

# Agile Information Systems for Collaborative Enterprises

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**Abstract:** In the last years, new challenges have arisen for both business and technical aspects due to the movement towards a collaborative-SMEs-driven society, where collaborative enterprises are used as catalysts of competitive advantages. However, between 50%-70% of Collaborative Enterprises fails, due to the lack of tools and methods to measure performance in an inter-organizational environment, where common boundaries of firms fail. In this scenario, a new role has been recognized to Enterprise Information Systems. As stated from FInES annual report, IS should “enable new forms of participation and collaboration, catalyze further the formation of networked enterprises and business ecosystems. In this project, a possible solution to face these challenges is offered. The general objective is to build a framework and a set of tools to support the governance of CEs through monitoring and benchmarking. This can be enabled through a comprehensive online service, based on enterprise modelling techniques, the creation of a collaborative web application and of repositories, taxonomies and ontologies for CEs.

## 1 INTRODUCTION

In the last twenty years, organizational relationships have moved from intra-organizational to inter-organizational ones and are moving towards trans-organizational relations, with a prediction of a speed for value creation never seen before (Bititci et al. 2012). However, it is known that globally 50%-70% of CEs fails, often due to the lack of a comprehensive analysis that combine strategic goals and KPIs (Kaplan et al. 2010; Bititci et al. 2008) with a possible negative impact on component firms. The risk of failure or low success for CEs “... is mostly the avoidable result of inadequate governance resulting in inadequate strategy development and implementation” (Hoogervorst 2009). Indeed, performance measurement is a key element in turning goals into reality (Popova & Sharpanskykh 2010).

This has led to new challenges related to the performance measurement in a collaborative-SMEs-driven society for both business and technical aspects.

Indeed, as stated from the “Future Internet Enterprise Systems” annual report, Information System (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” (FInES 2010). Therefore, the question is how to design and develop IS for CEs and for networked SMEs. In particular, the monitoring should be performed at two level of granularity, which are the CE level and the firm level, with a guarantee of comparability between KPIs and perspectives of the two levels. More in detail, at each level it is important to offer domain-specific KPIs (Parung & Bititci 2006), which depends on the type of the CE, on the maturity of the collaboration and on the goals of the CE. In this project, a possible solution to face these challenges is offered.

The work is structured as follows: Section 2 is for the outline of the research problems and Section 3 for the objectives of the research. In Section 4 an analysis of the current state of research is presented. In Section 5 is for the methodology and Section 6 for the stage of the research. Section 7 is for the expected outcome.

## 2 RESEARCH PROBLEM

Performance measurement is a key aspect in the

management of all kinds of organizations, no matter if the level of granularity is the individual enterprise or a CE. In particular, through performance measurement and KPIs analysis it is possible to understand if the organization is achieving its strategic goals. Indeed, monitoring and benchmarking are essential in order to notice promptly a gap between goals and achieved result and to define which actions to undertake in order to reduce the gap. However, performance management has a high degree of complexity in inter-organizational settings, due to the fail of traditional organizational boundaries and it is not yet possible to analyze in detail which costs and which revenues of a firm are ascribable to the CE. Thus, currently it is not possible to know in detail the impact of a CE on components firms. Indeed, although several authors (Caglio & Ditillo 2008) studied the role of management accounting in inter-organizational environments, no one applied these results in order to quantitatively analyze the performance of CEs and of involved firms (Bochicchio et al. 2013; Bititci et al. 2012; Krathu et al. 2013). In addition, in several proposals, the skills required for CEs' managers are far from those available in the largest part of existing SMEs. In this context, firms and CEs would benefit from methodologies and tools allowing them to better link desired objectives and achieved results in an inter-organizational environment. In other words, firms could find useful having more structured and rich information not only on their own performance but also on how it compares with partners and competitors (Parmenter 2011), even in different CEs, in order to understand the drivers of CEs' success and, thus, to enhance their performance. Moreover, benchmarking within a CEs, even with a comparison of synthetic data, enable the analysis of benefits, of their distribution among partners and of the performance drivers for the CE. Indeed, firms are concerned both with performance drivers and targets; therefore benchmarking is relevant not only for KPIs comparison, but also for the identification of the "collaborative practices" that contribute to the success of a CE (Simatupang & Sridharan 2004).

This implies, for managers, the ability "to observe and evaluate", the awareness of "being observed and evaluated", a stronger perception of the "value of the collaborative enterprise", the personal consciousness of the "impact of CEs on firms" (and vice-versa) and the knowledge of the different meaning that performance indicators assume in a collaborative enterprise. 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 the style of management adopted for modern CEs, 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 a networked society (FInES 2012). In traditional control systems built for individual enterprises, there is a clear-cut between external and internal environment. Indeed, whilst for CEs it is possible to use the same performance measurement frameworks used for individual firms, it is still necessary to structurally and operatively change the measurement system (Bititci et al. 2004).

**General Problem.** *In order to measure performance in CEs there is the need to develop an agile Information System built for inter-organizational and changing environments and able to analyze the phenomenon.*

In particular, the same KPI can be calculated or interpreted in several ways, making them not comparable within a CE or among different CEs (P.1). This problem concerns both financial and non-financial KPIs and derives from the need to share a common understanding of the domain (Bertolazzi et al. 2001).

**Problem 1.** *In order to monitor CEs and to perform benchmarking within and between CEs and firms in CEs, it is necessary to share a common language for KPIs.*

Moreover, benchmarking within a CE enable the analysis of benefits, of their distribution among partners and of the performance drivers for the CE. Indeed, firms are concerned both with performance drivers and targets; therefore benchmarking is relevant not only for KPIs comparison, but also for the identification of the "collaborative practices" that contribute to the success of a CE (Simatupang & Sridharan 2004). However, CEs are heterogeneous clusters of partnerships among enterprises (FInES 2012). CEs can indeed be of different types (e.g., horizontal CEs, vertical CEs), be at different stages of maturity and have different goals. In this frame, it is obviously not enough to compare CEs only taking into account the business sector or the size, but other factors, such as the CE type, maturity, organizational structures and goals, come into play.

**Problem 2.** *There is the need to analyze and understand CEs type, lifecycle, organizational structures, roles and goals in order to comprehend the phenomenon.*

**Problem 3.** *CEs goals, types, structure, role and maturity are relevant in order to perform an effective and accurate benchmarking.*

Moreover, different CEs types need for different KPIs (Parung & Bititci 2006); therefore firms and CEs have to understand which KPIs are relevant and what a KPIs mean in a given firm or a CE with defined goals. However, this kind of understanding is not immediate, especially in several SMEs, which lack of the know-how needed to perform this kind of analysis and often choose the more “known” KPI, instead of the more relevant one, with possible negative effects on the CE equilibrium. Therefore, CEs need to understand which KPIs are relevant for them, considered their “type”, maturity, and “goals”.

**Problem 4.** *Build domain-specific KPIs, which means KPIs specific for the CE type, maturity and goals.*

Furthermore, CEs are a multifaceted phenomena, that is sometimes difficult to analyze and to comprehend in abstract ways. The analysis by itself of CEs’ goals, CEs type and related KPIs could be misleading for firms and CEs.

**Problem 5.** *Reduce the complexity of the analysis and of the monitoring of CEs performance, through graphical representations.*

Moreover, in order to “track” and store KPIs large enterprises usually benefit from internal control systems (Enterprise Information Systems), whilst SMEs perform, whenever that even happens, a manual analysis of their financial statements and compare their values with those of similar firms, by means of public databases of financial statements. The choice is often due to the high costs and the complexity of EIS.

**Problem 6.** *Build Information System suitable for SMEs, that means more user-friendly.*

Finally, firms who cooperate need to exchange information (e.g., on their transactions, goals), since this can increase their performance (Essa et al. 2013). Also, in case they decide to share more data not only with partners but also with other firms, this can increase the effectiveness of benchmarking.

**Problem 7.** *Enable information sharing with partners or with other firms and CEs.*

### 3 OUTLINE OF OBJECTIVES

Aim of the project is to build a framework and a set of tools to support the governance of CEs through monitoring and benchmarking. The sub-objectives

include: (a) the definition of a shared knowledge on KPIs formulas, rationales and explanations; (b) the classification of CEs types, lifecycle, organizational structure and firms role in order to perform an effective benchmarking; (c) the analysis of the linkage among KPIs, CEs goals, type, maturity and structure; (d) the analysis and use of graphic tools to facilitate the comprehension of CE-related phenomena; (e) the design, prototyping and testing of an online service suitable for CE-oriented SMEs and for information sharing among partners.

## 4 STATE OF THE ART

At the best of my knowledge, there are no tools or conceptual framework offered as a means of operatively manage and quantitatively analyze collaborative enterprises. Therefore, in this paragraph is presented a short analysis of the literature on performance measurement and enterprise modelling for collaborative enterprises, on enterprise ontologies and on cross-organizational Information Systems, which are necessary for enabling performance measurement. For each topic, the current state of research, the existing gap and the prospective of future research are analyzed, thus outlining how these topics have to evolve in order to face the new challenges deriving from the changes in society.

### 4.1 Performance Measurement

Performance management and performance measurement have a key role in the assessment of CEs and of how the CE is affecting firms, according to the principle of “if you cannot measure it, you cannot manage it” (Kaplan & Norton 1996; Parung & Bititci 2006). Indeed, several authors (Caglio & Ditillo 2008) have analyzed control mechanism in inter-organizational environments, such as management accounting. In particular, in CEs the monitoring can operate on three layers: a) firm; b) effects of the CE on the firm; c) CE. For sub-c) researchers and practitioners propose several guidelines, performance and cost management tools (e.g., modified Balanced Scorecard and scorecards) (Fayard et al. 2012; Kaplan et al. 2010) and enforcement methods, such as Open Book Accounting (Caglio & Ditillo 2012; Romano & Formentini 2012; Agndal & Nilsson 2010). In particular, Open Book Accounting (OBA) allows firms of a network to share accounting information, which enable an improvement in the decision

process (Caglio & Ditillo 2012). However, many firms are reluctant to disclose these data, because OBA is sometimes seen as formal control mechanism that damages trust (Windolph & Moeller 2012). Moreover, while there is a consolidate literature on sub-a), there are still few works on how to measure the effects of networks on firms (sub-b)) (Dekker 2003), and even in those there is no focus on quantitative aspects (Bititci et al. 2012; Bochicchio et al. 2013). Furthermore, there are few works that takes into account both CEs and SMEs (Pittino et al. 2013; Lee 2007). Nonetheless, performance management and performance measurement have a key role in the assessment of the achievement of CE goals and of how the partnership is affecting firms. Therefore, whilst we are going towards a network-SMEs-driven society, new challenges arise for performance measurement system, since they have to be developed and used across the traditional organizational boundaries. The question is how to manage both the performance of CEs and of firms for SMEs (Bititci et al. 2012). In order to face this question, 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 individual firms, it is still necessary to structurally and operatively change the measurement system (Bititci et al. 2004).

## 4.2 Enterprise Modelling

The research on enterprise modelling has three main topics. Some authors focus on the analysis of business processes (Comuzzi et al. 2012; Pan et al. 2004), others on the information architecture (Kulkarni 2012) of firms and some others on the modelling of strategic and organizational aspects as well (Strecker et al. 2011; Frank 2012). In this sense, a comprehensive research work in this field has been performed at University of Duisburg-Essen (MEMO: multi-perspective enterprise modelling). For the purpose of this research project, MEMO and MML (Meta Model Language) are relevant because of their ability to model software engineering, social, managerial and economic aspects of the firm (Strecker et al. 2011).

In general, modelling has several benefits for firms and for collaborative enterprises, such as: understanding how a CE works, giving a starting point for the re-arrangement, whereas needed, of the CE, giving a starting point for the development of IS for CEs and so on (Steen et al. 2002). In particular,

the need for EM is even more relevant in CEs, due to the increase in complexity. However, still few works exist on the subject. Therefore, the question is how and in what measure current EM techniques and tools can be used in order to face the issues deriving from the inter-organizational setting.

A possible solution could come from the principles adopted in Service Oriented Architectures for service compositions, i.e. by adopting graph based representations and graph-theory to represent and manage the network of relationships in CEs and among CEs. Other examples come from the adoption of a graph-based notation for collaboration contracts.

However, there is still much to do in order to culturally change for manager the awareness of CEs and to make possible for enterprise modelling to have an active role not only in single firms, but also in CEs.

## 4.3 Cross-organizational Information Systems

Coordination among partners is a key factor in order to achieve goals. This can result only from a flow of information among and within organizations (Eckartz et al. 2010), which can be assured by Information Systems (IS) and, in more detail, Enterprise Systems (ES) that takes into account the inter-organizational setting. An IS is indeed made by a set of applications which allow the collection, elaboration and storage of information useful for the decisional or operational processes (Laudon & Laudon 2011, p.15; Bracchi et al. 2010, p.1). However, according to the contingency theory, a change in the organizational structure, imply a change in the IS. Information Systems usually distinguish and oppose relations within a firm, from those across it. However, in an inter-organizational setting it is necessary to broaden data sources so to include partners as well and to consider them as a beneficiary of the information (Håkansson & Lind 2004). While at the business level coordination comes from coordination mechanisms, at the ES level, it is performed through shared databases, data warehouses, workflow management systems, web services, service oriented architecture (SOA) or cross-organizational ERP, which are used from several independent firms whom cooperate in an inter-organizational environment (value web) (Daneva & Wieringa 2008). Although even coordination mechanisms at the business level are partially integrated with ERPs, however the use of a cross-organizational ERP system can lead to a lost



on flexibility because it implies processes standardization and collaborative relations are now always stable. This limit can be overcome through customization; however it is usually very expensive and, therefore, is out of the reach of SMEs. Moreover, Information Systems represents only a potentiality for change, but in order to fulfil it there is the need for certain organizational characteristics (Maraghini 2010). Therefore, the actual implementation of cross-organizational ERP is not suitable for CEs in the first stages of cooperation. Moreover, most of IS adopted are not cross-organizational; thus, “they focus on a single enterprise with some supports towards sharing performance information with external parties” (Bititci et al. 2012). However, the key element in the future seems to be “cooperation” (Missikoff 2012), whilst 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” (FInES 2010). Therefore, the question is how to design and develop IS for CEs and for networked SMEs. Nowadays, there is a lack of a model which allows: a) in the pre-alliance phase, the opportunity of engaging in a CE; b) in the operational phase, the evaluation of goals achievements. In particular, the monitoring should be performed at two level of granularity, which are the CE level and the firm level, with a guarantee of comparability between KPIs and perspectives of the two levels.

#### 4.4 Enterprise Ontologies

Nowadays enterprise are entities far more complex than in the past; therefore, it is not easy to manage them. In this frame, there was the need for a “...a conceptual model [...that is...] coherent, comprehensive, consistent and concise...” (Dietz 2006). Indeed, enterprise ontologies are developed and used for several reasons linked with enterprise modelling, such as the development of Management Information Systems and strategic decision support systems, Business Process Reengineering and the construction of Virtual Enterprises. However, still few enterprise ontologies have been developed and use in productive settings, due to the complexity and the novelty of the methods (Bertolazzi et al. 2001). In more detail, there are two enterprise ontologies, which are: a) the Enterprise Ontology developed from the Edinburgh Group (Uschold et al. 1996) and b) the Toronto Virtual Enterprise Project (TOVE) (Fox et al. 1993). However, there is still a lack of ontologies for CEs, which are entities more complex

than individual enterprises, or, more in general, for KPIs and performance measurement. A first step towards this direction if offered by a taxonomy for CEs, developed by a FInES taskforce (FInES 2012).

## 5 METHODOLOGY

For the development of the research project, a structured approach is adopted for all the four phases here described.

In the first phase, a KAOS approach (Bresciani et al. 2004) is used in order to elicit the requirements of the service. In particular, an analysis of literature on CEs is performed in order to outline the CE lifecycle and to define the potential stakeholders and their goals in each phase. Goals are then refined and transformed in requirements. The output of this phase is a requirements specification document covering all phases of the collaborative enterprise lifecycle. These requirements are used in the second and in the third phase in order to design the system.

In the second phase, starting from this preliminary analysis, CEs are modelled both from an organizational and strategic point of view by means of Meta Model Language (MML) (Strecker et al. 2011), and through ontologies, for the information architectural part. Indeed, in order to properly model and use KPIs, several layers of the CE have to be taken into account.

- MML is used in order to describe the organizational structure of the CE and the role of each partner, e.g., how the decision power is distributed, if there is a vertical structure, if there is a focal firm and so on. This model should be integrated with the ontology of CEs types.
- Ontology are used to semantically model CEs (main ontology) with regards to the following aspects which constitute the domain ontologies: CEs' lifecycle; CEs' goals, CE's type and KPIs. CEs' goals are modelled using the representation of the strategic level as starting point. The modelling of CEs' type is based on the taxonomy already elaborated by (FInES 2012), which will be enriched with other classes and instances, with the analysis of the relations among classes. Finally, the ontology of KPIs the ontology has the aim of representing a shared conceptualization of the domain (Bertolazzi et al. 2001) and to allow for the aggregation of the data of component firms and for the comparison of the information among different firms and CEs. For each KPI, informative contents are enriched through literature references on the basic KPIs,

their rationales, formulas and “limit” values (Strecker et al. 2011). KPIs are also linked with CEs’ types, goals and lifecycle in order to provide domain-specific performance indicators. For the development of these ontologies OWL, as language, and Protegé, as tool, have been selected.

Indeed, ontologies are particularly useful in this context because of the heterogeneity of data connected to CEs, which are often stored in documents like contracts, textual reports, financial statements, web pages, and so on. Therefore, for the processing of these sources the use of Semantic Web techniques is suitable.

- Finally, information on CEs type, maturity, goals, structures and KPIs will be represented graphically by means of data and information visualization tools, such as hypertrees.

In Fig.1 is visually represented the second phase.

In the left part, the objects of analysis are shown. In the second column, each object of analysis is linked with the method (except for the visualization tools, which take into account the outputs). In the third column the outputs of the use of methods on information objects are represented. Finally, in the right column the overall results are shown.

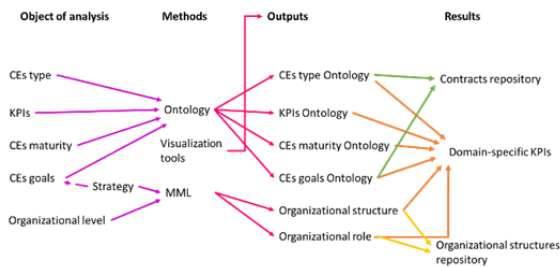


Figure 1: Second phase of the methodology.

The results of the second phase are: (a) the development of reflective (Strecker et al. 2011) domain specific KPIS, starting from the information on CEs type, maturity, goals, structure and KPIs types; (b) the modelling of the organizational and semantic level of CEs; (c) the visual representation of the elements. In the third phase, the collaborative, cloud-based Information System is designed through a structured approach based on HDM/IDM (for the hypermedia design) and on UML (for all other modelling aspects) and developed. The IS should be composed by all the elements described in the second phase. Indeed, ontologies can be easily integrated in Java web application by means of tools such as OWLAPI. The Information system has three aims.

- Firms and CEs monitoring and benchmarking, through the creation of personalized dashboards, KPIs evaluation and information sharing. Using the models and semantic tools developed in the second phase, the IS should retrieve from different sources information on component firms, financial and non-financial data, contracts, KPIs, etc. and store them in a central database. The processing of data through the semantic layer, enable the system to define which is the type of the CE, its organizational structure. In this way the IS can propose the use of relevant KPIs, possible changes in contracts or in structures and pertinent comparisons with other firms and CEs.
- A repository of templates. Contracts or agreements and organizational structures, whereas available, can be furthermore processed, in order to make available an online repository of templates for CEs, such as those provided by the Legal-IST project ([www.legal-ist.org](http://www.legal-ist.org)), for firms 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.

In order to achieve these goals, data mining and semantic web techniques, Business Intelligence tools, relational databases and a cloud architecture will be used.

In the fourth phase, the validity of the approach and of the system will be tested, with the analysis of coherence with existing literature, of the usefulness of the approach to firms and CEs and of the performance of the IS. The coherence validation is aimed at analysing whether the research contribution is consistent with previous literature and can therefore contribute to existing literature: this analysis is particularly useful in the early-middle stages of the research, when it's not yet possible to test the system with users. Moreover, the usefulness of the approach will assess the contribution to practice of the research and will be tested through controlled tests with students purposely trained and, then, with managers of CEs. Both test will be performed in two phases. During the tests/experiments, each participant will act as a manager of a CE; therefore, individuals will receive a case study of their CE, with a description of the type, maturity, goals and participant firms. In the first phase, each individual will choose a set of KPIs that he consider more appropriate in order to understand the performance of his CE. Individual will be asked to make strategic decisions considering

the values of the set of KPIs and results of the choices will be evaluated. In the second phase, another set of individuals will be provided with a prototype of the system and they will be asked to perform the same tasks of phase 1. At the end of the second phase, the results will be compared with the ones of the first phase. Finally, the performance test will ensure that the system can be used by a large number of users, with an adequate level of performance.

The feasibility of the proposed approach is supported by the joint effort of two research groups, which cover the technical and business aspects of the project. The specific contribution of the PhD Student regards the requirements specification, the development of the ontologies, the design and test of the prototype of the online service and the overall management of the project research aspects. The contribution of the PhD Student, although contextualized in a broader project, has an autonomous scientific validity, whereas enterprise modelling is a fast growing research theme, as well as the design of IS.

## 6 STAGE OF THE RESEARCH

The first phase of the project is almost been completed. The requirements specification document is available, although it will be subject to change whereas new interviews with firms and CEs will highlight other key aspects. A preliminary version of the approach and of the requirements has been submitted to 26<sup>th</sup> International Conference on Advanced Information Systems Engineering (CAiSE Forum 2014). As for the second phase, the KPIs ontology is almost completed in its first version and is now being formalized with OWL. The KPIs ontology will be submitted to the Conference on Business Informatics 2014. The CEs type ontology has been drafted, and will be furthermore elaborated, partly through student theses. It will be submitted to the 15<sup>th</sup> IFIP Working Conference on Virtual Enterprises (PRO-VE 2014); an extended version will be submitted to EMISA 2014.

Regarding the third phase, a preliminary version of the prototype of the system has been developed and presented to itAIS 2013. The prototype is currently able to store quantitative data on firms and perform statistical analysis on financial statements.

The validation has been performed as coherence with literature for phase 1 and 2 and as performance and usefulness tests for phase 3. Each single component (i.e., ontologies, taxonomies, etc.) will

be tested and verified with a small set of users or simulated users (e.g. students trained to do so). Finally, the system will be integrated and the system test will be performed on a small group of final users.

## 7 EXPECTED OUTCOME

The expected outcome of the research project is the design and test of the prototype of a comprehensive online service, based on enterprise modelling techniques, for CEs governance and analysis, through the creation of a collaborative web application and of repositories, taxonomies and ontologies for CEs.

This system should offer a customized monitoring and benchmarking platform with a semantic layer able to analyze the CEs and to return a classification and relevant KPIs and CEs for benchmarking. Another expected outcome is the development of a KPIs ontology, a CEs ontology, a goals' taxonomy and a lifecycle ontology. Moreover, the online service should enable the creation of templates for contracts and organizational structures and the information sharing among partners. The approach should facilitate firms and CEs in the choice of which KPIs to include in the dashboard, thus which KPIs are relevant for their goals, CE type and maturity, therefore it should be a suitable approach for SMEs which lack of the financial and organizational resources needed for the adoption of cross-organizational ERPs. The design of the system will be based on a GORE analysis approach.

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