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Activity Management System with Automatic Priority Adjustment Using Simple Multi-Attribute Rating Technique

Monica Widiasri ; Susana Limanto ; Jordan Valentino Lomanto ; Liliana ; Maya Hilda Lestari Louk **All Authors**

Abstract:
Activity management is needed to increase a person's productivity in arranging a more efficient activity schedule. To help organize activities, especially for workers or students who have many activities, the use of a planner is very necessary. However, the determination of inappropriate priorities in scheduling activities and diffic ulties in rescheduling are obstacles in using the planner. Therefore, this study aims to create an activity management system that is able to calculate the priority of each user activity and provide automatic rescheduling recommendations. The system implements the Simple Multi-Attribute Rating Technique (SMART) method for the priority configuration process. If the system's priority order does not match the user's priority order, then the weight changes for each criterion are carried out by a learning process. The resulting replacement priority is used as a limitation in generating new schedule recommendations. Based on the experiments, it can be concluded that the system has succeeded in helping to determine activity priorities automatically using the SMART method. From the validation results, the average value of the suitability of the ranking between the SMART calculation results and the user was 63.84%, indicating that the automatic ranking system has met the average expectations of respondents, although it is not yet optimal. The reschedule feature in the system based on a survey conducted resulted in a usability value of 68.75%, which means that on average this feature can help facilitate rescheduling.

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***Abstract*— Activity management is needed to increase a person's productivity in arranging a more efficient activity schedule. To help organize activities, especially for workers or students who have many activities, the use of a planner is very necessary. However, the determination of inappropriate priorities in scheduling activities and diffic ulties in rescheduling are obstacles in using the planner. Therefore, this study aims to create an activity management system that is able to calculate the priority of each user activity and provide automatic rescheduling recommendations. The system implements the Simple Multi-Attribute Rating Technique (SMART) method for the priority configuration process. If the system's priority order does not match the user's priority order, then the weight changes for each criterion are carried out by a learning process. The resulting replacement priority is used as a limitation in generating new schedule recommendations. Based on the experiments, it can be concluded that the system has succeeded in helping to determine activity priorities automatically using the SMART method. From the validation results, the average value of the suitability of the ranking between the SMART calculation results and the user was 63.84% , indicating that the automatic ranking system has met the average expectations of respondents, although it is not yet optimal. The reschedule feature in the system based on a survey conducted resulted in a usability value of 68.75%, which means that on average this feature can help facilitate rescheduling.**

Keywords*— *activity management system, SMART, priority calculation, rescheduling

I. Introduction

Productivity needs to be improved by making the best use of time so more activities can be completed in the shortest time possible. Workers or students who have many activities usually use a planner to help organize their activity schedules. The planner will be effective if each activity recorded has the right and clear priority. However, it is not an easy task, often every activity is considered a top priority. As a result, difficulties in organizing schedules for various activities still occur even though various conveniences in organizing schedules have been provided by planners. In addition, unpredictable things such as traffic jams, accidents, or negligence can also result in delays in various planned schedules, resulting in overlapping schedules of activities if not readjusted. The effort required to rearrange the schedule of an activity, coupled with the high possibility of similar events in everyday life, makes rescheduling quite a challenge. From the benchmark of two common digital planners, Google Calendar and TickTick, they both divide the types of activities into two types, namely events and tasks/reminders. Priority determination can be done on both systems and the order of activities is displayed based on the priority given. However, these features only function as reminders/priority recorders. Priority determination is still done manually by the user, no features support adding determining factors for assessing activity's priority, and no features can help with rescheduling problems.

Therefore, this study proposes an activity management system that is able to intelligently calculate the priority of each user activity and provide recommendations for automatic rescheduling of activity schedules. This study applies the Simple Multi-Attribute Rating Technique (SMART) method for the activity priority calculation process. SMART is a method for conducting Multi-Criteria Decision Analysis (MCDA), in which assessment and selection of the best project alternative, amongst several different alternatives, is based on a list of relevant criteria [1].

In the context of Multi-Criteria Decision Making (MCDM), there are several popular and widely used methods other than SMART like Analytical Hierarchy Process (AHP), Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), and Viekriterijumsko Kompromisno Rangiranje (VIKOR). AHP is an easy-to-use method that takes into account the decision maker's judgements in the process of assigning ranks. AHP requires decision makers to compare alternatives in a pairwise manner to determine the relative importance of different criteria of alternatives. This step is employed because it is deemed to be easier for humans to manage simpler comparison. Although simpler, it is very likely that inconsistencies occur during the assessments. In more complex cases with the increasing number of criteria and alternatives, numbers of pairwise comparison will also increase, thus leading to more confusing comparisons and questionable results [2] [3]. TOPSIS decides the best alternative by searching for the most similar alternative to the most ideal solution. The method utilizes Euclidean distance measurement to determine which solution is the closest to the positive ideal solution while being the farthest from the negative one. It assumes if an alternative is far from the negative ideal, it is also close to the positive ideal, even though an alternative may be both from the positive and negative ideals. With being dependent only on decision matrices and not including criteria importance weighting in the formula, TOPSIS may not be able to produce result to satisfy MCDM problems. Like AHP, TOPSIS method also got criticized in terms of the lack of consistency in ranking when alternatives are added or dropped, this is known as "the rank reversal phenomenon" [4]. While TOPSIS obtains ideal result by using Euclidean distance, VIKOR focuses on finding the best alternative by providing a balanced approach of maximizing collective benefits using Manhattan distance as well as minimizing the potential loss of any individual criterion using Chebyshev distance. With these, VIKOR tries to compromise solution ensuring both group's overall interest and individual concerns are addressed. Both TOPSIS and VIKOR share the same problem, which is the limited extent to which the best alternative can be found. When the number of alternatives and criteria are increased, both methods will produce very different results[5].

The SMART method was chosen in this proposed system because of its ability to place more emphasis on important attributes and less on unimportant attributes in determining the overall utility of alternative solutions [6]. SMART is a widely utilized method due to its simplicity [7]. SMART has applications in a wide range of sectors, including urban planning, business, engineering, and environmental studies [1], [7]. The use of SMART to evaluate water quality study indicate that the SMART method is able to accelerate the process of determining river water quality to meet the needs of the surrounding community [8]. In addition, the SMART method has also been proven to be able to help determine the best teacher [9], [10], assess employee performance [10], and monitor toddler growth and development [11].

In the proposed system, activities will be divided into two types, namely activities that have a duration of implementation (events) or activities that only have a time limit for completion (tasks). These two types of activities are activities that are generally owned by workers and students. However, each worker and student has different characteristics in determining the priority of activities to be worked on first. In the proposed system, the differences in characteristics between workers and students will be overcome by the weighting in the SMART method. The weight for each criterion that will be used as the basis for recommendations can be adjusted according to user preferences so that the proposed system can accommodate the needs of workers and students. The proposed system will provide recommendations in the form of activity priority ranking.

The main contributions of this study are as follows: the system can automatically determine the priority ranking of schedule activities by applying the SMART method, the system can re-learn to adjust the criteria weights if the priority order of the system does not match the priority order of the user, and the system can help users reschedule activities.

II. METHODS

Each person has different preferences in determining the priority of an activity. A multicriteria decision-making aid approach can be used to determine the priority of each activity. A survey was conducted with 63 respondents consisting of 21 junior high/high school students, 30 college students, and 12 workers, to obtain factors in determining the priorities used in scheduling activities that are in accordance with the needs of the respondents. From the survey results, seven factors/criteria were obtained to determine the priority of an activity along with the default weight of each criterion used in the proposed system.

In this study, activities are divided into two types, namely: event and task. Events are activities that have a duration of implementation (eg: a meeting activity that lasts for 2 hours). While tasks are activities that only have a time limit to end. The factors that will be used as criteria for calculating the SMART method for events will be distinguished from tasks, as shown in Table I.

TABLE I. CRITERIA FOR ACTIVITY PRIORITY CALCULATION

Activity Type	Criteria
Event	Date created (dcr)
	Duration (dur)
	Participant (par)
	Involvement (inv)
Task	Date created/deadline (dcd)
	Difficulty (dif)
	Benefit (ben)

There are three main processes in this study, namely priority calculation, criteria weight update, and rescheduling. Priority calculation and criteria weight update run automatically on the system, rescheduling is a supporting feature provided by the system to generate recommendations for selected schedules if you want to change the schedule of a delayed event.. The system methodology diagram is depicted in Fig. 1.

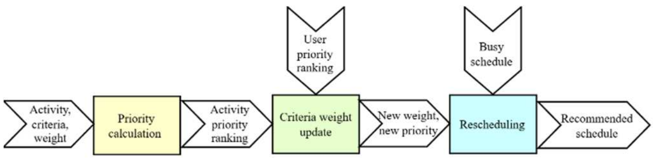

Fig. 1. The system methodology diagram.

A. Activity Prioritization Calculation Method

The priority calculation process in the system will be run automatically every time a user adds, changes, or deletes an activity schedule. This priority calculation is carried out on all activity schedules in the active week range (Monday-Sunday). The priority value of all activities in the weekly range obtained will be calculated using the SMART method. From the total priority score obtained, a rank will be given to each activity schedule in order according to the total score obtained. The priority calculation process using the SMART method used in this study is as follows:

- Determining activity type and corresponding criteria for priority calculation.
- Assign weights and normalize the weights for each criterion with a total criteria weight of 1.
- Provides a performance score for each alternative on each criterion with a value range of 0-100.
- Calculate the total SMART score using (1), with $f(j)$ is total score of jth alternative, n is number of criteria, w_i is ith-criteria weight value, and v_{ij} is ith-criteria of jth alternative value.

$$f(j) = \sum_{i=1}^{n} w_i * v_{ij} \quad (1)$$

Rank each alternative based on the total score. The alternative with the highest score will be recommended as first priority.

B. *Criteria Weight Update Method*

Priority rank of activities recommended by the system can be readjusted if deemed unsuitable, therefore may result in the diversity between system's and user's ranking. This difference in values will be used by the system for the weight update learning process, that will be executed at the end of Sunday or Monday at 12 a.m. (Indonesia Western Time).

The process of changing the weight by the system is carried out based on the previous week's activities, the priority ranking recommended by the system, the priority ranking adjusted by the user, the previous weight, and the learning rate set by the user. The process is carried out by comparing the ranking of the system with the ranking of the user for each pair of activities that have been sorted based on the user's ranking. If the priority order of the system does not match the priority order of the user, then the weight will be changed for each criterion using (2). The weight of each comparison is stored in a list. After the comparison of the ranking of all pairs of activities is complete, the list contains *(n-1)* weights. The new weight is calculated based on the average of the weights in the list. The new weight generated will be used to calculate the priority ranking of the next activity.

$$W_i(A_j, A_k) = w_i \pm \left(\eta \times \frac{|v_{ij} - v_{ik}|}{\Sigma|V|}\right) \tag{2}$$

Wi is the new weight of i-th criterion, wi is the old weight of i-th criterion, Aj, Ak = pairs of alternatives being compared (jth and kth), and v_{ij} is ith-criteria of jth alternative value, and V = set of differences of similar v values (positive or negative). Learning rate, η, or what can also be called step size, is a hyperparameter that is used as a component of adjustment in the process of configuring the architecture or machine learning model [12].

C. *Rescheduling Method*

If the implementation of an event is delayed, the system can help users to reschedule (prioritize). The system recommends the best time to perform the delayed event based on free time and the priority level of other events.

The process of finding free time begins by retrieving a list of events that have an implementation date after the postponed event date. After that, the system will calculate the priority of all events on the list using the SMART method but without using the date range criteria. This criterion is not taken into account because the ultimate goal of rescheduling is to get a new implementation date. After the priority ranking is obtained, the system will search for free time among events that have a higher and lower ranking than the event to be rescheduled. In the free time between events, the system will also take into account the user's busy schedule. A busy schedule is a routine activity that cannot be disturbed by the user. The system will record each free time span that has a duration at least the same as the duration of the event to be rescheduled. The resulting free time list will be recommended to the user.

III. Results and Discussion

A. *Creating Activity Schedule*

The experiment was conducted to create 3 schedules, namely 1 event and 2 steps. The activity "Event A1" is scheduled on December 14, 2019 at 20:00 to 21:00. Two tasks with the titles "Task B1" and "Task B2". "Task B1" is scheduled on December 9, 2019 at 17:30, while "Task B2" is scheduled on the same date but at 18:00. The results of creating activities on the proposed system can be seen in Figure 2. In the activity list there are three items with two different colors. The purple item is used as the activity schedule, while the orange item is the task schedule. Priority is displayed as a number on the right side of the event and task. The activity list is displayed in order of start time (for the event schedule) and due time (for the task schedule).

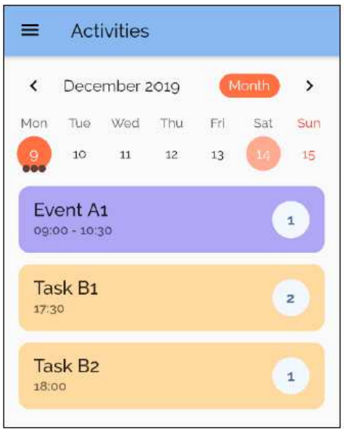

Fig. 2. Activities page example.

B. *Priority Calculation*

Experiments of priority calculation process using 3 events as alternatives to the SMART method. The alternative variables and attributes used in this case study can be seen in Table II.

TABLE II. Experiment Variable Priority Calculation

Attributes	Alternative variables		
Title	Event A1	Event A2	Event A3
Date	12/2/2024	12/5/2024	12/6/2024
Time Start	18.30	8.00	10.00
Time End	21.00	9.15	10.15
Date Created	10/28/2024	10/28/2024	11/1/2024
Participant	22	4	1
Involvement	80	20	100

For the calculation of event priority, the initial weight of the four criteria used is determined, namely date range (*drn*) calculated from the range between the date created to the event date, duration (*dur*) calculated from the difference between time end and time start, participant (*par*), and involvement (*inv*). The default weight of the criteria is obtained from the survey results, with the following values: *drn* of 47, *dur* of 64, *par* of 21, and *inv* of 68. After that, the normalization process of the criteria weight and the calculation of the standardization value for each alternative criterion are carried out, to obtain a total score using (1). The results of the activity priority calculation with normalized criteria weight values can be seen in Table III. The display of the results of the activity schedule priority calculation in the planner system can be seen in Fig. 3.

TABLE III. ACTIVITY PRIORITIZATION CALCULATION

Alternative	Criteria				Total score	Rank
	drn	***dur***	***par***	***inv***		
	0.235	***0.32***	***0.105***	***0.34***		
Event A1	0	100	100	75	68	1
Event A2	100	44.44	14.29	0	39.22	2
Event A3	0	0	0	100	34	3

Fig. 3. The results of the activity priority calculation.

C. Criteria Weight Update

Criteria weight changes if the system priority order does not match the user's desired priority order. The previous system priority order (system rank) and the user's desired priority (user rank) used in the experiment are as shown in Table IV.

TABLE IV. DIFFERENCE IN SYSTEM AND USER RANK PRIORITY

Alternative	System rank	User rank
Event A1	1	1
Event A2	2	3
Event A3	3	2

The calculation of criteria weight update by using a *learning rate* of 0.5 using Equation (2) can be seen in Table V. The display of weight changes in the system can be seen in Fig. 4.

TABLE V. CALCULATION OF CRITERIA WEIGHT UPDATE

Variable	Criteria			
	drn	*dur*	*par*	*inv*
Default weigth	47	64	21	68
Normalized weight 1st iteration	0.235	0.32	0.105	0.34
Normalized 2nd iteration	-0.08	0.18	0.06	0.84
Normalized final weight norm.	0.078	0.25	0.083	0.59
Final weight (range 1-100)	12.4	40	13.2	94.4

Determination of the learning rate value used in the learning process of updating the weight of the criteria is evaluated for its performance. The learning rate performance is based on two variables, namely the total difference in total scores (*total diff*) and the error distance between the total values of the alternatives (*err dist*). The total difference in total scores is used as an evaluation variable because the change in weight is not only intended to improve the total value of the alternatives so that the ranking order becomes more precise, but also to increase tolerance by reducing the range between the total values of the alternatives. Meanwhile, the error distance is used to determine how much discrepancy occurs in the total score of the updated alternative results. The total difference is obtained by adding up all the differences in total scores between alternatives with the i-th and (i+1) system rankings. Meanwhile, the error distance is calculated using the Euclidean Distance method on the alternative with the i-th system ranking and the alternative with the i-th user ranking.

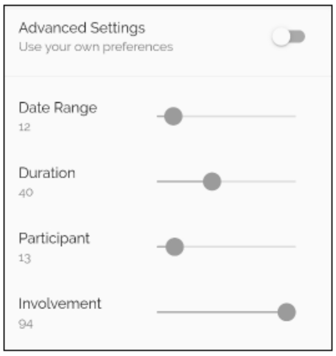

Fig. 4. The display of weight changes.

Based on the results of the previous system ranking and the ranking desired by the user as in Table VI, the results of the performance assessment for determining the learning rate in the weight update process are shown in Table VII. It can be seen from Table VII that the most optimal learning rate performance to use in the first case is 0.1 with a performance of 1. The value of the *total diff* is 34.51. The value of *err dist* is 0 because the system ranking result after going through the weight change process is the same as the ranking desired by the user.

TABLE VI. PREVIOUS SYSTEM RANKING AND USER DESIRED RANKING

Alternative	System rank	User rank
Event A1	1	1
Event A2	3	2
Event A3	2	3

TABLE VII. PERFORMANCE ASSESSMENT DETERMINES LEARNING RATE

LR	Alternative	Total Score	New rank	Total diff.	Err dist.	Performance
0.1	A1	69.9	1	34.51	0	**1**
	A2	39	2			
	A3	35.39	3			
0.3	A1	73.7	1	45.99	0	0.84
	A2	49	2			
	A3	27.71	3			
0.5	A1	77.5	1	57.46	0	0.69
	A2	59	2			
	A3	20.03	3			
0.7	A1	81.3	1	68.93	0	0.54
	A2	69	2			
	A3	12.37	3			
0.9	A1	81.16	1	72.06	0	0.5
	A2	75.35	2			
	A3	9.1	3			

D. Validation Results

For the validation process, data gathering was done beforehand by collecting 56 sets monthly (4 weeks) activity schedules from 14 respondents consisting of 4 students, 6 university students, and 4 employees. For the priority assessment function, validation was done by comparing the system's rankings with the respondents', the schedule set owners, given rankings. After that, respondents were also asked to evaluate the comparison results by giving scores of 1-4, where 1 indicates that the system's rank does not match at all with their preference, whereas 4 indicates that the result completely matches their preference. The results of the assessment of the suitability of the system ranking with what the user wants can be seen in Table VIII. From these results, the average value of the suitability of the system's priority ranking with users can be calculated as 2.55 or 63.84% of very suitable value. This result shows that the priority ranking calculated by the system has met the average expectations of respondents, although not yet optimal.

TABLE VIII. SYSTEM ACTIVITY PRIORITY RANKING SUITABILITY ASSESSMENT

Value	Percentage (%)	Total
Not suitable (1)	21.43	12
Less suitable (2)	25	14
Suitable (3)	30.36	17
Very suitable (4)	23.21	13

To find out the factors that cause the low level of conformity between the priority rankings between the system and the user, a re-test was conducted. The re-test was conducted by asking respondents to re-rank without looking at the rankings that had been previously given. The results of the trial showed that most respondents gave different rankings to the same activity. This indicates an indication of inconsistency from users in giving activity rankings which resulted in the level of conformity of the priority rankings between the system and the user not being optimal.

To anticipate the possibility of differences in priority rankings between the system and consistent users, the proposed system is equipped with the ability to learn. The system's ability to learn allows the system to adjust the weights so that the resulting priority rankings are closer to the user's rankings.

To assess the usefulness of the reschedule feature, validation was conducted using a questionnaire to 20 respondents consisting of 4 students, 11 students, and 5 employees. After the reschedule feature trial process was carried out, each respondent was asked to provide an assessment. Respondents can give a value of 1 which means the reschedule feature is less helpful or not appropriate, to 4 which means the reschedule feature is very helpful or very appropriate to the respondent's expectations. The results of the assessment of the suitability of the reschedule feature system can be seen in Table IX. Of the 20 respondents surveyed, the average usability value of the reschedule feature obtained from the survey results was 2.75 or 68.75% of very helpful value, meaning that this feature has been able to meet the average respondent's expectations but is not yet optimal.

After conducting several small experiments, it was found that the cause of less than optimal results was that users were inconsistent in providing assessments over time. In addition to user inconsistency in giving assessments or rankings, the use of linear weighting can be one of the causes of less than optimal results. Therefore, there is still an opportunity to develop this research in the future.

TABLE IX. RESCHEDULE FEATURE USABILITY ASSESSMENT

Value	Percentage (%)	Total
Not helpful (1)	5	1
Quite helpful (2)	30	6
Helpful (3)	50	10
Very helpful (4)	15	3

IV. CONCLUSIONS

The system created has successfully performed automatic activity priority calculations using the SMART method. Updating the criteria weights using the learning process can automatically correct any discrepancies that occur in determining the priority of system activities. The system's learning capability allows the system to adjust the weights so that the resulting priority ranking is closer to the user's ranking. The results of the assessment of the suitability of the system's ranking with that desired by the user indicate that the priority ranking calculated by the system has met the average expectations of respondents, although not optimal. User inconsistency in providing assessments or rankings or the use of linear weighting can be the cause of less than optimal results. Therefore, there is still an opportunity to develop this research by using non-linear functions in the weighting of alternative-criteria values for priority calculation so that the processing of subjective aspects is more optimal.

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