Optimization of Gaps Resolution Strategy in Implementation of ERP Systems

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Abstract: Enterprise Resources Planning (ERP) systems are packaged applications developed by their vendors. Their functionality is not specifically tailored to particular companies implementing these systems. Differences between provided functionality and company's needs are identified using fit-gap analysis. The paper develops a novel optimization model for fit-gap analysis. The model yields an optimal gaps resolution strategy, which defines type and timing of customizations made to resolve the gaps and decisions are made with respect to the vendor's software evolution roadmap. Thus, the model highlights trade-offs between in-house customization and adoption of standard features yet to be released. The optimization results are analysed depending on the company's customization preferences and an application example is also provided. The model allows for understanding and evaluation of relationships between the company implementing the ERP system and the vendor of the ERP system.

1 INTRODUCTION

Enterprise Resources Planning (ERP) systems are large software application used by companies to run their business processes. The ERP systems typically are packaged applications developed by software vendors. Their functionality is not specifically tailored to particular companies implementing these systems. However, they have some degree of flexibility and customization capabilities to accommodate specific requirements. Companies aim to select an ERP system best suited for their needs. ERP selection methods (Jadhav and Sonar, 2009) and fit-gap analysis (Gulledge, 2006) are employed to identify the most appropriate ERP system.

Nevertheless, there are gaps between functionality and capabilities provided and the requirements, and these gaps need to be resolved during implementation of the ERP system. The gaps can be resolved by customizing the ERP system. There are various approaches to customization in ERP systems (Aslam et al., 2012). This paper distinguishes between low-level and high-level modification approaches. Low-level customization is done using low level of abstraction tools such as programming languages while high-level customization uses high level of abstraction tools such as interactive development methods and workflows. Customization allows adding business specific features to a standard software. Several existing works investigate a choice between customization alternatives (Parthasarathy and Daneva, 2016) and implications of customization on business value and operation of ERP systems (Zach and Munkvold, 2012).

Customization often is time-consuming and costly and poses various risks to the ERP implementation (Kholeif et al., 2007). In order to reduce the amount of customization, companies might benefit from software updates released by ERP vendors. The updates might contain functionality or features requested by the companies. Information about forthcoming updates is often published as product development roadmaps by ERP vendors.

Therefore, it is suggested that the fit-gap analysis and selection of customization choices should be synchronized with the vendor's ERP development roadmap. In general, the fit-gap analysis should be viewed as a more strategically oriented activity creating an ERP evolution strategy at the organization. A gaps resolution strategy is proposed as a part of this overall evolution strategy in this paper. The gaps resolution strategy specifies selection of ERP customization methods to deal with

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the gaps, timing of implementation of customizations and possibilities to avoid customization by adopting new features provided by the ERP vendor. Depending on preferences of the company implementing the ERP systems, the strategy might favour customization, alignment of development plans with the vendor's roadmap or redesign of business processes.

The objective of the paper is to develop a model for optimization of the gaps resolution strategy. The optimization model balances a trade-off between customization effort and value, and specifically takes into account the standard software evolution roadmap provided by the ERP vendor. The model allows conducting sensitivity analysis and evaluation of different ERP implementation policies. The specific research question of model analysis is: what is the impact of company's customization preferences on the gaps resolution strategy. Application of the model is demonstrated using an example of customization of the lead qualification process in a customer relationships management module of the ERP system.

The rest of the paper is organized as follows. Section 2 reviews background information and related work on ERP systems and fit-gap analysis. Section 3 defines the concept of gaps resolution strategy. The optimization model is elaborated in Section 4. Section 5 provides model analysis results and the application example is explored in Section 6. Section 7 concludes.

2 BACKGROUND

2.1 ERP Implementation Process

The ERP implementation process consists of project planning, design and customization, implementation and maintenance and continuous improvement phases (Erazo et al., 2017). During the project planning phase, key requirements are identified and a suitable ERP system is selected. Detailed analysis of the requirements and functionality of the ERP system is performed in the design and customization phase. If the enterprise chooses to adopt standard features of the ERP system it might need to redesign its business processes. If the enterprise opts for retaining existing business processes, customization of the ERP system is required. As the result necessary changes at the enterprise and in the ERP system are identified and the ERP system is customized.

The important part of the implementation process is interplay with software vendor. The software vendor continuously evolves the software and the recent move to software as a service mode of software delivery implies that new features are delivered continuously without the need for upgrading from one version to another. The envisioned changes are announced in advance in a form of software development roadmap (Keizer, 2018). The development roadmap includes the expected new features and their estimated release dates. This way companies can take into account that some of the currently missing features might be delivered within a specified time period.

2.2 Fit-gap Analysis

The fit-gap analysis is a part of the planning and design phases of the ERP implementation process. Initially, it is performed for the high level requirements to provide input for selection among alternative ERP systems, and, once the ERP system is selected, detailed fit-gap analysis is performed to provide inputs for design of system's implementation.

The fit-gap analysis yields a set of fits and a set of gaps. The gaps should be resolved for successful implementation of the ERP systems. They can be resolved either by customizing the ERP systems or by adjusting the enterprise. This decision has major implications for the organization and enterprise adjustment leads to transformation of business processes. These transformation decisions are beyond the scope of this paper, which focuses solely on software related aspects and customization decisions. In relation to ERP evolution roadmap, some features might be missing at the time of fit-gap analysis, however, they might become available in new releases of the system. If the enterprise is willing to wait, then gaps can be resolved without customization.

2.3 ERP Customization

ERP customization concerns modification of out-of-the-box functionality of ERP systems using various tools provided. It is performed in the customization and implementation phases and is aimed at reducing gaps between the required and provided functionality. Aslam et al. (2012) summarize several typologies of customizations in ERP systems. They include configuration, bolt-ons, screen masks, reporting, workflow development, interface modification and package code modification.

Hustad et al. (2016) consider tailoring of reports, interfaces, enhancements, forms, workflows and portals. Luo and Strong (2004) developed a framework relating technical customization and process customization options.

There is no agreement on benefits of customization (Aslam et al., 2012). Several authors point out that customization is time consuming and complicates system's maintenance (Zach and Munkvold, 2012). Research by Parthasarathy and Sharma (2016) suggests that customization does not yield expected benefits. Yet, companies have strong desire for customization (Gool and Seymour, 2018), and Holsapple et al. (2005) argue that customization has a major importance on preserving value-adding functions at companies using packaged applications. Obviously, customization requires some development effort and must have sufficient value or utility for the enterprise to be considered for implementation.

2.4 Related Work on Fit-gap Analysis

A number of fit gap analysis methods have been developed. One group of the methods focus on identification of gaps and another group of the methods also consider selection of customization choices to address the gaps.

Identification of gaps is analyzed by Wu et al. (2007). Enterprise requirements are captured in goal, activity and data models, which are compared with the ERP systems to identify the differences. Yen et al. (2011) identify misfits at the strategic level and propose their classification framework, where the misfits are categorized as enterprise, industry or country specific.

Sarfaraz et al. (2012) proposed to use AHP to evaluate technical customization choices vs process customization choices with respect to degree of customization. Parthasarathy and Daneva (2016) develop a requirements prioritization framework and a heuristic algorithm to find a justifiable degree of customization. They consider introduction of new standard features in future releases of the ERP system as one of the evaluation criteria. Pajk and Kovacic (2013) describe a detailed fit-gap analysis process including high-level fit-gap analysis, identification of gaps and fits, and gaps resolution. Process adaptation, system adaption, third party solution and workaround are identified as resolution strategies. These and other fit-gap analysis methods are also reviewed by Ancveire (2018).

The proposed model is an optimization model as opposed to heuristic method used in literature and it specifically takes into account dynamics of introduction of new standard features by the ERP vendor what is of particular relevance in the case of ERP in the form of SaaS.

3 GAPS RESOLUTION STRATEGY

The gaps resolution strategy defines selection of customization options and their timing to reduce gaps between the required functionality and the functionality provided by the selected ERP system. It takes into account vendor's ERP development roadmap and aims to optimize business value achieved by satisfying requirements in the best possible manner.

The conceptual model of the gaps resolution strategy is shown in Figure 1. It is assumed that the company has identified requirements towards the ERP system. If the selected ERP package does not satisfy some of the requirements, corresponding gaps are identified. The strategy is driven by company's preferences concerning customization. The vendor's roadmap indicates timing of the release of new features. The new features might address some of the gaps though there is no guarantee that they will be definitely delivered. The gaps resolution strategy consists of customization choices. The customization choice indicates when and what gaps resolution approaches will be used. The selection of the customization choice is made per gap and one of the customization options is selected. The customization options are specific to particular ERP systems.

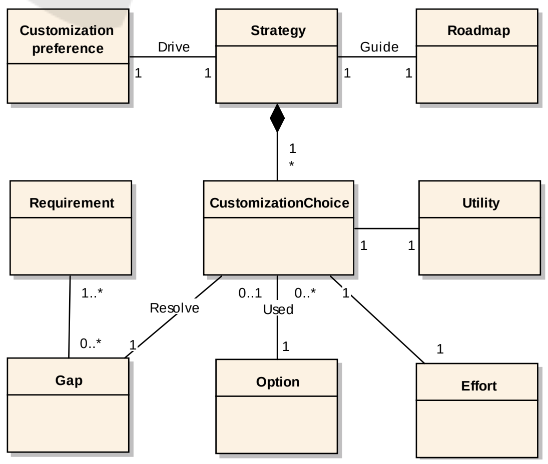

Figure 1: The conceptual model of the gaps resolution strategy.

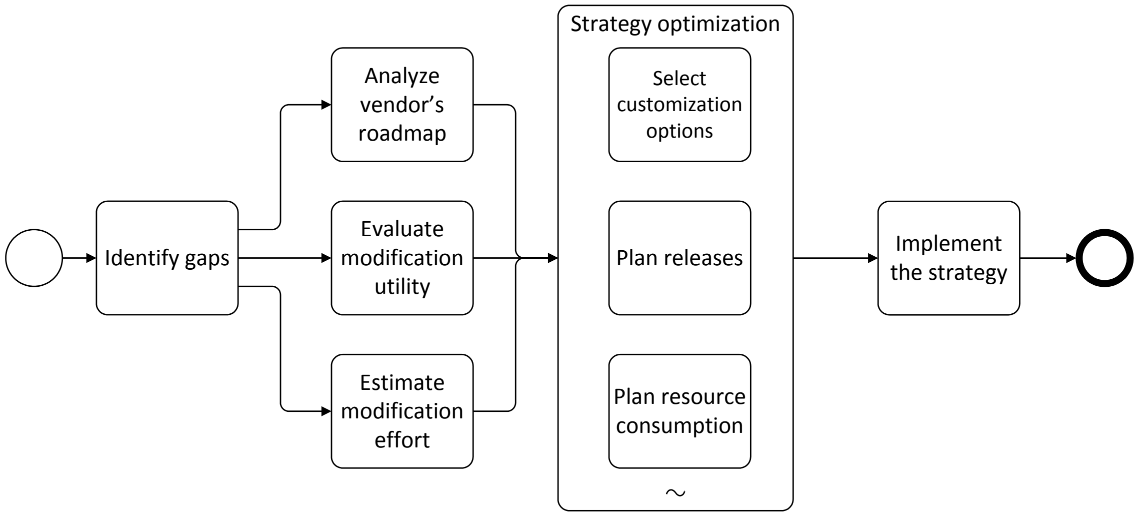

Figure 2: The process of establishing the gaps resolution strategy.

Every customization choice has its utility and associated implementation effort. The utility and effort are specific to a combination of the gap and its resolution option. The utility characterizes business value achieved by making a specific customization choice. The effort characterizes the implementation effort. The utility does not necessarily out-weight the effort.

The process of establishing the gaps resolution strategy is illustrated in Figure 2. It is assumed that requirements towards the ERP system have been elicited and there is sufficient information about functionality of the ERP system. The first task of the process is identification of gaps. The gaps can be resolved by employing appropriate customization options. Utility and effort associated with every customization option are evaluated per gap. The paper does not investigate specific methods for estimating utility and effort, and effort estimation by planning poker (Qureshi 2012) is adopted for illustrative purposes. The utility can be determined using cost of delay criterion as described by Leffingwell (2011). If a customization option is not suitable for the gap then modification effort is set to infinity. Simultaneously, the vendor's roadmap is analyzed and opportunities for using newly released features to resolve the gaps are identified. There is a utility associated with adopting the new features as well.

The utility and effort estimates, and roadmap are inputs to gaps resolution strategy optimization. The optimizations steps are performed in an iterative manner. The strategy is established for a finite planning horizon and the optimization results are selection of customization options and timing of implementation of the changes bundled as releases. The optimization is performed subject to development resource constraints. Finally, the strategy is implemented. Implementation adjustments might be required because of changes in the vendor's roadmap as well as inaccuracies in utility and effort estimation.

4 OPTIMIZATION MODEL

As a part of the process of establishing the gaps resolution strategy, the optimization model is formulated. The optimization model selects customization choices to maximize the difference between customization utility and effort. It takes into account expected release of new features by the ERP's vendor and availability of development resources needed for customization.

4.1 Notation

i – gaps index
j – customization options index
t – time period index
TT – planning horizon
G_i – gaps
O_j – implementation options
X_{ijt} – selected implementation option equals to 1 if ith gap is resolved using jth option in tth period and 0 otherwise
τ_i – release time period of new standard feature for ith gap

E_{ij} – implementation effort for gap i using option j in points
V_{ij} – unadjusted variable implementation utility for gap i using option j in points
V_{ij}^* – unadjusted fixed implementation utility for gap i using option j in points
U_{ij} – variable implementation utility for gap i using option j in points adjusted according to customization preferences
U_{ij}^* – fixed implementation utility for gap i using option j in points adjusted according to customization preferences
R_t – resources available in period t in points
δ – customization preference coefficient

4.2 Assumptions

The following assumptions are made in the optimization model:

- Gaps are independent;
- Customizations are independent;
- Tasks are small enough to be completed within one period;
- Customizations are rolled-out at the end of every period if any;
- Only one customization option can be selected for a gap;
- Effort, utility and resource capacity are measured in points, which are appropriately scaled.

4.3 Objective

The objective function (Eq. 1) selects customization choices that maximize customization gains expected as the difference between customization utility and effort. The utility is divided in two terms, namely, variable and fixed returns. The fixed returns are evaluated over the whole ERP life-cycle and are accounted for regardless when the gap is resolved. The variable returns are realized during the strategy's planning horizon starting with the period when the gap is resolved.

$$Z = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{TT}\left((TT-t)U_{ij}+U_{ij}^*\right)X_{ijt} - \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{t=1}^{TT}E_{ij}X_{ijt} \quad (1)$$

4.4 Constraints

The optimization is performed subject to:

$$\sum_{j=1}^{J}\sum_{t=1}^{TT}X_{ijt} \le 1, \forall i \quad (2)$$

$$\sum_{i=1}^{I}\sum_{j=1}^{J}E_{ij}X_{ijt} \le R_t, t = 1,...,TT \quad (3)$$

$$t \ge \tau_i X_{i1t}, \forall i,t \quad (4)$$

$$U_{ij} = \delta V_{ij}, U_{ij}^* = \delta V_{ij}^*, \forall i,j \quad (5)$$

The constraint (2) implies that every gap can be resolved no more than just once (including using just one customization option). The constraint (3) represents limited availability of development resources and total effort spent on customization cannot exceed available resources in every period. The constraint (4) states that the vendor's released features cannot be adopted before they are released. The equation (5) adjusts the customization utility. If the customization preference coefficient δ is increased the company has stronger incentives to customize system. If the customization preference coefficient is decreased the company prefers usage of standard features and the gaps are resolved by either changing business processes or waiting for appropriate updates to be released by the vendor. Thus, the equation represents company's strategic preference for customization or standardization.

5 MODEL ANALYSIS

Experimental studies are conducted with the model. Their objective is to demonstrate impact of the customization preferences on the gap resolution strategy. A synthetic data set is used in the studies. It is assumed that 20 gaps are identified and 5 customization options including adoption of newly released standard features. Customization effort varies from 0 (for standard features) to 13 points. The utility is generated as a randomized multiple of the effort and on average is by 20% larger than the effort over the planning horizon. There are 12 periods within the planning horizon, and development capacity for each period is 20 points. The vendor releases new features after every four periods and they are good for resolving 12 gaps although some of the features become available quite late in the planning horizon.

During the experimentation, the customization preference coefficient δ is varied from 0.25 to 2, where the former value resembles company's preference to use standard features while the latter value resembles company's preference to customize. The optimization is performed for ten different randomly generated sets of utility values. The optimization results (Figure 3) show that customization choices significantly depend on the customization preference coefficient. If δ =0.25 the enterprise opts for changing business processes or using standard features as they become available. If customization utility is high almost all gaps are resolved and there are few incentives to wait for standard features to be delivered. That, however, is also affected by availability of development resources (in this case resource utilization is about 70% for δ =2).

The optimization model clearly allows to identify trade-offs between customization and adoption of standard features depending on customization preferences of the enterprise.

Figure 4 shows an example of the gap resolution strategy. It shows timing of implementing customizations and adoption of newly released standard features. If the standard features are adopted they are introduced immediately. For Gaps 5 and 12, the optimal approach is to customize the systems not to wait till the new standard features are released. The customizations are introduced at different time periods because of resources limitations. Gap 13 is not resolved because its resolution utility is lower than the effort.

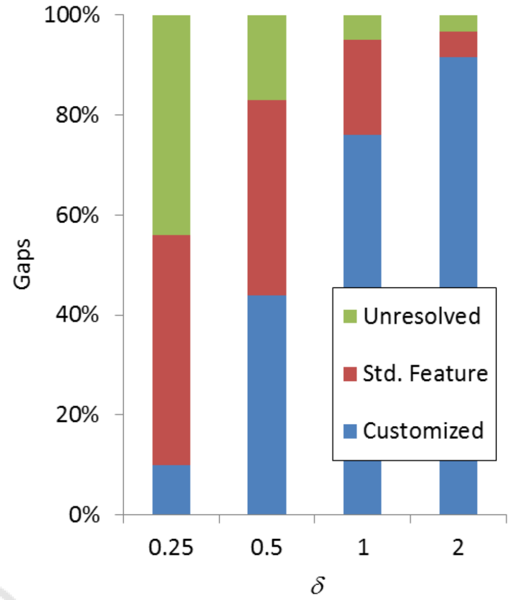

Figure 3: The gap resolution approach chosen depending on the customization preference coefficient δ

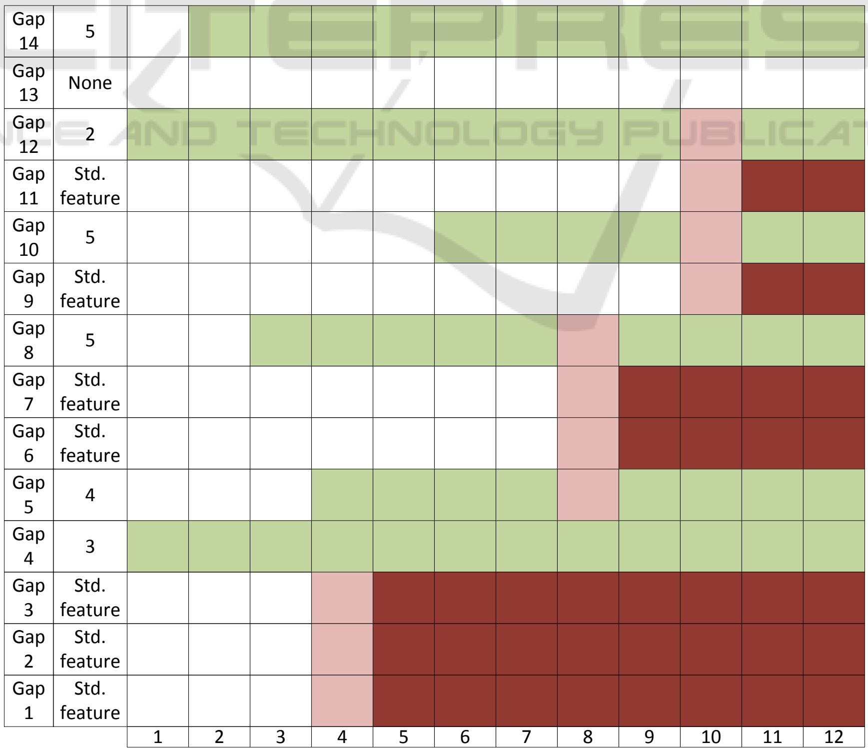

Figure 4: A fragment of the sample gap resolution strategy. The second column indicates the customization approach used, green filling indicates periods the customization is implemented and used, light read indicates availability of new standard features and dark red indicates usage of the new standard features.

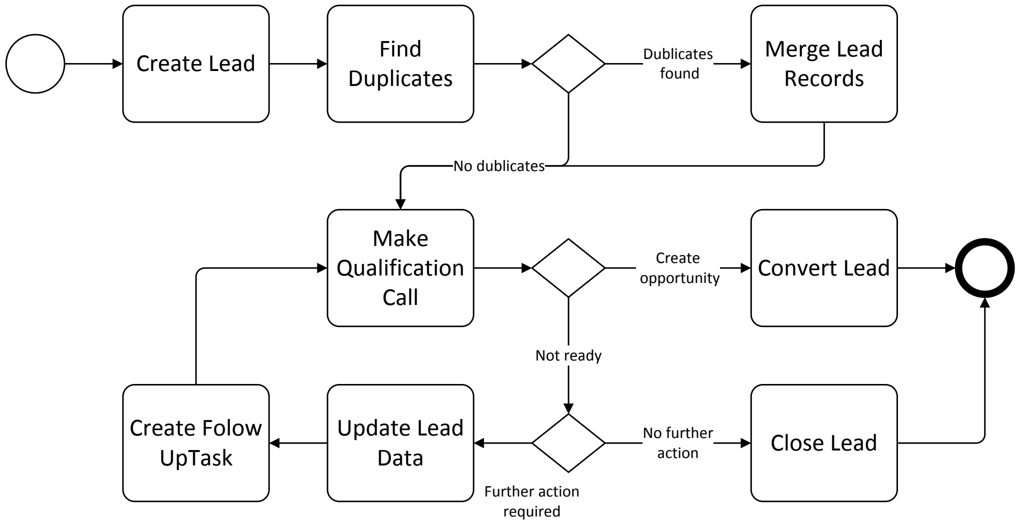

Figure 5: The lead qualification process.

6 EXAMPLE

Application of the model is demonstrated using an example of implementing CRM module (the functionality and available customization options are inspired by Microsoft Dynamics 365). More specifically, the lead qualification process (Monat 2011) is considered (Figure 5). In this process, a lead represents a potential source of sales. Information about lead is registered in the system. Initial information might be incomplete and initial data cleansing is required to identify duplicated records. The leads are contacted by sales representatives to gather additional data and to evaluate sales potential. If potential customers respond positively they are converted into opportunities. If initial contacts are not successful, further activities are planed until the lead is converted into an opportunity or dropped. The number of leads can be substantial and there are many opportunities for process automation.

The CRM application provides multiple customization options categorized as data view, user interface (UI) modification, custom report, different types of workflows and add-ons. The data view customization option provides simple improvements for searching, filtering and performing other data processing operations. The UI customization option modifies the existing UI, for instance, to make data input more efficient. Reports typically provide analytical features. Basic processes provide process execution guidance while workflows support task automation and advanced process execution logics. Add-ons are developed using low-level modification techniques (i.e., custom code development) or purchased from third-parties.

Table 1: Gaps identified for the lead qualification process and available customization options.

Process tasks	Gap	Customization options
Create Lead	G1: The data entry is too time-consuming due to extra navigations steps	Std. feature Data view UI Basic process Workflow
Find Duplicates	G2: Provided data are not appropriately tailored and a lot of manual work	Data view UI Report Basic process Workflow Add-on
Make Qualification Call	G3: The conversation is not scripted	Std. feature Basic process Workflow
Update Lead data	G4: The update is manual and involves extra navigation steps	UI Basic process Workflow
Create Follow up Tasks	G5: Not all information to decide on follow up tasks is available	Data view UI Report
Close Lead	G6: Closing is manual	UI Basic process Workflow
Convert Lead	G7: Conversion is manual	UI Report Basic process Workflow

It is assumed that several gaps have been identified (Table 1). The company aims to make process execution more efficient and considers changes ranging from UI modification to introduction of automated processing. The available customization options are also listed (not all options are available for every gap). For instance, the report customization option is suitable for the Update lead data task. Six customizations options are available for gap G2 in the Find Duplicates task. The Data view customization provides a set of filter facilitating manual identification of duplicates. The UI customization emphasis data fields needed for the task. The report customization provides analytical data need for the task. Process defines standard steps to be performed to find duplicates and the workflow automates some of these tasks. The Add-on provides a classification algorithm for merging lead according to a set of attributes.

The effort and utility of the customization options is determined (Table 3). Generally, it is assumed that user interface modifications are the simplest and development (or procurement) of add-ons require the most effort. Similarly, usage of more advanced and lower level customization options potentially yields more benefits (i.e., higher utility). The values provided are illustrative and their actual values are determined from case to case.

Table 2: Effort and utility per customization choice.

Gap	Customization Option	Effort	Utility
G1	Std. feature	0	10
	Data view	1	2
	UI	3	3,5
	Basic process	3	3,5
	Workflow	8	10
G2	Std. feature	0	10
	Data view	1	1,5
	UI	3	4
	Report	5	12
	Basic process	3	4
	Workflow	8	10
	Add-on	13	25
G3	Std. feature	0	3
	Basic process	3	3,2
	Workflow	13	20
G4	UI	5	3,3
	Basic process	3	3,2
	Workflow	5	6
G5	Data view	1	1
	UI	1	1
	Report	5	6
G6	UI	3	2
	Basic process	1	2
	Workflow	5	6
G7	UI	3	3,5
	Report	3	4
	Basic process	1	2
	Workflow	8	10

The planning horizon is six periods and resources are available to implement 15 points worth of customization in each period. The vendor will provide new features for the first three gaps in the third period. Standard features are not expected for other four gaps. The customization preference coefficient δ =0.25.

Table 3 shows the optimized gap resolution strategy. Gaps 4 and 5 are left unresolved. The basic process customization option is favoured instead of the workflow customization option because it can be implemented sooner (due to smaller effort) and business benefits can be realized for the whole planning horizon.

Table 3: The gap resolution strategy for the lead qualification process.

Gap	Customization option	Time period
G1	Std. feature	3
G2	Add-on	1
G3	Std. feature	3
G6	Basic process	1
G7	Basic Process	1

The optimization is also performed without accounting for the vendor's roadmap. As the result, the value of the objective function is by 58% smaller than initially. That indicates that using the vendor's roadmap as an input one can find a better strategy. The comparison was also made with a heuristic method following the greedy principle. The heuristic started with implementation of customization choices with the largest difference between effort and utility as long as resources are sufficient for the period. The obtained value of the objective function was by 87% smaller than the optimal.

7 CONCLUSION

The new optimization model for resolving gaps in implementation of ERP systems has been elaborated. It provides dynamic view gaps resolution planning with respect to resource availability and vendor's software evolution roadmap. The model can be used to evaluate various ERP implementation policies, for instance, impact of company's preferences for customization or retaining standard features. This analysis is important because there is no consensus on business value of ERP customization and companies have different needs and preferences.

The optimization model can be extended in various ways. Currently, it assumes that maintenance considerations are captured using the utility measure though more explicit treatment of maintenance could be provided. The model also does not consider relationships among gaps and possibilities to used multiple customization options for a single gap.

Company and vendor relationships also could be explored further. Unfortunately, vendors change their roadmaps frequently and this uncertainty also should be represented in the model. Additionally, vendors charge support fees, which include delivery of new features. The model could be used to evaluate whether 1) these fees are justifiable and 2) features are delivered soon enough or the company is better off with implementing changes on its own.

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