Product Line Development as a Rational, Strategic Decision

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ABSTRACT[1]

Product line development requires a certain amount of up front investment in order to make assets reusable. This investment often keeps organizations from planning and realizing their products in a product line. But there are also major advantages of doing product line development which are often not taken into account when deciding for or against product lines. In this paper we present problems that need to be addressed in the strategic planning of transition towards product lines. These aspects include the involvement of uncertainty, the interdependence of technical solution and decision making, and the interdependence among the decision making and the market aspects. An approach which covers these aspects will determine an objective valuation of a product line.

Key Words:

Product Line Transition, Strategic Development, Real Options, Scoping, Business Case

1 INTRODUCTION

Transforming a classical, stove-pipe development organization into a product line organization is a major shift. Performing this shift requires major investments in reuse, but may also produce major benefits to the organization [Coh01]. Obviously, a decision of such importance should be driven from a strategy and should be the result of a thorough analysis of the pros and cons of introducing product line development for a family of products. In this paper, we will discuss some problems that need to be addressed when analyzing this decision in an objective, economically adequate manner.

When doing market driven development (as opposed to customer driven development), there are no contracts when starting product development. A product is planned for a certain market, development starts at one point in time and at a later point the product is released to the now different or even decaying market. Classically, strategy development is purely driven from the business objectives of an organization and results in a business development plan, which typically stretches over a multi-year time-horizon. In the particular situation of product line development, the business objectives usually refer to aspects like cost reduction, time-to-market reduction, or quality improvement and the corresponding question is whether a product line development approach should be implemented or not. In the rational case this decision is based on answering the question whether product line development will produce more benefits than its implementation will cost.

This question is fully analogous to the scoping problem [Sch00]. The scoping problem is to identify in a rational manner the specific assets that should be developed for reuse. Basically, scoping and business case analysis differ only in terms of size of the object under study. Scoping addresses planning the amount of reuse to be made, business case analysis addresses whether to reuse at all.

The arguments we will present in this paper apply equally to the formulation of business cases (i.e., on the overall product level) — whether they are formulated in the context of the big-bang introduction or in the context of incremental product line introduction, as well as on the level of scoping a reuse infrastructure (i.e., for individual features). Thus, throughout our paper we will not further make this distinction explicit.

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In this paper we will focus on some specific key aspects impacting the valuation of a strategy for product line transition. We will not provide a comprehensive discussion of the economic aspects of product line development as this has already been given in [Sch01]. Rather, for simplicity of our discussion, we will focus on the aspects of (development) costs, time, and revenues from the products and leave out aspects like risk or quality.

In this paper we will discuss three positions pertaining to the strategic decision of product line introduction:

- Valuation of uncertainty is a key ingredient of strategic planning.
- Product line development profoundly alters the decision making landscape for strategic planning.
- Software development and market aspects interact and so should be planned in an integrated manner.

We will now discuss each of the three positions in turn as they build in this order on each other.

2 VALUATION OF UNCERTAINTY IS A KEY INGREDIENT OF STRATEGIC PLANNING

The valuation of the decision to introduce product line development is composed of the investment required for the transition and the benefits that can be reaped from this transition. Typically, these are discussed solely as aspects of software engineering, i.e., how much do code assets cost to develop with a product line vs. without. If the cost of money is taken into account, typically some rough assumptions about the number of systems that can be expected are made, e.g., two per year [Coh01]. However, this approach falls short of modeling the true value of product line development. This is the case as we are discussing here multi-year planning. In industrial practice, the situation of on the market can change very rapidly. We therefore see often that what products to develop can be impossible to predict within a one year time-horizon, let alone a multi-year time-horizon as this kind of strategic decision calls for. Thus, without taking this uncertainty into account we are missing a major aspect in the valuation of the product line. On the other hand, a major reason for switching to product line development is the flexibility in product development which entails that new products can be brought to the market within a shorter time frame with less effort. This enables the organization to react more flexible to market developments. Therefore, we see that uncertainty actually comes in two disguises: opportunity (to be able to develop a product not explicitly planned for during product line planning) and risk (that a product taken into account during planning will not be developed).

For the valuation of uncertainty typical approaches are decision tree techniques or option approaches. In decision tree approaches we try to explicitly enumerate and valuate the different possibilities for the different product developments and their respective probabilities [Wit96]. Option value approaches directly address the evaluation of the value of flexibility [FFF98]. An individual option can be seen as a special case of a decision tree approach, however, the valuation approach is more sophisticated. Both techniques are integrated in the context of real options approaches [AK99, FFF98]. Therefore, these approaches are currently strongly gaining attention. Thus, we will use the option framework as a basis for our discussion of the next two positions. In order to do so, we need to introduce some terminology: an option is the possibility to buy (or sell) something at (or up to) a later point in time, the *strike date*. The something that can be traded is the *underlying*. And the fixed price at which it can be traded is called the *strike price*. The difference between the value of the underlying and the strike price is the benefit that can be acquired. Such an option has obviously a value, i.e., an *option price*.

3 PRODUCT LINE DEVELOPMENT PROFOUNDLY ALTERS THE DECISION MAKING LANDSCAPE FOR STRATEGIC PLANNING

Above we discussed that the uncertainty whether or not we are going to develop a product line will impact the valuation of the product line approach and thus the strategic decision. This is the approach typically taken in determining the value of an option [FFF98, AK99]. However, in terms of flexibility, product line development has a second major impact: the development for a product is shortened (cf. Figure 1). If we regard the point in time when a product is supposed to be released as fixed, then we can interpret this as a delay in the point in time when the decision needs to be made. Using the terminology of options, this implies that the strike date is delayed through reuse. This interpretation becomes particularly important when using option approaches for scoping product line development, as each addition of a feature implementation to the scope can be interpreted as exchanging an existing option (the option of developing the products with the current reuse infrastructure — and thus associated cost-savings) for an

option with a delayed strike date (the option of taking more parts directly from the new reuse infrastructure).

This interpretation is symmetrical to the situation when we regard the decision point as fixed and aim at fielding the product earlier. As this is usually expected to raise higher revenues on the market, we can interpret an expansion of the reuse scope as exchanging an option against another option with a higher value of the underlying. Both possibilities of determining the value of the reuse option obviously differ, as they refer to different decision-making scenarios. In particular, in the later interpretation we introduced the market value/revenues for the product as a decision-making parameter. This is a major extension of the typical existing approaches to reuse economics [Fav96, Lim96, Pou97], which do only refer to the saving of development costs (which is basically time-independent). However, this interpretation is quite standard in the context of option approaches.

Thus, we come to the conclusion, that either way the introduction of reuse in the development scenario alters the decision making scenario, which can be either interpreted as a change in the decision time or in the decision value. This change has to be explicitly taken into account in order to arrive at an appropriate valuation of a reuse scope, respectively the decision for product line development. However, this aspect is usually missing [Coh01] and should be integrated into methods for strategic planning of software products and projects.

4 SOFTWARE DEVELOPMENT AND MARKET ASPECTS INTERACT AND SO SHOULD BE PLANNED IN AN INTEGRATED MANNER

So far we treated the reuse decision as a strict consequence of the product line, i.e., the products that ought to be developed. We will illustrate that this dependency actually goes both ways: envisioned product line and software implementation influence each other. Actually, situations where entering a reuse initiative is only beneficial because of the additional opportunities this situation implies are imaginable. The example provided in Table 1 illustrates this point. (The data was explicitly constructed to provide a simple illustration.) In this table four products, their cost for development with reuse and without reuse and the revenues that are expected for them are given. For the moment we abstract from the phenomenons described in the previous sections. For the first three products the situation is rather clear, as they are expected to achieve higher revenues than their costs, independent of the development mode. The fourth product only achieves higher revenues than the cost for development with reuse. Thus we will develop this product only in a reuse-based situation. Should we now go for product line development?

Now, a rather interesting situation occurs: the total benefit of development without reuse is $1.1 Million (revenues – development cost without reuse for first three products), while the total benefit of the first three products with reuse is $0.6 Million (revenues – development with reuse – reuse investement). Thus, we would not vote for reuse. However, if we include the fourth product, for which an opportunity only exists in the reuse-based situation, we arrive at a benefit of $1.3 Million. Thus, this is the most preferable scenario!

This illustrates the strong interaction between market aspects and the technology choice of product line development.

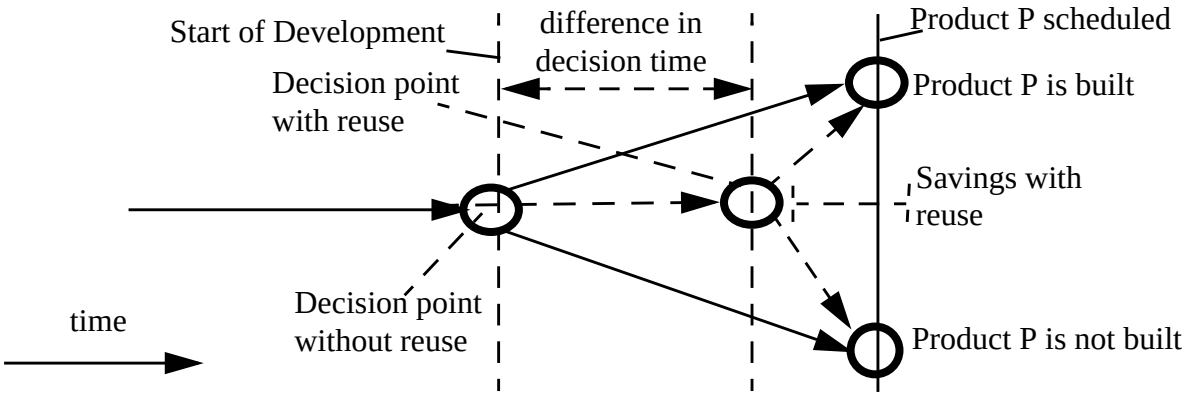


Figure 1. Decision Point in Time and Its Relation To Software Reuse

Product	Revenues [Million $]	Reuse Investment [Million $]	Dev. Cost with Reuse [Million $]	Dev. Cost without Reuse [Million $]	Reuse Savings in Product Dev. [Million $]
Reuse investment	—	3.5	—	—	—
Product 1	2.0	—	1.0	1.8	0.8
Product 2	2.4	—	1.2	2.0	0.8
Product 3	3.5	—	1.6	3.0	1.4
Product 4	1.5	—	0.8	1.8	1.0

Table 1. A Hypothetical Product Line Business Case

However, there is even a major interaction, which we dropped in the discussion above, and which leads us back to the option models discussed in the beginning. Typically, in market-driven development, the introduction of the nth product will have a profound negative impact on the revenues that can be accrued with the first n -1 products in the same market. This phenomenon is known as product line cannibalization [MM94] and should be taken into account as antipodal effect to the positive effect of reuse savings for a single product. In an option model this can be interpreted as a reduction of the value of the underlying.

5 CONCLUSIONS

In this paper we discussed problems that should be addressed by an approach to determine an objective valuation of a product line. Arriving at an objective valuation is a precondition for a rational strategy for product line introduction, for developing a business case for product line development, and for deriving an optimal product line scope. In particular, we identified three main aspects that such an approach needs to take into account: uncertainty needs to be taken into account, the repercussions that product line development itself has on the decision making situation, and the interactions between the technology aspects and the market for the product line should be explicitly modeled. Typically, even with the existing applications of real option approaches these problems are only partially addressed. Within, the Café-project we are currently focusing on the development of an approach which has said characteristics and thus supports product line transition in a rational and benefit-maximizing manner.

REFERENCES

[AK99] Martha Amram and Nalin Kulatilaka. *Real Options — Managing Strategic Investment in an Uncertain World*. Harvard Business School Press, 1999.

[Coh01] Sholom Cohen. Predicting when product line investment pays. In *Proceedings of the Second ICSE Workshop on Software Product Lines: Economics, Architectures, and Implications*, 2001.

[Fav96] John M. Favaro. A comparison of approaches to reuse investment analysis. In *Proceedings of the Fourth International Conference on Software Reuse*, pages 136–145, 1996.

[FFF98] John M. Favaro, Kenneth R. Favaro, and Paul F. Favaro. Value based software reuse investment. *Annals of Software Engineering*, 5:5–52, 1998.

[Lim96] Wayne C. Lim. Reuse economics: A comparison of seventeen models and directions for future research. In *Proceedings of the Fourth International Conference on Software Reuse*, pages 41–50, 1996.

[MM94] Charlotte H. Mason and George R. Milne. An approach for identifying cannibalization within product line extensions and multi-brand strategies. *Journal of Business Research*, 31:163–170, 1994.

[Pou97] Jeffrey S. Poulin. *Measuring Software Reuse*. Addison–Wesley, 1997.

[Sch00] Klaus Schmid. Scoping software product lines — an analysis of an emerging technology. In Patrick Donohoe, editor, *Software Product Lines: Experience and Research Directions; Proceedings of the First Software Product Line Conference (SPLC1)*, pages 513–532. Kluwer Academic Publishers, 2000.

[Sch01] Klaus Schmid. An initial model of product line economics. In *Proceedings of the International Workshop on Product Family Engineering, 2001*, 2001. To appear.

[Wit96] Jim Withey. Investment analysis of software assets for product lines. Technical Report CMU/SEI-96-TR-010, Software Engineering Institute, Carnegie Mellon University, 1996.