

# Survey Paper for Software Project Team, Staffing, Scheduling and Budgeting Problem

Rizwan Akram, Salman Ihsan, Shaista Zafar, Babar Hayat

Department of Software Engineering  
The University of Lahore, Chenab Campus  
Gujrat, Pakistan

**Abstract**—Software project scheduling is a standout amongst the most imperative scheduling zones looked by Software project management team. Software development companies are under substantial strain to finish projects on time, with budget, quality and with the suitable level of values and qualities. Inexperienced development team or potentially poor management can cause deferrals and costs that given scheduling and spending limitations are regularly unsuitable, prompting business basic disappointments. Software development companies frequently battle to convey extends on time, inside spending plan and with the required quality. For a fruitful project, both software building and software management are exceptionally vital. One conceivable reason for this issue is poor Software project management and, specifically, insufficient project scheduling and inadequate team staffing. Software project schedule issue is one of the essential and testing issues come across by the product project directors in the much focused software companies. Since matter is winding up hard with the expanding quantities of workers and tasks, just a couple of calculations exist and the execution is as yet not fulfilling, to build up an adaptable and powerful model for Software project arranging. In this paper we have attempted to expand a few systems and strategies and results yielded are explained.

**Keywords**—Software engineering; project management; software project resources; project scheduling; budgeting; team

## I. INTRODUCTION

Software development companies get by in a focused market by benefitting from the change of designer' push to helpful and effective software products. To fabricate such items, the organization as a rule takes after a procedure that partitions the development exertion into a few exercises. Each of these exercises requires particular attributes (for example, abilities, capacities, and experience) [2].

Software development companies frequently battle to convey extends on time, inside spending plan and with the user requirements or required quality [1]. One conceivable reason for this issue is low Software project management level, insufficient project scheduling, budgeting and unpracticed team staffing. Staffing a software project is exhausting movement [4], [14].

To build up a software project, the task chief needs to appraise the project amount of work and budget and choose the project calendar and asset distribution. Software project errands need representatives with various abilities, and expertise capability of workers altogether impacts the

effectiveness of project execution. Appointing workers to the well-suited tasks is trying for Software project supervisors, and human asset designation has turned into a significant part in Software project arranging in light of the abilities and encounters of the representatives [3].

Project management systems for the most part respect task planning and human asset portion as two isolated exercises and leave the activity of human asset designation to be finished by project directors physically, bringing about wasteful asset allotment and poor management execution. Principle assets in Software development are people rather than enormous machines, assets in Software projects can more often than not be distributed in a more adaptable manner than those in development or assembling projects [3].

The principle objective of our approach is to assist the project administrator with staffing his tasks, recommending teams that fulfill all requirements associated with the issue naturally. We likewise propose teams that fulfill the requirements, as well as streamline some factor of the issue. In our approach, project staffing is tended to as a requirement fulfillment issue [18], in light of utility capacities that ought to be boosted or limited by the chose development team, with a specific end goal to give more prominent incentive to the organization. A few utility capacities are displayed, to be chosen by the director as per authoritative requirements or imperatives [2].

The survey is planned about important issues counting engineering, planning, scheduling, cost estimation, and monitoring and control of the project operations, with the objectives to optimize cost and time throughout the capable uses of constrained/unconstrained resources [13].



Fig. 1. Project management.

## II. LITERATURE REVIEW

### A. Software Project Scheduling

Software Project scheduling is a system to communicate what tasks need to be done and which organizational resources should be designated to do those tasks in what time span. A project schedule is an archive assembling all the tasks estimated to deliver the task on time.

Nonetheless, concerning influencing a task to plan, well, that is something few have significant organization with.

What and who is being planned, and for what purposes, and where is this schedule occurring, in any case [12], [24]?

A project is contained many tasks, and each task is given a start and end (or due date), so it can be done on time. So also, people have particular timetables, and their availability and escape or leave dates ought to be recorded keeping in mind the end goal to effectively design those tasks [4], [23].

One of the fundamental obligations of a software project administration is to make sense of what work will be done, when and how it will be done. This duty comprises of distinguishing the different items to be conveyed, assessing the exertion for each task to be attempted, and additionally building the project's timetable. Because of the significance of this movement, it ought to have need over all others, and besides, project's calendar should be refreshed routinely to agree with the project's present status.

### B. Software Team Staffing

Staffing a software project isn't a basic action. There are a few engineer-to-action blends to assess, since the manager is generally required to pick a group or team from a bigger arrangement of accessible developers. In addition, team choice is generally compelled by project and hierarchical needs, for example, most extreme team month to month cost, assessed improvement time, and engineer's capacity confuse to exercises, necessities [9].

In these duties a software project administrator is to decide people and their part in teams for project work. Which project contains what level of work team, much the same as experienced or unpracticed representatives [5].

As expressed in [6], the most well-known staffing techniques accessible to software extend chiefs depend vigorously on the task manager's close to home encounters and learning. Be that as it may, these are exceedingly one-sided systems and objectivity does not generally produce the right or finest outcomes. Additional matter is the way that in light of the fact that each project is one of a kind, the utilization of a particular enrolling and staffing technique on a project may not yield the normal outcomes as it was connected on another task as a result of the distinctions in project qualities [7]. And this connects to the way that expertise based and encounter based techniques are not sufficiently reasonable for project chiefs to manage relational connections and social perspectives which emphatically exist in software development organizations [8].

## III. PROJECT MANAGEMENT PLAN – MAJOR COMPONENTS

Projects don't oversee themselves. Proficient project management requires the development of an arrangement that blueprints how it will be overseen. These are the segments that give the center paying little heed to industry or sort of project.

PMP Major Components:

**Scope Management** – defines the natural surroundings for the deliverables of the software project produced to fulfill the project needs and organization desires. It helps to define:

- Scope – what is out and what is in the scope
- Specification – of each of the main products

**Resources and Resource Management** – e.g. machinery and apparatuses, human and their abilities, crude equipment's and semi-completed items, common assets (vitality, water, arrive, and so on.), data, cash and so forth,

At the very least each project must have a project sustenance and project chief!

This section includes:

- Duty of project network – which describes who is in charge of the fulfillment of every item.
- Organization failure structure, which exhibits the organization progression of the project.
- Delegation schedules, which describes the position of specialist inside the project for the confirmation of records, intakes and response.
- Role descriptions which defines the basic requirements.

**Scheduling** – high level schedule, which features the strategic hopes as a topic of reference schedule. This is must to similarly integrate reviews of cost and quality needs. Particular substance includes:

- Preference diagrams
- Gantt charts
- Resource histograms
- Project lifespan

**Cost Management and Budgeting** – is the surveying of costs and the setting of an agreed spending plan, and the organization of genuine and gage costs against that money related calendar. Having the ability to anticipate with some affirmation the rate at which the task is spending its advantages is basic to knowing whether the endeavor is on track.

**Stake Holders** – Each project has stakeholders. Stakeholders are individuals who have an enthusiasm for the effective fulfillment of the project. There are a wide range of sorts of stakeholders, and the stakeholders change by project. Yet, the essential thing to recollect is that the stakeholders ought to have some part in characterizing the project targets, since they are the general population will's identity influenced by the result. When characterizing project stakeholders, the

project manager and individuals from her or his team ought to deliberately thoroughly consider will identify the end clients of the item, regardless of whether it be managements or merchandise, and whether the item will have a beneficial outcome, and how it is probably going to be gotten. Some of the stakeholders are Customers/customers, Sponsors, Company, Team individuals and the Project Manager [4].

#### IV. SOFTWARE PROJECT SCHEDULING PROBLEMS (SPSP)

SPSP is one of the communal issues in organization software projects. It comprises in choosing who ensures what amid the software product lifespan. SPSP ought to consider pay rates and employees abilities which should be appointed to extend tasks as indicated by the necessities of these tasks [11], [20]. We show the model in Table I.

Scheduling is setting a succession of time-subordinate capacities to play out an arrangement of ward tasks that make up a project [11]. Reliance of tasks is imperative as far as need and priority. So it is conceivable that doing a task identified with doing a few tasks which for this situation, it is said that project contains need confinements.

Deciding a scheduling program has been finished with thinking about the reason or determined purposes. Nearly, there are needs constraints between projects in the majority of the activities; however, notwithstanding this impediments might be there is another sort of confinements between errands in light of asset restrictions. So in project scheduling for expansion to thinking about need impediments, scheduling ought to be done so as to be reliable with asset imperatives. In SPSP, considering an arrangement of uses, for example, assets et cetera are required for tasks [18].

TABLE I. SPSP MODEL

Item	Description
$S = \{s_1, \dots, s_{sk}\}$	Set of skills associated with software projects
$T = \{t_1, \dots, t_T\}$	Set of task necessary for the project
$G(V,A)$	Precedence graph defined in the project's Gantt
$V = \{t_1, t_2, \dots, t_T\}$	Is vertex set consisted of all tasks
$A = \{(t_i, t_j), \dots, (t_n, t_T)\}$	Is an arc set, the task $t_i$ must be done before $t_j$
$t_j^{skills}$	Is a set of skills for the task $j$ . It is a subset of $S$
$t_j^{efforts}$	Is an effort person-months to complete the task $t_j$
$EM = \{e_1, \dots, e_E\}$	Is a set of employees
$e_i^{skills}$	Is the set of skills of $e_i$ . It is a subset of $S$
$e_i^{mazed}$	Is the maximum degree of dedication of $e_i, e_i \in (0, 1)$
$e_i^{salary}$	Is the monthly salary of $e_i$

Additionally identifies with the choice of who does what amid a product project lifetime, therefore including basically the two human serious exercises and HR. Two noteworthy clashing objectives emerge when scheduling a product project: lessening the two its budget and span. A multi-target methodology is accordingly the normal method for confronting the SPS issue. As organizations are getting associated with bigger and bigger software projects, there is a real need of calculations that can manage the gigantic pursuit spaces forced.

#### V. DYNAMIC TRAVELLING SALESMAN PROBLEM

Dynamic travelling salesman problem (DTSP) is one of the optimization problems which it isn't solvable with classical methods. To tackle this issue, different solutions in the literature can be seen that each one have advantages and disadvantages. Genetic Algorithm (GA) and Ant Colony Optimization (ACO) have regarded settle the DTSP [19].

#### VI. METHODOLOGY

##### A. Genetic Algorithm Overview

In 1975 John Holland introduced Genetic algorithms [5], work repetitive with populaces of contestant results challenging as an age band, in order to accomplish the set of individuals reflected as abets result to an issue.

Team staffing and Project scheduling may be reflected optimization issues, and as such will need specialized techniques to be solved. Hereditary calculations are one such enhancement strategy, with which it is conceivable to satisfactorily display the numerical idea of project scheduling and team staffing.

GAs keeps up a populace on a specific size. Every person, which speaks to a speculative answer for issue, is aggressively controlled by applying some variety managers to locate a worldwide ideal [10].

To accomplish the objective of finding a worldwide ideal the issue factors are programmed into what are famous as the chromosome. Along these lines, one individual is related with one programmed arrangement (chromosome) as well as its related wellness comparing to the arrangement. GAs enhance the person wellness, which implies the streamlining level of arrangement, by utilizing sorts of focused operations. Also, with the expansion of age quality, wellness of genetic material is ending up well [4].

In view of the procedure of regular advancement, their point is for acceptable single answers for 173 C. A.S. Andreou and Stylianou beat those that are fewer hard at every age. To accomplish this, the wellness of each single arrangement is assessed utilizing a few criteria in respect to the issue, and in this manner those assessed exceedingly are more plausible to frame the number of inhabitants in the people to come. Advancing sound, happier people and disposing of less reasonable, weaker people in a given age is helped by the utilization of varieties of the choice, hybrid, and change managers, which are in charge of picking the people of the following populace and modifying them to expand wellness as

ages advance – making in this manner the entire procedure take after the idea of ‘survival of the fittest’.

### B. Encoding and Representation

For the issue of team staffing and software project scheduling, the contestant results for optimization need to signify two sections of material. From one perspective, schedule imperative data, in regards to when and in which arrange projects are executed and, then again, expertise limitation data, concerning the task of workers to errands in view of ranges of abilities and experience necessary for a task. Fig. 1 beneath gives a case of the portrayal of a product project schedule holding four tasks and five possible workers. As appeared, the hereditary calculation utilizes a blended sort encoding: schedule data is spoken to by a positive, non-zero number symbolizing the begin day of the errand, though representative task data is spoken to by a twofold code, wherein each piece implies whether a worker is (an estimation of 1) or isn't (an estimation of 0) doled out to complete the task [5].

TABLE II. SOFTWARE PROJECT SCHEDULE REPRESENTATION EXAMPLE

1	10100	11	00010	16	01001	31	00110
---	-------	----	-------	----	-------	----	-------

In Table II, the

- 1<sup>st</sup> task starts at day one
- worker 1 and 3 will fulfill it
- Task 2<sup>nd</sup> starts at day 11 with only worker 4 allotted to it, and so on.

### C. Ant Colony Optimization

A heuristic optimization technique for most limited way and other advancement issues which obtains thoughts from natural ants. In view of the way that ants can discover most limited path between their nest and source of food.

Ant Colony Optimization (ACO) Overview “Ant Colony Optimization (ACO) thinks about simulated frameworks that take motivation from the conduct of real ant colonies and which are utilized to take care of discrete optimization issues.”

Ant Colony optimization procedure is an arrangement of guidelines in view of look artificial intelligence algorithms for ideal results; here is the notable part is ANT System, as suggested by Maniezzo Colormi and Dorigo [20]-[22]. Ants are outwardly disabled and little in dimension and still can locate the straight path to their sustenance source. They all make the utilization of projections and pheromone fluid to be in contact with one another. ACO encouraged from the performance of living ants, are equipped for management with scanning answers for nearby issue by keeping up exhibit rundown to keeping up past data accumulated by every ant.

Also, ACO manages two vital procedures, specifically: Pheromone statement and trail pheromone dissipation. Pheromone testimony is the marvel of ants including the pheromone all ways they take after. Pheromone trail vanishing implies diminishing the measure of pheromone kept on each way regarding time. Refreshing the trail is executed when ants either entire their hunt or catch the most limited way to

achieve the sustenance source. Every combinatorial issue characterizes its specific particular refreshing criteria relying upon its specific nearby hunt and worldwide inquiry individually [18].

Artificial ants left an essential trail gathered on the route sector they follow. The route for every ant is nominated on the source of quantity of “pheromone trail” extant on the thinkable route begin from the present ant node. In situation of equivalent on nearby routes, ants arbitrarily select the route.

On a route Pheromone trail growths the possibility of the route being taken after. Then Ant achieves the next node and another time organizes the route selective progression as defined above. This progression carries on till the ant achieves the present node. This completed visit gives the result for limited or best route which would then be assessed for optimality.

It may be useful for different combinatorial implementing problems. ACO algorithms are utilized by easy mediator called “ants” that is iterative developed contender result to combinatorial executing problems [15].

The “ants” result development has been conducted by artificial pheromone track & issue-dependent experimental information. By law, ACO algorithms may be useful to any combinatorial executing problems by significant “solution components” that the ants utilized to iterative developed contender result and on which they can put down pheromone [11].

Fig. 2 Flow chart of ACO Algorithm is among the best swarm based algorithm propounded by Dorigo and Di Caro in 1999 [20], [21]. It is a meta heuristic motivated by the scrounging activities of ants in the wild, and in addition, the marvels known as stigmergy, term utilized by Grasse in 1959. Stigmergy alludes to the backhanded correspondence among a self-organizing emanant framework through people adjusting their nearby condition.

The most intriguing part of the communitarian conduct of a few subterranean ant animal types is their capacity to discover briefest ways between the ants' nest and the food sources by following pheromone trails Then, ants pick the way to take after by a probabilistic choice one-sided by the measure of pheromone: the more grounded the pheromone trail, the higher its attractive quality. Since ants thus store pheromone on the way they are following, this conduct brings about a self-fortifying procedure prompting the development of ways set apart by high pheromone fixation. By displaying and reenacting subterranean insect searching conduct, brood arranging, settle building and self-collecting, and so on calculations can be created that could be utilized for unpredictable, combinatorial advancement issues [25].

A satisfactory model for software project planning needs to manage the issue of undertaking assignment planning as well as the issue of human asset portion. In any case, as both of these two issues are troublesome, existing models either experience from the effects of an extensive inquiry space or need to confine the adaptability of human asset assignment to improve the model. To build up an adaptable and powerful model for software project planning [16].

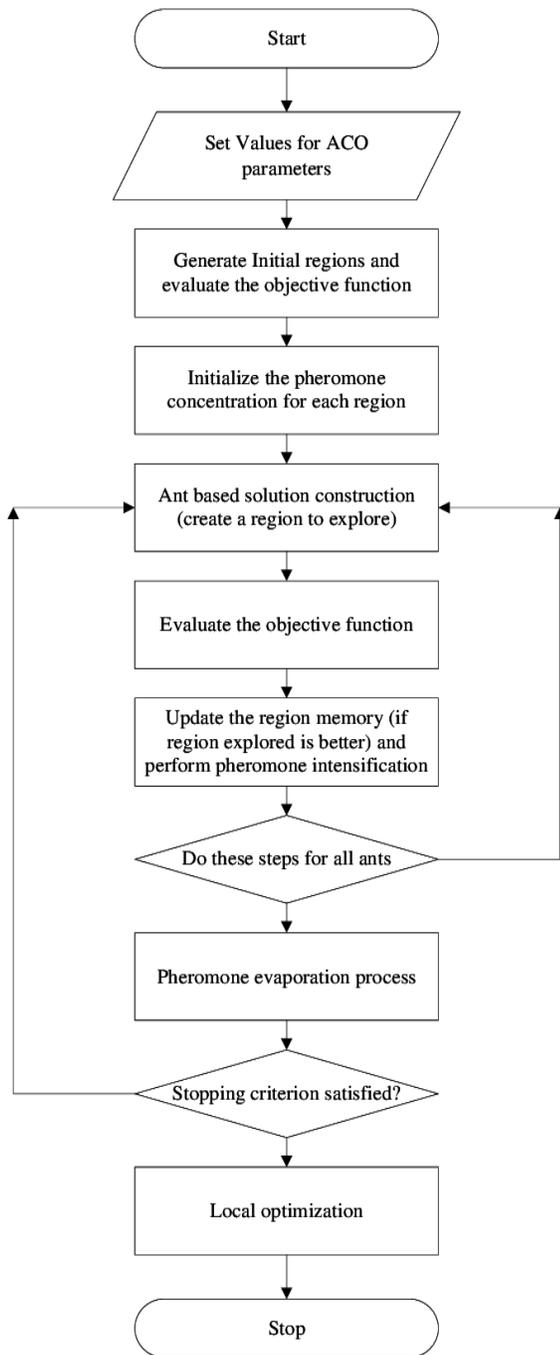


Fig. 2. ACO Flow Chart.

Network analysis provides an effective practical system for planning and controlling large projects in construction and many other fields. Ant Colony System is a recent approach used for solving path minimization problems [17].

#### D. Differential Evolution (DE) Algorithm

The algorithm DE is of meta-heuristic algorithm which was created in 1995 [18]. DE algorithm is a populace-based probabilistic search algorithm which solves optimization issues. This algorithm using the distance and direction information from the existing populace carries out the search processes. The benefits of this algorithm are speediness,

setting the constraints, its effectiveness in finding optimal results, being parallel, high accuracy and absence of need to sorting or matrix duplication. DE Algorithm in instruction to search the optimal results, has the ability to proficiently search the process in the route of coordinate axes of optimistic variables and also changes in the route of the coordinate axes in the right direction. DE Algorithm starts the evolutionary search process from a random initial population. DE Algorithm begins the developmental hunt process from an arbitrary introductory populace. Three managers of change and choice, and the incorporation and three control parameters, including the quantity of populace, scale factor and the likelihood of coordination are essential in the DE algorithm. DE algorithm forms are as per the following (shown in Fig. 3):

- Initial Population Generation
- Mutation Operator
- Crossover Operator
- Selection Operator
- Stopping Criteria

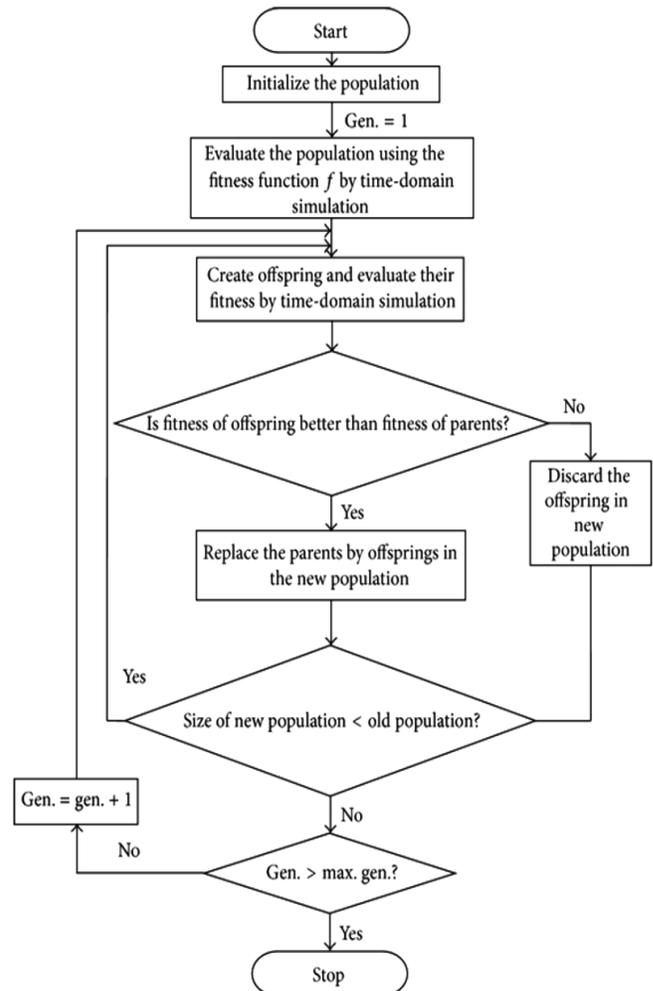


Fig. 3. Differential Evolution (DE) Algorithm Flow Chart.

## VII. PREEMPTABILITY

In many prototypes of project scheduling issues it's accepted that exercises are non-preemptible, however in a few projects this presumption is casual and it is permitted to seize exercises. All in all, for each the project exercises may be either preemptible or (non) preemptible. In any case, normally it is accepted that (non) preemptibility concerns all exercises on the double. Under this supposition, we discuss an arrangement of non-preemptible exercises if none of them might be seized, while we discuss an arrangement of preemptible exercises if every movement can be appropriated whenever and revived later with zero amount. Appropriation might be either distinct, if movement acquisition is permitted toward the finish of eras just, or ceaseless, if appropriation may happen at a self-assertive time moment.

## VIII. CONCLUSION

This paper exhibited a way to deal with tackling the issue of team staffing and software project schedule by receiving a hereditary calculation as a development system to build project's ideal calendar and to dole out the most experienced representatives to tasks.

Software development includes time, ability, and cash. In an aggressive market, a product development organization's real objective is to boost esteem creation for a given project. Subsequently, an appropriate use of each accessible asset in a product project is imperative.

Among a few strategies ACO noises well as it fabricates arrangements in a well ordered and iterative way empowering the utilization of issue based heuristics to control the inquiry bearing of ants, it is conceivable to outline valuable heuristics to guide the ants to plan the basic errands as right on time as could be allowed and to relegate the project tasks to appropriate representatives with required abilities.

This survey of different methods will be useful for better investigation and developing new thoughts for far and away superior schedule systems.

## REFERENCES

- [1] Optimizing Software Project Management Staffing and Work-Force Deployment Processes using Swarm Intelligence; Mazhar Hameed, Usman Qamar, Hiba Khalid, Syed Khizer Abass, Computing Conference 2017 18-20 July 2017 | London, UK.
- [2] Staffing a software project: A constraint satisfaction and optimization-based approach Ahilton Barreto, Márcio de O. Barros. *Computers & Operations Research* 35 (2008) 3073 – 3089.
- [3] A Hybrid Approach for Software Project Scheduling V.Karthiga and K.Sumangala, *International Journal of Computer Applications* (0975 – 8887) Volume 59– No.16, December 2012.
- [4] Survey paper for Software Project Scheduling And Staffing Problem Nandkishor Patil, Kedar Sawant, Pratik Warade and Yogesh Shinde, *International Journal of Advanced Research in Computer and Communication Engineering* Vol. 3, Issue 3, March 2014.
- [5] Intelligent Software Project Scheduling and Team Staffing with Genetic Algorithms. Stylianou C., Andreou A.S. In: Iliadis L, 2011.
- [6] , S.T., Juristo, N., Moreno, A. M.: Emphasizing Human Capabilities in Software Development. *IEEE Softw.* 23(2), 94–101 (2006).
- [7] Wi, H., Oh, S., Mun, J., Jung, M.: A Team Formation Model Based on Knowledge and Collaboration. *Expert Sys. Appl.* 36(5), 9121–9134 (2009).
- [8] Amrit, C.: Coordination in Software Development: The Problem of Task Allocation. In: 27th International Conference on Software Engineering, pp. 1–7. ACM, New York (2005).
- [9] Barreto, A., Barros, MdO, Werner, C.M.L.: Staffing a software project: a constraint satisfaction and optimization-based approach. *Comput. Oper. Res.* 35(10), 3073–3089 (2008).
- [10] Review of various Software Project Scheduling techniques, Ramandeep Kaur, Sukhpreet Singh, *International Journal of Computer Science & Engineering Technology (IJCSET)*.
- [11] Solving software project scheduling problems with ant colony optimization Jing Xiao a,n, Xian-TingA, *Computers & Operations Research* 40 (2013) 33–46.
- [12] A New Approach to Solve the Software Project Scheduling Problem Based on Max–Min Ant System, Broderick Crawford, Ricardo Soto, Franklin Johnson, May 2014.
- [13] Liao, T.W., Egbelu, P., Sarker, B., Leu, S.: Metaheuristics for project and construction management a state-of-the-art review. *Autom. Constr.* 20(5), 491–505 (2011).
- [14] N. Nan, D.E. Harter, "Impact of Budget and Schedule Pressure on Software Development Cycle Time and Effort", *IEEE Trans. Software Eng.*, vol. 35, no. 5, pp. 624-637, Sept./Oct. 2009.
- [15] Crawford, B., Soto, R., Johnson, F., Monfroy, E.: Ants can schedule software projects. In: Stephanidis, C. (ed.) HCI International 2013—Posters Extended Abstracts, volume 373 of Communications in Computer and Information Science, pp. 635–639. Springer, Berlin (2013).
- [16] Chen, W., Zhang, J.: Ant colony optimization for software project scheduling and staffing with an event-based scheduler. *Softw. Eng. IEEE Trans.* 39(1), 1–17 (2013).
- [17] Abdallah, H., Emara, H.M., Dorrah, H.T., Bahgat, A.: Using ant colony optimization algorithm for solving project management problems. *Expert Syst. Appl.* 36(6), 10004–10015 (2009).
- [18] Maghsoud Amiri, Javad Pashaei Barbi. : New Approach For Solving Software Project Scheduling Problem with Differential Evolution Algorithm. *International Journal in Foundations of Computer Science & Technology (IJFCST)*, Vol.5, No.1, (2015).
- [19] F.S. Gharehshogh, I. Maleki, M. Farahmandian, "New Approach for Solving Dynamic Traveling Salesman Problem with Hybrid Genetic Algorithms and Ant Colony Optimization", *International Journal of Computer Applications (IJCA)*, Vol.53, No.1, pp.39-44, 2012.
- [20] Crawford, B., Soto, R., Johnson, F., Monfroy, E.: Ants can schedule software projects. In: Stephanidis, C. (ed.) HCI International 2013—Posters Extended Abstracts, volume 373 of Communications in Computer and Information Science, pp. 635–639. Springer, Berlin (2013).
- [21] Chang, C.K., Yi Jiang, H., Di, Y., Zhu, D., Ge, Y.: Time-line based model for software project scheduling with genetic algorithms. *Inf. Softw. Technol.* 50(11), 1142–1154 (2008).
- [22] Dorigo, M., Stutzle, T.: *Ant Colony Optimization*. MIT Press, USA (2004).
- [23] M. di Penta, M. Harman, G. Antoniol, The use of search-based optimization techniques to schedule and staff software projects: an approach and an empirical study, *Software – Practice and Experience* 41 (5) (2011) 495 – 519.
- [24] M. Harman, S. A. Mansouri, Y. Zhang, Search-based software engineering: Trends, techniques and applications, *ACM Computing Surveys* 45 (2012) 11.
- [25] Anukaran Khanna, Akhilesh Mishra, Vineet Kumar Tiwari, P N Gupta; A literature based survey on swarm intelligence inspired optimization technique: *International Journal of Advanced Technology in Engineering and Science* Volume No 03, Special Issue No. 01, March 2015.
- [26] Subramaniam Sumithra and T. Aruldoss Albert Victoire; Differential Evolution Algorithm with Diversified Vicinity Operator for Optimal Routing and Clustering of Energy Efficient Wireless Sensor Networks: Hindawi Publishing Corporation, *The Scientific World Journal* Volume 2015, Article ID 729634, 7 pages (2015).