Integrating A Software Product Line Strategy with a Product Production Strategy: A Case Study

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Abstract

Many manufacturing organizations adopt product production strategies that influence a wide range of factors within the company. These strategies define policies, procedures and structures that affect the same areas as a software product line strategy. When an organization initiates a product line strategy, that strategy must be integrated with existing strategies while not losing the benefits of the software product line strategy. This paper is a brief report of our experience integrating a software product line strategy similar to that developed by the Software Engineering Institute with a specific product production strategy, the PACE model. Problems such as conflicts in terminology and clashes in organizational structure were identified and resolved. We present an integration process that can be used to coordinate a software product line approach with other manufacturing strategies.

Introduction

The software product line strategy is a comprehensive approach that touches many facets of an organization. Software product line initiation, even "green field" initiatives, typically occurs in an existing corporate environment. Corporate or business unit initiatives set goals and often mandate strategies to achieve those goals. The software product line effort must be consistent with these previously established strategies. Product production strategies are guidelines that define how the organization will manage the actual creation of a product [Chastek 02]. Aspects of the software product line strategy will, almost certainly, provide guidance on some of the same issues as the more general product production strategy. For example, a software development business unit can find itself constrained by the initiatives of the hard goods units of the corporation. These units have often been in existence longer or manufacture a more tangible portion of each product. In the remainder of this paper we will focus on the integration of a software product line strategy and product production strategies.

There are many widely recognized corporate strategies for product production or product manufacture such as Product And Cycle-time Excellence (PACE) [McGrath 96], Six Sigma [Pande 00], and Supply Chain Management [Chopra 00]. Each strategy solves specific types of problems and imposes assumptions that constrain possible solutions. The scope of each strategy varies. Supply chain management impacts most of the phases in a manufacturing process but it is limited to the management of inputs into these phases and delivery to customers. Six Sigma techniques impact the record keeping and decision making of most steps in the product development process but not the technical details of how to carryout the steps. The PACE strategy is a comprehensive strategy that specifies some portion of the organizational structure and establishes priorities among activities in the manufacturing process.

These examples illustrate how the software product line and product production strategies can have one of four relationships with one another. The product line strategy (PL) may overlap with another strategy (S),

as in *Figure 1a*, so that there is some region of potential conflict or agreement. There are also regions in which neither interacts with the other. The two strategies must be synchronized in the common region and each must be modified to accommodate the compromises necessary in the region of commonality. Strategy S may totally encompass strategy PL, *Figure 1b*. Strategy S will often dominate strategy PL by defining organizational and management structures. Strategy PL must be integrated into strategy S. This situation has the potential to reduce the effectiveness of the PL strategy.
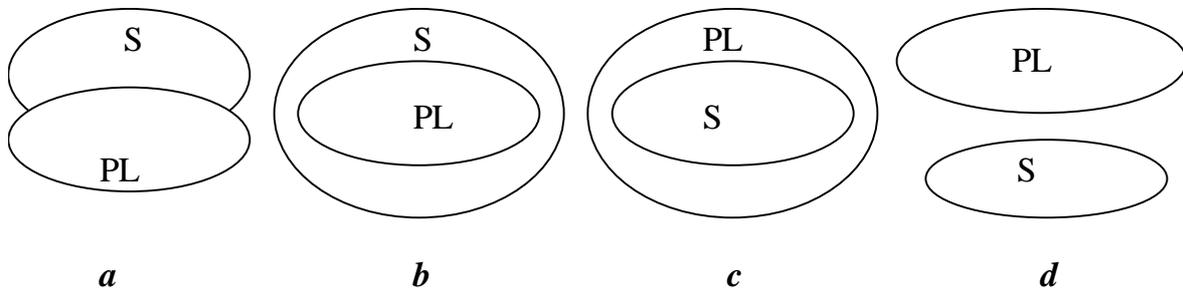

a   *b*   *c*   *d*

Figure 1

The PL strategy may totally encompass strategy S as in *Figure 1c*. Even though the PL strategy has the broader scope, if strategy S is a mandated corporate initiative, PL may still have to be modified to accommodate S. Finally strategies S and PL may be disjoint, *Figure 1d*, and each is implemented without regard to the other.

In this paper we present a study of initiating a software product line in an organization that had been using the PACE strategy for several years. For the sake of clarity we will refer to the software product line strategy we used, which is similar to the SEI approach, as the SPL strategy in the remainder of the paper. In the next section we provide an overview of PACE, but we will assume the reader has a knowledge of software product lines. The following sections identify the points of conflict between the PACE strategy and the software product line strategy, a list of lessons learned as we integrated the two strategies, and finally a process for integrating a software product line strategy with a product production strategy.

Context

This case study summarizes our experience in a business unit of a large multi-national enterprise that manufactures hardware devices with a significant software component. The experience spans approximately 2 years of training and mentoring covering management, requirements capture and analysis, asset acquisition, and architecture definition work. The president of the business unit introduced the PACE model roughly a year before the vice-president introduced the software product line strategy. The engineers in the business unit are highly technical and welcomed the new product line ideas. Members of the president's staff, other than the vice president, were concerned that the product line concept would interfere with the PACE strategy that was all ready in place. Middle managers in the software unit were the most resistant to the new product line ideas. Their role, as the source of experience, was threatened by this new approach. The initial support of the vice president and the eventual acceptance by the president has made progress possible. The reluctance of the middle managers continues to minimized that progress.

Pace Model Description

The PACE strategy focuses on product and cycle-time excellence, as the name implies. The rapid delivery of an individual product is the highest priority. In the local implementation of PACE, a second priority is

to give the customer exactly what they want. This leads to late changes in the requirements for a product since the customer will often decide to forego certain functionality in order to ensure an earlier delivery date. The organization is structured to keep decision making as close to the problem as possible. Rather than a hierarchical organizational structure, PACE defines a "core" team that comprises a representative from the functional product areas such as software development, hardware development, marketing and product planning. A Core Team is empowered to make any decisions that directly affect the delivery schedule of the product production project.

The Product Strategy in the PACE model consists of 4 phases.

?? Product Strategy Vision – This vision provides direction and context to the part of the organization that is responsible for product production. This vision can be the basis for selecting development techniques and for shaping the product itself.

?? Product Platform Strategy – This strategy identifies the common functionality among a set of products and formulates a strategy to build a software platform that can deliver this functionality to several products. The platform allows new projects to be more reliably estimated both in terms of costs and delivery schedule.

?? Product Line Strategy – This strategy determines the sequence in which a set of products will be built and the timing of the product releases. PACE views the Platform Strategy as more important than the Product Line Strategy.

?? New Product Development – A Product Approval Committee (PAC) approves new products. This committee charters a Core Team to direct each product production project. With each new product, the contents of the platform and the sequence of products may be changed. The PAC allocates the corporate resources available for new product development based on information provided by various analyses.

There are three keys to management in PACE.

?? Core Team – As mentioned previously, a Core Team controls and drives a product development project. The team is a cross-functional team that maintains a decision-making capability close to the source of problems and questions. In theory, this team ensures rapid decision-making. In practice, conflicts between processes often require investigation and compromise as each decision is made.

?? Phase Review Process – This is a process in which senior management reviews the market, costs, and schedule for the product to determine whether to continue the development of that product.

?? Structured methodology – PACE defines a structure for process definition. Only the overall product development process is specified. Otherwise the processes that are needed are identified and defined by the product team. The PACE model provides a terminology for describing four levels of breakdown in a process definition.

Points of Conflict

PACE has many similarities to SPL. There are, however, several definite points of conflict between the two approaches. In each subsection we will describe the conflict and then report on our recent experience with a specific client.

Core Team

Each Core Team is empowered to make decisions and spend money in order to produce its product. There is no line of responsibility from one Core Team to another. This is obviously in conflict with the SPL approach in which the entire set of products is closely coordinated.

This issue has not been totally resolved in our current engagement and the current organization will continue to evolve to the final accommodation. The company's culture was project-based. It has evolved to the point where the decision-making process considers commonality among products in the form of a platform used as a basis for all products. Most decisions, particularly tactical ones, are still largely product-centric. As the company's development process becomes more architecture-based, the decision-making process becomes broader in scope. We believe that as the client's SPL culture matures, the PACE Core Teams will see the benefits of cooperating through the SPL Manager when reaching decisions.

This was, and still is, the greatest risk that faces the client's organization.

Product as Primary Focus

SPL is focused on a set of products and their commonalities and variabilities. This approach to faster cycle time assumes that a growing stockpile of assets that include components and architecture will drive the rapid development of products. The PACE approach assumes that reducing the administrative overhead via the Core Teams is the best approach to reducing cycle time.

The initial products that were scheduled for development were several variations of a single product. The variations were actually based on a single factor; the country in which the product was to be deployed. This made the variations so closely related that the variations do not introduce any new functionality. As the product line expanded beyond this initial set of products the team recognized the need for a broader perspective. The SPL manager was added to the organizational structure and the team is including a product line perspective to its product focus.

This conflict has been adequately, though not completely, addressed in the client's organization.

Inadequate Treatment of Variability

The PACE approach specifies a platform – common functionality - for a sequence of products. This is useful but surprising in a strategy that emphasizes individual products. The Product Platform Strategy does not identify the full functionality of the products. It focuses on the commonality among the products and uses the commonalities to define the platform. This does not give a true picture of the entire scope of functionality for all of the products since variations among products may include significant functionality found only in a few of the products. The SPL strategy includes a variability, as well as commonality, analysis so that the full range of functionality is identified.

Adding the variability analysis of the SPL strategy does not conflict directly with any activities in the PACE strategy. It provides more information for planning and estimation activities. There is an indirect conflict with the Phase Review Process. This process allows a large number of new development projects to begin and applies increasingly rigorous criteria as the projects advance through the development process. Using this approach to determine membership in the product line, as opposed to the in-depth scope analysis used in SPL, results in a constantly changing degree of variability and changes to functionality. In this situation, variability analysis will over estimate the functionality that must be developed. The PACE planning process was modified to include variability analysis and to determine membership in the product line earlier in the development process.

Variability analysis has made the estimates of functionality and the shape of the architecture more precise.

Product Line Concept

The PACE strategy identifies what it refers to as a "product line strategy." The product line of PACE is not the product line of the SPL strategy. The PACE product line strategy does not provide a context in which all of the functionality of all the products is analyzed. Nor is this strategy the driving force of the PACE Product strategy. It is considered to be secondary to the Platform Strategy.

Since the PACE concept of a product line is essentially a small subset of SPL, training was required to expand the staff's understanding. The harder problem was the priority of the platform strategy over the product line strategy. The development team had a very tight deadline for the first product in the product line and needed to introduce the SPL strategy incrementally. The decision was made to limit the SPL core asset team's contribution to the first product to building the common platform rather than a complete set of core assets. The product developers' will provide the assets required to complete the product.

Senior management has agreed to a phased plan in which succeeding product development projects will have an expanding set of core assets on which to rely.

Lessons Learned

When the reward structure is tied to the strategy, analyses must show that the modifications to the strategy will not reduce rewards. The managers' bonuses, in the client's implementation of the PACE strategy, were tied to on-time acceptance of a delivered product. This puts pressure on project managers to ignore generalizing assets to be usable across the set of products. Projections about deliveries across the entire product line showed a greater likelihood of on-time deliveries as a result of the unification of the SPL strategy with the PACE strategy.

Conflicting terminology with different or overlapping meanings can hide disagreements until later in a project. The PACE model defines a "product line strategy" that is different from SPL. The extent of the difference was not understood until issues about priorities in assignments and scheduling arose. PACE places more emphasis on the product while the SPL strategy places more importance on the set of products. An integrated glossary was used to identify and resolve conflicts.

The existing manufacturing strategy usually has broad executive support, making it difficult to modify. This is particularly true if the product production strategy extends beyond the SPL, as shown in Figure 1*b*. Non-software executives often are not eager to make changes solely to improve the software development process. The local PACE implementation spanned product planning, project management, hardware engineering, and software engineering. The hardware professionals were not familiar with, and did not understand, some of the software development problems. Senior management training sessions were necessary to illustrate the advantages of close cooperation. Papers and case studies about other companies in the same domain were the most persuasive for senior management.

The "goodness of fit" of the product production strategy to software development predicts the effort that will be required to align the two strategies. The PACE documentation provides examples of software development organizations implementing the PACE strategy. However, those examples are focused on a single project at a time and do not incorporate many modern software development techniques. Building the Concept of Operations document was very useful in guiding the identification of areas in which conflicts had to be resolved.

Integration Process

We have specialized in introducing new technology into organizations for a number of years. Based on the experience from this engagement and many previous ones, we have evolved the following process for integrating an SPL approach with a product production strategy.

1. Determine the basic assumptions and principles of each strategy – We create a partial description of the product production strategy, as implemented in the organization, which focuses on those areas that are important in the SPL strategy. As illustrated by the description of PACE in this paper, we consider
   a. the extent to which the strategy considers multiple products,

b. the techniques used to analyze for commonality and variability among the products,

c. basic terminology, and

d. the breadth of coverage of the strategy.

2. Identify points where the strategies are inconsistent – We add to the description of each strategy an analysis of the differences in these critical areas as compared to the other strategy. For example, the product production strategy might not effectively handle variability.

3. Hypothesize modifications to each strategy – We consider possible ways to resolve the differences by modifying each of the strategies. For example, the SPL strategy could be modified to ignore variability or the PACE strategy could be modified to add a variability model.

4. Analyze the impact of each modification on the strategy – Each possible modification is analyzed for its impact on the ability of each strategy to deliver the expected results. For example, adding variability analysis to the product production strategy provides additional information and some additional overhead. Removing variability analysis from the product line strategy limits the team's ability to understand the full scope of the functionality that must be produced and we note that this would limit the accuracy of development estimates.

5. Create a unified approach – The interfaces between the two strategies are described in a section in the CONOPS. If variability analysis is to be included in the unified approach, we must define an interface with the product production process. Thus adding variability analysis to the PACE model provides additional information back to the PAC that is useful in allocating resources and making go/no-go decisions.

Conclusions

Software product line strategies are sufficiently comprehensive that they touch many aspects of the organization adopting an SPL strategy. Although this paper has examined the interaction of a single product production strategy with a single software product line strategy, it is often the case that a number of technical and organizational strategies may be affected. An interface must be established for each potential interaction. Software product line assets such as the CONOPS are useful in guiding this process.

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