Test City metaphor as support for visual testcase analysis within integration test domain

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***Abstract*—the majority of formal description for software testing in the industry is conducted at the system or acceptance level, however most formal research has been focused on the unit level. This paper shows formal test selection and analyzes criteria for system or integration test based on visualization analysis for low level test cases. Visual analysis for low level test case selection is to be based on inputs from available Test Management system. The paper presents a use case for visual metaphor as a base for analysis testware for a test project in the industry.**

I. Introduction

Software development is dealing with growing complexity, shorter delivery times and current progress made in the hardware technology. Within the software lifecycle the biggest, however not directly seen part, is the maintenance. Number of used systems in the corporation is continuously increasing. During time progression users get trusted to the used software, so tolerated number of deviations is decreasing. As soon as software is put in the production environment, every big change or even small adaption of the source code can cause potential danger in the best case monetary in the worst case image or even human being losses. Nevertheless the maintenance is very often provided during the whole period through different groups of technicians or business partners. This makes the task of programming, understanding and maintaining of the source code for the system and its testware more complex and difficult. Testware management, especially for the high (HLTC) and low level test cases (LLTC) [8], which are focusing on old but still valid functionality keeps going to be not affordable, or omitted on purpose. This causes increasing maintenance costs to the limit, when new development can produce less cost and even be easier to implement than creation of the new functionality within the old system.

Required quality of the software is very often to be reached through quality assurance activities on several levels, starting from unit test, through system, integration and ending on acceptance tests. Artifacts produced during the test process required to plan, design, and execute tests, such as documentation, scripts, inputs, expected out-comes, set-up and clear-up procedures, files, databases, environment, and any additional software or utilities used in testing are named, according to ISTQB, testware [8]. Detection of the problems within a testware can save much effort and reduce necessary maintenance costs. Number of executed tests in the first or second year of software maintenance is not being a disruptive factor for the test projects. As soon as software is coming into the last phase, associated teams are very often moved to the other development projects or taken out of the company (e.g. consultants are being moved from customer to customer). To prove necessary quality after performed adaptations, growing complexity of the system is demanding high professional skills and understanding from people and organizations taken over the responsibility for the system.

Software quality is according to definition:

1. The degree to which a system, component or process meets specified requirements [21].
2. Ability of a product, service, system, component, or process to meet customer or user needs, expectations, or requirements [22].
3. Degree to which the system satisfies the stated and implied needs of its various stakeholders, and thus provides value [23].
4. Degree to which a system, component, or process meets customer or user needs or expectations [21].
5. The degree to which a set of inherent characteristics fulfills requirements [24].

Above given definition is obligating quality assurance teams to perform planned and systematic pattern of actions to provide adequate confidence to the product or item that it conforms to established technical requirements [2]. Execution of needed actions to provide at least same quality during the whole maintenance phase is a big cost factor. According to survey-analysis presented during the iqnite 2011 conference in Düsseldorf [19], almost 60% of the software projects are spending between 20 and 30% of its budget on Quality Management (QM) and testing activities.

Especially big and complex systems are providing large number of functions and demanding even larger number of objects within the testware. To provide 100% fulfillment the test team has to ensure that each function is not affected through the code adaptation and its site effects. Adaptation of the system demands adaptation of testware to fulfill quality requirement for the current system.

Even best managed testware, after few years of usage, is not free of objects which are old, obsolete, duplicated or there are no HLTCs or LLTCs covering demanded functionality. Those objects are causing additional management effort and its existence does not increase expected quality needs.

Often developers and managers believe that a required change is minor and attempt to accomplish it as a quick fix. Insufficient planning, design, impact analysis and testing may lead to increased costs in the future. Over time successive quick fixes may degrade or obscure the original design, making modifications more difficult [7] and finishing in not acceptable, low quality of the system.

As long as we are accepting loose of the software and testware quality, its transparency, increasing maintenance costs, decreasing test efficiency, and continuous testware erosion is not a subject. However, in time of financial crisis and decreasing IT budgets, there is none of the project which can come over this dilemma. In the next chapters we would like to show results from pilot project which has been executed in the industry in order to prove usefulness for the approach of the visualization metaphor for testware reorganization.

II. Related Work

Since the early days of software visualization, software has been visualized at various levels of detail, from the module granularity seen in Rigi [13] to the individual lines of code depicted in SeeSoft [3]

The increase in computing power over the last 2 decades enabled the use of 3D metric-based visualizations, which provides the means to explore more realistic metaphors for software representation. One such approach is poly cylinders [20], which makes use of the third dimension to map more metrics. As opposed to this approach in which the representations of the software artifacts can be manipulated (i.e., moved around), our test cities imply a clear sense of locality which helps in viewer orientation. Moreover, our approach provides an overview of the hierarchical (i.e., package, test object) structure of the systems.

The value of a city metaphor for information visualization is proven by papers which proposed the idea, even without having an implementation. [15] Proposed this idea for visualizing information for network monitoring and later [14] proposed a similar idea for software production. Among the researchers who actually implemented the city metaphor, ([9]; [1]; [18]) represented classes are districts and the methods are buildings. Apart from the loss of package information (i.e., the big picture), this approach does not scale to the magnitude of today's software systems, because of its granularity.

The 3D visual approach closest in focus to ours is [10], which uses boxes to depict classes and maps software metrics on their height, color and twist. The classes' box representations are laid out using either a modified tree map layout or a sunburst layout, which split the space according to the package structure of the system. The authors address the detection of design principles violations or anti-patterns by visually correlating outlying properties of the representations, e.g., a twisted and tall box represents a class for which the two mapped metrics have an extremely high value. Besides false positives and negatives, the drawbacks of this approach is that one needs different sets of metrics for each design anomaly and the number of metrics needed for the detection oftentimes exceeds the mapping limit of the representation (i.e., 3). The detection strategies [12] were introduced as a mechanism to formulate complex rules using the composition of metrics-based filters, and extended later [11] by formalizing the detection strategies and providing aid in recovering from detected problems.

III. Visualization Metaphor

A visualization metaphor is defined as a map establishing the correspondence between concepts and objects of the application under test and a system of some similarities and analogies. This map generates a set of views and a set of methods for communication with visual objects in our case - test cases [6].

Lev Manovich has said: "an important innovation of computers is that they can transform any media into another". This gives us possibility to create a new world of data art that the viewer will find as interesting. It does not matter if the detail is important to the author; the translation of raw data into visual form gives a viewer possibility to get information which is the most important just for him. Hence, any type of visualization has specific connotations, which may become metaphoric when seen in context of a specific data source. Metaphor in visualization works at the level of structure, it compares the composition of a dataset to a particular conceptual construct, and the choice of any visualization is always a matter of interpretation.

Numerous currently existing visualization systems are divided into three main classes:

→Scientific visualization systems [4];
→Information visualization systems [5];
→Software visualization systems [16]

Although all visualization systems differ in purposes and implementation details, they do have something common; they manipulate some visual model of the abstract data and are translating this into a concrete graphical representation.

In this paper we are not aiming to present all possible visualization metaphors, as this is not the focus for our research. We would like to show basic and easy to understand "City metaphor" which is helpful for representation specific test data and allow easier test reorganization. After some of the previous research work which is however not in focus of this paper we settled our first attempt to the metaphor which is very widely presented in [17] and is a part of his PhD [17]. In its research and implementation for software source code classes are represented as buildings located in city districts which in turn represent packages, because of the following reasons:

→A city, with its downtown area and its suburbs is a familiar notion with a clear concept of orientation.

→A city, especially a large one, is still an intrinsically, complex construct and can only be incrementally explored, in the same way that the understanding of a complex system increases step by step. Using an all too simple visual metaphor (such as a large cube or sphere) does not do justice to the complexity of a software system, and leads to incorrect oversimplifications: Software is complex; there is no way around this.

→Classes are the cornerstone of the object-oriented paradigm, and together with the packages they reside in, the primary orientation point for developers.

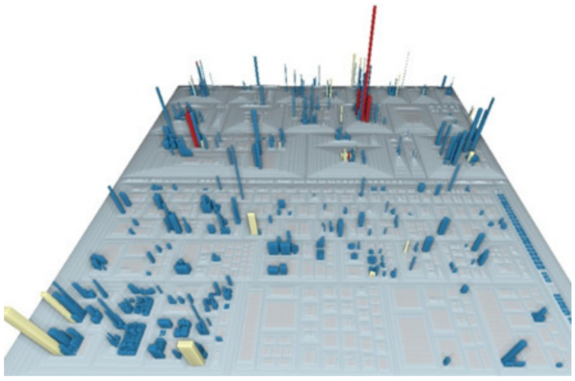


Fig. 1 Example of "Software City" representation of JBoss application server.

In our attempt we perform mapping between available LLTC and its basic metrics, perform testware reorganization and at the end provide easy to understand and manage overview about the current state of testware.

A. Test metrics

To be able to perform data visualization, defined set of the static and dynamic data has to be prepared. Based on the available information's for LLTC we are extracting following basic metrics, which we use for later mapping:

→Amount of LLTC

→Execution status for available LLTC

→Last modification date/age

→Number of executions

Dependent on the metrics type, those are to be taken as a data export through the available API from the test management tool or statistical data taken from the support or test organization.

Fetched metric can be mapped into the chosen visualization metaphor as:

→Data physical properties (color, geometry, height mapping, abstract shapes)

→Data granularity (unit cubes, building border or urban block related)

→Effect of Z axis mappings on the image of the city

→Abstraction of data and LOD are key issues

→Resulting "data compatible" urban models are much larger than the original VR urban models.

IV. Test Reorganization

In this paper we would like to show how useful can be usage of visualization based on the "Test City" metaphor. We would like to show how to perform test reorganization based on the very basic set of metrics available in the test project.

For our experimental work we have established a new system interacting with several Test Management applications placed on the market. The base idea of the system is an automation extraction and pre-evaluation of several different test metrics. Those metric are imported via available API connections from the Test Management tool and evaluated to get required set of metrics. The test metrics are provided as a text file, e.g. CSV (Comma Separated Values), and imported into visualization framework. Used visualization framework is based on the existing solution presented in [17] and allows us perform necessary analysis. The analysis result is taken as an input to the Test Management tool for Test-Set creation and evaluation.

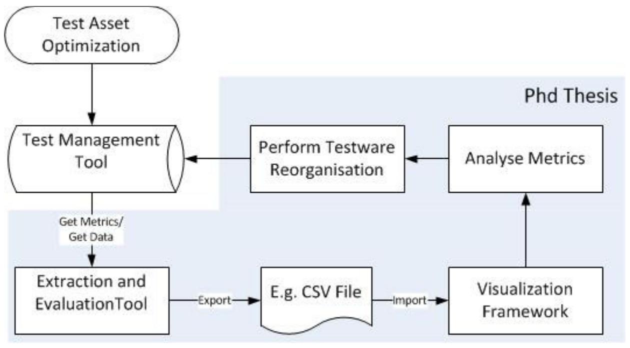


Fig. 2 - Block Structure created analysis system.

Within our research for one test project that contains over 4000 LLTC, we have performed analysis for basic and extended test metrics.

Visualization results for this test project with testware structure shown in the tables 1 and 2 are shown in the Figure 3, 4, 5 and 6. Parameters have been based on following test metrics:

1. Test execution age → mapped to the color.
2. Number of executions → mapped to the height.
3. Modification age → mapped to size.

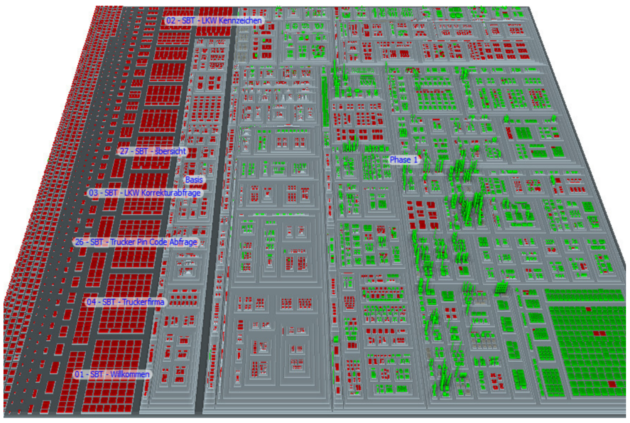

02 - SBT - LKW Kennzeichen
27 - SBT - šbersicht
Basis
03 - SBT - LKW Korrekturabfrage
26 - SBT - Trucker Pin Code Abfrage
04 - SBT - Truckerfirma
01 - SBT - Willkommen
Phase 1

Fig. 3 Test-City based on LLTC for Test Project

To provide real reference to the analysed testware, the districts (as a square group) of the Test City are mapped to the structure created by test teams and managed with help of the Test Management system (e.g. Test folder or Test object).

Looking at the possible analysis for testware visualization according to the Figure 3 we can provide following input for the improvements:

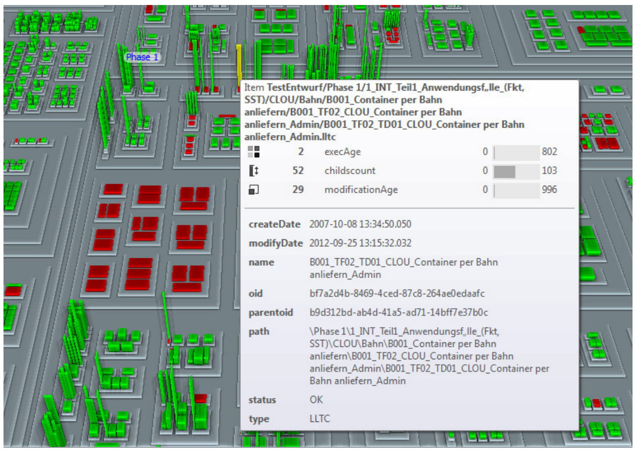
1. There is a large number of old LLTC which has been executed later than threshold set to 370 days (e.g. red buildings – left site in the Figure 3). Most of them had a small height which gives as an information about low number of executions. Those LLTC shall be either archived, or completely removed from the Testware. LLTC not modified for longer than 1 year and rarely executed is with very high probability obsolete.

2. There are other areas in the middle and the top, which has to be taken as well under investigation (red buildings). Based on the height we can assume, most of them are obsolete; however moving to the archive is better option than leaving them within the testware.

3. Each green building is representing LLTC been most likely commonly used in the last 370 days. Large number of high and green buildings allows us to assume area of regression tests. Those LLTC has been used in the last period to assure certain quality of the product and shall not be moved to the archive or adapted within the first phase for testware reorganization.

Below, the tables shows the visualized artifacts in numbers.

Using a visualization we are able to show up hotspots within the testware domain. In order to localize objects within the testware we are focusing the interesting area with help of built in zoom function. Please see Figure 4 for an example



Item **TestEntwurf/Phase 1/1_INT_Teil1_Anwendungsf„lle_(Fkt, SST)/CLOU/Bahn/B001_Container per Bahn anliefern/B001_TF02_CLOU_Container per Bahn anliefern_Admin/B001_TF02_TD01_CLOU_Container per Bahn anliefern_Admin.lltc**

```
2   execAge           0  802
52  childscount       0  103
29  modificationAge   0  996
```

createDate	2007-10-08 13:34:50.050
modifyDate	2012-09-25 13:15:32.032
name	B001_TF02_TD01_CLOU_Container per Bahn anliefern_Admin
oid	bf7a2d4b-8469-4ced-87c8-264ae0edaafc
parentoid	b9d312bd-ab4d-41a5-ad71-14bff7e37b0c
path	\Phase 1\1_INT_Teil1_Anwendungsf„lle_(Fkt, SST)\CLOU\Bahn\B001_Container per Bahn anliefern\B001_TF02_CLOU_Container per Bahn anliefern_Admin\B001_TF02_TD01_CLOU_Container per Bahn anliefern_Admin
status	OK
type	LLTC

Fig. 4 Zoom on interested LLTC for Test Project

TABLE II.
TESTWARE QUANTITY FOR GIVEN TEST PROJECT

Object type	Quantity
LLTC	18473
Executions	38182

Without having a deep knowledge about the current testware and objects details we can provide the test managers with exact information regarding that LLTCs. Presented and used metrics are very basic but are giving very good start for testware reorganization and have been taken as a feedback for involved test managers.

TABLE I.
TESTWARE QUANTITY STRUCTURE

Execution Age	LLTC	(%)
0	11519	62,36
1-370	6526	35,33
>370	428	2,32

A. *Reorganization results part 1*

Based on the given output testware reorganization hase been performed. After finishing the first part we have executed testware domain processing and present the results. As an outcome for our work we have presented new Test-City shown in the Figure 5.

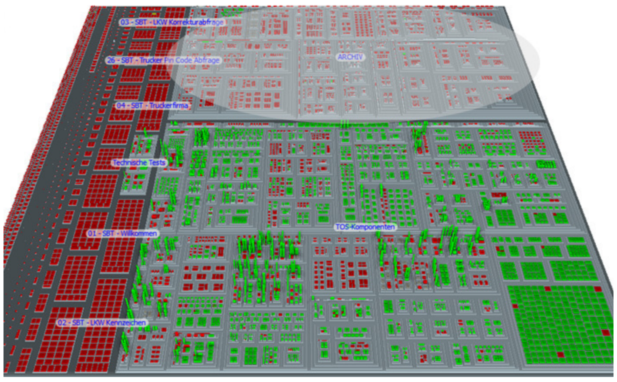

03 - SBT - LKW Korrekturabfrage
26 - SBT - Trucker Pin Code Abfrage
ARCHIV
04 - SBT - Truckerfirma
Technische Tests
TOS-Komponenten
01 - SBT - Willkommen
02 - SBT - LKW Kennzeichen

Fig. 5 Test City after first reorganization

There is a marked area where big part of obsolete LLTC has been moved. Most of the buildings are small and red colored, which shows correctness for our attempt.

Below the area we can see large district with several parcels of building which are green colored and relatively high. This allows us to assume commonly used regression tests.

Recursive execution our analysis has gave as result Test-City presented in Figure 6.

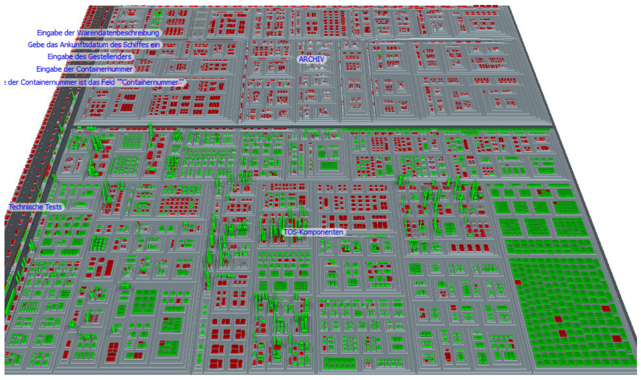

Eingabe der Warendatenbeschreibung
Gebe das Ankunftsdatum des Schiffes ein
Eingabe des Gestellenders
Eingabe der Containernummer
der Containernummer ist das Feld ""Containernummer""
ARCHIV
Technische Tests
TOS-Komponenten

Fig. 6. Final structure for LLTCs within Test Project

There is visible well organized structure within the domain. Current analyze state has been taken as end Phase with used metrics. Deeper analysis can be performed based on other set of metrics which will allow even smaller size of testware database afterwards.

V. Feedback from Test Managers

Created results have been presented to the involved experienced Test managers within the organization and their feedback has been checked. Following results has been achieved:

→There is no false positives, all ugly layouts represents real problems

→No false negatives, no beauty layout should be ugly

→Unique global overview on the testware landscape

→Identify of hotspots ("there was always a question")

→Identify cluster of issues (e.g. regression test)

→Identify cluster of stagnation

The feedback has proven our first impression we got by looking at the testware visual representation. Even if the system looks well-organized, in spite of the numerous disharmonious artifacts: we see a districts, where the test which were executed more than 365 days ago are localized and districts of increased number of high building, even skyscrapers, in which several very important and common tests are defined.

The skyscrapers are giving us the impression how many of existing LLTC have been executed very often. Their color shows execution age as an important factor for testware reorganization.

Within very short time we were able to locate and show large number of obsolete and suspicious LLTCs. Identified hotspots and pain points based on very basic test metrics has been confirmed by the personal working for longer time with the testware, even without our deeper knowledge for the system itself. Necessary data for LLTC adaptation and/or reorganization has been exported based on zooming information at interesting areas/districts given to the test managers and used for next iteration.

Testware reorganization has been done within integration test domain and has brought minimization of used LLTC within a database. This saves in long term necessary maintenance costs and gives well overview about the current testware status.

VI. Conclusion

Test case management, test analysis and test creation are the most important tasks within the whole test management process. It is very hard to concentrate the analysis on small set of the LLTC as it is not getting potential win against the requirement spectrum. Possible loss of testware quality can be threated only as additional cost factor and each activity steering against is helping to keep those on expected level. Performed visualization has shown, how easy in use and efficient can be presented method for testware analysis. Finding an obsolete LLTC based on available metrics is very comfortable and does not require deep system knowledge, even if analyzed system seems to be very complex. This saves needed time, resources and allows problem presentation not only on technical but as well on management level. Presented results have been used for further deeper analysis and reorganization activities.

Additionally we have observed person performing analysis is tending to point its view on maximum two metrics in time and not searching for further information on the third one. This behavior was partly driven via visualization framework and its available mapping attributes and partly human laziness.

Our future directions will focus on the points listed below:

1. Extension for more APIs to Test Management tools available on the market.
2. Comparison for analysis outcome when using same metrics but different Visualization Metaphors.
3. Visualization for metrics within the timeline.
4. Extend number of evaluated metrics, especially to find out duplicate tests.

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