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The Impact of Upgrades on ERP System Reliability

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Abstract**—**Constant upgrading of Enterprise Resource Planning (ERP) systems is necessary, but can cause new defects. This paper attempts to model the likelihood of defects after completed upgrades with Weibull defect probability density function (PDF). A case study is presented analyzing data of recorded defects obtained for one ERP subsystem. The trends are observed for the value of the parameters relevant to the proposed statistical Weibull distribution for a given one year period. As a result, the ability to predict the appearance of defects after the next upgrade is described.

Keywords**—**ERP, upgrade, reliability, Weibull model

I. INTRODUCTION

TODAY's ERP products are vulnerable to constant changes for different reasons. The speed of change depends primarily on the business environment. Today, telecommunications are generally one of major parts of that environment where changes are more likely to the similar ERP products deployed in different companies. In this paper one telecommunication provider is presented with one part of deployed ERP system which is taking regular monthly upgrades. The analyzed ERP subsystem is composed of three software modules (in this paper they are called Module1, Module2 and Module3) and it is used to collect some data from telephone exchange system for later billing. Presented business organization is complying strictly and consistently with standards implemented in existing change management procedures but defects caused by system upgrades cannot always be avoided. All defects are collected by internal helpdesk service. The model presented in this paper is applied to the data collected in one year period. The impact of upgrades on existing part of ERP system was analyzed through modeling of defect probability density function (PDF) for each month after implementation of upgrade. The initial assumption was that every upgrade is causing new defects and that process can be statistically modeled with Weibull distribution (4). The assumption was confirmed by later analysis of helpdesk data when defects were grouped by working days and measured defect PDF function was estimated with Weibull distribution. Kolmogorov-Smirnov test (5) was used to perform a goodness of fit between the measured and theoretical PDF curves for all periods. Another assumption was that Weibull defect PDF parameters can be predicted for future upgrades. Linear regression was used as an approach and estimated parameters were tested with comparison of measured and estimated defect cumulative distribution function (CDF).

II. BASIC DEFINITIONS

The key terms of software reliability are error, fault and failure. Error has two different meanings [1]:

- A discrepancy between a computed observed or measured value or condition and theoretically correct value or condition.
- A human action that results in software containing a fault.

Fault is the cause of the failure [1]. It is also referred as a bug. Failure occurs when the user perceives that the software ceases to deliver the expected service [1].

Defect can be used as generic parameter in modeling of ERP system reliability to refer to either a fault (cause) or a failure (effect). From the perspective of strict definition in ERP software it often captures the fault, sometimes the error and often the failure.

Software reliability is defined as the probability of failure-free software operation in a specified environment for a specified period of time [1]. The same definition can be used for ERP system reliability but the term defect can be used instead of failure. Weibull reliability model is a binomial model [4] where defect rate function is obtained from the defect probability density function (PDF) $f_a(t)$ as:

$$\lambda(t) = \mathrm{N} f_a(t) \tag{1}$$

where the N is the expected number of defects in infinite time t.

According to (1), expected number of defects $\mu(t)$ at time t is calculated from the defect rate function $\lambda(t)$.

For the binomial model types, according to [1], expected number of defects $\mu(t)$ is in turn related to the defect cumulative distribution function (CDF) $F_{a(t)}$ as:

$$\mu(t) = \mathrm{N} F_{a(t)} \tag{2}$$

The equation for the Weibull probability density function is:

$$f_a(t) = \frac{\alpha}{\beta^{\alpha}} t^{\alpha-1} e^{-(\frac{t}{\beta})^{\alpha}} \tag{3}$$

The equation for the Weibull cumulative distribution function is:

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$$F_a(t) = 1 - e^{-(\frac{t}{\beta})^{\alpha}} \tag{4}$$

The shape parameter α of a distribution of strengths is known as the Weibull modulus. A value of α <1 indicates that the defect rate decreases over time. A value of α =1 indicates that the defect rate is constant over time. A value of α >1 indicates that the defect rate increases with time.

III. SOURCES OF ERP UPGRADES

Typical upgrade triggers in ERP systems are:

User requirements

- Missed, erroneous, or unnecessary requirements
- Architecture, design, and implementation changes
- Evolving business needs
- Uncertain customer needs
- Marketplace demands
- Changes in stakeholders or their expectations
- Competitive catch-up or leap-ahead
- Changing requirement priorities

Technology and development process

- Delivery platforms (hardware, operating systems, browsers)
- Interfaces to external components
- Changes in third-party components
- Changes in technologies and software development methodologies
- Exploit of new technology
- Retirement of old technology
- Updates in the field of acquired technology

Causes of ERP upgrades and consequences on reliability are well described with the laws of software evolution also known as Lehman's laws [2]. An E-type system (according to Lehman [2]- programs that are embedded in the real world and become part of it) as the telecom ERP subsystem mentioned in this paper, must be permanently changed as a consequence of the above causes because otherwise it may become unusable (follows from Lehman's 1st law, also known as *Continuing Change* [2]). An ERP system evolves its complexity after upgrades and probability of future defects is increasing unless work is done to maintain or reduce it (follows from Lehman's 2nd law, also known as *Increasing Complexity* [2]).

IV. MODELING

In general, the technical systems that are maintained (preventive replacement of parts due to fatigue, etc.) at best, break down evenly. Something similar could be identified in the case of software, where all design errors are fixed and improvements are not planned in the near future [6]. In accordance with the consideration given in section 3, such modeling is not an option for the presented study. Described system is changed frequently and the number of errors in a cumulative is increasing, partly as a result of existing errors, and partly as a result of new errors created by introducing new functionality. The proposed model should provide also an answer whether it is possible to predict the defect PDF and CDF in the system.

It is common to use statistical functions in modeling of defect PDF, based on performed measurements. Weibull distribution is generally proved as very successful in modeling of software reliability [3].

In this paper the following assumptions are made while modeling the impact of upgrades on ERP system reliability:

- Regular system upgrades are performed at regular intervals (in this case study every month)
- Upgrade is a version of the system with new functionalities introduced. Within this definition, a correction of the existing version in terms of removing errors in software code is not considered as an upgrade.
- Upgrading of any part of the system means using the new system and it is necessary to repeat the modeling of the reliability for every upgraded component and all components that are associated with it, for the period since the last upgrade is made
- Defect rate for each module is viewed as a set of different Weibull PDFs made for every upgrade separately
- The overall reliability of a part or the entire ERP system depends on the reliability of each of its modules and is calculated as the group contribution to the reliability of all modules for the observed period

According to the above assumptions, the PDF parameters of the Weibull distribution will vary from period to period, depending on the intensity of the appearance of defects in the system. As an illustration of such modeling Fig. 1 is shows an approximation of the measured defect PDF with estimated Weibull PDF for the Module1, for all months with applied upgrades. Upgrades are released at the beginning of each month and the measured defect PDF curve is approximated with a series of smaller Weibull PDFs for every period of upgrade. It would be interesting to establish a trend in which the parameters of Weibull PDF are changing after upgrades and so predict future values.

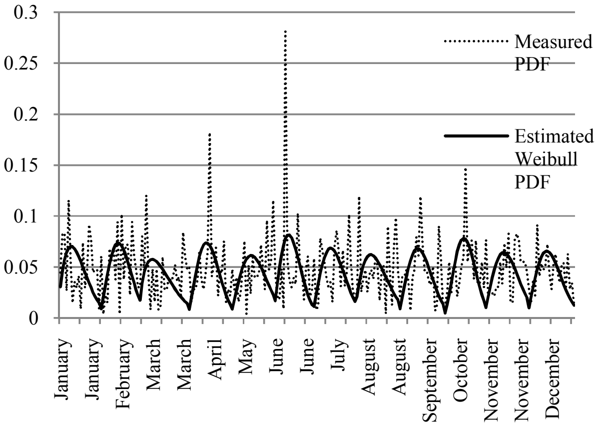

Fig. 1 Approximation of the measured defect PDF with estimated Weibull PDF for the Module1

The entire process of modeling the impact of the new upgrades on the reliability of the existing ERP system could be described by the following algorithm:

```
For each ERP module
{
        Measure PDF for the period after last upgrade

        Make a estimated best fit Weibull PDF from measured data
        and determine distribution parameters for the period after
        last upgrade

        From the existing Weibull PDF parameters for all periods
        from the beginning, predict parameters for the period after
        next upgrade
}
Calculate group contribution of all modules to the defect Weibull
PDF, for the period after next upgrade
```

V. CASE STUDY

In the presented case study, the observed defects were recorded for three modules which form a separate subsystem within the introduced telecommunication ERP solution for the period of one year (January 2010 through December 2010). In this period, the monitored software modules were updated monthly on the required changes due to the reasons described in chapter 3. All observed defects were recorded and collected by the internal helpdesk service after completed upgrade. The upgrades have been executed at regular monthly intervals, after detailed testing on a test system. Based on the analysis of measurements obtained through the 2010th year, for each month Weibull best fit PDF was extracted and compared to actual measurements with EasyFit software [5].

Measured defect PDF curves were compared with the derived defect Weibull PDF curves using the Kolmogorov-Smirnov test, built in EasyFit software. Matching has been found between the measured and the Weibull PDFs for all months, for the chosen significance level $\alpha=\{0.2;\ 0.1;\ 0.05;\ 0.02;\ 0.01\}$. This is very good matching because value of $\alpha=0.05$ is typically used for most technical applications. Comparison of estimated and measured defect PDF is shown as an example for Module2 in 7th month in Fig. 2.

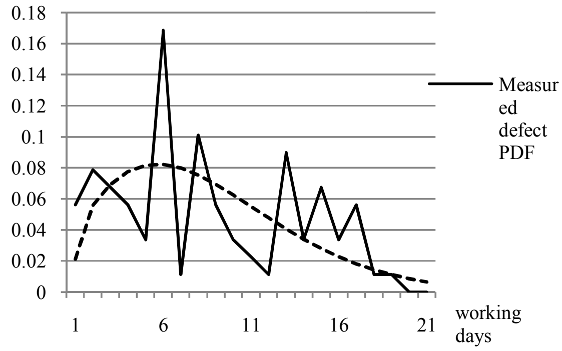

Fig. 2 Comparison of estimated and measured defect PDF for Module2 in 7th month

TABLE I
ESTIMATED WEIBULL DEFECT PDF PARAMETERS FOR ALL MODULES

	Module1		**Module2**		**Module3**	
Month	**α**	**β**	**α**	**β**	**α**	**β**
1	1,6595	10,943	2,0332	10,782	1,7206	10,754
2	2,1759	12,31	2,2002	11,271	2,0826	11,087
3	1,4631	12,838	1,8156	11,668	1,6122	12,235
4	2,201	12,393	1,7235	10,207	1,8453	9,9421
5	2,0541	14,194	1,7159	11,846	1,6778	8,8015
6	2,0276	10,567	1,4497	8,1064	2,249	12,237
7	2,0442	12,666	1,7035	9,5102	1,7523	12,474
8	1,7303	12,627	1,8506	9,6252	1,8393	12,309
9	2,1154	13,013	2,075	9,6442	2,0487	13,946
10	2,4365	12,623	1,5375	9,6027	2,0607	12,037
11	2,0338	13,468	2,3344	12,969	1,3788	11,101
12	2,0586	13,3	1,5526	6,9069	2,0595	12,295

Defect CDFs can be calculated and compared with measured defect CDFs based on estimated Weibull defect PDFs,. Comparison of estimated and measured defect CDF is shown as an example for 7th month in Fig. 3.

The group contribution of all modules can be used in the context of the entire presented ERP subsystem reliability. All probabilities of defect occurrence are summing and dividing by the number of modules:

$$P(system) = (P(module1) + P(module2) + ... + P(module\ n))/n$$

where n is the total number of modules that make up the ERP system. In presented case study three modules are analyzed so the probability of defect occurrence in a subsystem is:

$$P(system) = (P(module1) + P(module2) + P(module\ 3))/3$$

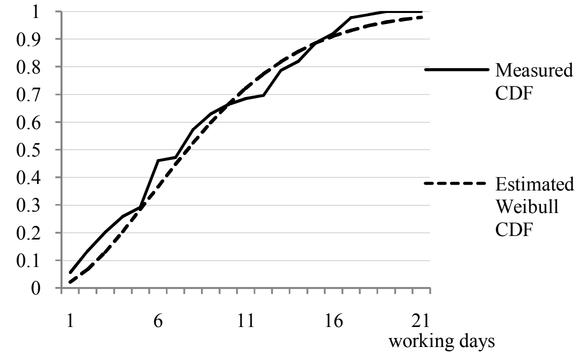

Fig. 3 Comparison of estimated and measured defect CDF for Module2 in 7th month

The group contribution of all modules on entire ERP subsystem defect CDF for the 7th month is presented at Fig 4 as an example.

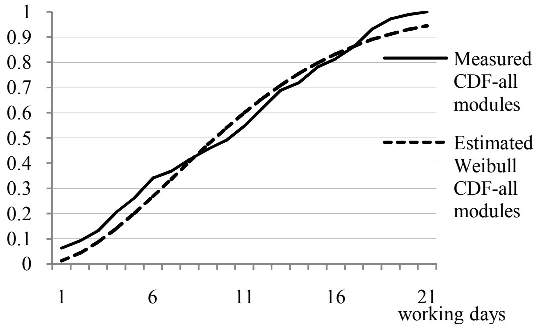

Fig. 4 The group contribution of all modules on entire ERP subsystem defect CDF for the 7th month

The group contribution of all modules on entire ERP subsystem defect PDF for the 7th month is presented at Fig. 5.

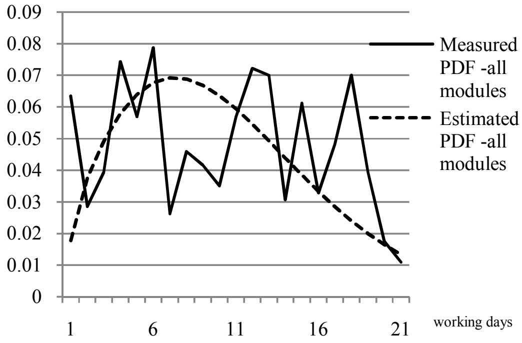

Fig. 5 The group contribution of all modules on entire ERP subsystem defect PDF for the 7th month

Prediction of the Weibull PDF parameters can be made for future upgrade from existing parameters estimated from past upgrades. Linear regression is used to adjust the predictive model for the presented case study. To adjust the model for existing parameter values Microsoft Excel linear regression function with least squares method has been used. As an example, showing a forecast for 9th month, based on the calculated parameter values for the previous six months from Table I is presented at Fig. 6 and Fig. 7.

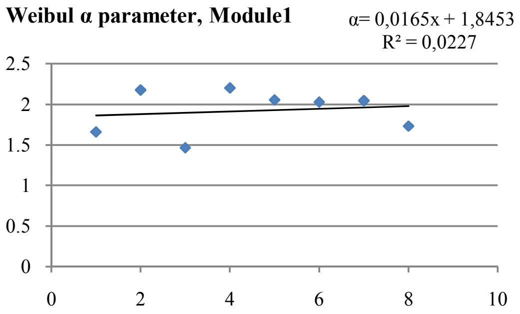

Fig. 6 Linear regression for Weibul α parameter, after 8 months, for Module1

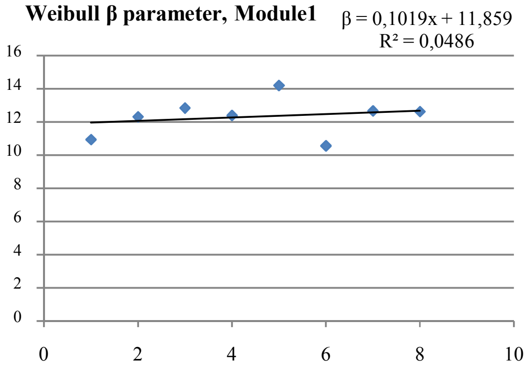

Fig. 7 Linear regression for Weibul β parameter, after 8 months, for Module1

Predicted values of Weibull α and β parameter for Module1, from Fig, 6 and 7 in 9th month are:

$\alpha_{p9-module1}$= 1,9938 and $\beta_{p9-module1}$ = 12,7761.

The same procedure can be applied to other modules. For Module2, predicted parameters in 9th month are:

$\alpha_{p9-module2}$ = 1,5512 and $\beta_{p9-module2}$= 8,9869.

For Module3, predicted parameters in 9th month are:

$\alpha_{p9-module3}$= 1,8970 and $\beta_{p9-module3}$= 12,1234.

The predicted group contribution of all modules on entire ERP subsystem defect CDF for the 9th month is calculated from predicted Weibull parameters for all modules and compared with measured defect CDF at Fig. 8.

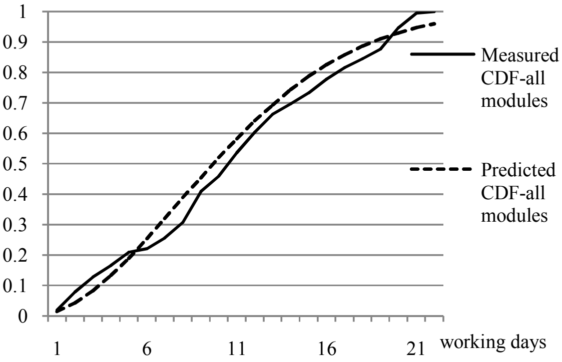

Fig. 8 Predicted group contribution for all modules on entire ERP subsystem defect CDF for the 9th month

The predicted group contribution of all modules on entire ERP subsystem defect PDF for the 9th month is calculated from predicted Weibull parameters for all modules and compared with measured defect PDF at Fig. 9.

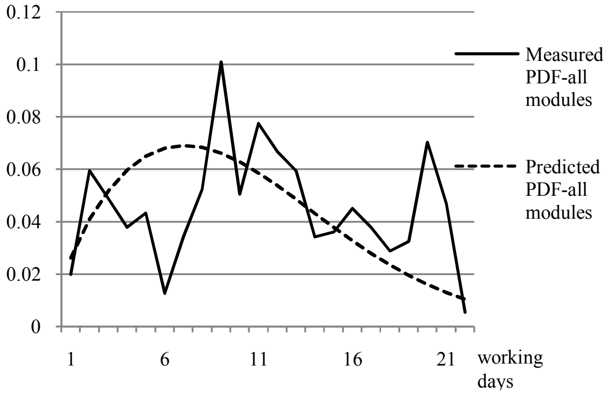

Fig. 9 Predicted group contribution of all modules on entire ERP subsystem defect PDF for the 9th month

This prediction can be made for any period and prediction is better if a larger number of Weibull parameters is known.

VI. CONCLUSION

The presented case study has confirmed the initial hypothesis that the upgrades are introducing new defects into the existing ERP subsystem. That process is stochastic and Weibull distribution is a good tool for modeling defect PDF and CDF for all observed modules.

Derived Weibull α parameters have values within certain limits for all modules and it can be interpreted in different ways for presented case. Value of Weibull α parameter is always greater than one and that always means a higher incidence of defects based on mathematical properties of the Weibull distribution. But in a presented case it is obviously controlled by well-meaning change management.

Group contribution af all modules can be applied for later calculation of defect PDF and CDF on entire system for every period after upgrade. Weibull parameters were analyzed for the entire period of upgrades and ability to predict the future parameter values is presented with a simple linear regression procedure. There are also more advanced methods for predicting future values of the Weibull parameters and that can be explored in the future research.

REFERENCES

[1] Michael R. Lyu, „Handbook of Software Reliability Engineering“, Computer Society Press. ISBN: 0-07-039400-8. 1996
[2] Lehman, Meir M. (1980). "Programs, Life Cycles, and Laws of Software Evolution". Proc. IEEE 68 (9): 1060–1076.
[3] Hribar L., Duka D., "Software component quality prediction in the legacy product development environment using Weibull and other mathematical distributions ", SoftCOM 2009. , Page(s): 254 - 259
[4] Weibull, W.,"A statistical distribution function of wide applicability", 1951.,J. Appl. Mech.-Trans. ASME 18 (3): 293–297
[5] EasyFit Distribution Fitting Software, www.mathwave.com
[6] Frane Urem, Želimir Mikulić, "Using NHHP model for ERP software module reliability growth", MIPRO 2010, , Proceedings of the 33rd International Convention,page(s): 165-168