Measuring the Size of Small Functional Enhancements to Software

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A requirement for productivity models and productivity analysis is to know the size of the product, or the output, of a work process. In software engineering, the product is the software itself. Function Points Analysis (FPA) has been designed to measure the functional size of software applications from a user's perspective. While it is being used extensively to measure either medium or large software development or enhancement projects, it has not been used to measure very small functional enhancements: its current measurement structure does not allow it to discriminate small size increments. This paper describes an extended version of FPA which is proposed to address this measurement issue of lack of sensitivity to small size changes. It also presents the design and the results of an empirical study carried out using this extended version.

Measurement of small functional enhancements

Small functional enhancements are carried out based on a service concept, while both major maintenance work and development projects are handled within a project management structure (Abran et al., 1993). The main characteristic of small functional enhancements is the limited scope and time required to complete them, usually with only one or two programmers (Abran et al., 1993). Another characteristic is the absence of structured planning and formal project reporting during the process.

Maintenance work is fairly diversified and various classifications have been proposed in the literature. Many of these classifications are based on the classification of maintenance activities, e.g. the process view (Swanson, 1976; Martin and McClure, 1983; Dekleva, 1990; Zvegintzov, 1991). Another has been proposed in (Abran et al., 1993) and is based on the concept of the measurement of the maintenance work product (see Table 1). This proposed classification meets the requirements of a measurement of the work output required to measure productivity; in economics, productivity is indeed defined as the ratio of the output of a process to its inputs (here, the software product over the effort required to develop this software).

For productivity studies of software maintenance, measures of the output of the maintenance process are therefore required. Ideally, different types of output would require different types of measures. This paper addresses the measurement issue involved in one of the four maintenance work product categories as defined in (Abran et al., 1993), the measurement of maintenance products which consist of small functional enhancements.

Category	Description
Corrective	Changes made to correct program failures, performance failures and implementation failures.
Enhancements	Changes made to add or modify functional changes in data requirements or functional processing requirements.
Perfective	Changes made to enhance technical performance, improve cost-effectiveness, efficiency and maintainability.
User Support	Information provided to users at their specific request and which did not require changes to the software.

Table 1 - Maintenance Work Product Categories (Abran, 1993)

Proposed measure of small functional enhancements: FPA extended version

A candidate measure of small functional enhancements is Function Points Analysis (FPA), which has been designed to measure the functional size of software applications from a user's perspective. While it is being used extensively to measure either medium or large software development or enhancements projects, it has not been used to measure the very small functional enhancements most often completed by maintenance staff. This section illustrates this issue and proposes an extended version of FPA to improve its sensitivity to small size changes.

The standard FPA measurement framework includes five function types and three levels of complexity for the assignment of function points (or weights) to individual user functions, as illustrated in Table 2 (IFPUG, 1994). The numbers in Table 2 represent the number of function points (FP) per function type and level of complexity.

	Complexity Level		
Function Type	Low	Average	High
Internal Logical Files (ILF)	7	10	15
External Interface Files (EIF)	5	7	10
External Inputs (EI)	3	4	6
External Outputs (EO)	4	5	7
External Inquiries (EQ)	3	4	6

Table 2 - FPA weights framework

The concept of complexity level is defined by a two-dimensional decision table used to assign weights based on step-wise intervals of two factors. Figure 1(a) shows the decision table of one function type, the Internal Logical File (ILF). Because small functional enhancements consist of small additions or modifications to existing software, they almost always fall within the smaller of the three intervals of the standard FPA sizing technique. The FPA measurement structure, as currently defined by the IFPUG standards, does not discriminate between small functional size increments.

To address the issue of granularity, the extended FPA proposed in (Abran and Maya, 1995) subdivides the smaller of the FPA standard intervals into five intermediate sub-intervals. Figure 1(b) presents an example of this subdivision into more granular intervals for the Internal Logical File function type.

	1-19 DET	**20-50 DET**	**51+ DET**
1 RET	7	7	10
2-5 RET	7	10	15
6+ RET	10	15	15

(a) Standard FPA (IFPUG 94)

<table>
<tr><th></th><th>1-3 DET</th><th>4-6 DET</th><th>7-9 DET</th><th>10-14 DET</th><th>15-19 DET</th><th>20-50 DET</th><th>51+ DET</th></tr>
<tr><td>1 RET</td><td>1</td><td>1</td><td>2</td><td>3</td><td>5</td><td>7</td><td>10</td></tr>
<tr><td>2 RET</td><td>1</td><td>2</td><td>3</td><td>5</td><td>7</td><td rowspan="4">10</td><td rowspan="4">15</td></tr>
<tr><td>3 RET</td><td>2</td><td>3</td><td>5</td><td>7</td><td>7</td></tr>
<tr><td>4 RET</td><td>3</td><td>5</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>5 RET</td><td>5</td><td>7</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>6+ RET</td><td colspan="5">10</td><td>15</td><td>15</td></tr>
</table>

(b) Extended FPA

DET = Data Element Type RET = Record Element Type

Figure 1 - Complexity matrix for Internal Logical Files

Instead of having only three possible weights, from 7 to 15, we now have seven weights, from 1 to 15. For the other function types, the number of possible weights was also changed, as follows (Appendix A shows the new complexity matrix for these function types):

- External Interface Files: from three weights (5 to 10) to seven (1 to 10).
- External Inputs: from three weights (3 to 6) to eight (0.5 to 6).
- External Outputs: from three weights (4 to 7) to ten (0.5 to 7).

This subdivision of the original intervals provides a more powerful size measurement discrimination technique for small functional deliverables. It should allow better analysis, in productivity studies, of the relationship between the functional size of small functional enhancements and the work-effort required to complete them.

Productivity analysis: a field study

A field study was conducted at a Canadian financial institution to test the benefits of using the extended FPA version for the measurement of small functional enhancements. Between 1990 and 1994, the output of 752 small functional enhancements maintenance requests was measured using extended FPA, together with the work effort that had been required to complete each of these requests. These enhancements were carried out on 24 different business software applications, five of which provided over 90% of the data points. The extended FPA data were collected by 28 software staff (either programmers or analysts) on the special data collection form designed for this field study, while the effort was obtained from the time reporting system in place at this industrial site. It is important to note that not only the total number of extended FPA data were collected for each observation, but also their lower levels of measurement detail, including the sub-totals of extended FPA data for each of the five function types.

To ensure the quality of the data points for research purposes, a validation process was carried out based on the validation procedures described in (Desharnais, 1993). Results of this validation process are described in (Abran and Taboubi, 1994). As a result of this validation process, observations missing a required level of detail were eliminated, leaving a total of 504 observations for analysis. For productivity analysis purposes, two population samples were defined: a first set of outliers and a set of normal populations; the outliers were defined as large maintenance requests in terms of either functional size or work effort. The following triggers were used to characterize 11% of the full data set as outliers: over 20 FP or 100 hours of effort. The distribution of the other 89% of the data points was analyzed and found to have a Gaussian distribution, thus facilitating the use of simple statistical analyses with a minimal set of assumptions. The results reported in this paper represent only the analysis of the normal distribution sample and exclude the outliers.

Size measurement results

Using the extended FPA measurement technique, the median of the sample at 3.5 FP indicates that 50% of the sample has between 0.5 and 3.5 FP, while the other 50% of the sample has between 3.5 and 20 FP (Maya, 1995). With the conventional FPA technique, none of the very small functional enhancements would have been given a size less than 3 FP, the smallest standard FPA weight. It can be noted also that 85% of the observations have a size less than or equal to 10 FP, and 95% less than 15 FP. Therefore, this technique makes it possible to differentiate between very small and small functional enhancements.

At the same industrial site, the average functional size of the projects that add or modify major functions to existing software applications has been reported to be 232 FP (Abran, 1994). This is in contrast to the average functional size of 5 FP for this dataset of small maintenance products, a size difference of more than one order of magnitude. This confirms the usefulness of a more granular size measurement technique more sensitive to the small size increments of the work product of small functional enhancements.

FP analysis by function type has pointed up another major size difference between major enhancement projects and small enhancement maintenance work output. For development and major enhancement projects, the five function types are usually present in the output of each project.

However, this is not the case for small functional maintenance enhancements; in the sample from this field study, they usually have only one or two of the five function types (for example: a maintenance work product consisting of a modification to one or two elements of an input screen would have 1 FP of only one function type, the Input type).

There is the possibility of over a hundred combinations of the five FPA function types: the five function types one at a time, then ten combinations of two function types at a time, and so on. In the data sample from this field study, thirty combinations were identified. Combinations of three, four or five simultaneous function types were the most infrequent, while most maintenance work products included some combination of one or two function types only. Each distinct combination was labeled a *profile*, and the most frequent profiles, representing 77% of the observations, were (Figure 2): External Inquiries (EQ) only, a combination of External Interface Files (EIF) and External Outputs (EO), External Outputs only, a combination of External Interface Files and External Inquiries, and External Interface Files only.

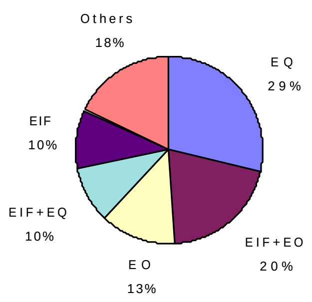

Figure 2 - Most frequent profiles

Work-effort relationship

The correlation between the two variables, functional size in extended FP and the effort, is very weak: r^2=0.285 (Maya, 1995). This means that the functional size as the only independent variable is not enough to explain the effort required to process a small functional enhancement. Many other factors are reported in the literature to have an influence on the work-effort relationship, like for example, the type of application (batch, on-line, telecom, etc.), the size and the number of the applications involved in the enhancement, etc. Statistical analyses were conducted for many of these factors, but for most the relationship to work effort did not produce better productivity models, nor did further analyses by profile.

However, the detailed analysis of mean unit costs revealed the most insightful results. Figure 3 shows some examples of the extended FP mean unit costs by year (from 1990 to 1994) and between applications. The mean unit costs analysis by year showed significant productivity increase for this organization. The analysis by application permits us to compare the maintenance productivity between applications. The original FP framework does not differentiate between sizes sufficiently to allow such analyses.

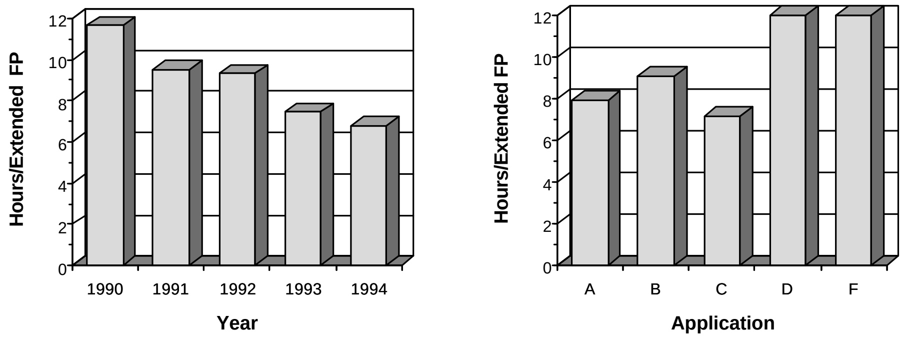

Figure 3 - Extended Function Points Unit Cost

Observations and future research

The sizing technique based on an extended version of FPA provides an adequate level of measurement sensitivity to functional size change in small maintenance software products of the enhancements type, as defined in (Abran et al., 1993). The results of this field study provided further insights into this type of maintenance, including identification of the function type profiles most frequently found in small functional enhancements. Further research is being conducted to analyze the impact of other factors on the work-effort relationship, such as the application type and profiles. Research is also being carried out to define size measures for the output of the other categories of maintenance products.

Acknowledgments

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Appendix A - Extended Function Points Framework

<table>
<tr><th></th><th>1-3 DET</th><th>4-6 DET</th><th>7-9 DET</th><th>10-14 DET</th><th>15-19 DET</th><th>20-50 DET</th><th>51+ DET</th></tr>
<tr><td>1 RET</td><td>1</td><td>1</td><td>2</td><td>3</td><td>5</td><td>7</td><td>10</td></tr>
<tr><td>2 RET</td><td>1</td><td>2</td><td>3</td><td>5</td><td>7</td><td rowspan="4">10</td><td rowspan="4">15</td></tr>
<tr><td>3 RET</td><td>2</td><td>3</td><td>5</td><td>7</td><td>7</td></tr>
<tr><td>4 RET</td><td>3</td><td>5</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>5 RET</td><td>5</td><td>7</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>6+ RET</td><td colspan="5">10</td><td>15</td><td>15</td></tr>
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Internal Logical Files (ILF)

<table>
<tr><th></th><th>1-3 DET</th><th>4-6 DET</th><th>7-9 DET</th><th>10-14 DET</th><th>15-19 DET</th><th>20-50 DET</th><th>51+ DET</th></tr>
<tr><td>1 RET</td><td>1</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>7</td></tr>
<tr><td>2 RET</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td rowspan="4">7</td><td rowspan="4">10</td></tr>
<tr><td>3 RET</td><td>2</td><td>3</td><td>4</td><td>5</td><td>5</td></tr>
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<tr><td>5 RET</td><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td></tr>
<tr><td>6+ RET</td><td colspan="5">7</td><td>10</td><td>10</td></tr>
</table>

External Logical Files (ELF)

<table>
<tr><th></th><th>1-2 DET</th><th>3-4 DET</th><th>5-6 DET</th><th>7-8 DET</th><th>9-11 DET</th><th>12-15 DET</th><th>16+ DET</th></tr>
<tr><td>1 FTR</td><td>0.5</td><td>1</td><td>1.5</td><td>2</td><td>2.5</td><td>3</td><td>4</td></tr>
<tr><td>2 FTR</td><td>2</td><td>3</td><td colspan="4">4</td><td>6</td></tr>
<tr><td>3+ FTR</td><td colspan="2">4</td><td colspan="4">6</td><td>6</td></tr>
</table>

External Inputs (EI)

<table>
<tr><th></th><th>1 DET</th><th>2-3 DET</th><th>4-5 DET</th><th>6-7 DET</th><th>8-9 DET</th><th>10-12 DET</th><th>13-15 DET</th><th>16-19 DET</th><th>20+ DET</th></tr>
<tr><td>1 FTR</td><td>0.5</td><td>1</td><td>1.5</td><td>2</td><td>2.5</td><td>3</td><td>3.5</td><td>4</td><td>5</td></tr>
<tr><td>2 FTR</td><td>1</td><td>1.5</td><td>2</td><td colspan="5" rowspan="2">5</td><td rowspan="2">7</td></tr>
<tr><td>3 FTR</td><td>1.5</td><td>2</td><td>4</td></tr>
<tr><td>4 FTR</td><td colspan="3">5</td><td colspan="5">7</td><td>7</td></tr>
</table>

External Outputs (EO)

DET = Data Element Type RET = Record Element Type FTR = File Type Referenced