A Systematic Literature Review: Optimization of Implementation of Project Development in the Company with PERT and CPM Method

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Abstract

This study aims to analyze the timeliness in the construction of a project. Time efficiency of project implementation is one of the efforts in optimizing the use of implementation time. CPM is a network method used to determine the critical path of each implementation. Schedule delays in construction projects are one of the problems that can harm various parties to the project. This method is taken by eliminating multitasking, student syndrome, parkinson's law and providing a buffer at the end of the project. This study uses a System Literature Review (SLR) approach which is used to identify and answer existing questions and the results are relevant. Project implementation wants to find a useful method to improve the quality of planning and control in the face of a complex number of activities. Then a network method was found that serves to provide systematic planning, scheduling, and control. With the PERT and CPM methods, the time scheduling of a project will be more regular, as well as the availability of human resources which greatly affect the success of the development of a project. This study aims to compare the Pert and CPM methods in carrying out the development of a project. Based on research using this method to prove that by using the PERT and CPM methods the development of a project will run optimally, effectively and efficiently. So that it can be used as a reference in project implementation performance.

Keywords
Time Duration, PERT and CPM, project and time, project management, Systematic Literature Review.

1. Introduction
Discussing a project or business will always be related to management (Davis and Comeau, 2020). Management is concerned with planning, executing, and supervising a specific project (eg, home renovation). Managing a home renovation project is different from building a house from scratch, including managing resources such as labor, materials, duration of completion, and costs required (Aithal, 2017). Obviously, the main goal is to avoid losses and obtain maximum profits (Naldi et al., 2019). A project implementation in accordance with the planning, it is necessary to make a schedule so that the project runs smoothly. According to (Telaumbauna, et al, 2017), the project is considered successful or not depending on a project planning, scheduling and control that is managed effectively and efficiently. Project management is a process of planning, organizing, directing, and controlling the activities of organizational members as well as other resources so that they can achieve predetermined organizational goals (Arianie and Puspitasari, 2017, Ekanugraha, 2016).

In a network analysis, several control systems are needed in doing so, including single activities, combined activities, parallel activities, and critical paths. The network is a description of a flow and sequence in each work activity so that each individual project work can more easily understand (Husen, 2018). According to Pontan and Christianto, (2019), the success of a project is if the project can be carried out based on the schedule and project guidelines, namely on time, right quality, and right cost, zero accident, zero waste, satisfaction of all parties, and others. Opinion Putri et al., (2020) states that the quality and condition of the equipment is one of the dominant factors influencing the success of a construction project.

1.1 Formulation of the Problem
1. How to analyze project development time using PERT and CPM methods?
2. Can the project development run optimally by using PERT and CPM methods?

1.2 Research Objectives
The purpose of this study is to analyze the completion time of project development in order to obtain an optimal, effective and efficient duration so that companies can determine project scheduling. To produce an analysis of the flow, work duration, and optimal probability using the CPM and PERT methods.

2. Lietrature Review

According to (Ikhtisoliyah, 2017), Critical Path Method (CPM) and PERT are project planning techniques (a collection of activities) that are modeled in an interconnected network. The goal of CPM and PERT is to determine the shortest time to complete the series of activities. Gantt chart, PERT, and CPM methods are three popular techniques that allow managers to plan, schedule, and control their projects properly (Heizer et al.2017). Information about these activities is also not available on Gantt charts and this is another reason why this planning method is usually used in combination with network diagrams, which are especially prominent when it comes to complex projects (Stevenson, 2018). The creation of this network is intended to determine the critical path (Gunasti et al. 2019). Meanwhile, in project scheduling using the PERT method, it begins by estimating the completion time of each project activity item into 3 types of time estimates, namely optimistic time (a), most likely time (m), and pessimistic time (b) (Abdurrasyid et al. 2019).

This study uses the Critical Path Method (CPM)/Project Evaluation and Review Technique (PERT), the Project Crashing Method, and combines it with the Activity-Based Costing (ABC) method to resolve this challenge. CPM/PERT is a management technique (Simmonds and Pence, 2017). Several studies that apply the CPM/PERT method, including project management information systems, ship development project management (Abdurrasyid et al. 2019), automotive engine repair analysis (SLIŻ, 2018), and planning in the industry (Marpaung et al. 2019). Furthermore, the results of the method will be calculated using the Project Crashing method (Yang et al. 2019).

3. Method

The data collected are journals that discuss the development of information systems from 2016 to 2022. By using the SLR method, a systematic review and identification of journals can be carried out which in each process follows the steps or protocols that have been set (Razavian et al. 2019). In addition, the SLR method can avoid subjective identification and it is hoped that the identification results can add to the literature on the use of the SLR method in journal identification (Razavian et al. 2019) (Figure 1).
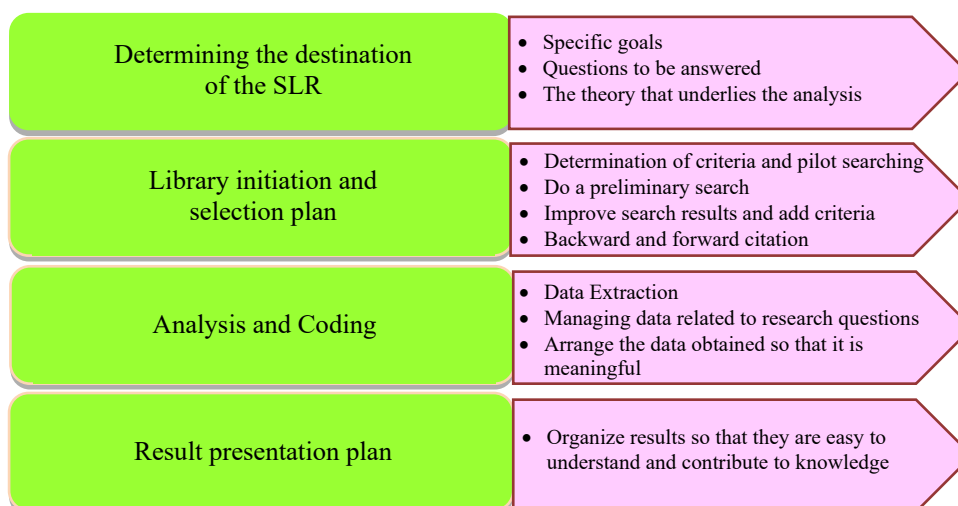
Determining the destination of the SLR	• Specific goals • Questions to be answered • The theory that underlies the analysis
Library initiation and selection plan	• Determination of criteria and pilot searching • Do a preliminary search • Improve search results and add criteria • Backward and forward citation
Analysis and Coding	• Data Extraction • Managing data related to research questions • Arrange the data obtained so that it is meaningful
Result presentation plan	• Organize results so that they are easy to understand and contribute to knowledge

Figure 1 Steps for a Systematic Literature Review
Source: https://images.app.goo.gl/3F1eniob2TSxfctR6

a. Planning

The initial stage is planning the process of searching and extracting publications. The questioning at this stage is based on five elements, namely Population, Intervention, Comparison, Outcome, and Context or known as PICOC.

b. To do

This stage is the implementation of the SLR that has been determined. The process is based on criteria.

c. Inclusionthat is

✓ Journal publications are carried out in 2016-2022.
✓ Data obtained from Google Scholar obtained through the Publish or Perish application.
✓ The data used is within the scope of the information system.
✓ Data has a clear source and sales in accredited journals.
✓ Journal data obtained as a reference for other research at least once.

4. Data Collection

In conducting research, researchers obtain the required journals or literature through various platforms, such as Google Scholar. Literature review is a systematic and explicit method for identifying, evaluating, and synthesizing a high-quality original research topic (Fink, 2019). This technique helps researchers in understanding in depth related to the research topic. This research focuses on identifying the PERT and CPM method used in project development. Based on all the journals that have been used, the researchers compiled and made a systematic literature review with the topic of PERT and CPM sorted from 2016 to 2022 which is depicted in the diagram as follows in Figure 2:
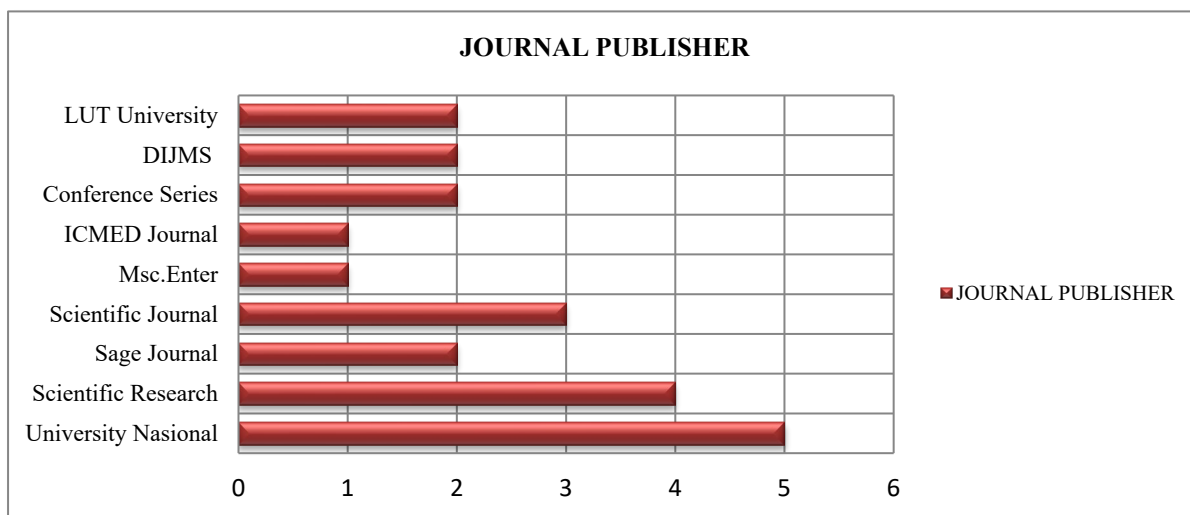

Figure 2. Data paper based on the name of the researcher.
Sources: from several paper sources, processed by the author (2022)

From the diagram, it can be seen that from 2016 – 2022 journal articles from Google Schoolar were used in the System Literature Review of relevant journals in 2019, namely 19 journals from researchers. .(Pinto), (A. Mishakova, A. Vakhrushkina, V. Murgul, and T. Sazonova), (S. Kanyukova, N. Vatin, D. Leybman, and T. Sazonova), (M. Nabawy and L. M. Khodeir), (H. A. Rani), (A.R.Ekanugraha), (G. P. Arianie and N. B. Puspitasari), (Aribisala A, Otenaike A, Balogun O,Ofusori L), (Ikhtisoliyah), (Andhika), (Arianie & Puspitasari), (Razdan et al), (P. S. Aithal), (Telaumbauna,dkk), (Heizer, Render dan Munson), (Sengamalaselvi, Keerthi, dan Kiran), (Aja), (Razdan et al), (Fadllan), (Elisabeth Riska Anggraeni et al), (D. Simmonds and N. Pence), (M.H.Calp And M. A. Akcayol), (Clayton), (T. T Dimyati And Dimyati), (S. Zareei), (R. Hidayah, A. Ridwan, and Y. C. S. P), (O. R.Antika), (Kholil, Alfa, dan Hariadi), (Stevenson), (Citra), (I. Oka Suputra), (Husen), (M. Razavian, B. Paech, and A. Tang), (N. Kühl, M.Goutier, A. Ensslen, and P. Jochem), (Wibowo, Agung, and J. Utomo,A. Syaiful), (A.C. Siregar and I. Iffiginia), (Fink), (A. P. Hendradewa), (Sari & Abdullah), (C. Ou-Yang and W.-L. Chen), (M. Naldi, G. Nicosia, A. Pacifici, and U. Pfersch), (J. Oka and D. Kartikasari, J. Harmawanto, Y. C. S. P, and S Winarto), (Pontan&Christianto), (Gunasti, Rofiqi, &Priyono), (Abdurrasyid, Luqman, Haris & Indrianto), (E.K. Owusu, A.P.C. Chan,O. M. DeGraft, E. E. Ameyaw, and O. K. Robert), (Samson, O.O., Afolalu, S. A., Ojo, S. F., & Oladipupo S), (Abdurrasyid, Luqman, A. Haris, and Indrianto), (S. T. Marpaung,C.N. Rosyidi, and W. A. Jauhari), (Burritt et al), (F.Usmani), (C.Orumie Ukamaka), (W. Vetchagool, M.M.Augustyn, and M.Tayles), (I. M. Premachandra), (Utomo, Hendriyani, & Aida), (M. D. Sruthi

and A. Aravindan), (Putri et al), (A. Garg) , (C. H. Davis and J. Comeau), (C. Orumie Ukamaka), (I. C. Yilmaz and D. Yilmaz), (Ikumapayi, O.M.,Oyinbo,S.T., Akinlabi, E.T., Madushele, N), (Putra & Milenia).
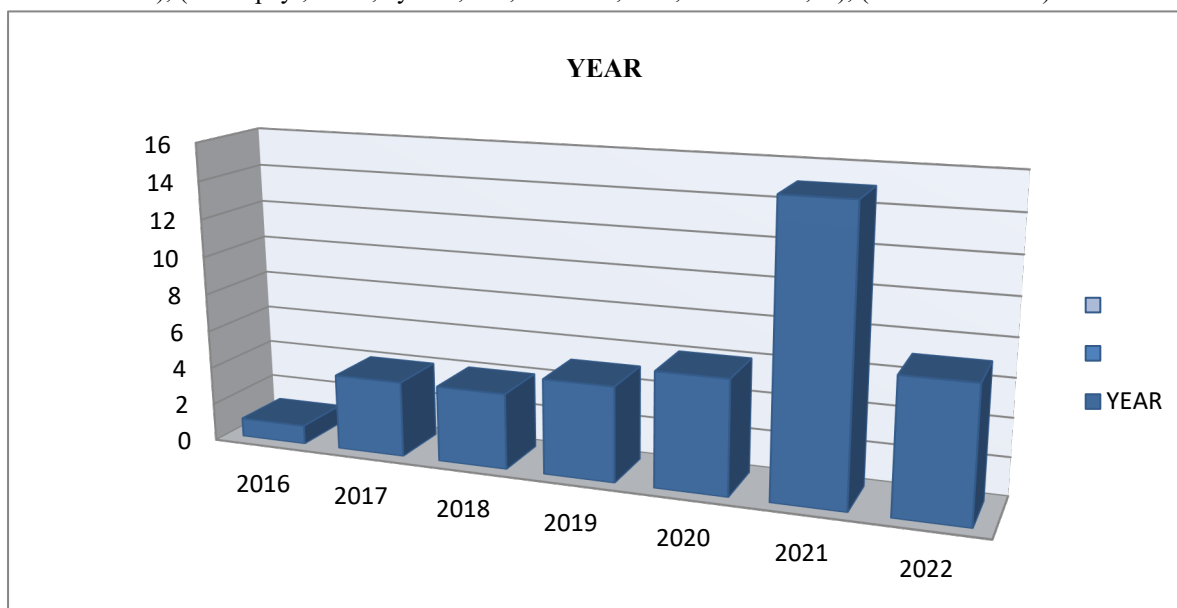
YEAR

Figure 3. Paper data by year of publication.
Source: from several papers based on the year of publication, by the author (2020)

The diagram above shows the number of journals taken from Google Schoolar along with the year the journal was published (Figure 3). Google Schoolar is the most widely used journal reference in System Literature review research because the contents of the journal are relevant. Systematic Literature Review is a term used in research methodologies where in its development by collecting data, then conducting an evaluation on certain research topics (Putra & Millennia, 2021). The purpose of using this method is to collect as much previous research as possible according to the research topic (Sari & Abdullah, 2019).

5. Results and Discussion
5.1 How to analyze project development time using PERT and CPM methods?
 In the scheduling process there is a very detailed and accurate arrangement of activities and relationships (Rani 2016). Scheduling is a time allocator that aims to carry out each respective work to achieve optimal results for a project by considering existing limitations. Therefore, scheduling can be applied with technical methods that have been used such as the bar chart project scheduling method, PDM, CPM, and PERT, (Wibowo et al. 2018). The network is a description of a flow and sequence in each work activity so that each individual project work can more easily understand (Husen, 2018). Then found a network method that serves to systematically present planning, scheduling, and control (Andhika, 2017).

Data collection as research material was obtained from implementing contractors and also some from supervisory consultants (Mishakova et al. 2016). The types of data collected are secondary data such as the project implementation schedule which is a reference or time plan for each work/implementation, the budget plan (RAB) which is the budgeted cost to complete all work items (Nabawy et al. 2016) , as well as weekly project reports, namely progress reports on project achievements that have been achieved in one weekly period (Nabawy et al. 2016).

The main difference between CPM and PERT is in predicting the estimated time. CPM determines the critical path using nodes each time, while PERT describes activities using a line with an arrow between two nodes (I. M. Premachandra, 2020). The CPM/PERT method helps in checking risk analysis during project completion (A. P. Hendradewa 2019). Therefore, the use of CPM/PERT can optimize the project construction schedule (Calp et al. 2018) and minimize the required costs (Ou-Yang and Chen 2019). In network diagrams, dummy activity is most often indicated by a dotted line (Pinto, 2016). The initial event indicates the start of the activity, and the final event indicates the end of the activity, namely the beginning of the next activity (Pinto, 2016). With the preparation of this network, project implementers can find out which activities must be carried out first, which activities can be postponed, and which activities can be used for other activities. This becomes a reference in carrying out further activities (Nurwahidin, 2016).

Making a project schedule using the Critical Path Method in accordance with the order of project dependencies (Yilmaz and Yilmaz, 2021). CPM is applied by calculating several operating parameters such as Early Start (ES), Latest Start (LS), Early Finish (EF), Latest Finish (LF), Maximum available Time, and Free time (S. Zareei. 2018, M. D. Sruthi and A. Aravindan, 2020). The network planning step with the PERT approach is intended to find out how much the opportunity value of project activities, especially on the critical path, is completed on time according to the expected schedule (Utomo et al. 2020). To determine the project duration, slack time and project critical path, it is necessary to determine the following times (Stevenson, 2018):
• ES - earliest time activity can start,
• EF - earliest time the activity can be completed,
• LS - the last time the activity can be started and does not delay the project,
• LF - the last time the activity can be completed and does not delay the project

Indeed, if each route through the network has the same duration, it can be said that the project is optimized (Clayton, 2018). Determining free time is very important for managers. Based on that time, they have the opportunity to get information about which activities need special attention and which activities contribute the most to the delay of a project (Stevenson, 2018). However, the PERT calculation supports assigning the task completion time probabilities according to three time estimates. This uncertainty is represented by a threefold estimate, which needs to be considered for each activity (Heizer et al. 2017):
• Optimistic time (a) = the time an activity would take if everything went according to plan - the probability of this time being achieved is usually less than 1 percent
• Pessimistic time (b) = time required for an activity assuming very unfavorable conditions - the probability that this time can be achieved is usually less than 1 percent
• The most likely time (m) = the most realistic estimate of the time required to complete an activity.

Beta distribution is a powerful tool used to describe the variability inherent in time estimates (Stevenson, 2018). After that, look for activity time (TE) or expected time (Lokajaya, 2019).

$$\text{te} = \frac{a+4m+b}{6}$$

From equation 7 below, the variance can be found by squaring the standard deviation, and can be obtained as the square of the sixth difference between the optimistic and pessimistic time estimates.

$$\sigma^2 = \left(\frac{b-a}{6}\right)^2$$

The variance indicates the uncertainty over the time of an activity, and the higher it is, the greater the uncertainty. To calculate the variance of a path, it is necessary to add up the variance of activity on that path, using the following formula (Stevenson, 2018):

$$\sigma^2{}_{path} = \Sigma \; \textbf{\textit{Variances}}$$

Variations on the critical path can significantly lead to possible delays in project completion. Thus, the PERT method uses the variance of the critical path activity, to arrive at the variance value of the entire project. Therefore, following the example of the equation mentioned earlier, the project variance can be calculated by adding up the critical activity variance, using the following equation (Heizer, Render, and Munson, 2017):

$$\sigma p2 = \textbf{\textit{Project variance}} = \Sigma \textbf{\textit{Variances of activities on critical path}}$$

Also, a very important part is the calculation of the probability that a certain path will be completed in a certain period. According to (Stevenson 2018) it is calculated using Equation 10, and the z value indicates how many standard deviations the target completion time is far from the arithmetic mean.

$$Z = \frac{Target - Path \; mean \; Path}{Standard \; Deviation}$$

Definition (Stevenson,2018), the path probability corresponds to the area under the normal curve to the left of the standard z value. Also, probabilities can be calculated using certain Excel functions, the use of which will be shown later in this section of the experimental paper. In the construction of a project environmental conditions are very important. The relationship between environment and organization has been the subject of considerable research (Burritt et al., 2019). Around the world, concerns about the environmental impact of business and regulatory pressures are growing rapidly (Mokhtar et al., 2016). Environmental calculations have been introduced to provide a basis for business organizations in making informed decisions, because with information inefficient use of resources, pollution, and even disasters can occur (Burritt et al., 2019).

Crashing is a systematic and analytical process of accelerating project completion time through testing of all activities in the project, but focusing on activities that are on the critical path (Elisabeth 2017). The crashing process is carried out through an estimate of the cost variable in determining the maximum and economical reduction in the duration of an activity that may still be accelerated to further analyze the relationship between costs and the time of an activity (Antika, 2018). This method is also useful for re-analyzing the effectiveness of each raw material and activity and eliminating raw materials or activities if necessary. (Vetchagool et al. 2020).

Process crash is a way to estimate variable costs in determining the most optimal and economical reduction in the duration of a project activity that is still possible to be reduced. Crashing can cause a trade off between cost and time (Arianie and Puspitasari, 2017). The calculation of cost growth in the crashing effort is carried out based on the critical path formed and carried out in the following stages:
- Find the desired speed up duration
- Calculating the cost slope, using the formula (T. T Dimyati And Dimyati, 2018):

Acceleration cost = $\frac{Waktu\ Normal}{Waktu\ percepatan}$ x Normal cost `

Time scheduling in manufacturing companies, Manufacturing always pays attention to component fabrication and assembly, focuses on queuing work on machines, balancing output, and ensuring each component is available for both sub and final assembly (Samson et al. 2019). In the manufacturing sector, production scheduling is focused primarily on the effective use of resources and tracking of assembly parts (Ikumapayi, et al. 2020).

Proper manufacturing processes are often influenced to a large extent on schedule, which is why the direct focus is on maintaining continuous production under any constraint situation (Ikumapayi et al. 2020). Process industries such as food and beverage products are faced with insufficient available time and therefore take advantage of production networks to overcome these problems. Therefore, due date scheduling strategy is applied in production. This challenge is also encountered when there are few or no storage facilities or capacity or where timely production strategies are employed (Ikumapayi et al. 2020).

5.2 Is it possible to optimize the project development by using PERT and CPM methods?

Develop a Critical Path Method (CPM), Making a project schedule using the Critical Path Method in accordance with the order of project dependencies (Yilmaz and Yilmaz, 2020). Early Start (ES) is prepared in advance where all existing activities must be linked to each other and then the Late Start (LS) countdown is carried out for the last time of a project activity. After the calculation is done, the Early Finish (EF) calculation is carried out the earliest time an activity can be completed according to its duration. If there is only one previous activity, then the EF of a previous activity is the ES of the next activity and the Late Finish (LF) the last time an activity can be started without slowing down the completion of the project (MNabawy and Khodeir, 2020).

Develop a delay scenario by including work risks that can slow down the project by including what things can cause delays in the project (Orumie 2020, Usmani, 2019) and how it affects the duration of the building construction project. Knowing Delayed Activities With sensitivity analysis it will be known which activities can cause project delays. However, if late activities are not known, then reschedule using the Critical Path Method is carried out until finding activities that can delay the project completion time (Kanyukova et al. 2016, Orumie 2020). Calculate the direct costs of the BPN Blitar building construction project after it has been accelerated and calculate the costs if there is a delay. The direct costs calculated are labor salaries and equipment costs (Owusu et al. 2019).

In order for efficiency and effectiveness to be fulfilled properly in carrying out a project, it is influenced by 2 factors, namely planning and scheduling (Oka et al. 2019). Scheduling is part of the planning results, which can provide information about the planned schedule and project progress (Fadllan, 2017, Hidayah, et al. 2018). Analysis to find the most optimal time and minimize the risk of work delays is very important to do to get the optimum implementation time and achieve efficient costs (Siregar and Iffiginia, 2019).

Both CPM and PERT are network-based techniques (Aja, 2017) and therefore help in programming and monitoring the progress of the stages involved so that the project is completed within the deadline. The main difference is that, in CPM activity times are assumed to be proportional to the number of resources allocated to them, and by changing resource levels, activity times and project completion times can vary. CPM thus assumes previous experience with similar projects from which the relationship between resources and work time is available (Elisabeth et al., 2017). Total slack time indicates how long the start of an activity can be delayed or

the duration of a particular activity can be extended without extending the duration. the entire project (Stevenson, 2018).

The success of using the PERT technique can save project completion time two years ahead of the planned schedule, so this method is widely used on large projects, especially on research and research projects where these projects have never been carried out and do not have However, if the late activity is not known, then a rescheduling is carried out using the Critical Path Method to find activities that can delay the project completion time (Ukamaka, 2020). In addition, there are several benefits to using the CPM method, these benefits include (Citra, 2018). In the implementation of the project, there are obstacles or deviations, causing the project completion time to be inaccurate. According to Cynthia in an article written by Aribisala, et.al. (Aribisala ey al. 2017) said that most organizations that carry out project work are not completed on time because the executive does not have access to real-time project plans and schedules.

6. Conclusions

In a project, there are many activities that have complex dependencies, and project management here is a very challenging job for all managers. In this case, both the CPM and PERT analyzes show almost the same results, and the project completion time using the two methods differs by only one day. PERT analysis proved to be more effective with a calculated project completion probability of 99.8%. This paper also proves that the method is effective and efficient to apply in this field. Examples of the application of the CPM method are widely used in development projects. One example is used to optimize the ATV (all-terrain vehicle) manufacturing process by considering time constraints and available resources.

7. Suggestion

In building a project it is highly recommended to use this method, namely PERT and CPM. Timeliness in project development depends on the situation and conditions, the most important of which is the available manpower. PERT and CPM assist in programming and monitoring the progress of the stages involved so that the project is completed within the deadline.

The development of a project can run optimally with the PERT and CPM methods because it has been proven that the methods are very effective and efficient. Many researchers find it very helpful with the PERT and CPM methods. The success of using the PERT technique can save project completion time two years ahead of the planned schedule, so this method is widely used on large projects, especially on research and research projects. where these projects have never been carried out and do not have definite completion data.

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