal strategic agreements among firms and between each firm and the CE, on partnership contracts, on their governance, duration, obligations and expected outcomes.

5.2 The Role of Ontologies

In our proposal, the main role of ontologies is to provide a description of the context used by the recommender system, enabling also the use of reasoning functionalities [46]. Indeed, ontologies are often used in recommender systems [47]. In this case, they are particularly useful, since the recommender system should deal with different domains, such as KPIs, goals, organizational aspects and collaborative types and features that should be considered simultaneously. Indeed, without the use of domain ontologies, the system might return non-accurate suggestions [46].

For example, let us suppose we have two collaborative enterprises (Alpha and Beta), both among organizations operating in the same business sector. The CE Alpha is made up by manufacturing companies that want to increase their performance through the reduction of the distribution costs. On the other hand, the CE Beta, is made up by manufacturing companies that want to increase their performance through innovation, thus investing in research. In both cases, we have the same structure of collaboration with an horizontal integration, the same general goal, the same business sector, but the performance needs to be measured in different ways. In the first case, we have to look at costs indicators and profits indicators, whilst in the latter what matters is the potential increase of incomes or the potential cost reduction, since the financial effects can only be visible after years.

A first step towards this goal, is to provide a shared understanding on what collaboration is and what types of collaboration exist. However, the literature on collaboration is vast and multidisciplinary, thus it sometimes lacks of coherence in the definition and understanding of collaboration. In particular, this is due to two issues:

1. Sometimes the same term is used to describe different concepts or, on turn, the same concept is described by means of different terms. For instance, the term *alliance* is sometimes referred indistinctly to both horizontal or vertical partnerships [48], while it is often used only to describe vertical alliances and sometimes only dyadic relations, which accordingly to [49] should not be considered as alliances. The same goes for the term *joint venture*, which sometimes is regarded as one of the possible types of alliances [48,50] and sometimes as a different concepts [51].
2. In order to classify the collaboration types, different authors refers to different perspectives (e.g., temporal, geographical, integration type, goal-related and so on). Even when the same perspective is used, it can result in a different classification or in a classification that refers to different meaning of the term *collaboration*, as above mentioned.

In this sense, ontologies are particularly useful when there is a lack of a shared knowledge on a specific domain.

Moreover, for what concerns the modeling of indicators and their conjunct use among the organizations participating in the collaborative enterprise, as outlined by Diamantini et al. (2013) "*the formal representation and manipulation of the structure of a formula is essential in Virtual Enterprises to check inconsistencies among independent indicator definitions, reconcile indicators values coming from different sources, and provide the necessary flexibility to indicators management*" [36]. Indeed, bot semi-formal and rigorously formal ontologies [52] are well known as a solution to heterogeneity issues [53], which can originate when dealing with indicators.

Finally, complex information systems rely on robust and coherent, formal representations of their subject matter. In this sense, ontologies can provide models of different aspects of a business entity contributing to intra- and inter-enterprise information systems. By committing to the same ontological specification, different applications share a common vocabulary with a formal language and clear semantics. Also, by representing knowledge with a well-established formalism [54], internal consistency and compliance checking can be performed in order to determine content adequacy.

5.3 High-Level Architecture

The block diagram of a software architecture implementing the above-mentioned functions and satisfying the requirements specified in Sect. 3.2 is depicted in Fig. 1.

The system is composed by two type of nodes, namely Base and Aggregator. The internal structure of the Base Nodes is represented in the upper part of Fig. 1. Base Nodes are replicated for each CE and, for confidentiality reasons, the access to each base node is reserved only to the members of the belonging CE. For the same reason Base Nodes can be deployed and managed directly by CE members or on the Cloud. Organizations data is stored in three databases, namely the ORG database for organizational structures, the PPI database for inter-organizational processes and their performance indicators, and the ADM database for financial data and the related indicators. Each CE member can work only on its own data and on partners data for which it has been explicitly authorized. Dashboards for the whole CE and for each one of its participants are managed by the DSB module and by its components named CEC and SFC. The DSB module is also in charge of receiving recommendations from the Aggregator Node and to notify them to the proper users according to their state and to the context. User models and context models are managed locally by the LOM (Local Ontology Manager) Module. The non-private data and indicators representing

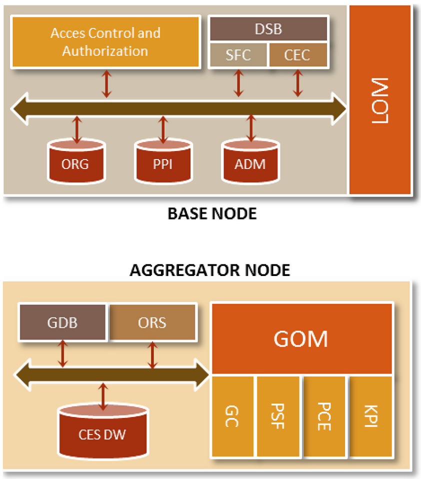

Fig. 1. High-level architecture

each organization and each CE (e.g. financial statements and public reports) is then brought to the Aggregator Node, represented in the lower part of Fig. 1, where acquired data is stored in a global repository (CES-DW). In this Node, a Global Dashboard module (GDB) summarizes the main indicators representing the whole set of CEs adopting the system. Moreover, the GDB module allows organizations and collaborative enterprises to benchmarks their performance.

One of the role of the Aggregator Node is to gather data from the Base Nodes and to enrich KPI models with user-preferences for the collaborative filtering part of the recommender system. The ontological model of the global context is built by the GC module, also based on the information coming from the public information available on CEs (PCE module) and on single organizations (PSF module). All the above-mentioned ontological models are based on the Global Ontology Manager (GOM) module. The ORS component collect contextualized recommendation data and send it to the Base Nodes. To summarize, the aggregator node retrieves information from different sources on component organizations, financial and non-financial data, contracts, KPIs, etc. and stores them in the respective databases. The Ontology-based modeling of both single organizations and CEs easily permit to classify CEs and their organizational structures. Other context data comes from sources, such as public data (e.g., financial statements, publicly available in several countries, web pages, collaboration agreements), organizations internal data (e.g., business plan, business processes, etc.).

6 Use Case

The detailed design of the software system includes several use cases. Here, we present one of these use cases as an example. The main actor is the agent whose role is to monitor the performance of the collaborative enterprise. In order to do so, the CE must be already defined in terms of participants, goals and temporal perspective. The requirements defined in Sect. 3.2 is satisfied if the classification of the CE type is correct and the suggestion of the KPIs is compliant with the type and the goals.

In order to classify the collaboration, the system needs some basic information regarding the CE. The information can be divided in information regarding the individual organizations and information regarding the collaborative enterprise. The information on individual enterprises concerns the geographical area in which the organizations operate, the business sector; the business sector of the activities on which the individual organizations collaborate, the shared resources, the main goals, the role that the organization play inside the collaboration. The information on the collaborative enterprise concerns the expected years of collaboration, the number of participants, the main goals, the joint activities. This data is also used in order to determine other relevant information, such as the temporal horizon (short, medium or long term), the CE size, the organizational structure (from the roles), the integration type (from the business sectors), etc. Based on this, it is possible to determine the type of collaboration and to check its compliance with the main goals. This information, compared with the goals, is then used to derive domain-specific KPIs.

Let us suppose that we have a CE made up by 81 organizations (bathing establishments), which aim is to increase the overall competitiveness of the participants, by means of the increase of security on the beaches, the improvement of environmental sustainability and the coordination in the supply of services. Since all organizations are operating in the same business sector, we know that it is a big (81 members) horizontal alliance, with a long term perspective (no term defined). From this input, the system will return some domain-specific KPIs, such as the total occupancy of umbrellas, the space between umbrellas (to account for the quality of the service) and the % of recycled garbage. These KPIs are relevant for both the type of alliance and for the goals. Indeed, if we had known only the goals of the CE, it would not have been possible to eliminate KPIs such as, for instance, the reduction of the supply costs, the investment in research and so on.

7 Conclusions

In this paper, through the analysis of existing literature, we discussed how the research on Information Systems (IS) can contribute to reshape the performance measurement process to better integrate it in the management cycle. In this perspective, Information Systems (IS) have to face the new challenge offered by a networked society. Starting from the literature analysis, we elicit a set of high level requirement for the IS architecture and propose an approach to develop a comprehensive service, based on ontologies, for CEs governance and analysis, through the creation of a collaborative IS and of repositories. In particular, in the present work, we analyze the functionalities required to the IS, the role of ontologies and the high-level architecture. Finally, we discuss a use case in order to clarify how the recommender system functionality works. Indeed, the designed architecture is useful for understanding KPIs in relation to CEs goals, types and maturity signaling promptly anomalies and offering information on relevant variables, depending on the typology of CEs. The application of this approach is particularly useful when SMEs comes into play, since they often lack of the financial and the know-how required to enforce a complex and heterogeneous performance measurement system. Future research should move towards the development of cloud based IS designed for collaboration among SMEs.

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