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Implementation of Genetic Algorithms for Scheduling the Village Development Work Plan (RKPD) in Central Sulawesi Province

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Abstract: The Regional Development Planning Agency (Bappeda) of Central Sulawesi Province arranges the facilitation meetings on the village development work plan (RKPD) of each regency by hand. This study documents a PHP and MySQL web system that stores the meeting records and sets meeting times with a genetic algorithm (GA), and evaluates it with a black-box test, a re-examination of the published GA worked example, and a DeLone and McLean survey of 30 respondents. All five black-box functions passed, but the suite does not test the scheduling output. In the worked example of 12 meetings held at one venue, the only double-booked time slot was removed. However, the selection probabilities were divided by 4.6 instead of the fitness total of 8.4, one crossover is missing from the final schedule, mutation of the topic gene changes the content of a meeting rather than its time, and neither the fitness function nor the GA parameters are reported. Survey means were 4.29 for system quality, 4.34 for information quality, and 4.26 for user satisfaction; 87–93% of ratings were 4 or 5 and none was below 3, although the four satisfaction items have low reliability ($\alpha = 0.61$). Users accept the system, but its scheduling claim needs a defined fitness function, repeated runs, and a baseline before it can be judged.

Keywords : genetic algorithm; meeting scheduling; regional development planning; DeLone and McLean model; information system success.

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1. Introduction

Regional governments in Indonesia prepare an annual village development work plan (RKPD, *Rencana Kerja Pembangunan Daerah*) that must be consistent with the medium-term plan (RPJMD) and with national planning, as set out in the national development planning system [1]. The provincial planning agency (Bappeda) facilitates this work: regencies and cities submit their plans, and Bappeda holds meetings to check consistency, answer facilitation requests, and review control results. At Bappeda of Central Sulawesi Province these meetings and their documents were handled manually within a short facilitation window, so meeting times were set by hand and the progress of each regency could not be followed in one place.

Arranging meetings in time slots is a timetabling problem. Timetabling has a long literature, and most practical instances are hard to solve exactly, so heuristic and evolutionary methods are widely used [2], [3]. A genetic algorithm (GA) represents candidate solutions as chromosomes and improves them by selection, crossover, and mutation, guided by a fitness function [4]. Whether a GA is appropriate here depends on details that decide its behavior: what a chromosome stands for, how fitness is defined, which operators preserve a feasible schedule, and how many generations are run. Reports of GA-based schedulers often show a worked example without these details, which makes the claim that the algorithm "works" hard to check.

The system built at Bappeda was also judged by its users. The DeLone and McLean model of information system success distinguishes system quality, information quality, and user satisfaction, among

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other dimensions [5], [6]; its dimensions are related, but how they relate has been debated [7], and it has been applied to government systems [8]. We pose three questions. (RQ1) Do the functions of the web system behave as specified? (RQ2) Are the steps of the GA worked example internally consistent, and what does the example show about the schedule it produces? (RQ3) How do users rate the system on the three dimensions, and how reliable and how related are these ratings? The contributions are a documented web scheduler for RKPD facilitation meetings, a re-examination of its GA worked example that corrects the selection probabilities and quantifies the effect on the schedule, and a reanalysis of the raw questionnaire data with reliability, confidence intervals, and item-level results. Section 2 describes the methods, Section 3 reports and discusses the results, and Section 4 concludes.

2. Method

2.1. Setting and data

The study was set at Bappeda of Central Sulawesi Province, Palu. The inputs were the RKPD facilitation records of the regencies: topic of the meeting, regency, venue, date and time, deadline, input date, and an attached file. The worked example uses 12 meetings held on 10 May 2024, all at the Bappeda venue, one for each of 12 regencies; the four meeting topics are consistency of RPJMD and RKPD, facilitation request, control results, and review results. The list covers the 12 regencies of the province but not Palu City, the only city, so the example does not span all regions. The research period was February to August 2023, and the meetings of 10 May 2024 are the records of the following planning cycle, which the agency supplied for the worked example.

2.2. System development

The system is a web application written in PHP with a MySQL database and was developed with the Waterfall model [9]: requirements analysis from documents, interviews, and observation; design; implementation and unit testing; integration and system testing; and operation and maintenance. Two tables hold the data: an administrator table (identifier, user name, password) and a meeting table (identifier, agenda, regency, venue, duration, deadline, input date, file, progress). The administrator logs in, enters or deletes meeting records, and opens the schedule and progress pages. Fig. 1 shows the processing chain and the three evaluations applied to it.

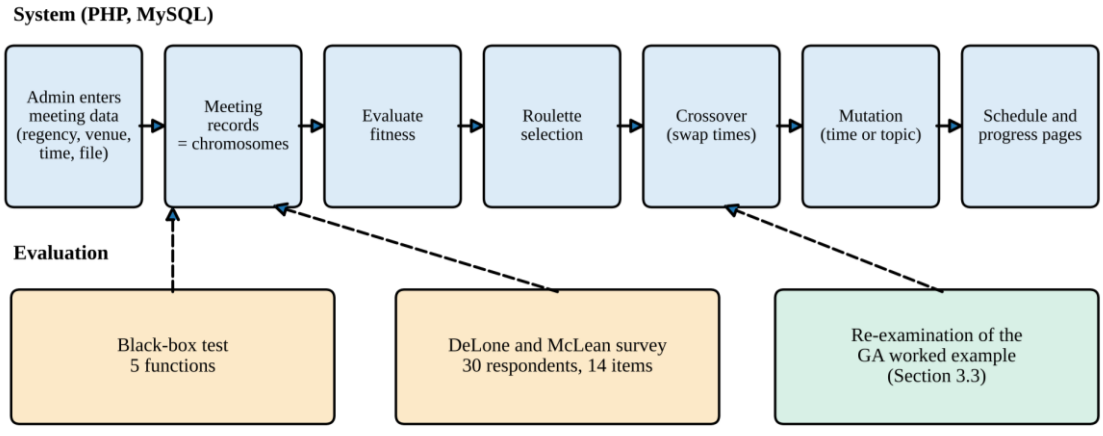


Figure 1. Processing chain of the scheduling system (top) and the evaluations reported in this article (bottom).

2.3. Genetic algorithm as documented

In the documented design each meeting record is a chromosome with four genes: topic, regency, venue, and start time. The 12 chromosomes form the population. A fitness value is assigned to every chromosome, and selection uses the roulette wheel, in which chromosome i is chosen with probability proportional to its fitness [10], [11]:

$$p_i = \frac{f_i}{\sum_{k=1}^{N} f_k}, \qquad E_i = N\, p_i \tag{1}$$

where f_i is the fitness, N = 12 the population size, and E_i the expected number of copies of chromosome i in a draw of N parents. Selected chromosomes are then crossed, by exchanging genes between two chromosomes, and mutated, by changing one gene. The documented steps are: initialize the population, evaluate fitness, select, cross, mutate, and read off the final schedule.

2.4. Evaluation design

Black-box test. Each of the five functions of the administrator interface was run and the observed result compared with the expected result [12]. *GA re-examination.* We recomputed Eq. (1) from the published fitness values, traced every crossover and mutation from the initial to the final table, and counted how many pairs of meetings would overlap in the single venue. Because meeting durations are not recorded in the source, the overlap count is computed for assumed lengths L of 15, 30, 45, and 60 minutes:

$$O(L) = \sum_{i<j} \mathbf{1}\left[\, |t_i - t_j| < L \,\right] \tag{2}$$

where t_i is the start time of meeting i in minutes. O(L) is not the fitness function of the system, whose definition is not reported; it is an external measure of how many meetings collide in time for a given length. *User survey.* A questionnaire based on the DeLone and McLean model with 14 statements on a five-point Likert scale [13] was answered by 30 respondents: five statements on system quality (X1.1–X1.5), five on information quality (X2.1–X2.5), and four on user satisfaction (X3.1–X3.4). We reanalyzed the raw responses of the source. For each dimension we report the mean of respondent-level scores, the standard deviation, a 95% t-interval, the share of responses of 4 or 5, and Cronbach's α [14], [15], computed as

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_T^2}\right) \tag{3}$$

where k is the number of items, σ_i^2 the variance of item i, and σ_T^2 the variance of the total score [16]. Associations between dimensions are measured with Spearman's rank correlation across respondents. The 30 respondents were Bappeda staff and regency planning officers who used the system during the facilitation round. They were selected by purposive sampling among its users, and all gave informed consent.

3. Results and Discussion

3.1. Implemented system

After login, the dashboard leads to three pages. The data page lists the meeting records with agenda, regency, venue, time, deadline, input date, attached file, and a delete action, and a form adds a new record and uploads its file. The progress page shows the status of each scheduled meeting and the file, and the schedule page shows the schedule that the system determined. Fig. 2 shows the data page and the schedule page. The schedule page in the screenshots lists eight meetings for two localities from January 2024, which is not the 12-meeting example of Section 3.3, so the screenshots cannot be used to check the worked example. The schedule produced from the 12 records of Table 2 is therefore shown as a start-time chart in Fig. 3a.

3.2. Black-box test (RQ1)

All five tested functions gave the expected result (Table 1), a pass rate of 5/5. The suite checks navigation, data entry, deletion, and display. It does not check the content of the schedule: the "show schedule" test records only that the schedule page opens. Editing a record, which the data page offers, and the GA run itself are not tested, and each function was run once with valid input. The suite therefore supports the statement that the interface works, not that the schedule is correct.

Table 1. Black-box test of the administrator interface.

No	Function	Expected result	Observed	Pass
1	Login	Valid user name and password open the system	Successful	Yes
2	Add meeting data	New meeting record is stored	Successful	Yes
3	Delete meeting data	Selected record is deleted after confirmation	Successful	Yes
4	Show meeting schedule	Schedule menu opens and displays the schedule	Successful	Yes
5	Show meeting progress	Progress of the meetings is displayed	Successful	Yes

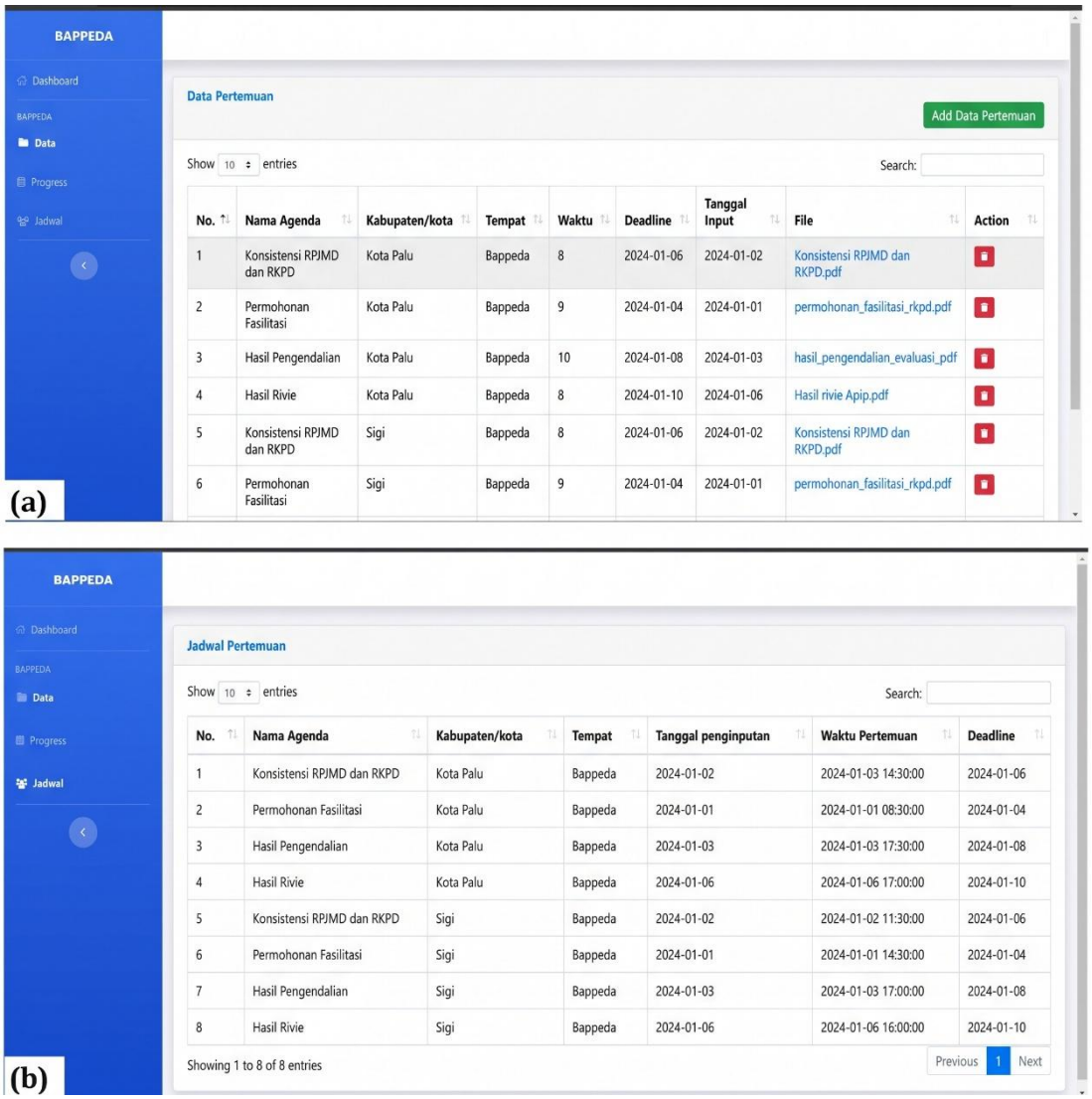


Figure 2. Screens of the system: (a) meeting data page; (b) meeting schedule page.

3.3. GA worked example (RQ2)

Table 2 gives the example of the source: the 12 chromosomes, their start times before and after the operators, the fitness values, the selection probabilities printed in the source, and the probabilities recomputed with Eq. (1). The fitness values lie between 0.4 and 0.9 and sum to 8.4. The source divides each value by 4.6 (for example 0.8/4.6 = 0.174), so its probabilities sum to 1.83 and cannot form a roulette wheel; dividing by 8.4 gives probabilities of 0.048–0.107 that sum to 1. The correction does not change the order of the chromosomes, but it changes the selection pressure. The best chromosomes (3 and 7, f = 0.9) have an expected 1.29 copies in 12 draws and the worst (8, f = 0.4) 0.57; the ratio of the largest to the mean fitness is only 1.29, so the roulette wheel favors good schedules mildly and a weakly fit chromosome is still drawn often.

Table 2. GA worked example: start times (10 May 2024) before and after the operators, fitness f, and selection probability as printed in the source (f/4.6) and recomputed (f/8.4). Topics: Consistency = consistency of RPJMD and RKPD.

No	Regency	Topic	Initial	Final	f	p source	p (Eq. 1)
1	Banggai	Consistency	09:00	09:00	0.8	0.174	0.095
2	Banggai Kepulauan	Facilitation	10:00	10:00	0.6	0.130	0.071
3	Banggai Laut	Control	11:00	10:30	0.9	0.196	0.107
4	Buol	Review	09:30	09:30	0.7	0.152	0.083
5	Donggala	Consistency	12:00	12:00	0.8	0.174	0.095
6	Morowali	Facilitation	09:00	14:00	0.5	0.109	0.060
7	Morowali Utara	Control	10:30	11:00	0.9	0.196	0.107
8	Parigi Moutong	Review	08:30	08:30	0.4	0.087	0.048
9	Poso	Consistency → Program evaluation	11:30	11:30	0.7	0.152	0.083
10	Sigi	Facilitation	13:00	13:00	0.8	0.174	0.095
11	Tojo Una-Una	Control	09:45	09:45	0.6	0.130	0.071
12	Tolitoli	Review	10:15	10:15	0.7	0.152	0.083
	Sum				8.4	1.826	1.000

Tracing the operators from the initial to the final table gives four observations. First, the crossover of chromosomes 3 and 7 exchanges their times (11:00 and 10:30), and the final table agrees. Second, the crossover of chromosomes 5 and 10 is described as exchanging 12:00 and 13:00, but the final table keeps 12:00 for Donggala and 13:00 for Sigi, so this crossover is either not applied or undone, and the text does not say which. Third, the mutations are introduced by "suppose we choose": the time of chromosome 6 is set to 14:00 and the topic of chromosome 9 is changed. They are therefore illustrations chosen by hand, not draws of a random operator, and the example shows what the operators would do but not that the program does it. Fourth, the mutation of the topic gene is not a scheduling operation. The topic is a property of the facilitation request, so replacing "consistency of RPJMD and RKPD" by "program evaluation" changes what the meeting is about instead of when it takes place; only the start time (and, with several rooms, the venue) is a decision variable, and the other genes should be fixed.

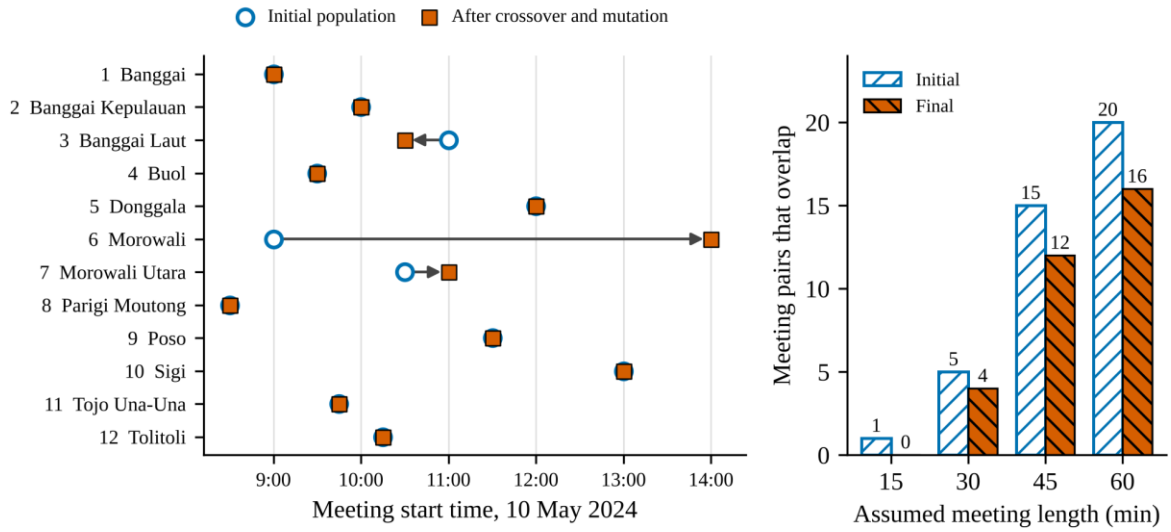


Figure 3. Effect of the operators on the schedule: (a) start times before and after; arrows mark the three changed meetings; (b) number of meeting pairs that would overlap for assumed meeting lengths (Eq. 2).

Fig. 3 shows the effect on the schedule. The initial population contains one hard conflict, chromosomes 1 and 6, both at 09:00 in the same venue, and the final schedule has none: all 12 start times are distinct and at least 15 minutes apart. This is the main benefit visible in the example, and it was produced by the mutation

of chromosome 6, whose fitness (0.5) is among the lowest. If meetings last 30 minutes, however, four pairs still overlap (five at the start), and for 60 minutes 16 of 66 pairs overlap (20 at the start), because 12 meetings are packed into 5.5 hours in one venue, with gaps as short as 15 minutes. The span of the schedule also grows from 4.5 to 5.5 hours, since the moved meeting is placed at 14:00. The example therefore removes the exact double-booking but does not by itself produce a feasible schedule unless meetings last 15 minutes or less. Whether the fitness function penalizes overlap, deadlines, or the length of the day cannot be established, since neither the function nor the meaning of the values 0.4–0.9 is stated.

This answers RQ2. The example is consistent for one crossover and for the mutations as illustrations, but inconsistent in the selection probabilities and in the second crossover, uses a gene (topic) that should not mutate, and covers a single generation with no stopping rule. A population of 12 meetings is also one schedule, not 12 candidate schedules; selection, crossover, and mutation then act on parts of a single timetable, whereas a GA normally evolves a population of complete timetables and compares them. The source does not report the chromosome encoding in the code, the fitness function, the crossover and mutation rates, the number of generations, or the stopping rule, and it gives no pseudocode; only the population size, 12, is stated.

3.4. User evaluation (RQ3)

Table 3 and Fig. 4 give the results. The means of the three dimensions are 4.29 for system quality, 4.34 for information quality, and 4.26 for user satisfaction; the source reports 4.28, 4.34, and 4.25, truncating the first and the last. In the percentage form used by the source, mean divided by five, the values are 85.7%, 86.8%, and 85.2%. Across the 14 items, 90% of the 420 responses are 4 or 5 and none is below 3, and the 95% intervals of the dimension means lie between 4.08 and 4.49. The lowest item means are "information is convincing" (X2.1, 4.07), "display design helps users" (X1.2, 4.17), "easy to learn" (X1.3, 4.17), and "effective" (X3.2, 4.17); the highest are "information is presented in a form that is good and easy to understand" and "information fits user needs" (X2.3 and X2.4, 4.50) and "content can be accessed without problems" (X1.4, 4.47).

Table 3. DeLone and McLean survey, 30 respondents: mean of respondent-level scores (1–5), standard deviation, 95% confidence interval, Cronbach's α, and share of responses of 4 or 5.

Dimension	Items	Mean	SD	95% CI	α	% 4–5
System quality	5	4.29	0.48	4.11–4.47	0.79	89%
Information quality	5	4.34	0.40	4.19–4.49	0.73	93%
User satisfaction	4	4.26	0.47	4.08–4.43	0.61	87%

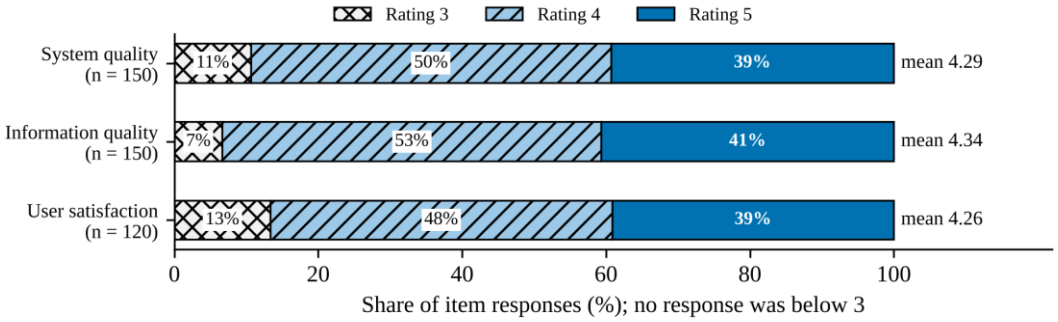


Figure 4. Distribution of item responses by dimension (counts of ratings 3, 4, and 5; ratings 1 and 2 were not given).

Four points qualify the favorable picture. First, the responses are concentrated at the top of the scale: respondents 11 and 12 rated all 14 statements with 5, and no one used 1 or 2, so the ratings have little room to differentiate and probably reflect a ceiling effect or acquiescence. Second, reliability is acceptable for system quality (α = 0.79) and information quality (0.73) but low for user satisfaction (0.61) with only four

items [16]. One of the four satisfaction items (X3.4, "easy to use") repeats the content of X1.1, and X2.1 and X2.4 are both labeled "accuracy" in the source, so the dimensions are not cleanly separated. Third, the dimensions are only weakly related across respondents: Spearman's ρ is 0.19 (system and information quality), 0.15 (system quality and satisfaction), and 0.21 (information quality and satisfaction), none significant at n = 30 (p = 0.31, 0.44, 0.27). The model predicts that quality drives satisfaction [5], [7], [8], but this sample, which is restricted at the top of the scale, neither supports nor contradicts that prediction. Fourth, one arithmetic slip was found in the source table: the score total of respondent 23 for information quality is printed as 24, but the five answers (3, 5, 4, 4, 4) sum to 20, and the printed respondent mean (4.0) agrees with 20, so the means are unaffected.

3.5. Limitations

We could not run the system, so statements about the program rest on its screenshots and the source text. The worked example is one generation on 12 records and, as shown, was partly hand-constructed; there is no repeated run, no convergence curve, no comparison with the manual schedule or with a simple rule such as sorting by deadline, and no timing of the scheduling run. Meeting durations and availability of the regencies were not modeled, so our overlap measure rests on assumed lengths. The survey measures perceived quality only: it has no task-based test and no measure of the time saved against the manual process, and the respondents are not described. The threshold of 0.7 for α is a convention [16], and only two of the three dimensions reach it. The password column of the administrator table is a plain text field in the source; whether passwords are stored hashed is not stated, and the system should not be used with real credentials until it is.

4. Conclusion

The web system gives Bappeda of Central Sulawesi Province a stored record of RKPD facilitation meetings with schedule and progress pages, and all five tested functions work. Thirty respondents rated system quality (4.29), information quality (4.34), and user satisfaction (4.26) highly, with intervals above 4.0, although the ratings are concentrated at the top of the scale and the four satisfaction items are of low reliability. The GA worked example removes the one double-booked slot but does not demonstrate an optimizing scheduler: its selection probabilities were mis-normalized (f/4.6 instead of f/8.4), one crossover is not reflected in the final schedule, the topic gene is mutated, and the fitness function and parameters are not reported.

To support the claim that a genetic algorithm schedules the meetings, the authors should define the fitness function with explicit penalties for overlap and deadlines, restrict mutation and crossover to the time and venue genes, encode each chromosome as a complete schedule, report parameters and stopping rules, and compare the result over repeated runs with the manual schedule and a simple baseline. The survey should be repeated with a described sample and with a measure of time saved.

AI Disclosure Statement

The authors used Generative AI and AI-Assisted Technologies throughout the preparation of this manuscript: to draft and revise portions of the text, to write and run the scripts behind the re-examination of the GA worked example and the analysis of the survey data, to generate the figures, and to format the document from the authors' own research data. The authors verified the scripts and their outputs, reviewed the resulting text, cross-checked every reference against its original source, and accept full responsibility for the content of this publication.

Author Contributions Statement

M. Fikry Rachmat: Conceptualization, Methodology, Software, Investigation, Data Curation.
Rahmah Laila: Methodology, Formal Analysis, Validation, Writing – Review and Editing.

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