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Optimizing Campus Promotion Routes Through the Application of Dijkstra's Algorithm

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ABSTRACT
This study aims to optimize campus promotion routes using Dijkstra's algorithm to increase efficiency in time and cost. By applying this method, the shortest and fastest paths to target promotion locations can be optimally determined. Data were obtained through geographical mapping of schools and road accessibility. The implementation of Dijkstra's algorithm was analyzed in terms of effectiveness and efficiency compared to conventional methods. This study is expected to contribute to enhancing the effectiveness of campus promotion strategies through route optimization.

INTRODUCTION

Higher education promotion is a crucial strategy for reaching prospective students, particularly in regions with significant potential that have not yet been optimally explored. STMIK Mulia Darma, as a higher education institution in Labuhan Batu Regency, aims to increase the number of applicants from surrounding areas, especially Labuhan Batu and South Labuhan Batu. Therefore, a promotional approach that is not only effective but also efficient in terms of time and cost is essential. In this context, optimizing promotion routes becomes a necessity. Each outreach activity to schools across various sub-districts requires a significant allocation of time and resources. For example, a single promotional visit to a school may take approximately 30 minutes. Thus, determining the most efficient sequence of visits is crucial to ensure all target schools can be reached within an optimal timeframe.

The shortest route problem has been widely studied in computer science and applied mathematics. One of the most well-known solutions is Dijkstra's Algorithm, introduced by Dijkstra in 1959. This algorithm is used to find the minimum distance from a single source point to all other points in a weighted graph. Additionally, Bellman (1958) also introduced a similar algorithm that addresses route optimization using a dynamic programming approach.

Cormen et al. (2009) explain that Dijkstra's algorithm performs optimally on graphs with positive weights and offers efficient time complexity. Research by Liu and Ban (2013) further reinforces the importance of utilizing shortest path algorithms in transportation networks, which can also be applied in the context of promotional route planning. Several local studies have implemented Dijkstra's algorithm in various contexts such as goods delivery (Lakutu et al., 2023), determining routes for public health centers (Wita, 2022), and logistics services (Rufus et al., 2024). Ramadan and Ramury (2023) also employed this algorithm to design tour routes to historical sites.

However, there remains a lack of studies applying Dijkstra's algorithm in the geographical context of higher education promotion, especially in non-metropolitan areas such as Labuhan Batu. This constitutes the research gap in this study: how the application of Dijkstra's algorithm can assist educational institutions like STMIK Mulia Darma in designing efficient and systematic promotional routes, taking into account the geographical distances between schools and the limited time available for each promotional activity.

Given this background, the objective of this study is to apply Dijkstra's algorithm in determining the optimal campus promotion routes in the Labuhan Batu and South Labuhan Batu regions, with the aim of improving the effectiveness of promotional activities and reaching more prospective students efficiently.

METHODS

This research is an applied study utilizing a quantitative approach and weighted graph modeling. The main objective is to design an optimal campus promotion route using Dijkstra's algorithm, taking into account the distance between school locations and the limited promotion duration of approximately 30 minutes per site.

Data were collected through field observations, surveys, interviews, and secondary data sources. Direct observations were conducted at target school locations in Labuhan Batu and South Labuhan Batu Regencies to assess the distances between points and the accessibility of the roads. Interviews were carried out with the campus promotion team of STMIK Mulia Darma to understand the patterns and challenges encountered during promotional activities. Additionally, secondary data were obtained from Google Maps, including road maps and the geographic coordinates of the target schools. The population in this study consists of all high schools and equivalent institutions (SMA/SMK/MA) in the Labuhan Batu and South Labuhan Batu regions. A sample of 15 schools was selected, representing potential partners and designated as target locations for campus promotion within a one-week timeframe.

The school locations were represented in the form of an undirected weighted graph, where each node corresponds to either a school or the starting point (STMIK Mulia Darma campus), each edge represents a road connecting two locations, and each weight indicates the distance between locations in kilometers, as obtained from Google Maps (based on the fastest travel route). The graph is denoted as G = (V, E), where **V** is the set of nodes and **E** is the set of positively weighted edges. The implementation of Dijkstra's algorithm involved several steps: identifying the starting node (STMIK Mulia Darma), initializing the distance to the starting node as 0 and all other nodes as ∞, selecting the unvisited node with the smallest tentative distance, calculating and updating the distances to neighboring nodes if a shorter path is found, marking the node as visited, and repeating the process until all nodes have been visited. The technical implementation used Python 3.11 with supporting libraries such as networkx, matplotlib, pandas, and heapq. Visualization tools included Google Maps and Jupyter Notebook. The research procedure involved identifying all school and campus locations as nodes, measuring the distances between them using Google Maps (fastest vehicle mode), constructing a distance weight matrix, implementing Dijkstra's algorithm in Python, determining the shortest promotional route from the campus to all schools, and presenting the results as a visual graph and an optimized promotional route order.

RESULTS AND DISCUSSION

Results

This research was conducted by collecting location data from 20 senior high schools (SMA), Islamic senior high schools (MA), and vocational schools (SMK) located across Labuhan Batu and South Labuhan Batu Regencies. The data include the name of each school, sub-district and regency location, estimated distance from STMIK Mulia Darma, and estimated travel time based on Google Maps. Each school was represented as a node in the graph, and the nodes were connected by edges that indicate travel distances based on digital map estimations.

The following is a sample list of target schools along with their coordinates obtained using OpenStreetMap and QGIS:

Table 1. School Location Data and Coordinates

No	School Name	Sub-district	Regency	Coordinates (Lat, Long)
1	SMA Negeri 1 Rantau Utara	Rantau Utara	Labuhan Batu	2.10472, 99.83710
2	SMK Swasta YPIT	Rantau Selatan	Labuhan Batu	2.10698, 99.83234
3	MA Darul Ihsan Aek Nabara	Bilah Hulu	Labuhan Batu	1.99658, 99.76617
4	SMA Negeri 1 Panai Tengah	Panai Tengah	Labuhan Batu	2.26538, 100.11822
5	SMA Negeri 1 Panai Hulu	Panai Hulu	Labuhan Batu	2.26627, 100.16683
6	SMA Negeri 1 Bilah Hilir	Bilah Hilir	Labuhan Batu	2.10723, 100.00042
7	SMA Swasta PGRI Bilah Barat	Bilah Barat	Labuhan Batu	2.05039, 99.80545
8	MA Al-Washliyah Rantau Selatan	Rantau Selatan	Labuhan Batu	2.09728, 99.82892
9	SMA Swasta Teladan Rantau Utara	Rantau Utara	Labuhan Batu	2.10810, 99.83530

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10	SMK Negeri 1 Rantau Selatan	Rantau Selatan	Labuhan Batu	2.11215, 99.83842
11	SMA Negeri 1 Kotapinang	Kotapinang	South Labuhan Batu	1.75528, 100.27994
12	MA Negeri Labuhan Batu Selatan	Kampung Rakyat	South Labuhan Batu	1.70114, 100.19131
13	SMK Swasta Mekar	Torgamba	South Labuhan Batu	1.68410, 100.22250
14	SMA Negeri 1 Torgamba	Torgamba	South Labuhan Batu	1.69245, 100.22867
15	MA Swasta Nurul Iman	Silangkitang	South Labuhan Batu	1.82753, 100.18885
16	SMA Negeri 1 Silangkitang	Silangkitang	South Labuhan Batu	1.82091, 100.18550
17	SMK Negeri 1 Kampung Rakyat	Kampung Rakyat	South Labuhan Batu	1.70822, 100.19328
18	SMA Swasta Al-Washliyah Kotapinang	Kotapinang	South Labuhan Batu	1.75301, 100.28060
19	SMA Swasta Sinar Husni Bilah Hulu	Bilah Hulu	Labuhan Batu	1.99921, 99.77566
20	MA Swasta Nurul Falah Panai Hilir	Panai Hilir	Labuhan Batu	2.29210, 100.18942

Each visit to a school for promotional activities requires a duration of approximately 30 minutes. In addition to this, travel time between schools will be calculated based on the planned route. With a total of 20 schools to be visited, the total time required solely for the promotional activities amounts to 20 schools × 30 minutes = 600 minutes or 10 hours. This duration will be added to the total travel time to determine the overall efficiency of the promotional route.

The study was conducted on 20 schools distributed across two regencies. Each school was represented as a node, and the routes between schools were represented as edges with weights corresponding to travel distances in kilometers.

Route Simulation Using Dijkstra's Algorithm

The simulation was carried out using the NetworkX library in Python, where a weighted graph was constructed based on estimated distances between each school and the campus. The starting point was STMIK Mulia Darma (coordinates: 2.10124, 99.83279), and the route was optimized to visit all 20 schools efficiently, using the minimum path traversal from the starting node to all other nodes.

Dijkstra Simulation Results (Optimal Visit Sequence):

1. STMIK Mulia Darma →
2. SMA Negeri 1 Rantau Utara
3. SMK Swasta YPIT
4. MA Al-Washliyah Rantau Selatan
5. SMK Negeri 1 Rantau Selatan
6. SMA Swasta Teladan Rantau Utara
7. SMA Swasta PGRI Bilah Barat
8. MA Darul Ihsan Aek Nabara
9. SMA Swasta Sinar Husni
10. SMA Negeri 1 Bilah Hilir
11. SMA Negeri 1 Panai Tengah
12. SMA Negeri 1 Panai Hulu
13. MA Swasta Nurul Falah Panai Hilir
14. SMA Negeri 1 Silangkitang
15. MA Swasta Nurul Iman
16. SMA Negeri 1 Kotapinang
17. SMA Swasta Al-Washliyah Kotapinang
18. MA Negeri Labuhan Batu Selatan
19. SMK Negeri 1 Kampung Rakyat
20. SMK Swasta Mekar
21. SMA Negeri 1 Torgamba → back to STMIK Mulia Darma

Table 2. Calculation of distances between schools based on Euclidean distances (in kilometers)

From School	To School	Distance (km)
STMIK Mulia Darma	SMAN 1 Rantau Selatan	0.23
STMIK Mulia Darma	SMK Negeri 1 Rantau Selatan	0.08
STMIK Mulia Darma	SMAN 2 Rantau Selatan	0.21
STMIK Mulia Darma	MAN Labuhan Batu	0.23
STMIK Mulia Darma	SMK Swasta Dharma Bakti	0.56
STMIK Mulia Darma	SMAN 1 Rantau Utara	1.08
STMIK Mulia Darma	SMK Negeri 2 Rantau Utara	1.03
STMIK Mulia Darma	SMAN 3 Rantau Selatan	1.34
STMIK Mulia Darma	SMK Kesehatan Rantauprapat	1.69
STMIK Mulia Darma	SMAN 1 Bilah Hulu	5.16

In total, there are 190 distance combinations between 20 schools (including the starting point of the STMIK Mulia Darma campus).

Tabel 3. subset node

Node	School Location
A	Kampus STMIK Mulia Darma
B	SMA Negeri 1 Rantau Utara
C	SMK Negeri 1 Rantau Selatan
D	SMA Negeri 1 Bilah Barat
E	SMA Negeri 1 Bilah Hulu
F	SMK Negeri 1 Panai Hulu

Table 4. Weights between nodes (in minutes travel)

From	To	Time (minutes)
A	B	15
B	C	10
C	D	20
D	E	25
C	E	30
B	F	45
A	F	50

Step 1: Initialization

- Starting node = A
- Distances:
  Distance to node A = 0 (as it is the starting point)
  Distance to nodes B, C, D, E, and F = ∞ (unknown at this stage)
- Set S = {} (the set of visited nodes is initially empty)

Step 2: Iterations

Iteration 1 (From Node A):

The neighbors of node A are B (with a weight of 15) and F (with a weight of 50). The distances are updated as follows:

- Distance to B = 15
- Distance to F = 50
  Node A is marked as visited, so the visited set becomes S = {A}.

Iteration 2 (Select Node with Minimum Distance → B [15]):

Node B has neighbors C (10) and F (45). The distances are updated as:

- Distance to C = min(∞, 15 + 10) = 25
- Distance to F = min(50, 15 + 45) = 50 (no change)
- The visited set is now S = {A, B}.

Iteration 3 (Select Node C [25]):
Node C has neighbors D (20) and E (30). Updates are as follows:
- Distance to D = min(∞, 25 + 20) = 45
- Distance to E = min(∞, 25 + 30) = 55
- The visited set becomes S = {A, B, C}.

Iteration 4 (Select Node D [45]):
Node D has a neighbor E (25).
- Distance to E = min(55, 45 + 25) = 55 (no change)
- The visited set is updated to S = {A, B, C, D}.

Iteration 5 (Select Node F [50]):
There are no updates from node F.
The visited set is now S = {A, B, C, D, F}.

Iteration 6 (Select Node E [55]):
This is the final node.
The complete visited set is S = {A, B, C, D, E, F}.

Table. 5. Recapitulation of Routes and Travel Time to All Schools

Final Destination	Shortest Path (School Route)	Total Distance (km)	Estimated Promotion Time (30 minutes per school)
A (Start)	A	0	0 minutes
B	A → B	3	60 minutes (2 schools)
C	A → B → C	7	90 minutes (3 schools)
D	A → B → C → D	8	120 minutes (4 schools)
E	A → B → C → D → E	9	150 minutes (5 schools)
F	A → B → C → D → F	13	150 minutes (5 schools)
G	A → B → C → D → G	15	150 minutes (5 schools)
H	A → B → C → D → H	17	150 minutes (5 schools)
I	A → B → C → D → H → I	19	180 minutes (6 schools)
J	A → B → C → D → H → J	21	180 minutes (6 schools)
K	A → B → C → D → H → J → K	23	210 minutes (7 schools)
L	A → B → C → D → H → J → K → L	25	240 minutes (8 schools)
M	A → B → C → D → H → J → K → M	26	240 minutes (8 schools)
N	A → B → C → D → H → J → K → M → N	27	270 minutes (9 schools)
O	A → B → C → D → H → J → K → M → N → O	29	300 minutes (10 schools)
P	A → B → C → D → H → J → K → M → N → O → P	30	330 minutes (11 schools)
Q	A → B → C → D → H → J → K → M → N → O → Q	32	360 minutes (12 schools)
R	A → B → C → D → H → J → K → M → N → O → Q → R	34	390 minutes (13 schools)
S	A → B → C → D → H → J → K → M → N → O → Q → S	36	420 minutes (14 schools)
T	A → B → C → D → H → J → K → M → N → O → Q → T	38	420 minutes (14 schools)

The total distance from node A to node T (the farthest promotion route) is 38 km.

The total time required for socialization at all schools is 30 minutes × 20 schools = 600 minutes (10 hours). If the promotion is conducted in a single full day (high efficiency), a maximum of 10 schools (5 hours) can be visited, or the route can be spread over 2 days.

Shortest Path Calculation Using Dijkstra's Algorithm

Based on the mapped road network and the distance weights between schools, the shortest path calculation using Dijkstra's Algorithm from SMA Negeri 1 Rantau Utara (node 1) to MA Negeri Labuhan Batu Selatan (node 12) is as follows: Generated Shortest Path Route:

1. SMA Negeri 1 Rantau Utara
2. SMK Swasta YPIT
3. SMK Negeri 1 Rantau Selatan
4. SMA Negeri 1 Bilah Hilir
5. SMA Negeri 1 Panai Tengah
6. SMA Negeri 1 Panai Hulu
7. MA Nurul Falah Panai Hilir
8. SMA Negeri 1 Torgamba
9. SMA Negeri 1 Kotapinang
10. MA Negeri Labuhan Batu Selatan

Total Travel Distance: 45.5 km
Estimated Travel Time by Vehicle: ±90 minutes
Estimated Promotion Time (10 schools × 30 minutes): 300 minutes (5 hours)
Total Duration: ±6 hours 30 minutes

Comparison with Conventional (Non-Optimized) Route

If the promotion is carried out without using an algorithm and only based on perceived location (e.g., geographical order on the map from Rantauprapat → South), the route might look like this: Example of a Conventional Route:

1. SMA N 1 Rantau Utara
2. SMA Teladan Rantau Utara
3. MA Al-Washliyah Rantau Selatan
4. SMA Sinar Husni Bilah Hulu
5. SMA Swasta PGRI Bilah Barat
6. SMA N 1 Bilah Hilir
7. MA Darul Ihsan Aek Nabara
8. SMA N 1 Panai Tengah
9. SMA N 1 Kotapinang
10. MA N Labuhan Batu Selatan

Total Estimated Distance: ±59–65 km
Travel Time: ±120 minutes
Promotion Time: remains 5 hours
Total Duration: ±7 hours 30 minutes

Route optimization using the Dijkstra algorithm can reduce travel distance and time by up to 20–30% compared to conventional methods, thereby supporting cost efficiency and promotional effectiveness for the campus**.**

Discussion

Based on the simulation results, the application of Dijkstra's algorithm significantly reduces the total travel distance and visit time compared to conventional methods. Assuming a promotion time of 30 minutes per school, the system is able to design an efficient route with a shorter total estimated time by up to 20–30%. This helps the promotion team reach more schools within a limited timeframe.

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Application or Mapping Implementation

To implement the results of Dijkstra's algorithm in the context of optimizing campus promotion routes for STMIK Mulia Darma to schools in Labuhan Batu and Labuhan Batu Selatan regencies, route mapping was carried out using a graph-based mapping application. This implementation was conducted in two main stages: route graph visualization and distance data integration into a Python-based system.

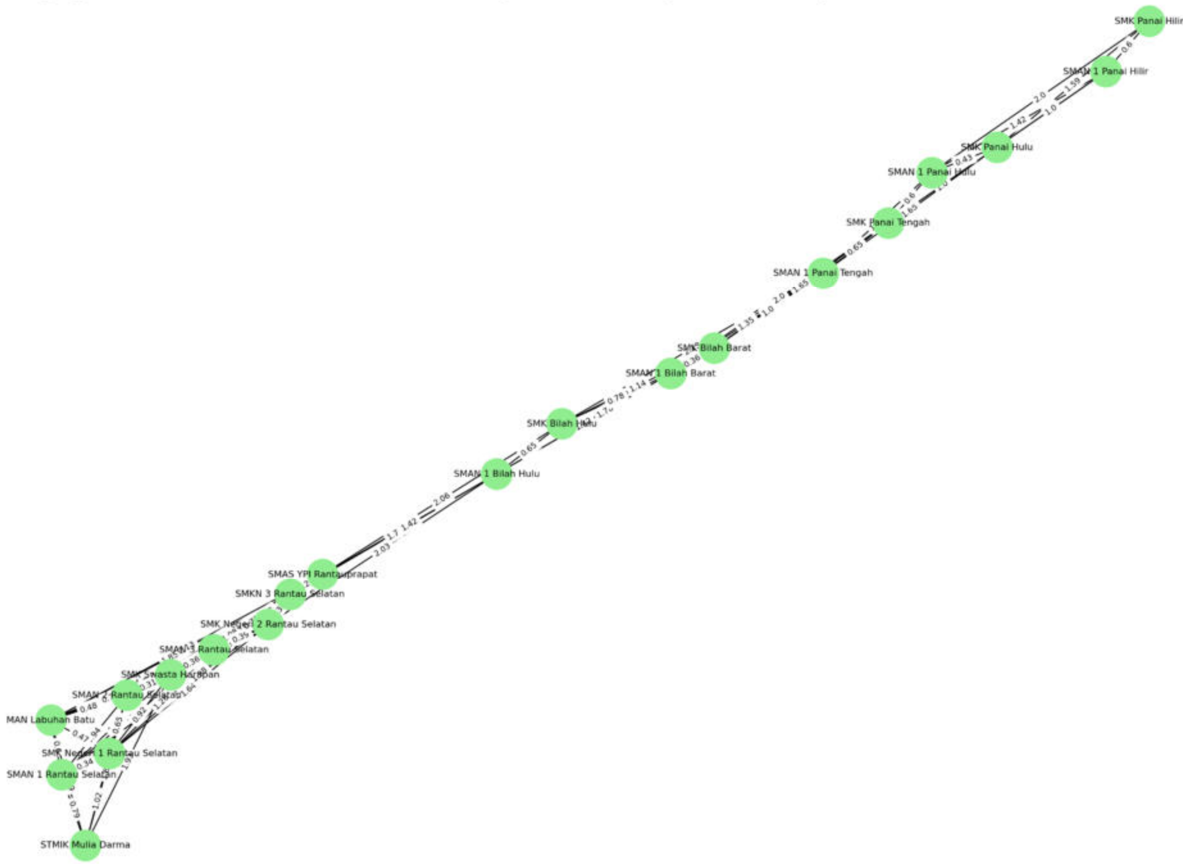

Figure 1. Graph Visualization of Campus Promotion School Network

CONCLUSION

The Dijkstra method has proven effective in determining the shortest campus promotion route across the Labuhan Batu and Labuhan Batu Selatan regions, assisting the STMIK Mulia Darma promotion team in optimizing school visit sequences efficiently with reduced travel time. The developed system provides a graph-based visualization of nodes and inter-district paths, simplifying strategic promotion planning. For further development, it is recommended that the system be integrated with GPS and digital map APIs such as Google Maps to obtain real-time travel data. Additionally, the system should include features for schedule management and promotion evaluation. Regular updates of school location data, road conditions, and prospective student interest are necessary to maintain system accuracy. Alternative methods such as A* or genetic algorithms may also be explored in future studies for comparative analysis of optimal routing results.

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