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Cost Estimation for Mobile Application Development: Review

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Abstract: A Mobile phone has evolved from being a voice communication system to a medium for technology. Mobile applications are a kind of software that is installed on a mobile device with some important differences than traditional software application and web applications. Most of the organizations have switched their web application based software's to a mobile application based software's. With the growth of smart phones there is a great demand for smart applications. For software companies it is important to deliver application software's on time, within budget and with high accuracy. Cost estimation is the fundamental area that chooses budgetary constraints related to mobile application development which keeps company to maintain accurate estimates for mobile application development to maintain their reputation in the market. In this paper, different reviews are made clear to propose a way cosmic an appropriate method that can be used to size mobile application in a fast and accurate way.

Keywords: Mobile cost estimation, Function size measurement, Estimation models.

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I. INTRODUCTION

The progressive interest and fast evolution of smart mobile phones have forced software companies to develop versatile smart applications. Because of demonetization and advancement of e-shopping, e-banks, e-bills and other related online activities the popularity of smart phones in general and smart

applications, in particular, have been expanded all over the country. Functional Size Measurement methods were introduced to overcome the limitations posed by LOC. The FPA was the first FSM (Functional Size Measurement) method introduced in 1979 by Albrecht with other variants known as First generation method. The COSMIC method was defined to overcome the limitations of Function Point Analysis by redefining the basic principles in a way that is applicable to both traditional software application and newly revolutionized mobile applications. It is known as 2nd generation method. The available functional sizing methods are extensions of FPA. COSMIC is based on the fundamental principle of data movements that correspond to various operations a mobile or web application supposed to deliver and consequently the size of their development. Mobile cost estimation is a systematic process involving a series of activities to approximate the effort required for its successful development. Estimation can be of size estimation, resource estimation, schedule estimation and the last estimate the overall cost. Since size plays an important role in cost estimation. Sizing can be defined as the volume of different functionalities that a software application in general and mobile application, in particular, is expected to deliver. The Functionality of the software development is directly proportional to the size of an application development. Estimation models: Estimation models are developing from most 3 decades however still in its developmental years. So the existing models depend on the statistical analysis, numerical formulas of previous data stored e.g., software projects. Such models came into the category of algorithmic models. On the other side models such as Expert judgment, Machine-learning based models come into the category of Non-Algorithmic models. The success of estimation models relies upon the accuracy of the evaluations which thus relies upon the user requirements including system requirements, human power and duration.**(Ziema Mushtaq & Abdul Wahid, 2017)**

II. LITERATURE REVIEW

(Universit, 2001) performed a study to develop a costing model to investigate the cost requirements for project development. In this study, SLIM and COSMIC-FFP metrics measurement approach were used to obtain functional size of project development. Data from 5 projects were used to validate the effectivenss of SLIM and COSMIC-FFP. The results obtined were evualuated using MMRE,MdMRE and Pred(0.25) and it was reported that COSMIC- FFP method produced comparatively promising results than SLIM

metrics.However, the study advocates to further analysie the effectivess and validity of results obtained on much larger data set..

Costagliola, Ferrucci, & Gravino, 2004, developed an approach to estimate efforts required for the development of dynamic web application. In this study COSMIC-FFP were used to identify various data movements to obtain functional size. In order to calculate efforts from COSMIC size ordinary least-square regression analysis were used as prediction model. Data from 32 web applications using MMRE and Pred(0.25) were used to evaluate the effectivenss of the proposed approach and the results reported were promising.

(Demirors & Gencel, 2004) provided an insight into the existing effort estimation techniques for large software applications. The data from large software intensive military applications were used to emperically analyze the results. The research work reported that the results showed greater deviations due to inapproximation for large projects.The metrics and methods can be used for early size estimations however they all have their limitations. This study advocates new methods, metrics and guidelines required to ensure size estimations with more precision.

(Tran-Cao, Levesque, & Meunier, 2005) performed a comparative study to investigate the effectiveness & accuracy of COSMIC for early software effort estimation. The data from 15 software projects were used to validate the accuracy in results using MRE and MMRE in combination with linear regression and multiple regressions. The complexity of the projects was measured with wood's task modeln and the results reported that the proposed model is relaible for early effort estimations because of small data samples. Larger data sets are required for more empirical tests.

(Santillo, 2007) performed an investigation on seizing and sizing SOA applications with COSMIC function points. The boundary problem from the software measurment perspective is described and the guidelines for application of COSMIC function point sizing method is provided. In this study IFPUG is denoted as "near black box" and COSMIC FSM as " near white box" approach to software measurement. It is revealed that COSMIC FFP is more promising than any other first generation FSM methods. This study advocates field to wlecome trials and practical experiences to test an approach that can lead to a wider set of guidelines for practical application of COSMIC measurment for SOA- like systems.

(Condori-Fernández, Abrahão, & Pastor, 2007) in their introduced measurement approach RmFFP that adapts the base of Cosmic FFP for estimating the size of object-oriented software systems at the early stage of development process. In this study data was analysed using SPSS tool and evaluated using Shapiro-will test and reported that 33 observations showed an accuracy of 95% for early size prediction of software projects with proposed model RmFFP. This study advocates implementation RmFFP model on different Real case projects to see its reliability.

(Gencel, 2008) conducted a study to perform effort estimation using COSMIC as functional size measurement method. Three projects studied in this research were measured using COSMIC-FFP v.3.0 utilizing the software requirements specification documents. CHAR method was used to determine functional domains of the case projects. This study observed the results building estimation models using the vector of measures for functional size rather than on a single value is more promising.

(F. Ferrucci, Gravino, & Di Martino, 2008) Performed an empirical study to investigate the effectiveness of COSMIC and Web Objects for web effort estimation using OLS regression method. Fifteen web applications were used to validate the effectiveness of the proposed methods and the reported results were evaluated by using MMRE, MdMRE and Pred(0.25). The effort estimation results obtained reported that both COSMIC and Web Objects in combination with OLS regression were good indicators ofeffortestimation.

(Rabbi, Natraj, & Kazeem, 2009)performed a comparative study between Cosmic and IFPUG models to measure their applicability for sizing software projects and subsequently on efforts estimated using linear regression model. Data from two projects viz., PCGEEK and Locator were used to validate the accuracy of the proposed method. The reported in this study showed that Cosmic FFP provided better effort estimation results in comparison with IFPUG FP. This study advocates further research to establish a unique convertibility relationship between IFPUG FP and COSMIC independent of any application

(**Lavazza & Morasca, 2010)**performed a study to convert FP into their corresponding CFP(and vice versa).In this study hypothesis investigation using available datasets originated from different organisations that combine both FP and CFP have been analysed using rigorous statistical techniques in order to evaluate if non-linear

models representing the relationship between FP and CFP could be derived. This study performed an empirical analysis of the different datasets and it was reported that the analysis of the correlation between FP and CFP measures based on non–Linear regression models produces different results for the differently available datasets.It was further revealed that both existences of valid non-linear models and the positions of the discontinuity point depend on the dataset used to calibrate the method.

(Fehlmann & Santillo, 2010)performed effort estimation for agile software development using COSMIC FP. The transfer function(Six Sigma) was used to obtained efforts from calculated function size in COSMIC FPs. The results obtained in this study revealed that COSMIC with Six-Sigma proved out to be an efficient tool for early effort estimation. The proposed method measure changes that emerge over iteration in the overall estimation process. This study further reported that the proposed approach worked well for distributed development teams.

(Buglione, Ferrucci, Gencel, Gravino, & Sarro, 2010) Performed web effort estimation using COSMIC as the functional size of web application development. Data from twenty-five web applications were used to validate the accuracy of the proposed method using CHAR method and MMRE, MdMRE & Pred(0.25) were used to evaluate the results. The results obtained reported that COSMIC measurement method is reliable for web effort estimation. This study further advocates investigating the effectiveness of the proposed method using different datasets, considering different cost drivers.

(Hussain, Kosseim, & Ormandjieva, 2010)in their study developed a tool to automatically perform an approximation of cosmic size without requiring the requirements. The data from four projects were used to validate the efficiency of COSMIC using box-plot analysis and reported promising results. This study further advocates exploring the impact of impact of non-functional requirements on functional size software effort estimation for more accurate results.

(Filomena Ferrucci, Gravino, & Sarro, 2011) performed an effort estimation after converting IFPUG units into their corresponding COSMIC measure and using Ordinary Least-Squares Regression (OLSR) method. The data from 25 web applications were used to analyze results and it was reported that the accuracy of obtained results was close to threshold provided. This study observed that the transformation based on the equation is not necessary.

(Savithri, Sujathamma, Padmavati, & Visvavidyalayam, 2013)conducted a detailed review of estimation methods to find Required resources, Man-hours, Time and Cost required in developing software. In this study, the neural network was compared with COCOMO II and it was revealed that neural network based model showed better results. This study suggests developing software effort estimation by using neural network techniques to achieve more accuracy in comparison to other parametric models.

(André Nitze, 2013)performed a study to measure Mobile Application size using Cosmic-FP. In this study, the data from different applications were used to empirically analyze the results. The results reported showed better mobile effort estimation was reported using Cosmic-FP. This study further explored few inadequacies like Non-functional requirements, Team size, project size and Project complexity that might influence on the accuracy of effort estimation. This study advocates proper elicitation and identification of non-functional parameters required for mobile application development.

(Hussain, Kosseim, & Ormandjieva, 2013) performed a study to approximate early effort estimation using cosmic functional size in Agile projects. In this study, the data from four different case studies, two industrial projects and two university projects were used to validate the effectiveness of the proposed method. Box-plot analysis was used to evaluate the results.Due to the small number of samples, the results showed the promising behaviour of the classifier in terms of its performance. This study advocate on predicting the impact of Non-functional requirements on the function size for better precision in software effort estimation.

(Jošt, Huber, & Ičko, 2013) proposed a model to measure mobile applications size using object-oriented software metrics and compared the proposed model with the conventional model using chidamber and kemerrer(CK) matrices. The proposed method was validated using small scale mobile application developed across three different platforms (android, ios, windows) where the code was evaluated by using traditional software metrics. The results reported in this study showed that good and satisfactory size approximations were achieved for all the three cases using traditional software measures and therefore, advocates the implementation of traditional software metrics can be used for mobile application source code sizing as well.

(Abdullah, Rusli, & Ibrahim, 2013) performed a study to demonstrate the effectiveness of COSMIC measurement procedure for approximating mobile application development size and consequently efforts using UML representation. In a pragmatic analysis of the proposed study was carried out using Angry birds mobile application. The results reported in this study showed that CFP was effective to map functional size for mobile application and further reported that COSMIC-UML can be used to estimate CFP for mobile application development.

(De Marco, Ferrucci, & Gravino, 2013) studied the effectiveness of COSMIC approximate counting for early web effort estimation using COSMIC function process (CfunP) and average function process(AFP) approach asproposed in COSMIC Documentation. Liner regression analysis were used to build estimation model and MMRE, MdMRE and Pred(25) as evolution criteria. The Data from 25 web projects used to validate the results and reported CFunP and AFP provided good early size estimates for web applicationsand were statistically better than baseline benchmark and standalone models. It was further reported that estimation accuracy using standard COMIC were statistically significant with CfunP and AFP.

(Volkan Tunali, 2014)studied the effectiveness of FP to approximate Mobile tablet computer application size. The results obtained in this study reported about 1.2% deviation between estimate and actual value of development size. However, it was further reported that FPA performed comparatively better for small-scale mobile applications. This study advocates that correct identification of functional measures and elicitation of complexity classification could minimize the deviation between actual and estimated value.

(Paz, Zapata, & Pow-Sang, 2014) investigated the effectiveness of COSMIC Function Points for effort estimation incremental software projects. To validate the accuracy of COSMIC-FP two different projects were used and the results obtained were evaluated using MRE and it was reported that Incremental CFP performed better effort estimation. Further, the comparative analysis between global estimation model and Incremental CFP reported better results using incremental CFP. The study advocates the scope of the proposed approach in other contexts such as real-world projects and mobile application development.

(Heeringen & Gorp, 2014)conducted a survey to develop the effort estimation model using COSMIC to the approximate functional size and consequently the efforts required for mobile application development. In their study "approximate method" was proposed to calculate mobile size in fast and accurate approach. This study further explored the guidelines for quick implementation of COMIC for obtaining the functional size of mobile application development.

(Corazza, B, Ferrucci, Gravino, & Sarro, 2015) in their research work studied the performance of transfer learning approach from Function points to COSMIC. The effectiveness of transfer learning approach was validated using 25 projects and evaluated using MAR. The results reported in this study revealed that MAR value obtained using CFPtp was two times less in comparison with FP. These results advocate the effectiveness of CFPtp over FP and consequently the effectiveness in calculated efforts.

(Filomena Ferrucci, Gravino, Salza, & Sarro, 2015) conducted a study to measure mobile application size using COSMIC approach. The dataset from 13 android applications was used to analyze the results and was evaluated using MMRE, MdMRE and PRED(0.25). The results reported in this study, that size obtained as Cosmic Function Points using COSMIC were reportedly better in comparison with other approaches and also revealed its effectiveness in early effort estimation.

(D'Avanzo, Ferrucci, Gravino, & Salza, 2015) in his study performed a study to the approximate functional size of mobile application development using COSMIC measurement method and linear regression was used to build prediction model. Eight(8) mobile applications were used to validate the results and it was reported that COSMIC performed better mobile effort estimation.However, this study advocates the to validate the model on much larger and cross-company data sets.

(B, Soares, & Jr, 2015) performed a study to develop effort estimation model that can perform mobile application effort estimation in early design phases of development. In this study 13, mobile application characteristics were identified through a survey conducted over more than 70 locations and proposed MestiAM, an adaption of existing method Fisma. Further, in this study, a comparison between MestiAM and Fisma were performed and it was reported that very less deviation between estimated and actual efforts. The results reported advocated the close relevance of proposed method with mobile effort estimation.

(Shahwaiz, Malik, & Sabahat, 2016) proposed a new parametric model to estimate the effort required to develop mobile applications which are calibrated using data of more than 160 real-life applications. In this study, a comparison of the proposed model with COCOMO II is performed and it was reported that parametric model performs better than COCOMO II model when MMRE and PRED(30) were evaluation criteria. This study is limited to the data from single software industry only and needs to be validated on the cross-company dataset.

(Di Martino, Ferrucci, Gravino, & Sarro, 2016) pefromed an empirical study to investigate the effectiveness of COSMIC and FP for web effort estimation using SLR and CBR. In this study data from 25 web projects were used to validate the effectiveness of results, MdAR were used to evaluate the accuracy of results and it was reported that COSMIC performed better effort estimation in comparison to FP. These results generate its scope for its implementation for perform mobile effort estimation.

(Atiqah, Abdullah, & Rusli, n.d.) in their study performed functional size measurement of a mobile game application using COSMIC. COSMIC FSM were obtained using COSMIC FPA Calculator to approximate mobile application size to obtain its development cost. The results reported in this study showed that good proposed model was effective in estimating mobile application size. This study further revealed that adaption of game engine architecture was effective in representing and functional user requirements of mobile application development using Cosmic FSM rules and measurement.

(Philbin, 2017) in his study to investigate the accuracy of on COSMIC to obtain the functional size of distributed applications in cloud environments and found that software development cost depends on functional and non-functional characteristics of development. In this study, it was further reported that FPA failed to map functional user requirements efficiently. This study emphasises the usability of COMIC and other empirical approaches to measure non-functional requirements associated with mobile development efficiently to achieve better results effort estimates.

(Arnuphaptrairong & Suksawasd, 2017) conducted a study to compare the effectiveness of FPA and the effort estimation method proposed sakherlia[3] for approximating mobile development efforts. In order to compare their effectiveness towards mobile effort estimation dataset of 17 mobile applications were used and results were evaluated using MRE, MMRE and Pred(0.25). The results reported in this study showed that both FPA and method proposed in sakherlia[3] didn't perform good effort approximation. Therefore, this study highlights the need to have tailor-made approaches specific to mobile development to achieve good effort estimation results.

(avneet kaur, 2017) In their study proposed modified UCP model(M-UCP) to perform effort estimation for mobile application developed using use case points. In this study, mobile application characteristics were mapped and integrated with technical and environmental factors of UCP model. In order to validate the effectiveness of M-UCP data from five(5) android mobile applications were used and evaluated using MRE. The results reported in this study revealed that M-UCP performed good effort estimation for mobile application development, however, this study advocate that mobile development characteristics have influenced effort estimates, therefore, their early identification is important for accurate effort estimation.

III. FINDINGS

The review paper has provided a layout of different size matrices and cost estimation models. On the basis of literature work carried out by different researchers from past many years to investigate size metrics for estimating the cost of mobile application development. It was observed that most of the size metrics and models were not adequate to predict cost of Mobile Application Development with a high rate of accuracy. Since mobile applications are broken down into components and those components work accordingly to the functionality of a system. Therefore to measure the size of an application using FSM, the best example is COSMIC FFP whose suitability is demonstrated in the previous historic data to determine the size of a software. Where the size function points are counted on the basis of data movements. In this review, it was found that very less amount of work has been done in the field of mobile cost estimation and fewer models were used by research practitioners. Based on the review, the following are the recommendation:

1) Development of a standard framework for mobile application cost estimation.
2) A Standard list of parameters.
3) List out parameters including environmental and technical factors.
4) Frame out Size metrics for Mobile Application Development Cost Estimation.

5) Propose a model which is most suited for mobile application cost estimation.

IV. CONCLUSION

In this study, the literature reviewed has reported that COSMIC is performing better mobile cost estimation in comparison to other available cost estimation approaches. However, the results reported that there is further scope for the improvement in mobile cost estimation, results. In order to achieve more effectiveness and accuracy in mobile cost estimation the existing COSMIC approach needs to be revised in line with modern day mobile development technology.

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