DEFINING MEASURES FOR MEMORY EFFICIENCY OF THE SOFTWARE IN MOBILE TERMINALS

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Abstract *Efficient usage of memory is one of the key cost drivers of the software for mobile terminals. But how to measure, monitor and predict the memory efficiency of the software? This paper introduces a study and results of an undertaking to define a measure for memory efficiency of software. Memory efficiency was defined as the amount of functionality packed per megabyte of memory in the mobile terminal, where the functionality was seen from the viewpoint of the terminal user. Practical measurements were done for two different mobile phones.*

1. INTRODUCTION

Efficient usage of memory is one of the key cost drivers of the software for mobile terminals. But how to measure, monitor and predict the memory efficiency of the software?

A study of defining such a measure for memory efficiency of software was executed for evaluating its applicability and practical usage for business purposes. The study consisted of

- applying the COSMIC-FFP as a standard functional size measurement (FSM) method to determine the amount of functionality (seen by the end user) packed in two different mobile phones
- comparing the memory efficiency of software between these two phones, and
- conclusions of the applicability of the FSM method for measurement of memory efficiency of software in mobile terminals.

2. BACKGROUND

The *Memory Efficiency* in this context would mean “low memory consumption per feature” and could be measured as

= [Amount of functionality] / [Memory Size],

(Def. 1)

i.e. how much functionality is packed into an amount of memory.

The target for the measure would be the capability to compare memory efficiency with different terminal models, including terminals from different manufacturers. Therefore the source of determining the measures should be public.

COSMIC-FFP measurement method was used for measuring “amount of functionality” in this study.

Memory sizes of the terminals are assumed to be known.

Two existing mobile phones – A and B – were used as sample objects in this study.

3. ASSUMPTIONS

The primary reason for measuring memory efficiency is to monitor and manage the cost efficiency regarding memory usage in comparison with different terminal models. Measuring the absolute values is not important by definition, benchmarking is.

It makes sense to compare the comparable terminals only, i.e. within same technology, for instance GPRS phones.

The functionality is seen by the user's point of view without any knowledge of the internal architecture of the software. This is the only alternative for measuring other manufacturer's terminals.

4. MEASUREMENT WORK

1 Measuring the amount of functionality

The measurement was based on the functionalities documented in the User's Guide provided by the phone supplier. The total functionality of the phones was calculated by means of COSMIC-FFP Functional Size Measurement method, [2].

The general steps of the measurement process in COSMIC-FFP are

1. Define the scope of the measurement
2. Determine and get available the artifacts where the Functional User Requirements (FUR) are described
3. Define the boundaries of the software
4. Identify the actors and data groups interacting with the software (within the selected scope and boundary)
5. Identify all functional processes (one by one) by identifying the triggering events
6. Identify all data movements (and their types) within each functional process
7. Add up the total amount of data movements in each functional process and over all functional processes.

To test the applicability of the method in this context we first limited the scope of the measurement to the Phone book features only, and calculated the amount of functionality in the Phone book of those two phones. Discovering the results satisfactory it was decided to complete the measurement with all features of the phones resulting the entire user functionality to be measured. Although the total functionality could have been approximated by this piece of calculations (i.e. Phone book), this would not have been accurate enough to be used as a measure for memory efficiency for reliable comparisons between the two phones. (In fact, an approximation was made in this stage and was found to result into the range of 77 – 96 % of the ultimate calculated size.)

The measurement steps (defined above) were applied by feature such as Phone book, Messaging, Calling, Settings, etc. The functions of each feature of the phones were examined as “Use cases” experienced by the user (and documented in the User’s Guide) when he/she selects different Menu functions in the phone. The results of the measurement process from each feature were documented constantly in Excel-sheets so, that all identified functional processes, interacting actors and storages, and data movements between them were recorded separately. Totals from the separate feature sheets were then aggregated in one summary sheet for each phone.

Note: The FSM method does not take into account the space available to store user maintained data, amount of which varies in different phones, e.g. number of entries in the phone book, call registers, message folders, etc. If space is constrained for his/her purposes the user may, however, consider that as a reduced functionality. (Which actually is part of “Usability” in ISO 9126 quality requirements). This issue shall be concerned separately.

2 Measuring the memory size

There are alternatives to be considered as “memory size” in (Def. 1), for instance

1. the total size of Flash and RAM memory,
2. the total memory reduced by the size of memory reserved for user data (see Note in 4.1 above),
3. the total memory reduced by “free” memory (free = size of memory not used for any applications in the phone).

The total memory (1) is the only measure, which is fully known even of other manufacturer’s products (when publicly available).

The space for user data (2) could be approximated fairly confidently by knowing the maximum amounts of various entries of user data (which are normally documented in User’s Guides).

Free memory (3) is not known at all in foreign products.

5. RESULTS

1 Measuring the functionality of the phones A and B

The features of the phones were grouped and examined as they appeared in the contents of the User’s Guide. For example, feature groups in the phones included such as

- Calculator
- Calendar
- Call Counters
- Call Functions
- Call Registers
- Data Communication (with PC)
- Games
- Internet Services
- Messaging
- Phone book

- Settings
- etc.

Because the functions within each feature do not all fall into the same groups in each phones it is not appropriate to compare the exact numerical values of the functionality by feature but all together. However, in one phone some “same” features consist less functionality than in the other and some features do not exist at all.

The total amount of functionality in the phone A was measured to **1574 Cfsu**, and to **985 Cfsu** in B respectively, seen by the phone user’s perspective. Phone A thus has about 60 % more functionality than B.

The detailed measurements of each feature are recorded in separate Excel-sheets and summarized together in one aggregate sheet.

2 Measuring the size of memory of the phones A and B

The amount of physical memory of these two phones is known to be as follows:

A: 8 MB Flash + 1 MB RAM = 9 MB
B: 4 MB Flash + 0.5 MB RAM = 4.5 MB

As specified in section 4.2 above there are also other alternatives to consider the amount of memory used for the software embedded in the phone. Because the space where the different kind of user maintained data is stored and handled by the software is a “data base storage” rather than a storage for executable software it is justified to exclude that amount of memory from the concept of “memory efficient software”.

The amount of memory for the user data was approximated to be

0.54 MB in A, and
0.28 MB in B

The assumptions were made about the most significant attributes of user maintained data given in the User’s Guides, such as maximum

- number of entries/items in the phone book, call registers, calendar, folders
- length of voice recording
- number of voice tags
- etc.

3 Measuring the memory efficiency of the phones A and B

The memory efficiency defined in (Def. 1) as a proportion of amount of functionality to memory size, can now be determined for the target phones by means of the measures given in 4.1 and 4.2 in two different cases:

Memory Efficiency *	A	B
For total available memory:	175	219
Space for user data excluded:	186	233

* in units of Cfsu / MB

Table 3. Memory efficiency indexes for the phones A and B

Memory efficiency index (MEI) is expressed in Cfsu/MB (i.e. COSMIC Functional Size Units divided by Memory Size in megabytes). The figures exhibit that in phone B there is 25 % more user functionality packed per megabyte than in A (relative to available memory). However, as shown in 4.1, the total amount of functionality in A is 60 % more than in B.

6. CONCLUSIONS

As a conclusion of this study several lessons have been learned.

1 Measure for memory efficiency

The definition for a measure of memory efficiency as given in (Def. 1) is applicable for the purpose of monitoring and comparing the packing density of user functionality in different phones. Depending on the purpose of the measurement alternative *Memory Efficiency Indexes* can be defined where different divisors are used as *Memory Size*.

The analysis of memory usage in relation to user functionality may support business decisions as well.

2 Benefits of functional size measurement

The functional size depicts amount of functionality delivered to the user of the (software) product. It can be measured with standard methods (conformity with ISO 14143, [1]) from user requirements or specifications in any architecture layer of realization depending on the scope and purpose of the measurement. The functional size is independent of development tools and platforms.

The analysis of the size (=amount of functionality) is a vital means of managing the software project, e.g. for estimating the work effort and schedule needed to development, and controlling the scope of the product or the feature. Because the size measurements can be done separately on different layers and abstraction levels, the usage is applicable respectively depending on the purpose.

The size is also a measure for normalization of other metrics such as failure rates and development productivity for instance. By means of a given size and the knowledge of the history of these other metrics many important issues can be tracked and predicted - memory efficiency of software among others as seen in this study.

Thus one functional size measurement serves for several important purposes.

3 Cost of measurement

Measuring the functional size is a manual work at the moment because human interpretation of user requirements (given in User's Guide for instance) is needed. An experienced FSM analyst may measure (and document) about 15-25 Cfsu per hour from FUR like in this application (User Guides). However, several mobile phones contain same functionalities in their features, which means that all measurements need not be started from scratch but earlier measurements can be reused with need of validation only.

Depending on the purpose it is not always necessary to measure all features accurately, but the rest can be estimated by means of the known size profiles of corresponding concepts. And, as stated above one measurement serves for several purposes at the same time.

7. VOCABULARY

COSMIC	Common Software Measurement International Consortium
COSMIC-FFP	COSMIC Full Function Point size measurement method
Cfsu	COSMIC Functional Size Unit
FSM	Functional Size Measurement
FUR	Functional User Requirements
ISO	The International Organization for Standardization
MEI	Memory Efficiency Index

8. REFERENCES

[1] International Standard ISO/IEC 14143: Information Technology – Software Measurement – Functional Size Measurement.

[2] The COSMIC-FFP Measurement Manual, Version 2.1/May 2001,