A Brief Overview Of Software Testing Metrics

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***Abstract*—Metrics are gaining importance and acceptance in corporate sectors as organizations grow, mature and strive to improve enterprise qualities. Measurement of a test process is a required competence for an effective software test manager for designing and evaluating a cost effective test strategy. Effective management of any process requires quantification, measurement and modeling. Software Metrics provide quantitative approach to the development and validation of the software process models. Metrics help organization to obtain the information it needs to continue to improve its productivity, reduce errors and improve acceptance of processes, products and services and achieve the desired Goal. This paper, focusing on metrics lifecycle, various software testing metrics, need for having metrics, evaluation process and arriving at ideal conclusion have also been discussed in the present paper.**

Keywords- Software Testing, Software Testing Metrics

I. INTRODUCTION

In recent years software testing technologies have emerged as a dominant software engineering practice which helps in effective cost control, quality improvements, time and risk reduction etc. The growth of testing practices has required software testers to find new ways for estimating their projects. A key research area in this field has been ‘measurement of and metrics for’ the software testing. Measurement since plays a critical role in effective and efficient software development, making measurements of the software development and test process is very complex [2].

A. Business need

Increase in competition and leaps in technology have forced companies to adopt innovative approaches to assess themselves with respect to processes, products and services. This assessment helps them to improve their business so that they succeed and make more profits and acquire higher percentage of market. Metric is the cornerstone in assessment and also foundation for any business improvement.

B. Software Metrics

Metric is a standard unit of measurement that quantifies results. Metric used for evaluating the software processes, products and services is termed as Software Metrics.

Definition of Software Metrics:

Software Metrics is a Measurement Based Technique which is applied to processes, products and services to supply engineering and management information and working on the information supplied to improve processes, products and services, if required.

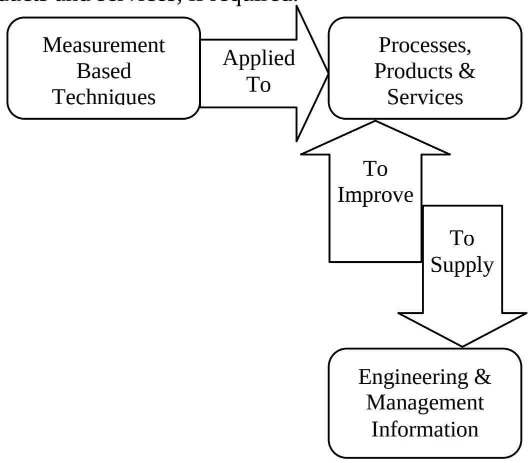

Measurement Based Techniques
Applied To
Processes, Products & Services
To Improve
To Supply
Engineering & Management Information

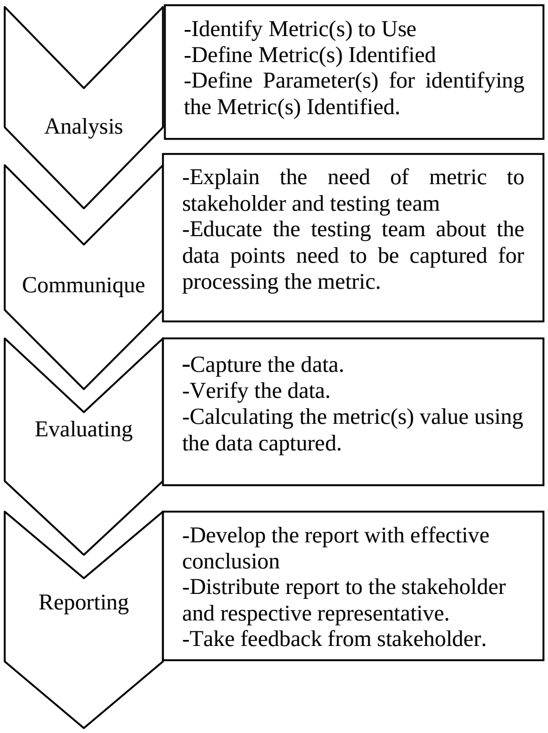
Fig. 1 Software Metrics

C. Importance of Metrics

- Metrics is used to improve the quality and productivity of products and services thus achieving Customer Satisfaction.
- Easy for management to digest one number and drill down, if required.
- Different Metric(s) trend act as monitor when the process is going out-of-control.
- Metrics provides improvement for current process.

D. Metrics Lifecycle

The process involved in setting up the metrics:



-Identify Metric(s) to Use
-Define Metric(s) Identified
-Define Parameter(s) for identifying the Metric(s) Identified.

-Explain the need of metric to stakeholder and testing team
-Educate the testing team about the data points need to be captured for processing the metric.

-Capture the data.
-Verify the data.
-Calculating the metric(s) value using the data captured.

-Develop the report with effective conclusion
-Distribute report to the stakeholder and respective representative.
-Take feedback from stakeholder.

Fig. 2 Software Metrics Lifecycle

II. TYPE OF SOFTWARE TESTING METRICS

Based on the types of testing performed, following are the types of software testing metrics:

1. Manual Testing Metrics
2. Performance Testing Metrics
3. Automation Testing Metrics

Following table shows different software testing metrics.

TABLE I. SOFTWARE TESTING METRICS

Manual	o Test Case Productivity o Test Execution Summary o Defect Acceptance o Defect Rejection o Bad Fix Defect o Test Execution Productivity o Test Efficiency o Defect Severity Index
Performance	o Performance Scripting Productivity o Performance Execution Summary o Performance Execution Data - Client Side o Performance Execution Data - Server Side o Performance Test Efficiency o Performance Severity Index
Automation	o Automation Scripting Productivity o Automation Test Execution Productivity o Automation Coverage o Cost Compression
Common Metrics	o Effort variance o Schedule Variance o Scope change

A. Manual Testing Metrics

1) Test Case Productivity (TCP)

This metric gives the test case writing productivity based on which one can have a conclusive remark.

$$\text{Total Case Productivi ty} = \left[\frac{\text{TotalRawTe st Steps}}{\text{Efforts(ho urs)}}\right]\text{Step(s)/ho ur}$$

Example

Test Case Name	Raw Steps
XYZ_1	30
XYZ_2	32
XYZ_3	40
XYZ_4	36
XYZ_5	45
Total Raw Steps	183

Efforts took for writing 183 steps is 8 hours.

TCP=183/8=22.8

Test case productivity = 23 steps/hour

One can compare the Test case productivity value with the previous release(s) and draw the most effective conclusion from it.

2) Defect Acceptance (DA)

This metric determine the number of valid defects that testing team has identified during execution.

$$\text{Defect Acceptance} = \left[\frac{\text{Number of valid Defects}}{\text{Total Number of Defects}} * 100\right]\%$$

The value of this metric can be compared with previous release for getting better picture

3) Defect Rejection (DR)

This metric determine the number of defects rejected during execution.

$$\text{Defect Rejection} = \left[\frac{\text{Number of Defects Rejected}}{\text{Total Number of Defects}} * 100 \right] \%$$

This metric gives the percentage of the invalid defect the testing team has opened and one can control, if required, in future.

4) *Bad Fix Defect (B)*

Defect whose resolution give rise to new defect(s) are bad fix defect.

This metric determine the effectiveness of defect resolution process.

$$\text{Bad Fix Defect} = \left[\frac{\text{Number of Bad Fix Defect(s)}}{\text{Total Number of Valid Defects}} * 100 \right] \%$$

This metric gives the percentage of the bad defect resolution which needs to be controlled.

5) *Test Execution Productivity (TEP)*

This metric gives the test cases execution productivity which on further analysis can give conclusive result.

$$\text{Test Execution Productivi ty} = \left[\frac{\text{Number of TCexecuted (Te)}}{\text{Execution Efforts (hours)}} * 8 \right] \text{Execution(s)/Day}$$

Where Te is calculated as,

Where,

Base Test Case = No. of TC executed at least once.

T (1) = No. of TC Retested with 71% to 100% of Total TC steps

T (0.66) = No. of TC Retested with 41% to 70% of Total TC steps

T (0.33) = No. of TC Retested with 1% to 40% of Total TC steps

6) *Test Efficiency (TE)*

This metric determine the efficiency of the testing team in identifying the defects. It also indicated the defects missed out during testing phase which migrated to the next phase.

$$\text{Test Efficiency} = \left[\frac{\text{DT}}{\text{DT} + \text{DU}} * 100 \right] \%$$

Where,

DT = Number of valid defects identified during testing.

DU = Number of valid defects identified by user after release of application. In other words, post-testing defect

7) *Defect Severity Index (DSI)*

This metric determine the quality of the product under test and at the time of release, based on which one can take decision for releasing of the product i.e. it indicates the product quality.

$$\text{Defect Severity Index} = \left[\frac{\sum \text{(Severity Index * No. of Valid Defect(s) for this severity}}{\text{Total Number of Valid Defects}} \right]$$

One can divide the Defect Severity Index in two parts:

a) *DSI for All Status defect(s):*

This value gives the product quality under test.

b) *DSI for Open Status defect(s):*

This value gives the product quality at the time of release. For calculation of DSI for this, only open status defect(s) must be considered.

$$\text{DSI (Open)} = \left[\frac{\sum \text{(Severity Index * No. of Open Valid Defect(s) for this severity}}{\text{Total Number of Valid Defects}} \right]$$

B. Performance Testing Metrics

1) *Performance Scripting Productivity (PSP)*

This metric gives the scripting productivity for performance test script and have trend over a period of time.

$$\text{Performance Scripting Productivity} = \left[\frac{\sum \text{Operations Performed}}{\text{Efforts (hours)}}\right] \text{Operation(s)/hour}$$

Where Operations performed is: -

1. No. of Click(s) i.e. click(s) on which data is refreshed.
2. No. of Input parameter
3. No. of Correlation parameter

Above evaluation process does include logic embedded into the script which is rarely used.

Example

Operation Performed	Total
No. of clicks	10
No. of Input Parameter	5
No. of Correlation Parameter	5
Total Operation Performed	20

Efforts took for scripting = 10 hours.

Performance scripting productivity =20/10=2 operations/hour.

2) Performance Execution Summary

This metric gives classification with respect to number of test conducted along with status (Pass/Fail), for various types of performance testing.

Some of the types of performance testing: -

1. Peak Volume Test.
2. Endurance/Soak Test.
3. Breakpoint/Stress Test.
4. Failover Test

3) Performance Execution Data - Client Side

This metric gives the detail information of Client side data for execution.

Following are some of the data points of this metric

1. Running Users
2. Response Time
3. Hits per Second
4. Throughput
5. Total Transaction per second
6. Time to first byte
7. Error per second

4) Performance Execution Data - Server Side

This metric gives the detail information of Server side date for execution.

Following are some of the data points of this metric -

1. CPU Utilization
2. Memory Utilization
3. HEAP Memory Utilization
4. Database connections per second

5) Performance Test Efficiency (PTE)

This metric determine the quality of the Performance testing team in meeting the requirements which can be used as an input for further improvisation, if required.

$$\text{Performance Test Efficiency} = \left[\frac{\text{Requirement during PT}}{\text{(Requirement during PT)Requirement after Signoff of PT}} * 100\right]\%$$

To evaluate this one need to collect data point during the performance testing and after the signoff of the performance testing.

Some of the requirements of Performance testing are:

1. Average response time.
2. Transaction per Second.
3. Application must be able to handle predefined max user load.
4. Server Stability

Example

Consider during the performance testing above mentioned requirements were met.

In production, average response time is greater than expected, then

Requirement met during PT = 4

Requirement not met after Signoff of PT = 1

PTE = (4 / (4+1)) * 100 = 80%
Performance Testing Efficiency is 80%

6) Performance Severity Index (PSI)

This metric determine the product quality based performance criteria on which one can take decision for releasing of the product to next phase i.e. it indicates quality of product under test with respect to performance.

$$\text{Performance Severity Index} = \left[\frac{\sum (\text{Severity Index} * \text{No. of Req. not met for this severity})}{\text{Total No. of Requirement not met}} * 100 \right]$$

If requirement is not met, one can assign the severity for the requirement so that decision can be taken for the product release with respect to performance.

Example
Consider, Average response time is important requirement which has not met, then tester can open defect with Severity as Critical.
Then Performance Severity Index = (4 * 1) / 1 = 4 (Critical)

C. Automation Testing Metrics

1) Automation Scripting Productivity (ASP)

This metric gives the scripting productivity for automation test script based on which one can analyze and draw most effective conclusion from the same.

$$\text{Automation Scripting Productivity} = \left[\frac{\sum \text{Operation Performed}}{\text{Efforts (hours)}} \right] \text{Operation(s)/hours}$$

Where Operations performed is: -

1. No. of Click(s) i.e. click(s) on which data is refreshed.
2. No. of Input parameter
3. No. of Checkpoint added

Above process does include logic embedded into the script which is rarely used.

Example
Automation scripting productivity = 2.5 operations/hour.

2) Automation Test Execution Productivity (AEP)

This metric gives the automated test case execution productivity.

$$\text{Automation Test Execution Productivity} = \left[\frac{\text{Total No. of Automated TCexecuted (ATe)}}{\text{Execution Efforts (hours)}} * 8 \right] \text{Execution(s)/Day}$$

Where Te is calculated as,

$$\text{ATe} = \text{Base Test Case} + ((\text{T}(0.33) * 0.33) + (\text{T}(0.66) * 0.66) + (\text{T}(1) * 1))$$

Evaluation process is similar to Manual Test Execution Productivity.

3) Automation Coverage

This metric gives the percentage of manual test cases automated.

$$\text{Automation Coverage} = \left[\frac{\text{Total No. of TC Automated}}{\text{Total No. of manual TC}} * 100 \right] \%$$

Example

If there are 100 Manual test cases and one has automated 60 test cases then Automation Coverage = 60%

4) Cost Comparison

This metrics gives the cost comparison between manual testing and automation testing. This metrics is used to have conclusive ROI (return on investment).

Manual Cost is evaluated as: -

Cost (M) =Execution Efforts (hours) * Billing Rate

Automation cost is evaluated as: -

Cost (A) =Tool Purchased Cost (One time investment) + Maintenance Cost + Script Development Cost + (Execution Efforts (hrs) * Billing Rate)

If Script is re-used the script development cost will be the script update cost.

Using this metric one can have an effective conclusion with respect to the currency which plays a vital role in IT industry.

III. COMMON METRICS FOR ALL TYPES OF TESTING

A. *Effort Variance (EV)*

This metric gives the variance in the estimated effort.

Operation Performed	Total
No. of clicks	10
No. of Input Parameter	5
No. of Checkpoint added	10
Total Operation Performed	25

Efforts took for scripting =
10 hours.
ASP=25/10=2.5

$$\text{Effort Varience} = \left[\frac{\text{Actual Effort - Estimated Effort}}{\text{Estimated Efforts}} * 100 \right] \%$$

B. *Schedule Variance (SV)*

This metric gives the variance in the estimated schedule i.e. number of days.

$$\text{Schedule Varience} = \left[\frac{\text{Actual No. of Days - Estimated No. of Days}}{\text{Estimated No. of Days}} * 100 \right] \%$$

C. *Scope Change (SC)*

This metric indicates how stable the scope of testing is.

$$\text{Scope Change} = \left[\frac{\text{Total Scope - Previous Scope}}{\text{Previous Scope}} * 100 \right] \%$$

Where,
Total Scope = Previous Scope + New Scope, if Scope increases
Total Scope = Previous Scope - New Scope, if Scope decreases

IV. CONCLUSION

Metric is the cornerstone in assessment and foundation for any business improvement. It is a Measurement Based Technique which is applied to processes, products and services to supply engineering and management information and working on the information supplied to improve processes, products and services, if required. It indicates level of Customer satisfaction, easy for management to digest number and drill down, whenever required and act as monitor when the process is going out-of-control.

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