The Use of Statistical Quality Control Charts for the Acceptance and Sign-off Process for Web Application Products

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Abstract

The fast development and use of IT and the customer interactive websites on the internet created great opportunities for companies involved in developing Web application product in project oriented environment. Many projects fail due to lack of clear identification of customer requirements, and moreover, lack of control of defects, especially when the defects have different weights according to their severity (effects) on the acceptance of the products. In this paper, firstly we will classify the severity of defects, secondly, define the sign-off criteria for web based application, and finally, determine whether the process is in statistical control using the demerits chart (U-chart).

Keywords
Quality Control, Quality Control Charts, Demerit Control Chart, Web Application Products.

1. Introduction
In recent years, the fast development and increased use of the internet created great opportunities for the development of interactive websites. An increased number of companies are specialized in the development of such website to meet the demand. The development of such websites (Web application products) is usually approached in a project oriented environment. The application products allow its users to navigate and search, message board other users, share ideas and buy products online. These products have many characteristics such as: user friendly; aesthetics (color, layout, spelling, etc.); and functionality (calculations, money transactions, searching mechanisms, etc.). The projects of Web application products go through the system development life cycle (SDLC) where it passes the following phases: Planning, System analysis and requirements definition, System design, System development, Testing, Acceptance and Sign-off, and maintenance. Many projects fail due to lack of clear identification of customer requirements, and moreover, lack of control of defects, especially when the defects have different weights according to their severity (effects) on the acceptance of the products as a result of the testing phase.

The America's National Institute of Standards (NIST) study released in 2004 estimated that $22.2 Billion (more than one-third) of the cost of software failures could be eliminated simply by improved testing [1]. Projects failure can be defined as not being able to meet the projects requirements. The project is considered successful if it meets three main goals: project scope, time, and cost [2]. These three goals are called the triple constraints. Project quality is the ability to balance these three constraints. Project quality, cost, and time are used to evaluate the project management internal efficiency [3]. Some of the software risk factors that may lead to project failures are: Developing the wrong functions, Developing the wrong interface, 'gold-plating' and continuing scope change [4]. Specifications and standards are identified as one of the strategies for controlling risk factors in software projects [5].

Control charts are the most important Statistical Process Control (SPC) tools for monitoring performance of products and services [6, 7]. Control charts are classified into two parts according to their application: Variable and attribute control charts [6, 7]. Attribute control charts are often used to monitor services because they are based on a quick decision of good or bad. C-charts and u-charts are commonly used to render decisions on the statistical control status of products and services. Defects of products and services usually do not have the same weight of effect on products or services. Not being able to access the site of the company on the internet does not have the same effect as when one finds that a world is misspelled. When testing the Web products many types of defects are usually

encountered. They are classified as: Low, Medium, High, Very High, and Show Stopper/Urgent (the definitions of these categories are included in the methodology section). These different types of defects have different impact on the product. The Demerits control charts (U Charts) are statistical quality control tools that best fit for monitoring such a problem. The Demerits control charts assign weights (Low, Medium, High, Very High, and Show Stopper/Urgent) to each category of defects found in the web application products and helps to identifying samples with large numbers of defects as well as large numbers of critical defects.

From the literature survey, the authors found that there is a lack of application of demerits charts in general, especially in web based application. The goal of this study is to develop a methodology of applying the Demerits Control Charts (U-Charts) in the Web application products environment. Once the model is developed, samples are collected from the testing group of web application products. The defects are classified and the control charts are constructed to determine if the process is within statistical control. Based on this contemplation, the remainder of this study is organized as follows: Section 2 discusses the methodology and analyzes the results. Finally, Section 3 draws conclusions.

2. Methodology

The proposed methodology will be applied in a software development and quality controlling company. The company function is outsourcing clients. The core product of the company is a collection of interactive website. Any website of these allows its users to navigate and search, message board other users, share idea, buy products online and follow up on their weight progress all online. Any product will follow the System Development Life Cycle (SDLC). Where it should go through the following phases:

- Planning
- System analysis & requirements definition
- System design
- System development
- Testing
- Acceptance & Sign-off
- Maintenance

2.1 Defect Severity Classification

The following defect severity classifications are identified by the quality assurance (QA) department:

- *Show Stopper / Urgent*- The “Server Error in Application” page appears. Testers ability to operate the system wither totally (system down), or almost totally, affected. A major area of the users system is affected by the incident and it is significant to business process. Must be fixed before the release day.

- *Very High*- The major functionality not working. User is unable to login. The data/content is missing on the page. Some modules of application are affected and not testable. Error should be fixed before the release but can be allowed to deploy to production pending business owner sign off. It is must be fixed in the next available release or post launch.

- *High*- A major feature is broken. Will be released to production but should be fixed in the next available release. Post launch or project. Exist like when problem is required in the spec but tester can go on with testing. Incident affects an area of functionality but there is a work around which negates impact to business process.

- *Medium*- It’s a bug that should be fixed. Minor loss of function, and there an easy work around. Will be released to production in the next available release. This is a problem that
    a) Affects a more isolated piece of functionality.
    b) Occurs only at certain boundary conditions.
    c) Has a workaround (where “don’t do that” might be an acceptable answer to the user).
    d) Occurs only at one or two customers is intermittent.

- *Low*- A cosmetic problem, such as a misspelled word or misaligned text. This is for minor problems, such as failures at extreme boundary conditions that are unlikely to occur in normal use, or minor errors in layout/formatting. Problems do not impact use of the product in any substantive way. These are incidents that are cosmetic in nature and of no or very low impact to business processes.

2.2 Sign-off Criteria

In any of the products release, QA will sign-off on the project to go to production if the following are met.

- Zero defects with a severity level of "Show Stopper".
- <5% defects with a severity level of "Very High".
- <10% defects with a severity level of "High".
- <20% defects with a severity level of "Medium".
- <30% defects with a severity level of "Low".

These criteria are based on the defects severity classification and their impact on the total product performance described in section 2.1.

For analysis, we took a sample of a number of completed releases that were set to production and calculated the total number of non-closed defects then normalized the numbers found the percentage.

The "U-Chart" and "Demerits calculation" approach will be followed to establish the statistical control chart. A sample of thirteen completed projects is taken. For each project we filtered the non-closed reported defects, and categorized those filtered according to their severity. The percentage of each non-closed category is then calculated accordingly. Table 1 below shows the thirteen completed projects with their severity classification.

Table 1. Percentage of non-closed defects according to their severity classification

Project No.	Severity				
	Low (30%)	Medium (20%)	High (10%)	Very High (5%)	Show Stopper (0%)
1	18.4%	5.1%	4.7%	0.4%	1.7%
2	0.0%	20.8%	4.2%	0.0%	0.0%
3	0.0%	51.3%	10.3%	2.6%	0.0%
4	8.5%	11.3%	11.3%	14.2%	2.8%
5	0.0%	0.1%	0.3%	0.1%	0.1%
6	4.5%	5.7%	2.3%	0.8%	0.0%
7	2.7%	4.0%	1.4%	1.1%	0.4%
8	1.1%	2.1%	1.6%	1.9%	0.5%
9	10.6%	15.6%	6.3%	0.5%	0.0%
10	0.7%	2.7%	3.1%	2.6%	0.3%
11	2.1%	5.0%	8.5%	2.9%	1.3%
12	1.4%	2.9%	6.9%	3.1%	0.2%
13	4.3%	6.4%	6.4%	3.2%	0.0%

The above table shows that most of the projects fail to meet the client's specification for one or more defects severity. Only projects 6, 9, and 13 meet sign-off criteria.

2.3 Process Statistical Control Analysis (U-Chart)

The use and demerits to construct the U-Chart states that for a sample of size (n), and a total number of different defects categories (c_1, c_2, c_3, c_4 and c_5 as in our case), we can denote the weight assigned to each category as (w_1, w_2, w_3, w_4, and w_5). By this, we can get the total number of demerits given by,

$$D = w_1 c_1 + w_2 c_2 + w_3 c_3 + w_4 c_4 + w_5 c_5 \quad (1)$$

The weight of defect severity is specified by the clients in Table 2 below.

Table 2. Assumed weights for each defect severity

Defects Severity	Weight
Low	70
Medium	80
High	90
Very High	95
Show Stopper	100

And the demerits per unit for the sample can be calculated by,

$$\bar{u}_i = D / n = (w_1 c_1 + w_2 c_2 + w_3 c_3 + w_4 c_4 + w_5 c_5) / n \tag{2}$$

The center line of the U-chart in this case is given by

$$\bar{U} = \sum_{i=1}^{5} w_i \bar{u}_i \tag{3}$$

The estimated standard deviation of U is given by

$$\hat{\sigma} = \sqrt{\frac{\sum_{i=1}^{5} w_i^2 \bar{u}_i}{n}}, \quad i = 1,...,5 \tag{4}$$

Finally, the control limits for the U-chart can be calculated by,

$$\begin{aligned} UCL &= \bar{U} + 3\hat{\sigma} \\ LCL &= \bar{U} - 3\hat{\sigma} \end{aligned} \tag{5}$$

After applying the above equations on the defects categories we obtained the results as given in Table 3.

Table 3. Demerits and U-factors calculations

Project No.	Low	Medium	High	Very High	Show Stopper	Total Demerits	Demerits/unit
1	184	51	47	4	17	23270	23.27
2	0	208	42	0	0	20420	20.42
3	0	513	103	26	0	52780	52.78
4	15	113	113	142	28	36550	36.55
5	0	1	3	1	1	546	0.545
6	45	57	23	8	0	10540	10.54
7	27	40	14	11	4	7795	7.795
8	11	21	16	19	5	6195	6.195
9	106	156	63	5	0	26045	26.045
10	7	27	31	26	3	8210	8.21
11	21	50	85	29	13	17175	17.175
12	14	29	69	31	2	12655	12.655
13	43	64	64	32	0	16930	16.93

Based on the above data, the Demerit control chart is plotted as shown in Figure 1.

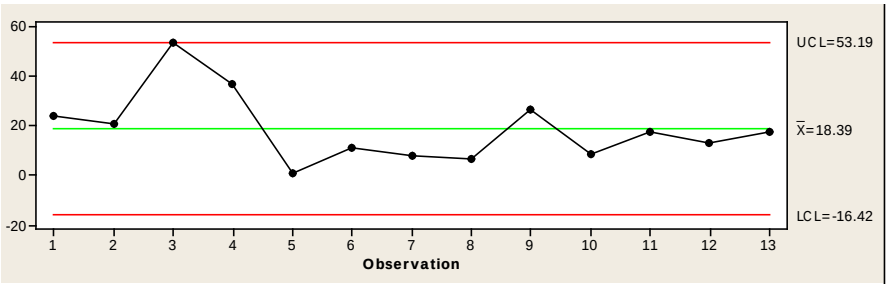

Figure 1: Demerit chart (U- Chart) for non- closed defects after production.

The above Figure 1 shows that the process is in statistical control.

3. Conclusions and future Research

This paper presented a new application of the demerits chart (U-chart) in the web based project environment. We define the sign off criteria, classified the defects severity and performed process control analysis using demerits chart in web based application. For future research work, we recommend performing the cause and effect and the process capability analysis for the different sign off criteria.

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