REVIEW ARTICLE

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EFFORT ESTIMATION TECHNIQUES FOR WEB APPLICATION DEVELOPMENT: A REVIEW

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Abstract: In present era of information technology web applications have become an indispensable and most pivotal source to disseminate information across geographically distant nodes. Most of the organisation public or private have switched their existence from traditional software based systems to web based software systems. Many characteristic differences between traditional software and web based software application made web based existence more popular with wide range adoption. The sudden surge in web application usability across different organisation have posed a grave challenge for web development companies to deliver their products onetime and within budget with much expected accurately, efficiency and reliability. Effort estimation is main domain that decides the budgetary constraints associated with web application development. Accurate estimates are very essential for both developer and client. Accurate estimates make web development companies to maintain their reputation, competitive edge and client base. Inaccuracy in effort estimates results to lose revenue, client base and competitive strength. Effort estimation is very import for every development organisation to estimate the development work in early stages of development to prove efficient, accurate and much reliable budget estimates. This paper is an effort to explore various effort estimation techniques for web development, their challenges and measures to predict accurate efforts.

Keywords: Web application development, Effort estimation, Effort estimation models.

I. INTRODUCTION

With the advent of soft technology, usability, demand and dependence on web based software applications have increased with much anticipated pace. Web applications are software application specifically developed to deliver through WWW. These application have many characteristic features that make them to be different from those of conventional software applications like their accessibility can be made from any remote lactation by anyone with ease via web browser[1][2][3][4]. The widespread popularity of web applications have made almost all organisation to switch there business, operations, management, information, etc, on WWW through web applications. The trends to procure presence over web have tremendously increased. To manage web application development different practices were deployed, these practices were either extended by using conventional software engineering approaches or by more tailored web engineering approaches. The main aim of these approaches were to ensure smooth, accurate, reliable and efficient web application development.

Effort estimation is very critical aspect in software development in general and web application in particular. Effort estimation is a process that is tailored to predict efforts requirement for the development of web application in early stages of its development. Efforts are estimated after approximating functional size, length and complexity measures of web application to be developed. On the basis of these size measures, efforts are obtained and these efforts more precisely indicate the extent of human efforts required for web application development. It is very much important for any development company to predict accurate efforts at early stages of web application development. The criticality of effort estimation is because of cost, as cost of the web

application development directly depends on the size, if size estimate are not accurate the effort estimation will have similar impact on their accuracy. Accurate effort estimation is one of the vital aspect in project management. Accurate estimates are not only important from developers point of view but equally from clients point of view. Accurate estimates helps development company to accept more and more development proposals from different clients, this leads development companies to stand high in competition against rival development companies. Accurate estimates helps project management to plan budgets required for development of web application more efficiently. Estimates can be either overestimation(over budgeting) or underestimation(under-budgeting), both over and under estimates are not good sign for web application development and it could prove out to be disastrous for development company[5]. Web application development needs to be within the budget, that is estimates should be accurate so that web project can be developed within the estimated efforts[6]. Different approaches were conceived for sizing web application to predict efforts. Traditional sizing methods like function points, COCOMO etc were used to size web application. As web application development is different from that of conventional software development, the approaches in place for conventional software sizing and estimation were not adequate predict effort estimates for web application development accurately[7].

Researchers are continuously working to develop new effort estimation techniques to predict more accurate and efficient effort estimates. There still exits a lacuna in effort estimation methodologies deployed to predict size and then efforts more accurately. The existence of this inadequacy and inaccuracy in effort estimation for web application can prove

out to be insane for web development companies. Cutter consortium [8] openly advocates the importance, critically and explicitness of effort estimation for web application and revealed some vital statistics about web projects:

➢ 79% presented schedule delays;

➢ 63% projects exceeded budgets;

➢ 84% projects did not meet requirements;

➢ 53% did't provide required function; and

➢ 52% had delivered poor quality services.

To ensure better and efficient web application development, web project management needs to be further streamlined so that the development can be within budget and within time.

The aim of this study is to explore the existing strategies available and deployed for web effort estimation. Section 3 provides the brief overview of effort estimation and its different categories section 4 details the literature survey to reveal different existing effort estimation approaches and section 5 draws a conclusion on existing approaches.

II. EFFORT ESTIMATION

Effort estimation is a systematic process to approximate or forecast the efforts required for the development any software application in general and web application in particular. Effort estimation techniques developed from past several year were categorised by Trendowicz and Jeffery categorised them into three groups: Data drive, Expert based and Hybrid[9]. Chulani, S. et al., categorised them into two groups: Algorithmic and Non-algorithmic models[10]. Similarly Shepherd, C., et al., also categorised them into three groups: Expert Judgment(EJ), Algorithmic models(AM) and Machine learning (ML) models[11] and even as parametric and non-parametric models.

Expert judgment: estimates efforts by using expert opinion and knowledge of previous development. Delphi, COBRA and other analogy based methods are few expert based estimation models

Algorithmic models: These are most popular and use a standard estimation procedure expressed by using mathematical equations between dependent and independent variables. These models are called as parametric models and are purely based on the state and degree of various required in the development of web application. Few popularly used algorithmic models are SLIM, FPA, COCOMO, WebMO, UCP, COSMIC.

Machine Learning based models: are based on the computational intelligence exploited from human problem solving approach. They largely depend on the context in which they are applied. Genetic Engineering, Neural network, Bayesian network, Soft Computing, CBR were few popular machine learning based estimation models.

From past several years good amount of research has beeb conducted to develop an estimation model to address the challenges dealt by practitioner to handle effort estimation. The trend of using traditional estimation models are still in use even though they were not particularly developed for web applications. In next session the detailed literature review is performed to understand the insights of various models developed at different times.

III. LITERATURE REVIEW

Donald, J. Reifer, 2000, performed a study to develop more specific web size metrics and effort estimation model for web effort estimation. In this study Web Objects(WO) were introduced as new web size metrics and WebMO as the estimation model. WO, an extension to FP model after adding four additional parameters specific to web development. WebMO were inspired from COCOMO II and used only 9 cost drives. Backfiring from WO to SLOC was also introduced. The empirical investigation of proposed metrics and model was performed on dataset of 64 web projects and the statistical results obtained showed WO performed more accurate estimates than traditional FP [3].

Emilia Mendes, et al. 2000, performed a study to estimate efforts for web application development by using analogy. This study advocated the popularity and usability of Algorithmic models but further mentioned their drawbacks to calibrate them with individual estimation environment. This study used ANGEL tool to obtain optimal combination of variables used to predict efforts. The statistical analysis on the estimation results obtained on 70 web projects revealed that analogy based estimation method can be used for effort estimation, but is not only solution for it [12].

Emilia Mendes and Ian Watson, 2002, performed a study on 37 web hypermedia applications to compare the prediction accuracy of CBR techniques and then performed comparative analysis between best CBR technique with SR,MLR and Regression Tree. ANGEL and Jackknife methods were used for selecting best variable combination. Three-fold cross validation approach were used on estimates, it was found that prediction accuracy of Multiple linear and Stepwise regressions produced best prediction accuracy than CBR and CART models and the study further reported that CBR and Multiple Regressions produced almost accurate predictions when Boxplots were used[13].

Melanie Ruhe, et al., 2003,performed effort estimation of web application by using COBRA method, results showed that analogy based estimation performed better in 60% of cases and 30% cases were unstable and inaccurate. To further enhance the accuracy of COBRA, Web-CORBA was developed and it was validated by data from 12 web projects from Allette Systems Australia. The statistical results obtained showed that Web-COBRA outperformed than OLS and Allettes formal methods. This study further advocated that variable selection have grave impact on effort estimation[14].

Emilia Mendes et. al. 2003, Conducted a study to obtain early size measure for costimation of web application and investigated the prediction accuracy of company specific data with multi-organisational databases. To obtain web size measure data from 133 online quotes were used, analysed and then grouped into five categories, size measureswere expressed by using attributes :length , functionality and complexity. 26 projects were used to investigate the stability of prediction model on company based and multi-company based datasets. The results obtained revealed that prediction accuracy of company specific dataset outperformed then multi-company datasets [15].

Luciano Baresi et al., 2003 performed a study to investigate the impact of design efforts on aggregate web development efforts. This study identified various dependent and independent attributes that impacted design efforts. Dependent attributes like information effort, navigation effort, presentation effort were identified.W2000 were used to elicit and identify these parameters. OLS was used to find correlation between these attributes. The results obtained concluded that design phase does have role in total effort estimation.[16].

Sergio F. Ochoa et. al, 2003a, in their study of web effort estimation, developed expert centric CWADEE model that can predict efforts for Chilean web application within 24-72 hours of their development. Data Web Points(DWP) were used to measure the functional size of web application. Along with five types of DWP, Cost drives from WebMO[3] were used to obtain functional size of web application. The empirical evaluation of model were performed on 22 web projects and the estimated efforts were rated as good, medium or poor. It was reported that 15 applications were good, 5 were medium and 2 poor. Finally this study revealed that better estimates can be achieved when more experience with CWADEE[17].

Melanie Ruhe et. al, 2003b, in their study compared traditional function points and Web Objects using OLS on 12 web projects. The results obtained in this study revealed that size expressed in WO were almost 55% more in comparison to FPs and this difference increased as the complexity of the projects increases. Empirical analysis of the results obtained have revealed that effort estimation by Web Objects(WO) with OLS regression tree produced significantly much better and accurate estimates and similarly WO outperformed Allette's Expert Opinion as well [18].

Edilson J. D. Candido et. al. 2004, performed a study to estimate the size of web application developed by Brazilian Software company, and proposed Simplified FP as new sizing measure. The proposed sizing measure advocated that all the functional process(transactions or data movements) were simplified with low complexity. This study further performed a comparison between IFPUG's FP, NESMA's estimated, indicative function points and simplified FP. The statistical results obtained on 20 web applications revealed that simplified FP and IFPUG FP performed better sizing measures than estimate FP and Indicative FP. The study reported that the validation of proposed sizing measure limited to specific company, domain and language for which it was developed only [19].

Paul Umbers et. al. 2004, in his study todevelop estimation model that is simple and easy and could predict accurate estimates. Estimation model was developed in four steps; size of the web application was calculated by using COSMIC FFP, design patterns were used to identify functional user requirements, intuitive factors that affect productivity and Monti Carlo Simulation to mitigate errors. Efforts of web application were calculated from size expressed in CPSU was expressed as CFSU and productivity as man-days . The initial statistical results obtained revealed that both efforts and duration overruns the actual efforts and duration. It was further found that the proposed model performed better than expert judgment. The validity of this model needs to revalidated on lager dataset[20].

Costagliola G. et al., 2005,in his study developed an effort estimation model for dynamic web application, COSMIF-FFP were used to obtain functional size. This study advocated that early estimates were made by applying COSMIC-FFP on analysis and design documents of dynamic web application. To capture data movements from analysis and design documents, sequence and class diagrams approach laid by[21][22] were used. 32 projects were used to empirically validate the results and it was reported best estimation results were achieved[23].

Emilia Mendes et. al 2005, performed a study to investigate web size measures and cost drivers that can be used for early effort estimation of web application development. The results obtained in this study were validated by mature development company and by online survey using TukuTuku database. It was reported that empirical investigation on 67 web application confirmed that, "Total no. of web pages" and "features/functionality" were two most inflectional effort predictors[24].

Costagliola et al. 2006 , performed an extension of his research work[8],about the effectiveness of COSMIC to predict efforts for web application development. Data from 44 Web applications developed by students were used to empirically analyse the results. The results of the study suggested thatcounting of data movements can be useful for estimating the development effort of dynamic Web applications[25].

Majid J. Moayed, et. al. 2007, conducted a study to review exiting effort estimation techniques used to predict efforts for web application development. It was reported that FPA, COCOMO performed relatively better. This study didn't mention comparative behaviour of efforts obtained by using COCOMO, FP with WO, however it was revealed that the size of the application obtained by using WO is almost double than FP which could have large impact on effort estimation accuracy[26].

Di Martino et al., 2007, investigated the effectiveness of four Web size measures (i.e., Tukutuku measures, Web objects, length measures, and functional measures) for predicting Web application development effort. Data from 15 web projects were used to validate the results and it was reported that effort estimated by implementing all these were statistically significantly[27].

Ferrucci et al. 2008, performed a study to investigate the performance of COSMIC and Web Objects to predict accuracy in efforts.Data from 15 web applications were used to statistically evaluated the results, it was found thatweb objects and COSMIC were goodeffort indicators[28].

Emilia Mendes, et al. 2008, in their research work performed effort estimation of web application by eight different Bayesian Network models. In this study efforts were estimated by using BN models and were compared with the efforts obtained with MSWR, CBR and Mean & Median based effort estimation models. 130 cross company datasets were used to validate the estimation results. The results obtained reported that MSWR performed better estimates than all BN based models, two BN models(BNAuHu & BNHyHu) performed significantly better than Mean & Median efforts models[29].

Zulkefli B. Mansor, et al. 2010 in their study developed WebCost tool to perform effort estimation of web applications. WebCost tool considered features of COCOMO II and expert based judgement model to perform actual estimation. User acceptance of the WebCost were analysed by SUMI technique on the basis of opinion collected from users by responding to questionnaire of 20 questions and was reported satisfactory. This study further reported that WebCost tool performed better estimation in comparison to CASE and COSTAR tools[30].

Ferrucci, et al. 2010, performed a study to investigate the effectiveness of Tabu Search(TS) for effort estimation of web application. In this research work cross company dataset of 195 projects from Tukutuku database[31] were used to empirically validate the accuracy of estimated efforts and the results obtained showed that selection of object function had influenced the accuracy of estimated efforts and it was further reported that MdMRE predicted better accuracy than MMRE. In this efforts predicted by using TS were compared with Mendes[32] and it was found that TS performed better estimates[33].

Silvia A. et al, 2010, performed a study to investigate OO-HFP, the size measures for web application development developed using model-driven development approach. Data from 31 web projects were used to validate results of OO-HFP, the results obtained were compared with a standard FPA method. It was found that functional size calculated by using model driven approach were more in comparison to FPA similarly efforts estimated by using OO-HFP were more accurate than FPA[34].

Aaron M. French, 2010, reported in his study that selection of development methodology made direct or indirect impact on the efforts for web application. This research work advocated that SDLC cannot be used for web development and proposed web development life cycle model, a hybrid modelfor web development[35].

Sergio D. Martino, et al., 2011, carried out a replicated study to investigate the effectiveness of WO[3] on effort estimation. Data from 25 web projects were used to empirically analyse the results and it was found that WO performed statistically better effort estimation when used in combination with OLSR or CBR or Web-COBRA estimation

techniques than FP as sizing measure. This study further mentioned that WO with web-COBRA produced best results than CBR and OLSR and there is no statically significant difference in results obtained withOLSR, CBR and Web-COBRA[36].

Steve Counsell, et. al. 2012, developed expert-based BN model to estimate web application efforts. In this research work KEBN process[37] was revised by adopting Domain expert at each step of BN to elicit the requirements to address the uncertainty inherited from estimation. Expert-based BN were built on single company dataset and were validated by dataset of 22 web projects and the results obtained showed that expert-based BN model produced significant results[38].

Saqib Bukhari, et al. 2012, performed an empirical study to investigate the factors that affect the accuracy of effort estimation. In their research work it was revealed that uncertainty of changing web technology and failure to manage it, accounted to underestimated efforts for web application development[39].

Erika Corona, et al. 2012, proposed Web CMF model to estimate efforts for web application developed by using CMF. Date from 4 web projects were used to validate Web CMF model and the results obtained showed that proposed model predicted accurate efforts in comparison to RWO and FP model[40].

Rosminaa, S. 2012, in their research proposed FHSWebEE model to estimate efforts for web application development by using Objective Oriented approach. The proposed model combined functional size model of OOmFPweb[41] and web metrics of Mendes[15] to measure web application. Data from 10 web projects were used to validate the effectiveness of FHSWebEE model to estimate efforts using CBR and the statistical results obtained revealed better results in comparison to [41] and [15], [42].

Thamer A., et al. 2012, performed a study to demonstrate the effectiveness of software development process to meet critical requirements for web application development. The results obtained showed that selection of project methodology had relative influence on web application requirements and further mentioned that distinctive nature of web application made it unsuitable to extend traditional methods for web development[43].

Lucia D. Marco et al. 2013, performed a study to investigate the effectiveness of COSMIC approximate counting for early effort prediction. Web approximation was performed by COSMIC function process and average function process approach, liner regression was used to build estimation model. 25 web projects were used to validate it and was revealed that CFunP and AFP provided good early size estimates for web application and were statistically better than the estimates obtained using baseline benchmark and standalone models[44].

Damir Azhar, et al. 2013, conducted a study to investigate the accuracy of ensembles for web effort estimation at early stages of web development. Replication of previous methods and Snott-Knott algorithm[45] were used to shortlist best out of available techniques for ensembles. The results obtained in

this research work showed better estimation accuracy by adapting ensembles in comparison to solo estimation models and identified 15 best estimation ensembles[46].

Denis Ceke et al. 2015, in their research work developed hybrid model by combing COSMIC-FP[47] and UML[48] model. Data from 19 web projects were used to statistically validate estimation results obtained by using simple linear regression. The results obtained showed that the proposed model was suitable to estimate efforts at early stages of web development with pred(25) best fits contes criteria[49] and further mentioned threats to its validity if validated with different dataset[50].

Leandro Minku et al. 2015, to investigate the effectiveness of CC model by using Dycom framework[64] for effort estimation. Data from 125 web projects from TukuTuku datasetswere used. The estimation results obtained showed that Dycom achieved better or similar results than WC models on conventional software. It was further reported that Dycom-RT performed significantly better estimates than CC baseline approaches, WC-RT and NN-filtering[51][52][53].

Giulio B., et al., 2015, in their research work proposed a methodology, Web Framework Points(WFP) to estimate efforts for web application development using CMF. The empirical validation of WFP model was performed on 29 real world web projects and it was found that WPF outperformed than in-house method and achieved 83 as pred(25) in comparison to 55 in in-house method[54].

Sergio Di Martino et. al. 2016, performed an empirical study to investigate the effectiveness of COSMIC over FPA model for web effort estimation. Data from 25 web projects were used to validate the results and it was reported that COSMIC was significantly more accurate than FP in estimating efforts when SLR & CBR were estimation models. This study further advocated Two step estimation process (2SEP) to carry out migration from FP to COSMIC by using conversation equation, and selection of equation had influenced the efforts [55][56].

IV. FINDINGS AND RECOMMENDATIONS

This review of literature, performed on the research work carried out by various researchers from past many years to investigate web size metrics, web size measures, cost drives and effort estimation model that can be used to predict accurate estimates for web application development. It was observed that most of the estimation models and web size metrics were not adequate enough to address these issues to

predict accurate efforts. In this review it was found that most of the research done during the time cited in literature above were academic research and very less very models were used by practitioners. It was further observed that there were no proper guidelines or standards used to obtain web size measures, cost drivers, web metrics and selection of valid estimation model, still remained ambiguous. The estimation results obtained across different studies were not accurate.

In most of the cases it was found that traditional methods were used to estimate web efforts. As there are internationally accepted standards for performing traditional software development such standards are need of hour for web development. Based on the research work reviewed, the following are the recommendation:

- Development a standard framework to identify more relevant functional size measures.

- Standard list of parameters(sizing measures) that make direct impact of size of web application

- Standard web size metrics.

- Standardise the list of parameters either as cost drives or technical parameters.

- To propose model for estimation which is more tailored for web application.

- Document guidelines and conventions for model as well as for size metrics to acquire university.

V. SUMMARY AND CONCLUSION

The widespread popularity and growing demand of web applications made it inevitable for development industry to acquire and use estimation techniques that can be used to predict accurate effort estimation for web application development. Insights from the review conducted clearly indicated that existing effort estimation approaches were not adequate to meet industrial demands more perfectly. Many efforts efforts were made by researchers to develop effort estimation model that can be specifically used for web effort estimation but in most of the cases efforts estimated were inaccurate.This review study advocates that the need of the hour is to develop web size metrics, estimation model and cost drives that are more specific and standard to perform web effort estimates with much expected accuracy. Objective oriented estimation methods like UCP[57], Re-UCP[58] can be used after due resist to develop estimation model for web application   development.

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