Effort, Duration and Cost Estimation in Agile Software Development

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***Abstract*—Estimation is very important and integral part of software development life cycle. Without estimation of effort, duration and cost, software cannot be developed. It is important to do accurate estimation as much as possible. Today in Information technology Industry Estimation in agile software development is mostly based on heuristic approaches like expert judgment and planning poker. In absence of agile experts, it is very difficult to estimate in agile software development. There is need of a algorithmic method in agile software development which can do accurate estimates. In this paper, we propose a simple algorithmic estimation method for agile software development and compare the results given by proposed method to check the feasibility of algorithmic method in real time.**

Keywords—Agile Software Development, Effort Estimation, Cost Estimation, Duration Estimation

I. INTRODUCTION

In today's world of software outsourcing, mainly American and European companies are giving their software projects to the Indian companies for development, support and maintenance. Indian Information Technology (IT) companies are developing the software in cheap prices in comparison of software developed on onsite. In start of 21th century there was very less competition in Indian software industry. Some companies earned lot of money by developing and supporting software from offshore and took higher resource billing from American and European companies. However in current scenario, there is lot of competition in Indian IT industry due to rise of many IT companies. Resource billing prices are gone down and Indian IT growth has come to maturity level. Now, American and European Companies want high quality software in less time and in cheap prices. If there requirement of the software are well known and freeze before the starting of the project. It can be developed using traditional waterfall model [1] but in most of the cases requirements are not finalized or they are evolved during the project lifetime therefore it is not recommended to use waterfall model in these cases.

Agile software development methodologies are famous for software development where there are chances of changing or reprioritizing the requirements in the later stages of software development but agile software methodologies require high level of cohesion in the development team, testing team, client facing group, quality team. In agile software development, it is recommended that entire team should be located on same place at the time of software development or at least in same city with different client office and vendor development office. Client facing group can visit to vendor office frequently or the development team can visit to client office if they are in same city. However in offshore software development, teams are located in different countries most of the time. Also due to increased competition and quality purposes, client gives development task to one company, testing task to other company and support and maintenance task to the third company. This makes software development difficult from agile approach also. But it is at least better than waterfall model as changes can be considered in the agile any time. As one of the meaning of agile is flexible, Indian IT companies have become agile in using agile software development and they are using tools like Skype for Business, Microsoft Live Meeting, Go To Meeting and WebEx etc. for the interaction and meeting between team members in different locations or most of the times in different time zones. But again there is one more limitation to agile software development and it is "Estimation". The agile software estimation currently do not have any proved Algorithmic estimation method like Constructive Cost Model (COCOMO) [1] in traditional waterfall software development. The estimation is mostly done by experts through their expert judgment. They use techniques like estimation by Analogy and Planning poker to estimate effort, duration and cost of the agile projects. If there are no agile experts in a company than it will be very difficult to estimate an agile project. Therefore there is a need of some algorithmic estimation method in agile software development. In this paper, we will discuss a simple algorithmic estimation method for agile software development and compare the results to check the feasibility of algorithmic method in real time.

In section II main agile estimation techniques are described. Section III describes related work in agile estimation field. Section IV describes the proposed method. Section V describes the results produced by proposed method. Section VI contains the conclusion and future work.

II. MAIN AGILE ESTIMATION TECHNIQUES

There are many heuristic approaches to agile estimation but mainly planning poker and estimation by Analogy comes under practice in Indian IT industry.

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Planning Poker [2] – In this technique a user story is told to agile experts by a moderator. Each expert gives a story point against the user story. The story points of all experts are matched. Moderator asks the reason of giving specific story point from the each expert. If there is major difference between story points given by experts, then they discuss their thoughts with other experts and decide a common story points to the story with everyone's consensus. The same thing is repeated for each user story and story points of all stories are found. Story points are used to find the duration and cost of the project using heuristic approach.

Estimation by Analogy – In this estimation technique, experts make estimation on the basis of previous project experience and previous project historical data. They compare current project work with similar work in past projects and do the estimates accordingly.

III. RELATED WORK

There are numerous research papers published on heuristics approaches of agile software estimation but only few papers are published on finding algorithmic method for estimation in agile software development. Recently research is conducted by Rashi Popli, Naresh Chauhan [3][4][5] focuses on finding algorithmic method for agile estimation.

In [3], simple algorithmic method is purposed to find effort, duration and cost in agile estimation but no factors like people or project related factors for estimation are considered in this paper.

In [4][5], some people and project related factors are also taken in consideration for much better estimation. These factors are inspired by a paper from S. Bhalerao, Maya Ingle[6] and are the extension of their work.

S. Bhalerao, Maya Ingle[6] proposed algorithm using some vital factors like project domain, configuration, performance, complex processing, data transactions, operation ease, multiple sites and security for estimation.

The method proposed by us also consider the factors like technology complexity, integration complexity, team complexity, risks, billings rates, team member locations etc to find the estimates.

IV. PROPOSED WORK

Following section illustrates the method's formulas and factors for calculating the effort, duration and cost estimation. First effort is calculated and on the basis of effort, cost and duration is calculated.

For Effort Estimation - First unadjusted effort is calculated using story points and Velocity.

- Unadjusted Effort = Total Story points/ Velocity of Pilot Sprint
- Velocity = Total Story points developed in a sprint / Sprint size in days
- Table I shows assumed values of factors affecting Effort Estimation.

TABLE I. VALUES OF PROPOSED FACTORS FOR EFFORT ESTIMATION

Level	**Value of Factors**					
	Technology Complexity	***Integration Complexity***	***Team Complexity***	***Different sites***	***Risk***	***Other Factor***
1	1	1	1	1	1	1
2	1.1	1.1	1.1	1.1	1.1	1.1
3	1.2	1.2	1.2	1.2	1.2	1.2
4	1.3	1.3	1.3	1.3	1.3	1.3
5	1.4	1.4	1.4	1.4	1.4	1.4

- Factors = Technology Complexity (Number of Technologies Involved) * Integration Complexity (Number of upstream or Downstream Integrations Involved) * Team Complexity (Number of Teams Involved) * Different sites * Risks (Evolving Requirements, Chances of change in requirement during project execution, Issues in integrations, Resource Management Issues due to Niche technologies involved etc) * Other Factors (Communication with team in different time zones speaking different languages, Familiarity within Teams, Experience in Previous Agile Project, Technical and Managerial ability of Team etc.).
- Effort in Person Days (PD) = Factors * Unadjusted Effort

For Duration Estimation – First unadjusted duration is calculated.

- Unadjusted Duration = Effort / (Mandatory Resources + Additional Resources)
- Factors affecting Duration Estimation
- Mandatory Resources 1 each (Product Owner, Scrum Master, Team Lead, Business Analyst, Support Specialist, Solution Architect, Quality Specialist, Developer, Tester) = 1
- Additional Resources = 1 for each additional Resource
- Buffer Time = 1.1 (Considering Parkinson Law, Murphy Law and Student Syndrome)
- Duration in Days = Unadjusted Duration* Buffer Time
- Total Sprints = Duration / Number of Days in a Sprint

For Cost Estimation – Material cost and Labor cost is added.

- Material Cost – cost of licenses, hardware, trainings etc
- Labor Cost - sum of billing rate of specific resource role * Number of specific Resource
- A resource may be on onsite or offshore location. Billing rate of associate will change as per resource location.

- Cost in Rupees = Material Cost + Labor Cost
- Table II shows assumed hypothetical values of onshore and offshore labor cost.

TABLE II. HYPOTHETICAL VALUES OF LABOR COST

Role	Billing Rate	
	Offshore billing rate per day in INR	*Onshore billing rate per day in INR*
Product Owner or Business Owner	Not Applicable	40000
Manager or Scrum Master	8000	32000
Team Lead	6000	24000
Business Analyst	6000	24000
Support Specialist	6000	24000
Solution Architect	6000	24000
Quality Specialist	5000	20000
Developer	3000	12000
Tester	3000	12000

V. RESULTS

We will take three scenarios' to compare the results given by the method.

Scenario 1- Considering factors affecting effort as Low, Medium, High with no additional resources, all resources offshore except product owner and other additional costs as Zero.

Inputs
User stories = 10
Total story points = 200
Desired Number of Days in a sprint = 10
Initial Velocity (How many story points completed in pilot sprint) =20

Case 1 output - when factors are low
Unadjusted Effort = 100
Effort in PD = 100
Duration in Days = 110
Total Sprints = 11
Cost in Rupees = 9130000

Case 2 output - when factors are medium
Unadjusted Effort = 200/10 = 100
Effort in PD = 298.5984 ~ 299.
Duration in Days = 328.45824 ~ 329
Total Sprints = 32.84 ~ 33
Cost in Rupees = 27262033.92 ~ 27262034

Case 3 output - when factors are High
Unadjusted Effort = 200/10 = 100
Effort in PD = 752.9536 ~ 753
Duration in Days = 828.24896 ~ 828
Total Sprints = 82.824896 ~ 83
Cost in Rupees = 68744663.68 ~ 68744664
Observation – If human resources are not increased with additional effort than duration and cost of the project will increase with effort. However, this is hypothetical situation because as per our method team involved in project also increasing in case 2, 3 and we have to increase the resources if team complexity increases. This is one of the limitations of the method and estimator has to infer the same at the time of estimation. Fig.1, 2 and 3 shows the observation in graphical form.

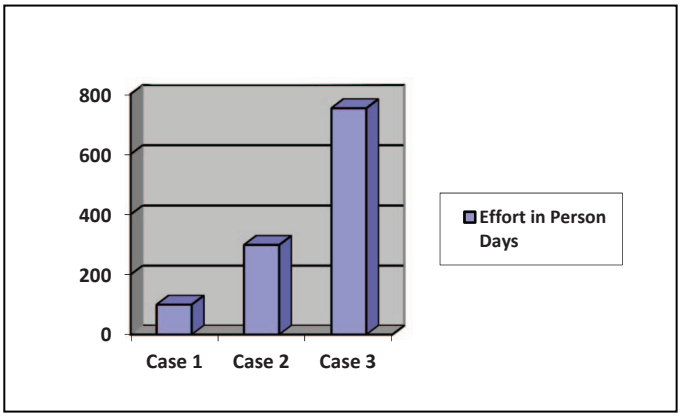

Fig. 1. Scenrio 1 Effort comaparion in different cases

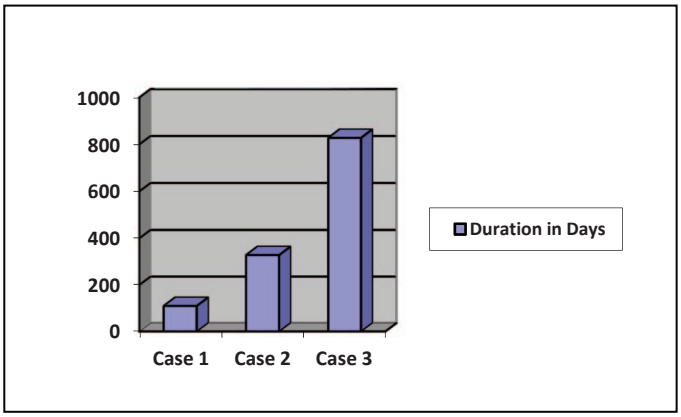

Fig. 2. Scenrio 1 Duration comaparion in different cases

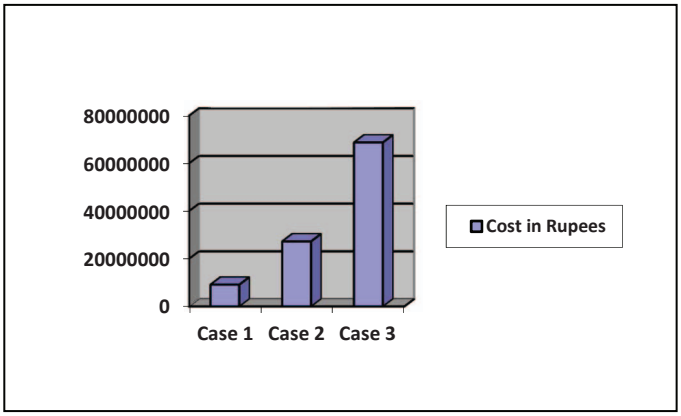

Fig. 3. Scenrio 1 Cost comaparion in different cases

Scenario 2- Considering factors affecting effort as Low, Medium, High with additional resources, all resources offshore except product owner and other additional costs as Zero.

Inputs
User stories = 10
Total story points = 200
Desired Number of Days in a sprint = 10
Initial Velocity (How many story points completed in pilot sprint) =20

Case 1 output - when factors are low
Unadjusted Effort = 100
Effort in PD = 100
Duration in Days = 110
Total Sprints = 11
Cost in Rupees = 9130000

Case 2 output - when factors are medium
Unadjusted Effort = 200/10 = 100
Effort in PD = 298.5984 ~ 299.
Duration in Days = 109.48608 ~ 110
Total Sprints = 10.948608~ 11
Cost in Rupees = 9744261.12~ 9744261

Case 3 output - when factors are High
Unadjusted Effort = 200/10 = 100
Effort in PD = 752.9536 ~ 753
Duration in Days = 103.53112~ 104
Total Sprints = 10.3531 ~ 11
Cost in Rupees = 10767236.48~ 10767236

Observation - If human resources are increased with proportion of additional effort than duration and cost of the project will remain more or less same with effort. However, There is a limitation of the method that estimator have to infer the number of additional resources as per requirements and by his/her experience at the time of estimation. Fig.4, 5 and 6 shows the observation in graphical form.

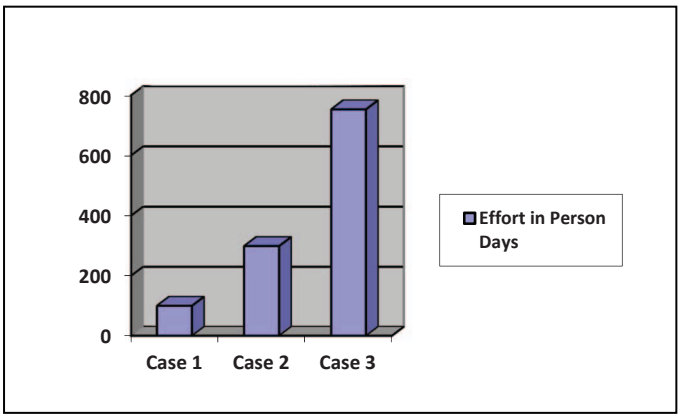

Fig. 4. Scenrio 2 Effort comaparion in different cases

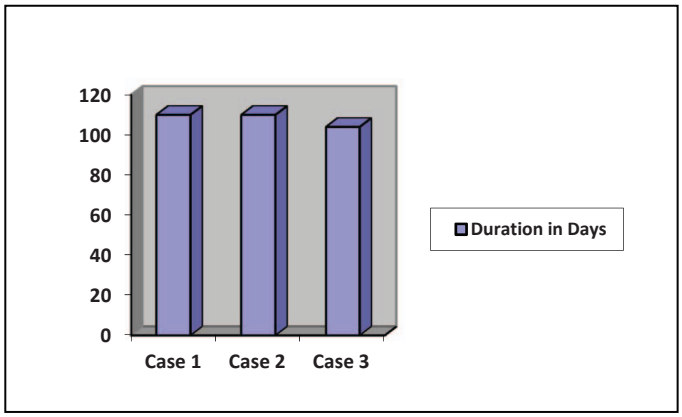

Fig. 5. Scenrio 2 Duration comaparion in different cases

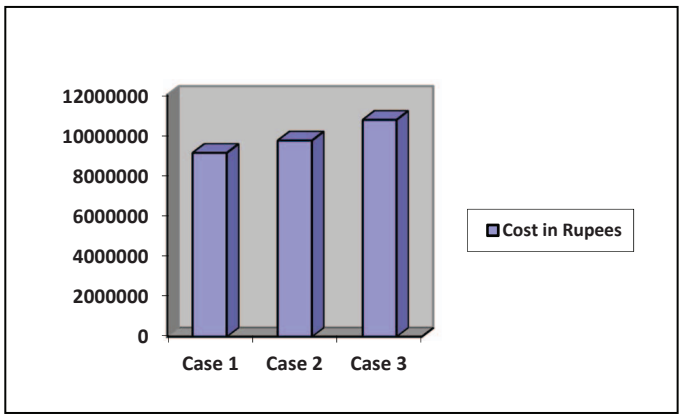

Fig. 6. Scenrio 2 Cost comaparion in different cases

Scenario 3- Considering factors affecting effort as Low with no additional resources but resources on both offshore and onshore.

Inputs
User stories = 10
Total story points = 200
Desired Number of Days in a sprint = 10
Initial Velocity (How many story points completed in pilot sprint) =20

Case 1 output - when factors are low
Unadjusted Effort = 100
Effort in PD = 100
Duration in Days = 110
Total Sprints = 11
Resources Onshore = 1
Resources offshore = 8
Cost in Rupees = 9130000

Case 2 output - when factors are medium
Unadjusted Effort = 200/10 = 100
Effort in PD = 100

Duration in Days = 110
Total Sprints = 11Resources Onshore = 4
Resources offshore = 5
Cost in Rupees = 15730000

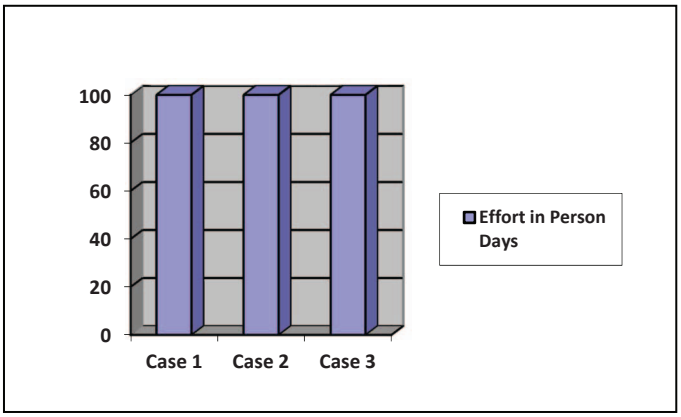

Fig. 7. Scenrio 3 Effort comaparion in different cases

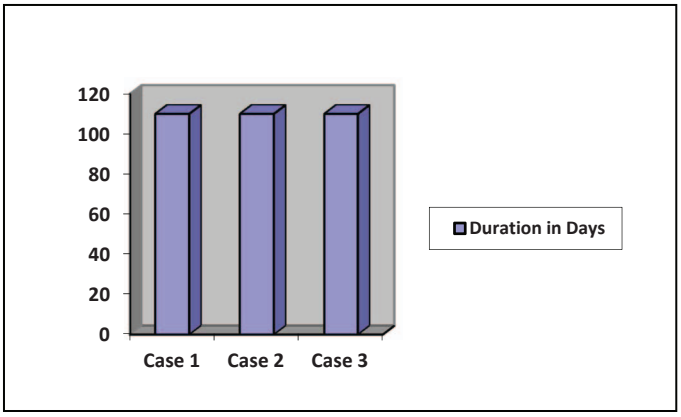

Fig. 8. Scenrio 3 Duration comaparion in different cases

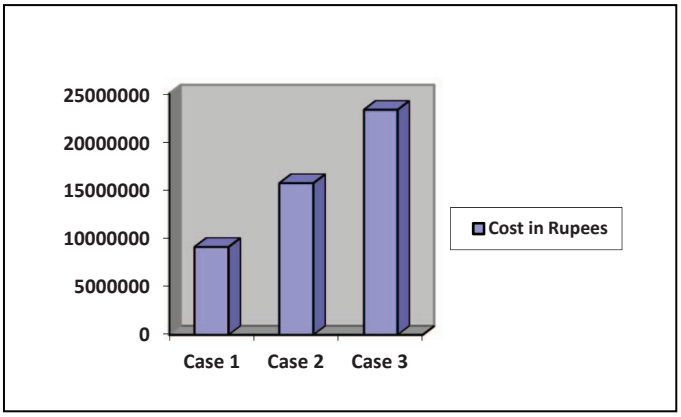

Fig. 9. Scenrio 3 Cost comaparion in different cases

Case 3 output - when factors are High
Unadjusted Effort = 100
Effort in PD = 100
Duration in Days = 110
Total Sprints = 11
Resources Onshore = 9
Resources offshore = 0
Cost in Rupees = 23320000

Observation - If human resources are moved to onshore than cost of project increases but factors like Communication with team in different time zones speaking different languages, Familiarity within Teams also improves resulting quality output. Again, There is a limitation of the method that estimator have to consider these factors in method inputs according to team locations for better estimation. Fig.7, 8 and 9 shows the observation in graphical form.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a simple algorithmic estimation method for agile software development and compared the results given by proposed method to check the feasibility of algorithmic method in real time. The result shows that the duration and cost of the project increases if effort increases but if resources are added with increased effort then duration and cost almost remain same.

Also, cost increases when resources are located onsite but with factors like Communication within team in different time zones speaking different languages, Familiarity within Teams also improves resulting quality output.

However, the purposed methods has some limitation like estimator has to input story points, desired number of days in sprints as per his/her expert understanding. Similarly for calculating initial velocity, a pilot sprint has to be executed and this even doesn't gives accurate velocity as velocity may change sprint to sprint. Estimator also has to infer factors affecting estimation as per his/her expert opinion for accurate estimation. These limitations of the method could be taken as future work and work can be done to overcome these limitations.

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