The Life Cycle Challenge of ERP System Integration

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Abstract

To serve its purpose as a backbone for business integration, Enterprise Resource Planning (ERP) systems need to be integrated with other information systems inside and outside the boundaries of an enterprise. An inductive case study was made to examine a long-term ERP system of a large manufacturing enterprise to better understand the nature and importance of ERP system integration. Our results can be summarized as four findings about the current life cycle models: 1) integration should be a major consideration when choosing ERPs, 2) deployments are continuous, 3) external integration is not just an extension phase after the project and 4) integration remains as a continuous challenge which is never fully achieved due to the constantly changing business requirements and organizational landscape. The results can help managers when making decisions on integration issues, yet effective approaches for integration governance are needed in order to avoid the increased costs and complexity.
Keywords: Information Systems, Enterprise Systems, ERP, Enterprise Resource Planning, Integration, Life Cycle, Case Study, Manufacturing Enterprise.

1. Introduction

Originally, Enterprise Resource Planning (ERP) systems integrated the core business functions of an enterprise [1]. Later, due to the requirements of collaborative business, the challenge of integration evolved from inside the company to consider also the customers and business partners [2]. In a modern enterprise, a multitude of different systems exists ERP being just one of them and integration of these systems is an unavoidable evil [3].

ERP systems have been investigated comprehensively since the mid-1990s. Especially, the implementation process of an ERP system [4] and critical success factors in ERP implementation projects [5] have been studied. ERP systems have become de facto standards in providing the backbone for enterprise integration and more attention has been paid to extending the ERP system through external integration with supply chain [6].

However, in the field of Information Systems (IS), *integration* has been identified as an "omitted variable" and a misunderstood concept [2, 6]. In addition, studies on ERP integration often focus on the integration of an ERP system and a specific target system [7]. We propose a broader perspective on ERP system integration by setting the following research question: *How does integration evolve during the ERP system life cycle?* We made an inquiry into the practice by conducting an inductive case study in a large manufacturing enterprise. Based on our meetings and interviews with practitioners, we concluded that the existing life cycle models fail to describe the nature of ERP system integration. After presenting the background of this study and briefly describing the research approach and the

case organization, we present the findings and compare them with the existing life cycle models. Before concluding the paper, we consider the reasons why our findings conflict with the existing models and discuss about our future research intents.

2. Background

2.1. ERP System Integration

As a term, *integration* is ambiguous and has different meanings. In the domain of IS, it is often considered as data exchange between two or more systems, standardization of business processes as well as cooperation and coordination between human actors [1]. There has been advances especially in integration technologies such as those related to EAI (Enterprise Application Integration) and SOA (Service Oriented Architecture) to overcome the technical challenges of integration [22]. However, it has been concluded that solving integration problems often requires combining of different technical approaches, instead of being solved by a single approach [10]. Moreover, integration has been identified as a socio-technical challenge that includes, besides the technical side, also organizational and social aspects [2].

Integration of business functions is the goal of an ERP implementation as the ERP system integrates business functions inside the organization and enables data flow between different units of an organization [9]. Moreover, numerous other information systems, such as Decision Support Systems (DSS) [12] and Manufacturing Execution Systems (MES) [13] are still needed, and application-level integration with these systems is necessary. The functionality of an ERP system is often enhanced by bolt-on applications, such as CRMs (Customer Relationship Management), and WMSs (Warehouse Management System) [21]. Because the purpose of a contemporary ERP is to provide the backbone for business collaboration, external integration with business partners' systems has to be done [2]. Another form of ERP system integration is to provide interfaces for users to access the system on mobile. This type of integration is called portal-oriented application integration where an interface is built to display the desired information needed by the intended user group [10]. Thus, we understand ERP system integration as a multidimensional *activity* that includes building of interfaces and managing of interconnections between the ERP and other internal and external systems during the ERP system life cycle aiming at *interoperability* between the systems.

2.2. Existing ERP System Life Cycle Models

We define life cycle as *a progression through a series of differing stages of development*[1]. By this we mean that an ERP system evolves through certain steps or milestones from the point when the acquisition decision is made to the point when the system is abandoned. We distinguish the life cycle models from software development methodologies. We see that development of an ERP system may utilize a variety of development methods. For example, the pilot version of the system may evolve through a strict waterfall process starting with a comprehensive definition phase and later, more features to the system can be implemented with agile approaches. Since our intent is to examine how integration evolves through different stages in the life cycle, comparing our findings to the life cycle models instead of development methods is necessary.

To our knowledge, four ERP system life cycle models have been proposed [5, 11, 16, 17]. Due to the limited space available for this paper, a comprehensive presentation of these models is omitted. Instead we focus on high-level comparison of the models and investigate how integration is presented in each of them. We intuitively classified the phases of the models according to the following categories: planning and design, implementation, using the system, improvement and extension and migration to a new system. In Figure 1, the phases of the life cycle models are shown and categorized.

[1] http://www.thefreedictionary.com/life+cycle

	Planning and design	Implementation	Using the system	Improvement and extension	Migration to a new system
Model 1: Esteves and Pastor (1999)	Adoption Decision, Acquisition	Implementation	Use & Maintenance	Extension	Retirement
Model 2: Ross and Vitale (2000)	Design	Implementation	Stabilization	Continuous Improvement	Transformation
Model 3: Markus and Tanis (2000)	Project Chartering	The Project (configure & rollout)	Shakedown	Onward and Upward	
Model 4: Rajagopal (2000)	Initiation, Adoption, Adaptation		Acceptance, Routinization, Infusion		

Fig. 1. Classification of the phases in the existing life cycle models.

Model 1 and Model 4 emphasize the planning and design by dedicating more than one phase for it. Model 4 does not have a dedicated phase for implementation unlike the others. Instead, the system is implemented in between "Adaptation" and "Acceptance". All the models identify the phase when the system is used. Model 1 and Model 2 have similar phases in post-implementation (the phases after implementation) considering adding more capabilities to the system, and migrating the system to another while the other two models do not have such emphasis on post-implementation. Unlike Models 1 and 2 that are waterfall-style models, Models 3 and 4 are iterative in which all the previous phases are revisited when an upgrade or retirement of the system is made.

Models emphasize integration differently. Model 1 has a dedicated phase for integration, "Extension". During this phase, more capabilities are integrated into the system and external collaboration is considered. Similarly, Model 2 considers "Continuous improvement" as a phase in which new modules and bolt-on applications are added to the system. Model 3 highlights system integration and roll-out during the project phase of the system. In addition, "Onward and upward" continues until the system is replaced by an upgrade or extension, which then starts a new cycle. Model 4 treats integration as milestones during the phases after implementation. "Integration of functional units" happens in the acceptance phase, "Oganizational integration" is realized in the routinization phase and "IT integration at global level" is realized in the infusion phase. To summarize, in these models integration is either regarded an activity during or after the implementation or it is considered as "milestones" that are reached during the life cycle.

3. Research Approach

Adopting Organization (AO, the organization taking the ERP system into use) is a large and global manufacturing enterprise with an annual turnover over 9 billion euros. AO decided to build a fully-customized ERP system for sales and logistics in order to replace several legacy systems and also to overcome the year 2000 problem without having to make the necessary updates to all the systems. The implementation started in the middle of 1990s and during that time the existing ERP packages did not have the desired functionality to support business processes of the domain and control the complex supply chain in AO's specific business field. The ERP project went through major challenges, including redesigning the insufficient system architecture and a large merger of two companies during the early phases of the implementation. Eventually, the project greatly exceeded the intended budged. However, at the time of writing, the system is currently in a global use and it is still in constant development. Benchmarking against ERP products in the market is constantly being done, but for the time being, AO has decided to keep the system to handle its core business processes. Figure 2 displays the timeline of the ERP system of AO including some of the key events that have occurred in the life cycle.

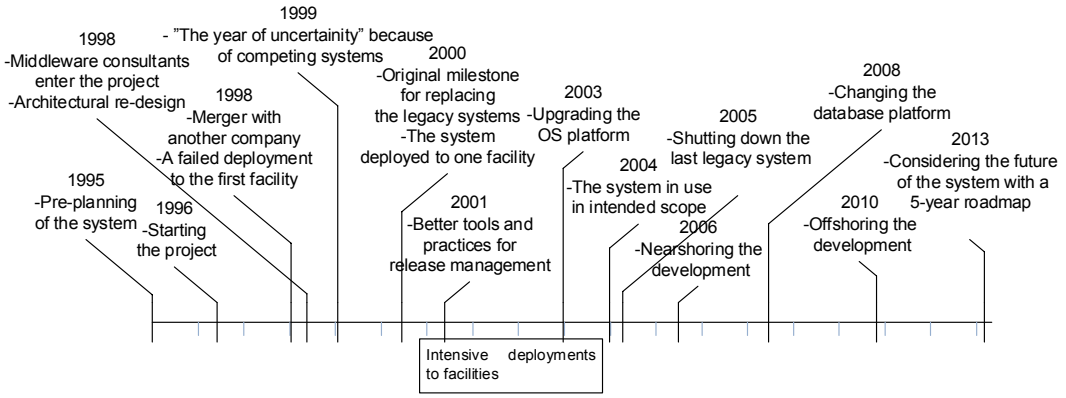

Fig. 2. ERP system timeline of the case organization.

The data for this study was collected with theme-based interviews, conducted between February and May 2013. The main goal of the interviews was to understand the role and practice of ERP system integration. The inquiry into a complex organizational phenomenon led to an approach in which, instead of determining a large number of fixed questions addressing specific areas of interest, the questions for the interviews were open-ended, focusing on the interviewee's experiences during ERP system development. For example, major challenges and successes experienced in ERP development were asked. The more detailed questions were asked based on the received responses. This way, we were able to get a rich set of data for further investigation.

Interviewees from AO:	**Interviewees from Vendor:**	**Interviewees from Middleware Provider:**
AO1: Business-IT negotiator	S1: Software manager	MP1: Middleware manager
AO2: IT manager of a business area	S2: Service owner	MP2: Technical consultant
AO3: Programme manager	S3: Continuous service manager	
AO4: Enterprise architect	S4: Infrastructure manager	
AO5: IT manager of sales	S5: Project manager	
AO6: IT support manager	S6: Lead software developer	
AO7: Representative of logistics	S7: Service manager	
AO8: Project manager		

Fig. 3. Roles of Interviewees.

The data collection started with discussions with our key contact person from the upper management of AO. The goals of the research project were briefly presented to him in order to identify the right persons to interview. In general, the snowballing technique [3], in which the next interviewee is a referral from the previous one, was used for selecting the interviewees to get different viewpoints to the same issues. In total we interviewed 17 industrial experts that had different positions, ranging from upper management to mid-level management and developers, and included people from AO, the supplier (the company that implemented the system) and the middleware provider (a consulting company that helped adding a middleware product to the system). Interviewees' roles and their organizations are listed in Figure 3. Due to the long duration of the ERP system development, the roles and responsibilities of the interviewees have been constantly changing. Some of the interviewees have been intensively involved in the early implementation of the system whereas others are currently working with the system. The duration of interviews ranged from 26 to 73 minutes, the average being 45 minutes. The interviews were transcribed and the data was analyzed by using the coding techniques of Grounded Theory [3] by using a software tool called ATLAS.ti, but because of the limited space available for this paper, the detailed description of the analysis is omitted.

In next section, we present four findings on ERP system integration that are in contrast with existing life cycle models, arguing that the models do not give a realistic image on integration in ERP system lifecycle.

4. Findings

4.1. Finding 1: The Emphasis on Integration in the Early Phases

Making decisions on system architecture and choosing the integration technologies turned out to be critical in the beginning of the project. The system architecture had to be redesigned because of the poor performance of the system that occurred when deploying the system to the first facility. It appeared that the scope of the system was not fully realized and it further increased as a merger with another company took place during the implementation phase:

"We underestimated the amount of staff and system and architecture solutions. Overall we had a large underestimation of the scale, which was then corrected along the way by bringing in the middleware [...]" –S5

Technical consultant argued that more comprehensive validation of technological solutions should have been done when making decisions on technologies in the design phase of the system development:

"I think [when investing several tens of millions to an ERP system] it's weird if there is no money for an extra validation round to be done in the very beginning. […] implementing one part of the system fast to see that will the chosen technology work at all, will it fly? [...] You should never believe in the sales speeches of salesmen, the organization should have sangfroid to test the options." –MP2

Even though the current life cycle modes have dedicated phases for the acquisition phase of an ERP project, none of the models emphasizes the integration capabilities of the ERP system. Model 1 highlights minimizing the need for customization and analyzing the maintenance services in the acquisition phase. Model 2 suggests that decisions on process change and standardization have to be made in the design phase. Model 3 lists general tasks that are to be done in project chartering, such as selecting the package, identifying project manager and approving the budget and schedule. Model 4 suggests choosing of appropriate technology and cost benefit analysis as tasks that are carried out in adoption phase. We claim that integration capabilities of the ERP system have to be emphasized in the early phases in the ERP system lifecycle.

4.2. Finding 2: Deployments and Therefore New Integrations are Continuous

It appeared that integrating the ERP system with internal systems was a challenging endeavor, because existing production planning systems in facilities were different and therefore needed their own integration approaches. As the company grew bigger, the scope of the ERP system increased and introduced more facilities that the system had to be integrated with. The last legacy system was shut down in 2004 and the project phase of the ERP system development, originally indented to be completed before the year 2000, was considered completed. However, roll-outs to new facilities were ongoing ever since. After the project phase, the business of AO extended to new geographical locations and some of the original facilities were shut down. Deployments to new facilities were going on in Europe, South America and Asia. The system was deployed to new facilities according to the global ERP strategy of AO:

"[The ERP system] replaces the existing system because of the synergy and integration benefits so it has been always taken into use." –AO4

Unlike in our case, the existing life cycle models mainly suggest that internal integration of the ERP system (including the deployments to facilities and also replacing the legacy systems) takes place during the project phase. Model 1 considers deployment of the system as the activity of the project phase. Similarly, Model 3 suggests that system integration and rollout takes place during the project phase. According to Model 2, the system goes live during the implementation phase and is later stabilized. Model 4 suggests that integration of functional units is realized during the acceptance phase and organizational integration is realized during the routinization phase. We claim that unlike the existing life cycle models suggest, deployments of an ERP system are continuous, instead of being realized during the project phase and stabilized after it.

4.3. Finding 3: External Integration with Supply Chain Should Start Early

Because the ERP system of AO was very much supply chain oriented, integration with external systems and collaboration with customers and business partners started already during the project phase of the system. An infrastructure to support a web interface to the system was initiated in order to let the customers to access the desired information. Furthermore, to enable the supply chain collaboration, e-business standardization activities were considered during the project phase:

"In logistics, for integration purposes we have had connections to global business integration standardization agencies. We have been cooperating with competitors and other companies of this industry in order to get our way of doing to these standards." –AO6

Moreover, it appeared that the system had to enable the integration with external systems, originally not intended to be integrated with:

"It was not originally specified as a requirement of the system – this transportation cost management system came there…One benefit of [the system] is that is has many things that allows external partners to operate in it." –AO7

According to Models 1 and 2, external integration takes place after the implementation. Models 3 and 4 suggest that extending the system starts a new cycle, which revisits all the previous phases. However, they do not emphasize the role of standardization or other organizations involved in ERP system integration during the life cycle. Thus we claim that external integration with supply chain should start in the early phases of the life cycle. It involves, besides the integration of systems, collaboration with business partners and standardization organizations.

4.4. Finding 4: Integration is Never Fully Achieved

Besides extending the system with additional capabilities, it was necessary to adjust the system with organizational changes. These changes introduced a need of such kind of integration that cannot necessarily be considered as "extension" or "adding new capabilities to the system":

"The scope has changed somewhat, as far as logistics goes we've moved away from [the system] and we've replaced it with external ERP systems, and integrated those with [the system]" –AO3

It appeared that certain application logic previously being automated by the ERP system was replaced by integrating the system with additional external systems. Because of this, the IT architecture became more complex which led to increased costs:

"[Logistics] started making separate islands by freezing [the system] in a certain point and integrating additional systems to it. Now this has been going on for ten years already and we have ended up to problems as costs have increased in this area. [Consultants] have evaluated these systems and concluded that it's a complete spaghetti, which needs an additional transportation management system." –AO1

In contrast with existing life cycle models, it appeared that integration is never fully achieved, due to the constantly evolving organizational landscape and business environment. This was especially highlighted by conflicting political agendas of different managerial organs of AO:

"You never reach the ideal world, you end up having different kinds of stuff [different systems] here and there, maybe all the possible ERP vendors in some way. And the you have the company-level roadmap of the system, it's being developed and it constantly evolves" – AO1

We claim that ERP system integration is never fully achieved. This calls for approaches to govern ERP system integration throughout the lifecycle to avoid the increased complexity and costs.

5. Discussion

We can identify several reasons why that the existing ERP system life cycle models fail to see the nature and importance of ERP system integration. First, the models have been published in early 2000s. In our earlier study we noted that the interest towards ERP system integration emerged as late as mid-2000s – after the life cycle models were developed [7]. In addition to our study, the limitations of the existing life cycle models have also been discussed in a study about maintenance and support during the ERP system life cycle [8], which concluded that maintenance and support is an activity taking place during the whole life cycle instead of just in the post-implementation phase.

Moreover, the purposes of the life cycle models seem to be different than our interest to view these models. For example, Model 4 seems to be more user-centric, as relations of users to the system is described whereas Models 2 and 3 focus on organizational performance. Moreover, Models 3 and 4 were not originally developed for ERP systems, but instead they are based on general models of information system adoption. The authors of Model 3 suggested that their model may not be suitable in the context of an extended ERP where the system is collaborating closely with the supply chain. Our findings support this claim since the ERP system of AO was very much oriented towards the supply chain, where standardization and integration with partners' system were essential since pre-implementation of the system.

Besides the four models, we were not able to find more recent models to describe the lifecycle of ERP systems. Since the 1980s, the concept of life cycle has been criticized, e.g. in [12]. Life cycle models seem to be too generic ones without practical applicability, and this might be the reason why new models have not been developed. The lifecycle models can describe certain aspects of the ERP systems, such as organizational performance as described in Model 3, but as our findings suggest they do not describe the nature of ERP system integration. Relying on them when making decisions on integration issues may lead to undesired consequences. Indeed, our findings reflect the principles of agile paradigm, such as early involvement of customers and the continuous nature of integration. Applying agile principles in integration governance are therefore necessary.

Investigating the ERP system life cycle of one case only is a limitation of this study. Even though AO had a fully customized ERP system instead of a packaged solution, we believe that integration challenges remain similar in other context where packaged ERP solutions are adopted. In future, our interest is not to create a new life cycle model but instead to study how integration can be effectively governed during the life cycle of the system. Especially, we are interested in other organizations' (such as the ERP vendor, consultants and customers of AO) role in ERP system integration. Finally, if compared to other life cycle phases, there is much less research on the final phase of ERP life cycle, retirement [4]. Indeed, we have just recently begun to have opportunities to investigate the retirement phase as companies are moving to new ERP solutions. At some point of time an ERP system becomes obsolete and needs to be replaced. There is a void of research on how to manage the interconnections with ERP and other systems when retiring the system. In future, the retirement phase of the ERP system should be studied from the integration point-of-view.

6. Conclusions

In this study, an inquiry into the practice was made to observe the ERP system life cycle of a large manufacturing enterprise, from the perspective of ERP system integration. According to our findings, integration should be a major consideration when choosing an ERP system. Deployments are continuous and so is external integration which starts already in the early phases. Finally, instead of being realized at the given point of time, integration is a continuous effort, constantly evolving with organizational changes. The findings reflect the agile principles and point out that practices for integration governance should not be based on the existing lifecycle models. The main contribution of this study is better understanding of the

nature of integration and its evolution during the life cycle of an ERP system which can help managers when making decisions on integration issues.

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References

1. Barki, H., Pinsonneault, A.: A Model of Organizational Integration, Implementation Effort, and Performance. Organ. Sci. 16 (2), 165–179 (2005)
2. Chowanetz, M., Legner, C., Thiesse, F.: Integration: An Omitted Variable in Information Systems Research. In: ECIS 2012 Proceedings. (2012)
3. Corbin, J.M.: Basics of qualitative research: techniques and procedures for developing grounded theory. Sage Publications, Inc, Los Angeles, Calif (2008)
4. Esteves, J., Bohorquez, V.: An Updated ERP Systems Annotated Bibliography: 2001-2005. Commun. Assoc. Inf. Syst. Vol. 19 (Article 18), (2007)
5. Esteves, J.M., Pastor, J.A.: An ERP Life cycle - based Research Agenda. In: First International workshop in Enterprise Management and Resource Planning: Methods, Tools and Architectures. , Venice, Italy (1999)
6. Gulledge, T.: What is integration? Ind. Manag. Data Syst. 106 (1), 5–20 (2006)
7. Kähkönen, T., Smolander, K.: ERP Integration - A Systematic Mapping Study. Presented15th International Conference on Enterprise Information Systems (ICEIS 2013), (2013)
8. Law, C.C.H., Chen, C.C., Wu, B.J.P.: Managing the full ERP life cycle: Considerations of maintenance and support requirements and IT governance practice as integral elements of the formula for successful ERP adoption. Comput. Ind. 61 (3), 297–308 (2010)
9. Lee, J., Siau, K., Hong, S.: Enterprise integration with ERP and EAI. Commun. ACM. 46 (2), 54–60 (2003)
10. Linthicum, D.S.: Next generation application integration: from simple information to Web services. Addison-Wesley, Boston (2004)
11. Markus, M.L., Tanis, C.: The enterprise systems experience–from adoption to success. In: Framing the domains of IT research: Glimpsing the future through the past. (2000)
12. McCracken, D.D., Jackson, M.A.: Life cycle concept considered harmful. ACM SIGSOFT Softw. Eng. Notes. 7 (2), 29–32 (1982)
13. Møller, C.: ERP II: a conceptual framework for next-generation enterprise systems? J. Enterp. Inf. Manag. 18 (4), 483–497 (2005)
14. Momoh, A., Roy, R., Shehab, E.: Challenges in enterprise resource planning implementation: state-of-the-art. Bus. Process Manag. J. 16 (4), 537–565 (2010)
15. Pekkola, S., Niemi, E., Rossi, M., Ruuskamo, M., Salmimaa, T.: ERP Research at ECIS and ICIS: a fashion wave calming down? In: ECIS 2013. (2013)
16. Rajagopal, P.: An innovation—diffusion view of implementation of enterprise resource planning (ERP) systems and development of a research model. Inf. Manage. 40 (2), 87–114 (2002)
17. Ross, J.W., Vitale, M.R.: The ERP Revolution: Surviving vs. Thriving. Inf. Syst. Front. 2 (2), 233–241 (2000)
18. Schlichter, B.R.S., Kraemmergaard, P.: A comprehensive literature review of the ERP research field over a decade. J. Enterp. Inf. Manag. 23 (4), 486–520 (2010)
19. Stefanou, C.J., Revanoglou, A.: ERP integration in a healthcare environment: a case study. J. Enterp. Inf. Manag. 19 (1), 115–130 (2006)
20. Umble, E.J., Haft, R.R., Umble, M.M.: Enterprise resource planning: Implementation procedures and critical success factors. Eur. J. Oper. Res. 146 (2), 241–257 (2003)

21. Watts, C.A., Mabert, V.A., Hartman, N.: Supply chain bolt-ons: investment and usage by manufacturers. Int. J. Oper. Prod. Manag. 28 (12), 1219–1243 (2008)
22. Xu, L.D.: Enterprise Systems: State-of-the-Art and Future Trends. IEEE Trans. Ind. Inform. 7 (4), 630–640 (2011)