VOL. 11, NO. 5, MARCH 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

OPTIMAL PAIRING OF TEAMMATES FOR ENHANCING COMMUNICATION RATES IN SOFTWARE PROJECTS USING ANT COLONY OPTIMIZATION APPROACH

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ABSTRACT

The power of human as a resource for project success is inevitable. In any firm every other resource surrounds the human resource thereby utilizing the resource for its full potential to deliver the right product at the right time. The main objective of this article is to investigate the relationship between communication and project success and to design novel techniques for formalizing person to person pairing based on interaction rates. A research model is constructed and a meta-heuristic Ant Colony Optimization (ACO) approach is deployed which is inspired by the biological behaviour of ants for achieving the goal. The proposed model is tested over a small scale design based start-up firm as a pilot scale attempt and results infer higher stability and reliability of the model. The result of this method is compared with the classical assignment model wrapped by Hungarian Method (HM). The comparative analysis infers that ACO approach is a perfect blend and choice for sequential continuous communication while HM is a better choice for discrete communication. This also infers that the communication is a key attribute for project success and there exists a direct relationship between the two paradigms success and interaction.

Keywords: eam interaction, ant colony optimization, Hungarian method, pair programming.

1. INTRODUCTION

Problem description

The idea of pair programming has been inspired by agile principles. The extreme programming has a feature named pair programming in which there are two members working on a single machine to complete a given set of task. There is one agent who works in the machine and the other who provides key knowledge and monitors the work that is being carried out in the machine (Cockburn, 2002)).This article presents a novel approach for team mates pairing so as to improve the rate of communication amongst team members by reducing the communication cost with a notion of improving the project's success rates. In a team based working scenario the rate of communication between each of the member with other member is not equal and so a systematic scheme has to be formulated for an effective communication and team harmony.

Related works

The traditional trends in software engineering deals with the concept of legacy process models (Pressman, 2009). The current era of software projects adopt agile mechanisms for an improved quality of the end product. These include the scrum, extreme programming, crystal method etc. (Cockburn, 2002). The concept of pairing comes as a handy approach for software development. This technique emerges from extreme programming and is much useful in mitigating the resource demand. The performance of the product in terms with quality improves in comparison with legacy model. The team is the key aspect of the agile strategy. The notion of this mechanism is that, there is always higher rate of uncertainty and unpredictability. In order to overcome these ambiguities the team must to dynamic (Arisholm *et al.* 2007; Bipp *et al.* 2008; Drury-Grogan, 2014). Such dynamism can be effectively handled using a proper team spirit and communication. The coordination and the interaction between a large group is sparse in nature (Cockburn, 2002). There are several strategies adopted to understand the better structure for communication. Out of different principles in agile; pair programming gives a better structure of team organization (Bella *et al.* 2013; da Silva *et al.* 2014; Erdogamus *et al.* 2010; Layman *et al.* 2006). The whole team is considered to be sub pairs and each pair communication effects the total team's communication thereby boosting the efficacy of the process. There is also an added benefit of less resource need. Similar to person pair researchers have concentrated on machine integration to reduce the acute need (Jurado *et al.* 2013). Different meta- heuristic methods are deployed for agile processes like fuzzy, neural, support vectors etc. (Yan and Xu, 2007; Panda *et al.* 2015; Shi, 2012; Thomas *et al.* 2005; Litoriya and Kothari, 2013; Singhal and Banati, 2011).The agile based principles are used effectively for many critical applications and also for boosting decision making, management sectors and knowledge transfer in firms for speeding the product delivery time (Drobka *et al.* 2004; Plonka *et al.* 2015; Qumer and Henderson-Sellers, 2008; Drury-Grogan, 2014).

Data description

A small scale start-up company is interviewed and a set of data is collected. These are used for understanding the trust and interaction rates of the community. The idea from SNAP repository has been obtained for constructing a set of inputs for processing. The Table-1 depicts the Interaction of Team mates in a Community. This interaction is calculated using a simple probability of success projects to total projects by a pair.

Table-1. Interaction of Team mates in a Community.

Person to person construct	Interaction cost
1-2	0.60
1-3	0.50
1-4	0.70
1-5	0.70
2-3	0.40
2-4	0.30
2-5	0.40
3-4	0.70
3-5	0.60
4-5	0.50

Each member is represented as a node and the Interaction Cost (IC) is the negated probability value of Interaction Rates (IR) that is (1-IR). This IC value is normalized and set to near round-off positions for efficacy reasons.The remainder of this article consists of Proposed Methodology in section 2, followed by Comparative Analysis of Communication in Social Community in section 3, Results and Discussion in section 4 and Conclusion in section 5

2. PROPOSED METHODOLOGY

An overview on Team Communication Model

The proposed model is a three sectored model that comprises of the traditional input, process and output mechanism. The Figure-1 depicts the Team Communication Model that describes the three layers in detail. The input section drives the essential data for evaluating the expected inference from the system. The data is prepared in the form of a data set based on an interview questionnaire mechanism performed with staff members of the start-up firm.

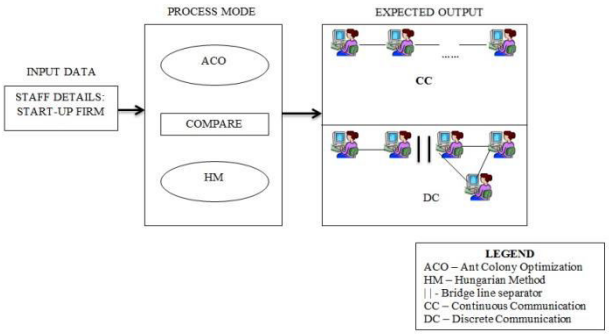

Figure-1. Team Communication Model.

The details given by the staff members are set confidential for the very reason of ethics and the main parameter that is concentrated by this article is calculated in Table-1. The second layer which is considered to be the central hub of the research model is the process mode section where the input is processed using meta-heuristic approach (ACO) and operation research method (HM) and the results are compared to derive intuitive inferences. The HM method follows a systematic task assignment strategy to estimate communication choices among each of the agent in the firm. Similarly ACO uses the ants a biological inspired trait for analysis of the interaction rates. These ants symbolize friendship with the very nature of their behaviour for the food source identification. The expected output is categorized into two sub-sections namely continuous and discrete communication. The continuous interaction is a full laid sequential interaction performed by a chain of members in an ordered fashion. The discrete form of interaction is a cooperation that exists between pairs and may be held subtle when seen for a group on the whole. There exist a logical separation in the interaction among agents due to the very reason of team size and diversity. From these outputs inferences are drawn which are being analysed in the further sections.

Implementation phase: Ant Colony Optimization

The ACO is the most powerful optimization technique that follows the ideology of an ant in its biological traits. The character of the ant is taken as a base of the construction of the ACO algorithm. As the phenomenon of ants; they search of a food source based on a following pattern that is being adopted by the ants in the search space domain. There is one or a set of ants that eventually reach the food source in an optimal way. This leads to the process way for other ants to follow the same path for optimal food source identification. In order to achieve the above said mechanism, ants adopt two principles called the foraging and pheromone tracing. These are bio inspired terms where foraging means searching the source of food and pheromone is a fluid that is emitted by a lead ant for its successors to follow (Dorigo and Stützle,2004).

This idea is inspired in the mathematics and ant based formulations are made. The algorithm for ACO is given below:

a) Formulate an undirected complete graph G(V,E) where V is the vertices or nodes representing the team member and E is the edge representing the interaction rates between each of the team member.
b) Initially set ants at each of the nodes and make these ants discover the next immediate feasible path. This done using equation (1).

$$TP_{ij}^{k} = \left(\frac{(\tau_{ij}^{\alpha})(\omega_{ij}^{\beta})}{\sum_{k=1}^{n}(\tau_{ij}^{\alpha})(\omega_{ij}^{\beta})}\right) \quad (1)$$

where, TP_{ij}^{k} is the transition probability of the ant k form node i to node j, τ is the intensity of trails, ω is the $(1/d_{ij})$ with d being distance or interaction rates, α is the trail importance and β is the visibility importance.

c) Once the transition probability is calculated from the source node to its corresponding destination nodes, the maximum of that transition probability is chosen and the ant moves to that respective node.
d) Once a migration occurs, the pheromone of that path has to be updated as this symbolises the ideal ant movement in search of the food source. The value is updated using equation (2)

$$\tau_{ij}(t+1) = \rho\tau_{ij}(t) + \Delta\tau_{ij}(t,t+1)$$
$$\Delta\tau_{ij}(t,t+1) = \begin{cases} \frac{Q}{d_{ij}} & if\ path\ is\ chosen \\ 0\ if\ path\ not\ chosen \end{cases} \quad (2)$$

where $\tau_{ij}(t+1)$ is updated pheromone, ρ is the evaporation rate, Q is the pheromone quantity and $\Delta\tau_{ij}(t,t+1)$ is the change in pheromone quantity.

e) Continue the above steps iteratively from each of the node in parallel to find a optimal communication pattern with minimum interaction cost.

3. COMPARATIVE ANALYSIS OF COMMUNICATION IN SOCIAL COMMUNITY

The ACO is a powerful meta-heuristic approach for solving complex optimization problem. In this article one such problem is concentrated; where there is a typical need for establishing effective paired communication for successfully completing the project adhering to the iron star paradigms(Atkinson, 1999)].There is another state of the art technique that is also equally good for solving the above specified problem. This method is called the HM by Konigfor assignment problem. The algorithm for the method is given below (Hillier, Taha and Lieberman, J 2003).

a) Consider a square matrix A. Each element of the matrix is an interaction cost. Find the minimum value from each row and column.
b) Subtract this value from the respective rows and columns, so as to ensure that there exist at least one zero in each row and column.
c) Strike that row or column with maximum zeros first and follow the step to ensure the number of strikes is equal to the order of the matrix. If not; select a minimum value from the remaining terms and perform subtraction of non-strike terms.
d) Add the minimum value to the line intersecting terms and perform step 3 again. If order of matrix equals the line strike then stop the process.
e) Select one zero for every row column pair as the assignment variable. Replace those zeros with the actual terms in that position from matrix A.
f) Add each of those values to get a minimum interaction cost.

The Table-2 shows the Comparative Analysis of Member to Member Pairing. The ACO and HM is implemented over a social network from a small scale start-up company and the results are investigated.

Table-2. Comparative analysis of member to member pairing.

Construct	**ACO** (IC)	**HM** (IC)	Status
A five member team	Ant 1= **1.68** Ant 2= 1.92 Ant 3= 1.88 Ant 4= 1.91 Ant 5= 2.61	Feasible IC=**2.24**	ACO approach is best suited for continuous communication. Hungarian method is feasible for discrete communication

The ACO approach sets ants from each of the node for traversal towards the food spot. The series of ants that start from node 1 has an optimal IC rate of 1.68 with a traversal path of 1-3-2-4-5.

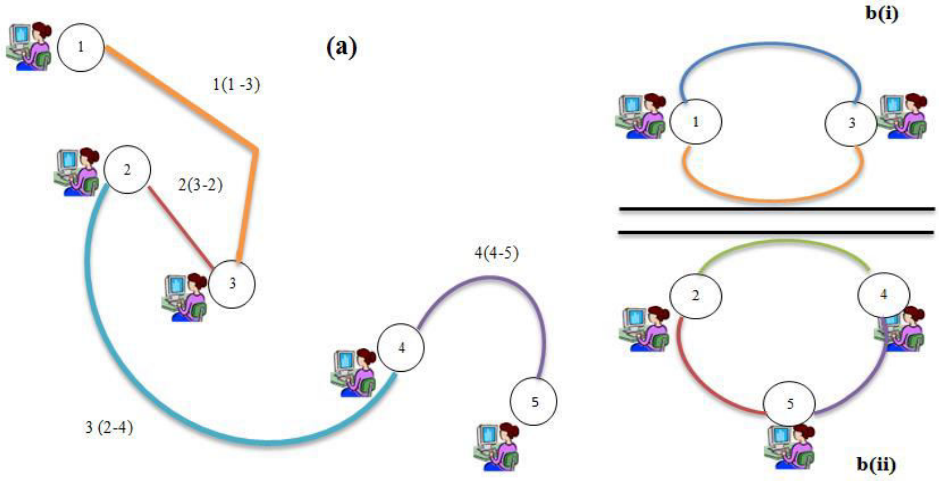

Figure-2. a) Continuous communication of social community; b) Discrete communication ofsocial community.

The Figure-2 shows the Continuous and Discrete Communication in Social Community. The two forms of communication are most common in any firm that is human factor dependent. The CC is studied and analysed using ACO and DC is studied and investigated by HM.

4. RESULTS AND DISCUSSIONS

The word agile means delivery of end product in a fast and feasible manner (Cockburn, 2002). In the agile process, communication among the staffs is a key aspect. The improvement in the interaction rate slowly improves coordination and trust between members of the team and thereby boosting the quality of the end product or service. In any firm; communication between members is not in a uniform rate. This means that the IC rates vary from pair to pair. A systematic formal approach for estimating such pairing is very vital and challenging for decisions to be made.In this research work, an intuitive strategy has been adopted for achieving the above challenge based on non-traditional meta heuristic methods. Communication is classified into two types as continuous (CC) and discrete (DC). The CC is a rare form of interaction in large and medium scale firms due to the very reason of team size and team dynamics. The small scale firms achieve CC for improving their throughput quality. The CC sets a chain of interaction among members without any interdependent break in the communication chain (sequential interaction path). On the other hand; DC is a communication prevalent in large and medium scale firms. In this type of interaction the chain dissolves into discrete pairs and trios and IC for interdependencies grows which causes overheads to the firms' development.The intuition gained from the inference of two approaches (Table-2) is that ACO is best suited for CC and it estimates an IC of 1.68 with a sequence of path in communication among staffs. In the contrary; HM works dominantly well for DC and calculates a feasible IC of 2.24. The HM is effective for large and medium scale firms. The HM pays special attention to the bi-directed trust and communication ignoring the implicit trait of A to B means B to A as well. Such special drivers are having higher impact of larger firms to make rational decisions. The intuitive inference derived out of Figure-2 is that the CC is a strongly connected sequential pairing with uniform interaction path (1-3-2-4-5) and DC is a strong connection establishment between isolated pairs (1-3, 3-1; 2-4, 2-5, 4-5)

5. CONCLUSIONS

The concept of agile and its components has changed the way of software engineering and the perspective of people who look at product end quality. A success of the team is imposed by the successful interaction among team members and the team's success directly influences the project's success; thereby increasing the organization profit and success. A novel attempt has been made in this article to use meta-heuristic methods for identifying interaction bonds and to make rational and right decision in the most uncertain climatic condition in the firm. The advantages of the proposed strategy are: (i) Systematic formal approach; (ii) Easy to deploy at all levels of uncertainty and complexity in the firm; (iii) helps leaders and project managers in faster and appropriate decision making. The limitations of the proposed method are: (i) Managers must acquire adequate skill set to drive intuitive inferences from the formal methods; (ii) Team dynamism (staff movement) creates an overhead to the approach by repeating executions several times. As a part of future scope; optimization techniques like particle swarm, fruit fly, artificial bee colony optimizations can be investigated and few more socio cultural attributes can be studied for its contribution in project success.

ACKNOWLEDGEMENT

We, the authors would like to thank the funding agencies, University Grants Commission for their financial support for the research from Rajiv Gandhi National Fellowship of Grant no: F./2015-17/RGNF-2015-17-TAM-83. We also thank the SASTRA University for providing an excellent infrastructure for performing our research work. We also thank the interview participants and the anonymous reviewers for their effort in making the research a successful work.

REFERENCES

[1] Arisholm E. *et al.* 2007. Evaluating pair programming with respect to system complexity and programmer expertise. IEEE Transactions on Software Engineering. 33(2): 65-86.

[2] Atkinson R. 1999. Project management: cost time and quality two best guesses and a phenomenon, it's time to accept other success criteria. International Journal of Project Management. 17(6): 337-342. Available at: http://eprints.bournemouth.ac.uk/3187/1/licence.txt.

[3] Bella E. *et al.* 2013. Pair Programming and Software Defects - A Large, Industrial Case Study. 39(7): 930-953.

[4] Bipp T., Lepper A. andSchmedding D. 2008. Pair programming in software development teams - An empirical study of its benefits. Information and Software Technology. 50(3): 231-240.

[5] Cockburn A. 2002. Agile software development. ELearning, 5(1): 97. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=947100\nhttp://www.ccs.neu.edu/home/lieber/com1205/w03/lectures/lec1d-short-agile-sd.ps.

[6] Dorigo, M. andStützle T., Optimization.

[7] Drobka J., Noftz D. and Raghu R. 2004. Piloting XP on Four Mission-Critical Projects. IEEE Softw. 21(6): 70-75. Available at: http://dx.doi.org/10.1109/MS.2004.47.

[8] Drury-Grogan M.L. 2014. Performance on agile teams: Relating iteration objectives and critical decisions to project management success factors. Information and Software Technology. 56(5): pp.506-515. Available at: http://dx.doi.org/10.1016/j.infsof.2013.11.003.

[9] Erdogamus H. *et al.* 2010. Responses to How Pair Programming Really Works. Software, IEEE. 27(2): 8-9.

[10] HillierTaha, H.A. and Lieberman J, M.K. 2003. Operations Research: 343 1. Linear Programming 2. Integer Programming Books : Linear Programming (LP).

[11] Jurado F. *et al.* 2013. Cole-Programming: Shaping Collaborative Learning Support in Eclipse. Tecnologiasdel Aprendizaje, IEEE RevistaIberoamericana de. 8(4): 153-162. Available at: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6634224.

[12] Layman L. *et al.* 2006. Essential communication practices for Extreme Programming in a global software development team. Information and Software Technology. 48(9): 781-794.

[13] Litoriya R. and Kothari A. 2013. An Efficient Approach for Agile Web Based Project Estimation: AgileMOW. Journal of Software Engineering and Applications, 06(06): 297-303. Available at: http://www.scirp.org/journal/PaperDownload.aspx?DOI=10.4236/jsea.2013.66037.

[14] Panda A., SatapathyS.M. andRathS.K. 2015. Neural Network Models for Agile Software Effort Estimation based on Story Points. Procedia - Procedia Computer Science. 57, pp.26-30. Available at: http://dx.doi.org/10.1016/j.procs.2015.07.474.

[15] Plonka L. *et al.* 2015. Knowledge transfer in pair programming: An in-depth analysis. International Journal of Human-Computer Studies. 73, pp.66-78. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1071581914001207.

[16] Pressman R.S. 2009. Software Engineering: A Practioner's Approach.

[17] Qumer a. and Henderson-Sellers B. 2008. An evaluation of the degree of agility in six agile methods and its applicability for method engineering. Information and Software Technology. 50(4): pp. 280-295.

[18] Shi S. 2012. Agile manufacturing predicting model based on neural network and automatic logistics

predicting system in China. Proceedings - 2012 International Conference on Intelligent Systems Design and Engineering Applications, ISDEA. pp. 764-767.

[19] Da Silva, I.F. *et al.* 2014. Using a Multi-Method Approach to Understand Agile Software Product Lines. Information and Software Technology. 57, pp.527-542. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0950584914001438.

[20] Singhal A. andBanati H. 2011. Fuzzy Logic Approach for Threat Prioritization in Agile Security Framework using DREAD Model. 8(4): 182-190.

[21] Thomas O., Adam O. and Seel C. 2005. A Fuzzy-based Approach to the Management of Agile Processes., pp.401-404. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.90.7527&rep=rep1&type=pdf.

[22] Yan H.-S. andXu D. 2007. An approach to estimating product design time based on fuzzy v-support vector machine. IEEE transactions on neural networks / a publication of the IEEE Neural Networks Council. 18(3): 721-31. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17526339.