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## Review on Software Project Scheduling Analysis

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**ABSTRACT:** In software development, project scheduling is a challenging task faced by the software management team as it involves uncertainty. It divides the effort among various software engineering tasks needed for the project completion across the given project duration. Software project scheduling subsumes a variety of scheduling constraints like completion deadline, accessibility of primary requirements, order of jobs and limitations on the duration of a task. It is used while implementing a project and for cost minimization. Ensuring the completion of software project within a given time frame requires the identification of milestones, the result of the tasks and their interdependence. Various resources and methods for estimating the schedule are already established. This paper mentions the advantages project scheduling has and the scope for its usage in industries. A review of certain recently used software project scheduling methods is formulated in this paper.

**KEYWORDS:** Software Project Scheduling, completion deadline, primary requirements, jobs, duration, minimization of cost, estimation.

### I. INTRODUCTION

Software project scheduling refers to a sequence of activities that need to be carried out in order to complete the project within the given time frame by using the required resources in an efficient manner. The importance of project scheduling is seen in the management of medium scale and large scale software projects which demand an optimal use of resources and the completion within the deadline. The task of project scheduling comprises of four paths namely the identification of project activities, their interdependency, estimation of resources required and the allocation of each task to the work force in the organization. Project scheduling also includes the creation of charts which help in analysis of task sequence and each task's duration and also gives a better picture of the project. Project scheduling enables us to manage the project costs more efficiently and it also improves the communication among the team members as they all are keeping track of the project progress. Another advantage of project scheduling is that it identifies an activity or a decision, which is taken by the project manager which is hampering its progress, easily and with the help of the dynamic project scheduling algorithms, the project schedule can be improvised accordingly. There are various project scheduling techniques like Work Breakdown Structure, Gantt Chart, Critical Path Method (CPM), Activity Chart and Project Evaluation Review Technique (PERT).

### II. LITERATURE REVIEW

<sup>[1]</sup>24th DAAAM International Symposium on Intelligent Manufacturing and Automation, 2013 Resource Constrained Multi-Project Scheduling with Priority Rules & Analytic Hierarchy Process Amol Singh: The main agenda is resolving the conflict that arises when we have multiple projects to handle simultaneously with limited resources. This paper considers multiple project scheduling as a NP hard problem where if the number of projects are made countable at the finger tips then we can come with a proper minimal expenditure of resources and scheduling all the projects with least time wastage. They have focused on priority indexing of projects and hierarchy tree algorithm also called as analytical hierarchy of processes for making various important constraints like time, expense to be spent wisely and with least wastage.



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<sup>[2]</sup>Project scheduling with limited resources using an efficient differential evolution algorithm by Behrouz Afshar-Nadjafi \*, Hamid Karimi, Amir Rahimi, Somayeh Khalili: In this particular paper, differential evolution is proposed which helps in encoding a project schedule with optimized makespan using an algorithm called resource constraint project scheduling(RCPSP). In RCPSP, the planning horizon is cleaved into discrete number of time periods and activity durations are distinctly divisible. The mechanism is divided into several steps as follows: Mutation, crossover and acceptance where we finally get near optimal or least satisfying solution. The implementation of genetic algorithm used for differential evolution using precedence relationship between the activities, thus helping us in easy backtracking if any error occurs. Hence, minimal time used for project finishing is calculated by meta-heuristic approaches same as used in NP-hard problem however the result obtained by differential evolution method is superior to NP-hard problem approach.

<sup>[3]</sup>Creative Construction Conference 2015 (CCC2015) Graphical modelling classification for construction project scheduling, Adel Francis, PEng., Ph.D.: Whenever management and upper hierarchy people are involved in decision making for a company, producing a physical report of progress made in project is very difficult for the technical staff so graphical modeling and data visualization is very effective way to deliver information clearly. These graphical means of scheduling methods are classified in many subdivisions, majorly 7; the classification shows how different strategies can reflect the presentation of same project in different compatible and understandable approaches just by simple steps of changing graphical parameters. The chronographical method as detailed helps in understanding the communication between graphical and tabular interfaces: helping the upper management to get better vision for decision making.

<sup>[4]</sup>On optimization of R&D Project Selection and Scheduling by Alina T. Latipova : Project scheduling does not only mean handling multiple projects simultaneously, it also involves taking care of vast projects like the ones having their core infrastructure of spiral modelling. Thus to reduce the computational complexity they have used GPU programming methods where we divide the problem a hierarchy of sub problems for each period of proposed time. Major steps as discussed about GPU programming are project data update (eg. Duration of stages, resources needed level of importance), set of new projects for the current week, set of sub projects to be implemented in the current week, similarly their delay and termination in the same week. They have derived a mathematical expression for weekly distribution of sub projects having a development span of less than a year. Thus, they have found this method to handle internal time distribution of a project.

<sup>[5]</sup>CONVR2013, International Conference on Construction Applications of Virtual Reality, 2013, EFFECTIVE PROJECT SCHEDULING UNDER WORKSPACE CONGESTION AND WORKFLOW DISTURBANCE FACTORS, Vitaly Semenov & Anton Anichkin :The objective of project management is to entail the use of advance planning along with the use of effective project scheduling techniques which results in the determination of an appropriate sequence of tasks and timely completion of the software project before the deadline. This method has overcome many shortcomings of the traditional scheduling tools like the construction projects where special factors play an essential role. The effective project management scheduling method moves towards minimization of project makespan while satiating time constraints and precedence relation without going beyond resource utilization limit, thus preventing any kind of discontinuities or crowding in the workflow. The analytical technique used those attempts for searching the best possible solution in the least project completion time possible while it generally needs a large amount of time leading to an infeasible scenario whereas heuristic approach assists us with suitable answers for mega scale projects in an achievable time. They also focused on priority scheduling rules for prioritizing spatial factors like the resource moving time for any company to prevent overloading of workspace and overhead of reallocation of resources.

<sup>[6]</sup>Project Scheduling Constraints – Best methods and practices -Timothy J. Kloppenborg and Lydia K. Lavigne :In this paper, the elements in the work breakdown structure are defined, creating the schedule and assigning resources to the project brings the final goal further to fruition and to reality. Here many methods dealing with multiple resources are compared based on various constraints like imposed dates, availability of key resources, logistics task order and activity duration limitations. Methods like (PMBOK) project management methodologies for working with constraints, agile



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method, critical chain method are compared based on key constraints. No method is blacklisted as all the methods have their specialties while dealing with various factors like resources capacity, tools, team members, resource used and so on. The paper also discusses external participants which are actively affecting the process scheduling like ways to monitor and control work, risk factor, individual task evaluation, planning tools. Similarly, the best practices' assessment is shown as a combination of multiple factors as discussed above and it also dominates the traditional methods and its procedure.

<sup>[7]</sup>An approach to Resource Constrained Project Scheduling: James M. Crawford, University of Oregon: Here, we get an overview of a very different approach to Resource Constraints Project Scheduling whose cardinal model is a combination of a novel optimization technique with limited discrepancy search and generates the best optimal solution. The main steps involve partial ordering on the task by specifying some task which should precede others to minimize makespan without violating the precedence constraints or over utilizing the resources. Likewise, they have explained a general benchmark problem that works in two steps and has schedule packing working independently as invented by Barry Fox [1996]. For optimizing work, they have used limited discrepancy search which has two majorly used algorithms namely, backtracking search tree and LDS search tree. The main goal is to generate a series of "seed" schedules that are pushed to an optimizer where it is visible while doing a kind of scheduling-specific local search.

<sup>[8]</sup>Project resources scheduling and leveling using Multi-Attribute Decision Models: Models implementation and case study Ch. Markou, G.K. Koulinas, A.P. Vavatsikos : This paper addresses an efficient method where resource levelling provides procedures and frameworks which helps in very effective management of resources for obtaining smooth resource usage profiles where we try to distinctively separate activities that should be delayed to resolve resource over allocation under time and cost constraints. Also, multi-attribute decision making models are discussed using standard resource levelling procedures when priority rule methods are implemented. Thus, to meet real time practical limitations, an acyclic activity-on-node method is derived mathematically. The expected outcome of the paper has framework with objective to elicit priorities, when priority-rule heuristic procedure are implemented with agenda of improving shape of the resource usage histogram. As a result the project attenuates under-allocation resource usage issue and moreover it can adapt easier to address unpredictable resource shortage during project execution.

<sup>[9]</sup>COMPLEX PROJECT SCHEDULING USING MULTI-AGENT METHODS: A CASE STUDY FOR RESEARCH PROJECTS -Constanta-Nicoleta, Ileana Ruxandra and Augustin Purnus: As a practical scenario, many times projects fail to succeed, so there is much demand for better project planning and scheduling approaches. Time constrained and resource constrained issues are distinctively differentiated using mathematical models to prove that each of them lies in different dimension. Similarly, complex project scheduling can be done by multi agent methods where agents refer to resource-leveller etc. having diversity characteristics like tagging-entity identification, internal model-adaptation and building blocks. Also focus is on project scheduling stochastic methods which play a pivotal role and management decision making which has been represented using MATLAB graphical representation.

<sup>[10]</sup>A Brief View of Project Scheduling Techniques by-1 Battu Hanumantha Rao, Assoc.Prof. & Dean-Academics, NH College of Engineering, 2. Ashwin Gandhi , Assoc.Prof. & Director, Daripally Anantharamulu College of Engineering, Khammam, 3 Rahul Ramkishan Rathod , Asst.Prof. Dept. of CSE, Sharadchandra Pawar College of Engineering: Paper provides a broad perspective on vivid project scheduling techniques by narrowing focus on software project managers to deliver the project on time along with the development of fully functional system. Evaluation of various techniques leads to the conclusion of primary aspects as delivery of project on time, effort distribution, managing human and technical difficulties. Many graphical models are criticized for supply of inaccurate information about the project completion time due to the negligence of the uncertainty factor which is very difficult to be estimated theoretically.

<sup>[11]</sup>Project Scheduling: Improved approach to incorporate uncertainty using Bayesian Networks- Vahid Khodakarami, Norman Fenton, Martin Neil: Many projects failed due to the factor of not considering the uncertainty and causality that can happen during project execution. This paper helps us in considering and establishing a random relationship between these project parameters which are theoretically neglected. Here, Bayesian Network Approach is discussed



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which assists in decision support application. Also, focus on Critical Path Method (CPM) is discussed for handling uncertainty to cater analysis to manage and represent multiple sources of uncertainty in project value.

<sup>[12]</sup>Improved Evolutionary Algorithm Design for the Project Scheduling Problem Based on Runtime Analysis by Leandro L. Minku, Dirk Sudholt, and Xin Yao, Fellow, IEEE: Here, they have discussed the first runtime analysis for the project scheduling problem and by that they gain insight into the performance of the evolutionary algorithm, where later the problem is treated as NP-hard problem. This traditional method uses various pieces of information which are determined in prior duties of finding correct tasks, interdependencies between them and estimating various requirement in respect of resources. Their approach is simple and straightforward with two parts, first normalizing the employee's dedication for getting better efficiency in work output and secondly, to give a clear gradient in our search of getting optimal or near-optimal solution. They have explicitly made extensive use of Gantt chart. The explained discussion makes use of linear schedules. This paper mainly focuses on theoretical analysis and the experimental trial and error method helps in understanding why the traditional evolutionary algorithm fails in a project scheduling problem.

<sup>[13]</sup>A Multi-Objective Dedicated Local Search for Project Scheduling Problem by K. Nino, G. Mejia, L. Amode: Various methods focus on handling multi-project scheduling or handling sub-projects of a mega project. This paper, however, divides even the lower level of sub-projects into local threads and dedicates its work on local search method for the multi objective resource constrained project scheduling problem by minimization of the maximization completion time of the project and the total weighted start times considered initially. Thus, we focus on understanding various methods discussed for reducing total completion time as far as possible in the project by making a project go through two phases, namely, the generation of an initial solution and then the generation of non-dominated solutions from the output obtained in first phase. These methods and approach find lot of attention especially in project management issues arising in Animation and Videogame industry.

<sup>[14]</sup>THE DYNAMICS OF SOFTWARE PROJECT SCHEDULING by TAREK K, ABDEL.HAMID and STUART E, MADNICK Massachusetts Institute of Technology: In this paper, the unresolved issues related to software project scheduling are addressed. A system dynamics approach is discussed which helps to tackle many dynamic issues of software project scheduling. Brooks' Law is used to explain the dynamic features that software managers fail to notice while tackling a particular problem. For example, if the project is running behind schedule, more employees are hired which can hamper its progress even further as it increases the communication cost. This is where the Systems Dynamics model plays its role as it can highlight the effect that every step taken in the past can have on the final outcome. System Dynamics uses feedback techniques to problems that are management and organization related. In this paper, the core idea behind the System Dynamics model is discussed, which is the effect that an entity of the organization has on its behavior. The System Dynamics model is designed after collecting pertinent data from various sources. This model comprises of many cause effect diagrams which explain that each decision taken has on the final result. Finally, the model mentioned above is expressed mathematically. After analyzing the mathematical model, it is concluded that simply improving the schedule as per the changes in features of the model is not the right thing to do and software managers need to develop an integrative model using the system Dynamics approach to isolate the features which are proving to be problematic.

<sup>[15]</sup>PMI. (2007). The Practice Standard for Scheduling. Project Management Institute, Newtown Square, PA.: The various scheduling levels are explained in this paper starting with Level 1 schedule and finishing with the Level 5. Level 1 schedule mentions the major project tasks, the tasks achieved and the final result for the whole project. It discusses the schedule of the project in the form of reports which give a more succinct view of the whole project than a more detailed one. Level 2 schedule gives a summary of the schedules which are utilized in the Level 3. It divides the whole project into various fragments and is used for reporting to the higher level management of the organization. Level 3 schedule, also known as the Project Coordination schedule, is maintained as a gist of the Level 4 scheduling. The third level is used as a tool to report the Level 4 scheduling activities to the higher management and is also used to document of the monthly report. General Managers, sponsors etc. are among the various people who are considered as an audience for this type of level. Level 4 schedule, better known as the Execution schedule is the working schedule which is considered as a detailed representation of the Level 3 schedule. This is the main working level Critical Path



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methodology schedule which displays the tasks to be met by the employees of the organization and is necessary for each project. The dates which are mentioned in this particular level are the tentative sates for the commencement and the conclusion of the project. Level 4 schedule can be defined for the whole project or for a part of it depending on its size and complexity. Level 5 schedule is known as the detail schedule and is a further detailed explanation of the tasks subsumed in the Level 4 schedule.

<sup>[16]</sup>Dynamic Software Project Scheduling through a Proactive-Rescheduling Method by Xiaoning Shen, Leandro L. Minku, Member, IEEE, Rami Bahsoon, and Xin Yao, Fellow, IEEE: This paper talks about the dynamic software project scheduling and implements it using a method known as the Proactive Rescheduling method. The dynamism in software scheduling captures its application in the real world and many software project scheduling techniques which revolve around deterministic models which might result in poor performance or disruptions while progressing through the project. This paper defines an algorithm for dynamic project scheduling which considers various aims of the project scheduling model namely the cost, robustness, duration and stability under some defined constraints. The project scheduling algorithm which is to be tackled has some requirements namely the identification of project tasks, identification of dependencies of the tasks ,allocation of tasks to the workforce and to estimate the resources which need to be allocated for the project. The static models consider the above mentioned factors as constant over the full period of the project completion whereas the dynamic methods defined in this paper consider these factors to be variable in order to handle uncertainties occurring during the project .The proactive Rescheduling method makes an effort to generate a schedule beforehand taking into account all the variable features and is a combination of the pro active and the reactive scheduling method. This method is analyzed in detail using various mathematical tools.

<sup>[17]</sup>Search-Based Software Project Management by Filomena Ferrucci, Mark Harman, Federica Sarro :In this paper, a method known as the search based software project management is introduced . Its primary purpose is to tackle problems like scheduling and the estimation of risk and effort in software project management. The main advantage that Search-Based Software Engineering (SBSE) provides is decision making as well as decision support. It helps to build software scheduling models faster, better and more efficient. SBSE is an identifies most optimal solutions to a software scheduling problem by exploring search space comprising of all possible candidate solutions. Each candidate solution can be considered as a combination of different attributes required for software project scheduling like dependencies of each task on others, their duration and the resources which would be allocated for each task. So, a fitness function should be defined which can evaluate various candidate solutions and could make comparisons between them feasible. Many techniques like Hill Climbing, Genetic Algorithms (GA) and genetic programming. This paper sheds light on various techniques mentioned above used by researchers.

<sup>[18]</sup>A Hybrid Technique for Software Project Scheduling and Human Resource Allocation by A. Avinash, Dr. K. Ramani Department of Information Technology Sree Vidyanikethan Engineering College, Tirupati: This paper talks about a hybrid technique which is devised for software project scheduling. Nowadays, many models designed for software project scheduling suffer from an increased search space and lack of flexibility as they don't take into account the dynamic nature of the software project scheduling model. Techniques like Program Evaluation and Review Technique (PERT) and the critical path method (CPM) have not succeeded in constructing scheduling models which cater to resource allocation as well and therefore, they are considered as different entities in the following paper. The proposed model in this paper, schedules the project tasks using the Event Based scheduler (EBS) and the efficiency of the workforce as well as the allocation of tasks is carried out by Ant Colony Optimization (ACO). The event based scheduler (EBS) is used to create events. It helps to calculate the working hours of each employee in the workforce. EBS enables us to consider the commencing point and the ending point as events which further results in an optimized consumption of resources. In the Ant Colony optimization technique, the pheromone plays the role of the past search experience of every employee. Using the pheromones, more ants will be attracted to select a particular path. This is how the optimal allocation of tasks will be carried out.

<sup>[19]</sup>Learning Curve Effect on Project Scheduling by Levente Malysz, Budapest :In this paper, the effect that a learning curve has on a software project scheduling is discussed. Usually, the project scheduling techniques are inaccurate as they cannot predict the time required for the task completion and the number of resources assigned to each employee



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and the interdependency of tasks. Thus, the traditional project scheduling technique cannot accommodate the learning curve in an efficient way. The objective of this paper is to show the effect of learning curves on the project duration. The theory of the learning curve is applied for the predicting the cost or the time of the work to be done in the future while assuming repetitive cycles with the same working conditions in every cycle. Some of the working conditions which are taken into consideration are technology, workers as well as the taskforce. The learning curve technique can only be applied on repetitive activities as it reduces their duration.

### III. RESULTS

Comparison is being made according to the various papers' discussion and their explanation. It is as follows

Sr. No	Paper Name	Technique used	Results/Conclusion
1.	Resource Constrained Multi-Project Scheduling with Priority Rules & Analytic Hierarchy Process	Priority indexing and Hierarchy Tree algorithm	The techniques used can handle multiple projects simultaneously with a limited number of resources and ensure least time wastage while scheduling the projects.
2.	Project scheduling with limited resources using an efficient differential evolution algorithm	Differential evolution algorithm	Implementation of differential evolution successfully encodes a project schedule using an algorithm called resource constrained project scheduling.
3.	Graphical modelling classification for construction project scheduling	Graphical modelling and data visualization	Physical report of progress made in project is produced using Graphical modelling technique making it a very effective way to deliver information clearly to the upper management of a company.
4.	On optimization of R&D Project Selection and Scheduling	GPU programming methods	GPU programming method divides the problem into hierarchy of sub problems for each time period making it an efficient method to handle internal time distribution of a project.
5.	EFFECTIVE PROJECT SCHEDULING UNDER WORKSPACE CONGESTION AND WORKFLOW DISTURBANCE FACTORS	Project Management scheduling method	Mentined Technique minimizes the project makespan while satisfying time and resource constraints. This avoids workspace congestion and keep the workflow continuous.



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6.	Project Scheduling Constraints – Best methods and practices	Project management methodologies (PMBOC), Agile and Critical Chain Method	The listed technique are compared based on constraints such as imposed dates, resource availability and task duration limitations. Thus bringing the final project goal near to reality.
7.	An approach to Resource Constrained Project Scheduling	Limited Discrepancy Search using backtracking search tree and LDS search tree	Partial ordering on the tasks is achieved without violating the precedence constraints and the resource utilization limit. Series of seed schedules are optimized.
8.	Project resources scheduling and leveling using Multi-Attribute Decision Models: Models implementation and case study	Standard resource levelling procedure	Multi-Attribute Decision making models used with resource levelling procedures attenuate under allocation resource usage and address unpredictable resource shortage.
9.	COMPLEX PROJECT SCHEDULING USING MULTI-AGENT METHODS: A CASE STUDY FOR RESEARCH PROJECTS	MULTI-AGENT METHODS	Complex project scheduling is achieved with the help of multi-agent methods. Thus, resulting in better project planning and scheduling.
10.	A Brief View of Project Scheduling Techniques	Various project scheduling techniques	An insight is given into several project scheduling techniques addressing issues such as timely delivery of the project, effort distribution and other technical difficulties.
11.	Project Scheduling: Improved approach to incorporate uncertainty using Bayesian Networks	Bayesian Networks approach	Project's CPM network is generated by Bayesian Network model which includes identification of risk and resource indicators.
12.	Improved Evolutionary Algorithm Design for the Project Scheduling Problem Based on Runtime Analysis	Evolutionary Algorithm	Failure of traditional evolutionary algorithm in a project scheduling problem is given the primary focus and analyzed in detail using Gantt Chart and linear schedules.
13.	A Multi-Objective Dedicated Local Search for Project Scheduling Problem	A Multi- Objective Local Search	The given technique enable the division of the lower level of subprojects into local threads by minimizing the completion time of project and the total weighted start times.



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14.	THE DYNAMICS OF SOFTWARE PROJECT SCHEDULING	System dynamics model	The unresolved issues related to the dynamism of software project scheduling are tackled using the system dynamics model which improves the final outcome of the project by taking the past-taken steps into account.
15.	The Practice Standard for Scheduling	CPM and other approaches	The various project scheduling levels are summarized starting from Level I and finishing with Level V.
16.	Dynamic Software Project Scheduling through a Proactive-Rescheduling Method	Proactive-Rescheduling Method	An algorithm for dynamic project scheduling is defined which considers objectives like cost, robustness and duration. The Proactive-Rescheduling method generates a schedule beforehand in order to handle uncertainty occurring during the project.
17.	Search-Based Software Project Management	Search-Based methods like Hill Climbing	Search based software engineering provides decision making and support which ensures efficient scheduling and an accurate estimation of risk.
18.	A Hybrid Technique for Software Project Scheduling and Human Resource Allocation	Event-based Scheduler(EBS), Ant-Colony Optimization (ACO)	EBS considers the start and end points of the projects leading to an optimized resource consumption. ACO assists in carrying out an optimal job allocation which results in the formation of a dynamic and flexible project scheduling model.
19.	Learning Curve Effect on Project Scheduling	Learning Curve Effect	The effect of learning curve on project duration is shown by discussing its application in the prediction of cost incurred in the project.

## IV. CONCLUSION

Software project scheduling is one among many important tasks that the software project team performs. The project scheduling refers to the efficient scheduling of the various activities that the project comprises of. The main aim of project scheduling is minimizing the project duration and ensuring completion of each task in a proper sequence. Software project scheduling techniques should be employed by project manager in order to manage the taskforce assigned for the project effectively. In this paper the various types of software scheduling techniques, both dynamic and static which can be used in software projects, are discussed. This review paper is helpful for deciding which software scheduling technique in a given situation.





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