A Coordination Complexity Model to Support Requirements Engineering for Cross-organizational ERP

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Abstract

Cross-organizational information systems projects, such as ERP, imply an expensive requirements engineering (RE) cycle. Little is known yet about how to carry it out with more predictable alignment results and chances for success. We propose an approach that allows incremental, systematic improvement of cross-organizational RE. It builds on organizational network research,coordination theory, ERP misalignments, and existing RE improvement standards.

1. Introduction

Collaborative approaches to business are increasingly being adopted by many companies. In essence, such approaches mean restricting organizations to their core competence and letting them cooperate with others by using cross-organizational coordination support systems. The results are networks of independent, or nearly independent, businesses delivering value for a customer. An example is the business network of WalMart Stores Inc. who collaborates with a large number of non-U.S. companies and gives them direct access to the American market [2].

To operate in a value network, companies need information technology that supports this cooperation. They must collaboratively identify the requirements for this technology. We claim that for each company, there there are different complexity levels of coordination in a value network, and that if a company aims to be involved in cross-organizational coordination at a certain level, then certain RE techniques are relevant and others are not. We substantiate this claim by looking into cross-organizational RE for one specific type of cross-organizational coordination technology, namely Enterprise Resource Planning (ERP). We draw on our previously published results on the application of a coordination theory perspective to this problem [5]. Our earlier work yielded a library of ERP-supported coordination mechanisms that the requirements engineer can match to the coordination needs of the businesses participating in a network. In this paper, we refine out earlier work by introducing coordination complexity levels (section 3) and relating these to appropriate RE techniques (section 4). We start with a survey of background and related work.

2. Background and Related Work

As argued in our earlier paper [5], requirements for cross-organizational coordination are concerned with the goals, processes, data, and communication channels that partner companies share in a value network and with the way *how* these companies intend to share them. These requirements are derived from the overall business objectives of the value network, for example to become superb at a business proposition that delivers new value to existing clients [2,17]. For RE professionals to be able to determine ERP coordination requirements, an analysis of four forms of coordination needs to be carried out [5]: utility-oriented, semantics-oriented, process-oriented, and communication-oriented coordination. Each form includes specific coordination mechanisms that companies may decide to use in isolation or in combination and which are supported (to various extents) in modern ERP packaged systems. Each coordination mechanism is a set of activities enacted by people and ERP transactions that are then composed into the cross-organizational collaborative processes [5]. The choice for ERP adopters is to arrange these coordination mechanisms in a way that makes it possible to achieve the execution of the cross-organizational collaborative processes.

Our approach to coordination RE rests on literature on:

- organization network research [12,15] which gave us the cues of why and how companies participate in networks;
- coordination studies [1,11] which provided background on how companies manage what they share in a network;

- ERP misalignments [3,5,9], which brought us to a hypothesized model of the trade-offs to be made in cross-organizational ERP implementations; and
- ERP RE [5,7,14] which helped us think holistically about the implication of our coordination theory perspective for RE professionals.

Our analysis of these sources indicated that ERP misalignments have been explored by both RE and IS communities, who approached them from a variety of perspectives but primarily in intra-organizational context. Very few explicitly explored how to prevent cross-organizational ERP misalignments [3,5,9]. Notwithstanding the extensive body of contributions, the literature fails to provide an ERP approach able to capture the multiplicity of inter-company coordination and architectures that fall under the term network.

3. Modelling Coordination Complexity

To facilitate the use of our library of coordination mechanisms [5], we sought to lay out a foundation for good cross-organizational RE practice. A useful starting point is the industry's current trend to build value networks by using three key participation forms [2], namely, participation on the buying side, on the sales side, and in intermediation. For example, we found that companies select different ERP-supported coordination mechanisms [5] to support different participation forms. Also, a company who shares processes with both its suppliers and corporate clients has requirements for coordination and alignment that are different from those of a company who shares a process with its individual consumers only. And this in turn has implications for RE practices.

To lay out the foundation for the systematic, incremental adoption of good ERP RE practice in cross-organizational projects, we first developed a coordination complexity model and, then, we linked it to existing RE improvement models. Our coordination model reflects our conviction that, although many unsolved problems exist in ERP RE due to misalignments in the coordination requirements, many of them can be solved by using a well-established good practice. Even where cross-organizational coordination requirements problems are inadequately understood, the consequences for individual projects can usually be contained if adequate support exists within the cross-organizational ERP RE process.

To model coordination complexity, we adapted Champy's levels of participation [2] to the context of implementing cross-organizational ERP coordination support systems. We defined four levels of coordination complexity, each reflecting how extensively a company crosses organizational boundaries and each characterized by types of partner companies involved, unique cross-organizational coordination goals, areas of sharing, and coordination mechanisms used. The more diverse the business actors are in a value network, and the larger their number, the greater the coordination challenge [2,15,17]. So, Level 1 represents the least challenging coordination scenarios and the least complex alignment requirements, while Levels 2, 3, and 4 successively progress to more and more challenging coordination processes and more complex alignment requirements. The levels are defined as follows:

- At Level 1, a company aligns its own processes. An ERP-adopter at Level 1 has the goal to improve internal coordination among departments.
- At Level 2 an organization aligns its processes along with the processes of one other type of organization. A Level 2 ERP-adopter's goal is to improve coordination with this type of organization, namely either a client, or a supplier [2].
- At Level 3, a company aligns its processes along with the processes of two other types of organizations. A Level 3 ERP-adopter's goal is to improve coordination with two more company types, e.g. suppliers as well as clients.
- At Level 4, a company aligns its processes with the processes of organizations of three other types. A Level 4 ERP-adopter works to improve coordination with three other types of organizations. At this level, it is not uncommon for these networks to change the coordination mechanisms in an entire business sector [9].

We observe that the choice of ERP-enabled coordination mechanisms that companies use as vehicles for sharing, depends on the coordination complexity level the companies decide to target. This observation came out of a study done as part of preparing this paper. Therein, we screened the 2005 list of Fortune 500 public companies [8] to identify those using ERP coordination technology. For each, we determined its coordination complexity level and the forms of ERP-supported coordination it activated to align its network partners' contributions to the entire cross-organizational processes. A detailed list of the sources in this study is available from the authors. Due to space limitations, we use in this paper a subset only which refers to circa 30 companies [2,4, 6,9,10,17].

4. Augmenting Existing ERP RE Practice

Our coordination complexity model served as input to the process of augmenting the state-of-the-art ERP RE practice. As our expertise lies in SAP package implementation, we chose to extend the Accelerated SAP (ASAP) RE framework [7] with guidelines that directly address the cross-organizational coordination requirements problem. The extension work was done by following the REAIMS project's [16] approach to qualitative assessment of RE practices. We abstracted 13 good practices from ERP experience reports on coordination, standards, and the first author's experience [7] and related these to coordination goals at each coordination complexity level. When formulating each practice, we considered how it can be introduced to an RE team, how it can be implemented, what benefits would bring to the project and what are the costs people may expect to incur due to the practice [16]. We, then, added the newly formulated practices to the existing ASAP RE framework. We have recognized that, while agreement is likely on the utility of some practices, the benefits of others are dependent on the position of the ERP adopter in the value network. To reflect this, we classified the practices according to whether they seem mostly applicable to organizations with coordination complexity level 2, 3, and 4. Table 1 presents three out of our 13 practices that resulted from this analysis. Table 1 formulates each practice as a RE guideline, explains what form of cross-organizational coordination the guideline addresses, indicates the benefits expected to happen when the guideline is implemented, and suggests the coordination complexity level of an organization most relevant to use and benefit from the guideline. The data in the rightmost column is not derived empirically. Instead, it is concluded from the first author's experience in cross-organizational projects (while being employed by TELUS [7]) and from case study reports about seven ERP adopters, namely IBM, Intel, Hewlet Packard, Lear Automotive, 3COM, Moen, and DHL, who developed and managed SAP global roll-outs [13]. They are therefore hypotheses that must be tested in further research.

Table 1 Cross-organizational ERP RE practices.

RE Practice	Coordination form	Key Expected Benefits	Relevant Complexity Level
Document values and goals to be shared and with whom.	Supports utility-oriented coordination	1. Documented shared values and goals is what will drive the cross-organizational ERP RE process and will keep partners with conflicting interests focused on what counts. 2. It increases one's sensitivity to cross-organizational factors which are potential sources of misalignments and which may conceal the real coordination requirements from requirements engineers. 3. In requirements validation, each process or data requirement can be validated against how it supports the shared goals and values.	4
Define how work gets divided between partner companies.	Supports utility-oriented coordination	1. Statements about shared vision and services are input to feasibility analysis to assess whether or not ERP coordination technology can effectively be integrated in the network's envisioned way of working. 2. Understanding which process fragments are executed by whom in a collaborative process model clarifies who to consult in selecting coordination mechanisms and validating the coordination requirements.	2, 3, 4
Collect enough knowledge about the ERP supported internal processes at each company before starting designing the cross-organizational ERP scenarios.	Supports process-oriented coordination	1. Knowledge of internal ERP processes helps making sure that what external coordination processes require can be integrated with the past, current, and future solution development plans of each partner company. 2. It helps understand which requirements of each partner are rigid and which are flexible and why.	3
Document the data which applications separately kept at partners' companies will share via interfaces to a common ERP system.	Supports semantic-oriented coordination	1. Fewer requirements for unnecessary customization. Unanswered questions of how applications would share data means complex and expensive customization in the later project stages if business owners find themselves unprepared to change their process designs late [7]. 2. Conforming to some company-specific interfaces may be an important interoperability requirement for the cross-organizational system.	4

5. Preliminary Assessment of Practices

As a preliminary sanity check, we compared our cross-organizational ERP RE practices to what experts see in their project realities. We presented the 13 practices as a checklist to eight ERP solution architects from four organizations in the telecommunications sector and asked them to review the checklist and mark those practices which they either personally used or witnessed someone else on the RE team using it in the early stage of their projects. The architects were selected among the American SAP User Group (ASUG) in Telecommunications. Each architect had at least six years of experience in cross-organizational ERP RE. Six of them were employed at Level 3 ERP adopters and two were working for Level 4 ERP adopters. Their responses indicated that 12 out of 13 practices made sense and were actually observed in real-life projects. One practice was not observed at all but this may be due to the fact that this practice refers to coordination with a company who is an intermediation business and that none of the architects worked on a project with intermediation businesses.

6. Results and Future Work

In cross-organizational ERP RE, the coordination goals for a system are the partner companies' shared goals to do things together. Our position is that while coordination requirements are not traditionally distinguished in the ERP vendors' standard RE processes, they can be incorporated simply by using the list of practices we suggest in this paper. As our approach is still developing, results are not yet definite. However, they are still worthy of being shared: We delivered a coordination complexity model that can serve as an instrument for determining and translating the goals and the needs of an ERP adopter for cross-organizational coordination into RE practices that offer practical solutions to certain challenges. The immediate benefit of our effort is that it makes knowledge about engineering cross-organizational ERP coordination requirements available to both researchers and practitioners for further evaluation or adoption. Preliminary assessment of the practices indicates that they make sense to ERP requirements architects, they add to existing RE practice, and that they are worth exploring in future case studies. However, we acknowledge the threats to validity because all eight architects came from one domain, telecommunications, and they all have only limited exposure.

Our future activities include carrying out case studies at companies' sites and action research to complete the approach and validate it internally and externally [18].

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