Controlling Lost Opportunity Costs in Agile Development – The Basic Lost Opportunity Estimation Model for Requirements Scoping

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Abstract. We present a model for estimating the final keep/cancel decision point, on a per-feature basis, for scope inclusion in a future release. The Basic Lost Opportunity Estimation Model (BLOEM), based on data from a company that uses an agile-inspired software development model, supports feature selection when the time-dependent business value estimates change as the requirements analysis progresses. The initial BLOEM validation, conducted on a set of 166 features, suggests that the model can valuable input to the feature selection process for a given release, helping to control lost opportunity costs due to feature cancellation. Limitations of BLOEM are discussed and issues for further research are presented.

Keywords: Requirements management, scope management, agile development, software business.

1 Introduction

Market-driven software development attempts to deliver the right product at the right time to the target market; time-to-market and release scheduling may strongly affect market success [1]. Threats include introducing new requirements in response to competitive pressures thereby creating a risk of feature creep negatively impacting timely (reliable) market introduction. Prior work [2] identified a pattern where features were pruned from a release only after significant (wasted) investment. These wasted efforts may negatively impact the effectiveness of requirements engineering and management activities.

Numerous prioritization techniques have been investigated and utilized to identify and select the most valuable features for the next release of a project. However, most techniques rely on accurate market value and effort estimates that can be difficult to generate early in the development process. The agile software development movement [3] attempts to increase requirements process flexibility and process

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responsiveness to unexpected changes in scope using continuous scope updating and one-dimensional (relative) methods for cost estimation and as a substitute for real market values [4]. However, it remains unclear how long potential features should be considered within project scope when there exist a high probability that scoping decisions may need to change due to unexpected events. Finally, this methodology does not address unexpected market forces such as revolutionary technologies or patent litigation nor does it target the release date as a critical success factor for software product delivery in a market-driven context [1].

We present the Basic Lost Opportunity Estimation Model (BLOEM), a simplified version of the previously published LOEM model [5] for controlling software project lost opportunity costs. BLOEM targets processes that use a one-dimensional requirements prioritization technique such as agile software development as well as processes where accurate effort estimation is challenging [4, 6]. BLOEM attempts to control wasted effort by facilitating earlier identification of feature cancellation candidates, promoting constructive use of resources. The model enhances existing processes by providing input to the keep/cancel scoping decision.

Cost functions identified in prior work [5] are collapsed into a single return on investment calculation represented by the Value function and we expect the Value to be obtained from marketing and sales information. The simplified model can use relative or absolute values for candidate features as well as their planned release date for estimating final decision points for inclusion or rejection within a release.

2 Background and Motivation

Agile software development focuses on continuously delivering business and customer value to increase the probability of early ROI [6]. Cao *et al.* noted that agile requirement engineering practitioners uniformly reported that their prioritization is principally based on business value [7]. While prioritizing based on business value is considered a key requirements prioritization criterion [4], it doesn't decrease the temporal uncertainty as a consequence of rapidly changing markets.

To illustrate the motivation behind BLOEM we present the results of our analysis of an agile-inspired prioritization process applied to a set of features for an embedded system product line developed at a large multinational company[1]. The case company has adopted a continuous development model with continuous feasibility assessment of proposed features and a one-dimensional prioritization model for scope management of a common platform technology based product line supporting more than 10 affiliated products.

Figure 1 depicts the normalized value of the (widely varying) business priority for each of a set of features plotted against the total time that the features were in the software development process (including the requirements phase). The case company data was collected with the help of the third author, currently under contract to the case company, who ensured that the collected data was correct and meaningful. Of 166 candidate features that were considered for this software product release, 83 were

[1] Due to space constraints in the conference format, we present the company description at `http://serg.cs.lth.se/research/experiment_packages/BLOEM/`

withdrawn. As can be seen in Figure 1, withdrawn features had both high and low priorities (value) and were withdrawn at all times throughout the release cycle.

BLOEM's intent is to quantify the effort spent on the features in the triangle labeled “area of interest” in Figure 1 to support efficient process management. Ultimately, we want to decide to keep/cancel a feature as quickly as possible – if a feature is withdrawn, it is best to withdraw it as early as possible to minimize wasted effort.

3 The Basic Lost Opportunity Estimation Model

The BLOEM model assumes that the decision-making criteria are temporal functions, not fixed values, which facilitates their use even in dynamic situations with uncertain scoping decisions. The model is based on the market-driven requirements engineering premise that the value of a requirement is a temporal function that is sensitive to market forces and opportunities – often a feature will only have market value for a limited time. Even features that offer unique capabilities see a significant reduction in their market value when competitors catch up and offer the feature in their own products.

Total value ***V(t)*** for a feature is defined in formula (1), where t=a is feature inception (when the feature begins to have non-zero value) and t=b is when the feature ceases to have any market value. A feature is cancelled at t=c. Maintenance, as both a cost and as a revenue source, is not considered in this simplified model.

$$V(t) = \int_a^b V(t)dt \qquad (1)$$

$$\int_a^c V(t)dt \leq \delta \qquad (2)$$

The value function will depend on the characteristics of the target market and must be estimated when applying the model.

From a management perspective we assume that features under investigation should be kept within the project scope until a defined value threshold ($\boldsymbol{\delta}$), known as the Final Decision Point (FDP), is reached. The threshold value can be unique to each feature and should be estimated per feature. High-value features (*e.g.* priority in the top 25%) could have the FDP threshold set higher than less valuable features (*e.g.* priority in the bottom 25%). Final decisions as to whether to keep (and realize the investment) or cancel (and minimize losses) are then delayed for the most valuable features while the least valuable features are canceled relatively early. The FDP can be used as to enforce a budget-like approach to the scoping management process.

We consider all canceled features to be wasted effort. However, investments in features that are canceled before the threshold are considered *controlled waste*: there is waste but it is under management control and the risk of inter-feature dependencies is held to an acceptable level. Features that are canceled after the final decision point are *uncontrolled waste* – something unexpected has happened and time or resource constraints cannot be met for this release cycle.

The flexibility required in the development process can be adjusted by changing the value of $\boldsymbol{\delta}$. The *overall impact* of a set $\boldsymbol{K}$ of withdrawn or cancelled features within a development cycle is calculated using formula 3:

$$\sum_{k=1}^{K} \frac{\int_a^b V_k(t)dt - \delta_k}{K} \tag{3}$$

4 Initial Model Evaluation

BLOEM was initially validated using a set of 166 features analyzed by the case company (depicted as dots in Figure 1). The feature status in the data set ranged from the definition phase, through implementation, to completion. During this period 87 features were canceled (dots with X's in Figure 1, several Xs overlap). The value function is defined relative to the lifespan for the feature, the period from feature inception until the feature ceases to have any market value. Two value functions were considered to observe their effects upon the results. The first function assumes a constant value across the lifespan of the feature. The second function assumes that value is normally distributed with the mean positioned at 50% of the lifespan and the standard deviation set to 1/6 of the lifespan. Under the normal value function, each

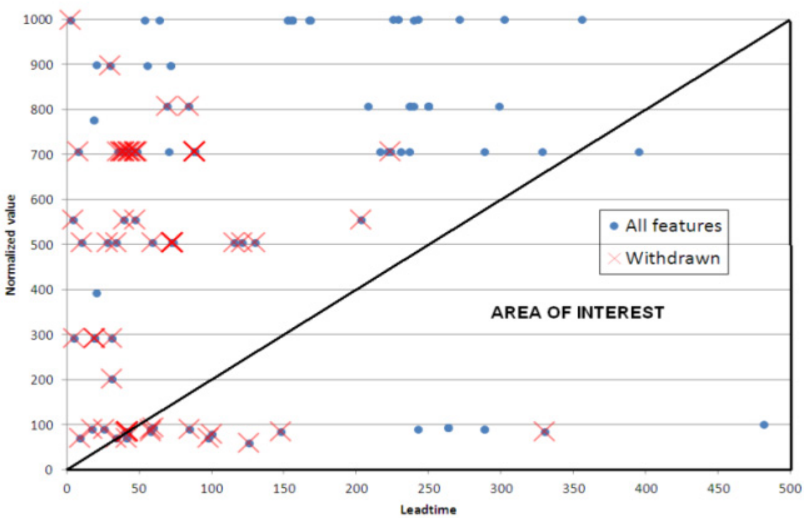

Fig. 1. Dots represent implemented features while crossed dots represent withdrawn features

feature has a very low value at the beginning of the lifespan. However, the value follows the cumulative distribution function therefore those features that exceed the FDP have much higher associated value on a per-feature basis that is realized as a loss (wasted effort) when the features are cancelled.

Results. Figure 2 depicts the results of using BLOEM with these two value functions (several data points overlap). The constant value function is represented by dots and the normal value function is represented by triangles. Because the value function is defined, in this case, to cover the entire product lifecycle, the final decision points should be only a small portion of the lifespan of the feature. The final decision points, represented by the red line in Figure 2, are set to 5% of the value function for low priority features (below 250), 10% for low-medium priority features (between 251 and 500), 20% for medium-high priority features (between 501 and 750) and 40% for high priority features (over 750). These exemplary final decision point values represent, in effect, the budget for feature scoping activities at each priority level – individual projects must set the thresholds in a contextually appropriate manner.

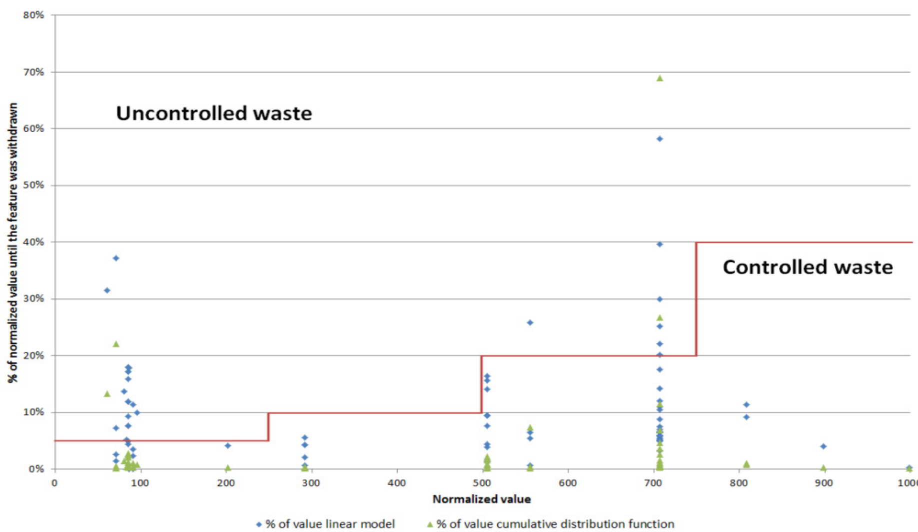

Fig. 2. Results from model validation

Discussion. Under the assumptions of the constant value function, the average *uncontrolled waste* was 10.2% of the normalized value for the 25 features that were withdrawn after their final decision point. Under the assumptions of the normal value function, the average *uncontrolled waste* was 20.3% of the normalized value for the 4 features that were withdrawn after their final decision point. The 25 features remained in the process for a cumulative 1021 days after the FDP while the 4 features remained in the process for a cumulative 75 days after the FDP. The resources expended upon these features during this period represent both direct costs and lost opportunity costs. In both cases, the overall impact of the entire feature set (kept and cancelled) was under the budget line (linear: -5.1%, normal: -37.6%) indicating that there was capacity to investigate more features within the given budget. Alternatively, the budget could have been tightened (final decision points set earlier) or fewer resources could have been allocated to the release as a whole (more features per human resource).

5 Conclusions and Further Work

The Basic Lost Opportunity Estimation Model (BLOEM) for controlling lost opportunity costs related to cancelled and withdrawn features was presented. Targeted at processes that employ one-dimensional requirements prioritization (such as agile methodologies where feature planning and roadmapping is required), its performance was investigated with an initial data set. The presented model is related to the models of investing under uncertainty described by Dixit and Pindych [8]. The analysis clearly identified opportunities to improve process efficiency within the examined data set. The costs associated with delayed feature cancellation were quantified and a budget-driven final decision point mechanism was presented as well as management guidance for interpreting the results. Preliminary discussions of the initial validation results were held with two practitioners at the case company who responded positively to the model concept and its potential for controlling lost opportunity costs.

This investigation showed that BLOEM results are sensitive to the cost function and further investigation into other cost functions is suggested to determine their utility for management decision support. For example, agile methodologies suggest a constant feature priority evaluation process – how well does BLOEM perform in such an environment? Further validation with other data sets is needed.

Regarding the validity of the obtained results, the first significant threat to validity is uncertainty as to whether or not the value functions provide proper guidelines to the management. The second main threat to validity is the fact that the study was conducted at one company and therefore the generalizability of the achieved results should be confirmed in the follow up studies.

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