Abstract
New paradigms in software engineering require new metrics to measure the size and estimate the effort for development or modification activities. One of these new software engineering methods is the approach of Process Families, which extends a Software Product Line engineering by a distinctive consideration of process flows. There are only a few theoretically based metrics for Product Line development available. Most of these measurement methods are practically immature and none of them takes account of process flows. Due to this fact we developed the metrics of Process Family Points which are briefly described within this article. Mainly this paper focuses an empirical comparison between the measures of Process Family Points and Function Points as well as Full Function Points.

Categories and Subject Descriptors: D.2.8 Metrics.

General Terms: Economics, Management, Measurement.

Keywords: Process Family Points, Function Point, Full Function Point, Process Families, Automotive, Electronic Business.

1. Introduction
“A Software Product Line is a set of software-intensive systems that share a common, managed feature set satisfying a particular market segment’s specific needs or mission and that are developed from a common set of core assets in a prescribed way” [7]. The consideration of software internal process flows realizes an additional optimization of Product Lines in domains which are driven by processes. These Process Families (PF) allow a more efficient software engineering based on an optimized reuse and automation. PF require an adoption of the requirements from the focused domain due to the high complexity of software internal process flows. This work has been done so far for the domains of Electronic Business (eBusiness) and Automotive [9].

Due to the novelty of PF there are no methods for quantifying the economic advantages of this new software engineering approach. However the existence of software metric is a main attribute for the acceptance of PF in the future. Only a reliable measurement of economic advantages enables the practical use of PF. The extensive utilization of PF will be restricted as long as there are no methods available to manage the cost, time and quality of development for PF.

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The metrics in [1], [6], [8] and [11] measure the characteristics of Software Product Lines only from a restricted viewpoint and are considered as related work. Moreover they disregard the explicit process focus of PF and lose sight of quality influences or effort estimation. Because of these reasons the framework of Process Family Points (PFP) were developed to realize a size measurement and effort estimation for PF. All PFP metrics are derived by goal-oriented actions according to the Goal Question Metric (GQM) paradigm.

None of the related work metrics is feasible for PF or realizes a effort estimation based on a size measurement. Therefore we compared the PFP analysis with the Full Function Point (FFP) method from the Common Software Measurement International Consortium (COSMIC) and with the Function Point (FP) analysis of the International Function Point Users Group (IFPUG). In contrast to the PFP analysis these practically proved metrics do not consider aspects of reuse, process characteristics or external influences of a PF development. All three software metrics will be compared in detail after a short description of the PFP analysis.

2. Size measurement and effort estimation
The first part of the PFP analysis which realize a size measurement of PF is illustrated in Figure 1. These metrics are based on an asset scoping and a functional specification of the PF.
counting types define if the PF is developed from scratch or built by a modification of an existing infrastructure. A third counting type is offered to measure a single software product which is derived from the PF.

The following stage of the PFP analysis is called “demarcation” and identifies the counting scope as well as the system borders of the PF. At this point the dynamic boundaries are outlined between the common and variable assets.

The micro analysis in figure 2 is characterized as an accumulation of software metrics to calculate an unadjusted size measure for PF. These metrics are partitioned in two sections as a result of the domain specific PF-usage:

- **eBusiness:** The actions to measure a PF in the domain of eBusiness comprise a data oriented and a process focused perspective. Both viewpoints realize a classification of the properties from PF in categories which differ in relation to their implementation size. Subsequently to this categorization a complexity weighting of every data and process function compose the foundation for the calculation of unadjusted PFP.

- **Automotive:** The metrics to measure PF in the automotive domain comprehend the characteristics of a real time and a process viewpoint with an important influence of the implementation size. The process to calculate the size measure of unadjusted PFP is also organized into the sections of categorization, complexity weighting and transformation.

Subsequently all calculated size measures were accumulated based on the preassigned “type of count”. This sum of unadjusted PFP can be used as an early indicator to estimate future efforts. Furthermore this size measure is companionable to unadjusted FP and the COSMIC functional size unit (Cfsu).

The PFP metrics which forecast efforts in developing or modifying a PF constitute a high flexible system to evaluate external influences in software engineering. With the all-purpose concept of Figure 2 it is possible to take account of relevant effort influences for PF which are up-to-date.

The domain independent software metrics from Figure 2 consider four common conditions of PF, each subclassified in five exemplary influences. After this evaluation of general influences the software metrics in Figure 2 focus 30 exemplary characteristics which are domain dependent. At this stage it is possible to calculate the size measure of adjusted PFP.

The consideration of 27 quality factors according to ISO/IEC 9126 is not obligatory in contrast with the preview metrics which are mandatory to execute. The additional application of this optional part from the PFP macro analysis enables the computation of the quality adjusted PFP measure.

The concluding estimation of effort for developing or modifying a PF is computed by usage of empirical equations. A number of functions to forecast efforts in man hours based on historical data are offered for the size measures of unadjusted, adjusted and quality adjusted PFP.

The other well known software metrics which are relevant for the validation of the PFP analysis are defined subsequently:

- **The IFPUG FP analysis** is a “standard method for measuring software development and maintenance from the customer’s point of view” [3].

- **The COSMIC FFP analysis** “involves the application of models, rules and procedures to a given piece of software as it is perceived from the perspective of functional user requirements” [2].

A comprehensive description of the IFPUG FP analysis can be found in [3] and the official handbook of the COMIC FFP method is distributed by [10].

3. **PFP versus IFPUG FP**

The correlation between the size measures of the PFP analysis and the effort to develop or modify a PF was investigated by scenarios of empirical validation. Within this framework it was possible to collect historical data for a derivation of domain specific equations to estimate the efforts in a PF project.

Every part of the PFP analysis with a focus on the domain of eBusiness was initially validated within a project at the University of Leipzig. Additionally to the development of a PF all efforts were estimated by a parallel usage of the PFP and the traditional FP analysis. Every point within the following diagrams shows a sub-project which is characterized by an effort in man hours and a size measure of the PFP or FP software metrics.

The independence between the adjusted size measure of the IFPUG FP analysis and the effort to develop a PF is visualized in Figure 3. Therefore the IFPUG FP analysis is not recommendable to estimate the effort for developing a PF.
Figure 3: Adjusted FP and man hours (eBusiness)

Figure 4 illustrates the PFP size measure with the highest effort correlation. Furthermore an equation to estimate man hours in dependence on quality adjusted PFP ($y=3.4784x$) is calculated by a linear regression.

Figure 4: Quality adjusted PFP and man hours (eBusiness)

The size measure of the IFPUG FP analysis is characterized by a low correlation to the recorded efforts. On the other side the result of the PFP analysis has a significant higher coherence to the required effort for developing a PF in the domain of eBusiness.

4. PFP versus COSMIC FFP

A first validation of the PFP analysis to measure the size and estimate the effort for PF in the automotive domain was executed in cooperation with DaimlerChrysler Research and Technology. The potential effort to realize a theoretical PF was identified within the framework of a Delphi-Study as a multistage expert interview. Therefore it was possible to compare the identified man hours for developing a PF with the precalculated size measures of the PFP analysis and the COSMIC Cfsu. Each point of the following diagrams visualizes the effort in man hours and a size measure of the PFP or FFP software metrics for a certain sub-project.

According to figure 5 there is no correlation between the Cfsu size measure of the COSMIC FFP analysis and the effort in developing a PF. For that reason it is not advisable to use the COSMIC FFP analysis for an economic management of PF in the domain of automotive.

Figure 5: Cfsu and man hours (Automotive)

Figure 5 shows the coherence between quality adjusted PFP and the efforts for developing a PF in the domain of automotive by an empirical based equation ($y=2.0534x$).

Figure 6: Quality adjusted PFP and man hours (Automotive)

In contrast to the Cfsu the PFP size measure is characterized by a much higher correlation to the determined effort.

5. Conclusion

The described validation is to be characterized as an laboratory study with an restricted scope. Nevertheless the PFP analysis is the only valid framework of software metrics to measure the size and forecast the effort in developing or modifying a PF.

The PFP analysis allows the identification of different influences to a project and supports an efficient problem management in software engineering for a PF. Furthermore, the discussed metrics enable a precise project planning and a tracking of the development progression. Based on the delivery of size measures and the estimation of future effort the PFP analysis calculates valuable information for the economical management of PF.

Despite the fact that these software metrics are the only approach to measure a PF they are first of all a scientific starting point which can be extended in different perspectives. For instance it is imaginable to match the PFP analysis with the rules of a functional size measurement according to ISO/IEC 14143 [4].
It is planned to collect additional data by usage of prototypical, domain specific implementations of the PFP software metrics. Based on these measurement tools the actual equations to estimate the efforts will be calibrated and optimized during the research project Process Family Engineering in Service-Oriented Applications (PESOA).

6. References


