Implementation of Traveling salesman problem Algorithm for Scheduling and Shortest Distance Optimization

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Abstract. PD Mitra Makmur Perkasa is a company that distributes bottled drinking water. The decline in service levels in the timeliness of delivery is one of the problems experienced by the company. Based on the analysis conducted, the cause is due to irregular and unsystematic scheduling. To overcome this problem, we need a system that can manage systematic scheduling and provide optimal mileage recommendations to streamline delivery times and maximize the number of deliveries. These papers aim to build a web-based information system for scheduling the delivery of bottled drinking water using the waterfall system development method and the heuristic TSP (travelling salesman problem) method. TSP used to determine travel routes and produce recommendations for the shortest distance to be traversed and to maximize the amount of drinking water that can be delivered optimally. The results TSP method can be applied to a web-based scheduling information system for the delivery of bottled drinking water. It will have an impact on increasing service and maintaining, as well as increasing the number of customers. The resulting testing with the structural and functional BlackBox test results declared appropriate and functional.

1. Introduction

PD Mitra Makmur Perkasa is a company that distributes bottled drinking water under the brand name “Yasmin”. This company is part of PT Jaya Lestari Sejahtera, which is a factory that produces bottled drinking water (AMDK). PD Mitra Makmur Perkasa Bogor has 19 shipping fleets and 3,531 customers in the Bogor area, with a branch company in Sukabumi [1]. Fleet limitations and irregular delivery scheduling resulted in delivery delays, sometimes not just a few days, but up to more than a week.

Another impact is that when a salesman goes the route of repeated visits, the customer will be reluctant to order this bottled water again for fear that the ordered item will not be delivered. 15 customers cancel orders every month. In the past year, there were recorded the number of subscribers, originally 3,531 subscribers, which are still active, amounting to 1,854 subscribers and 1,677 inactive subscribers.

The scheduling in the process of sending goods is not systematic, and there is no connectivity between the sales visit route and the planned delivery schedule, resulting in random and irregular shipments. This resulted in many delivery delays and failed deliveries because the shop was closed and orders canceled due to delivery schedule information that was difficult to obtain by customers. The decline in customers occurred due to poor delivery scheduling.
Based on these problems, we need a way of grouping customers based on rings or areas measured by distance travelled. It is also necessary to divide the fleet to determine delivery schedules and times as well as route recommendations to optimize travel times so that fleets can return quickly and be able to send back. Therefore, this study tries to answer all these problems by building a web-based scheduling information system for the delivery of bottled drinking water so that data and information can be obtained quickly and delivery schedules can be carried out regularly. The TSP (travelling salesman problem heuristic) method is used to be able to connect trips and produce recommendations for the shortest distance to be travelled [2], to streamline delivery times and maximize the amount of drinking water that can be sent.

2. Methodology

The system design in this paper uses the waterfall model. Waterfall model is a model that takes necessary process activities such as specification, development, validation and evolution by presenting them as process phases [3].

1. Requirement Analysis

The need for steps in determining the schedule and recommendation of the shortest distance using the TSP method are:

A. Stores/customers are grouped by ring or distance from the centre, which is the start of the delivery journey. By region or city, this is done to facilitate delivery scheduling and optimize delivery time so that the fleet can reach its destination quickly and return quickly to make deliveries back.

B. The order date is needed to determine the delivery schedule when and at what time the delivery can be scheduled. This date is a measure of service to customers.

C. The distance between regions or cities is critical to provide the shortest distance recommendation and to optimize travel time. So that timeliness and service can be achieved. The distance between cities can be determined by manual measurement or using the Google Map application. The results of measuring distances between regions can be seen in the table.

| City name      | Sentul | Cibinong | Babakan Madang | Citeureup | Ciluer |
|----------------|--------|----------|----------------|-----------|--------|
| Sentul Kws Industri | 0      | 8,7      | 12,5           | 4,4       | 9,4    |
| Cibinong       | 8,7    | 0        | 21,8           | 8         | 9,9    |
| Babakan Madang | 12,5   | 21,8     | 0              | 19,4      | 16,3   |
| Citeureup      | 4,4    | 8        | 7,4            | 0         | 15,6   |
| Ciluer         | 9,4    | 9,9      | 16,3           | 15,6      | 0      |

D. The old business process that is currently running is still manual. It is becoming a problem when many orders or invoices are printed. Because authorization is carried out after the invoice is
printed, and if an order is rejected, invoice cancellation occurs, scheduling is done manually by the warehouse head. It is challenging to control delivery services.

Figure 2. The Old Business Process

E. The proposed new business process is expected to be a solution to improve old business processes. In a new business process, all parts involved in the business flow are entered into the application system, authorization can be done before the invoice is printed, and authorization is carried out in an application, not in the form of a document.

Figure 3. The New Business Process

2. System Design
The system design stage consists of context design, use case design, activity design, sequence design, database design, and interface design. The following will explain the stages of the system design to be built.

A. Context Diagram illustrates the relationship between actors (actors) and the system to be built [4].

B. Use case diagrams are narrative documentation of business requirements that will be used by the system and provide an understanding to the stakeholders about the system to be built [5].

C. Activity diagrams are used to describe the activity of the lecture scheduling information system. There are 17 activity diagrams in the design [6]. Namely: activity login, user management, customer data input, ring data input, area data input, fleet data input, driver data input, data helper input, salesman data input, customer data input, distance data input, input set distance, input transaction data, input set fleet, input authorization data, the input set scheduling, TSP distance recommendation.
Figure 6. Activity Diagram TSP Distance Recommendation.

The calculation in finding the shortest distance is done by following the design stages of the travelling salesman problem algorithm shown in the flowchart image.

With the calculation of possible routes as follows:
\[
\frac{5!}{2(N)} = \frac{1 \times 2 \times 3 \times 4 \times 5}{2(5)} = \frac{120}{10} = 12 \text{ Peluang}
\] (1)

Base on data Table 1. Calculation of the Traveling Salesman problem method can be recommended that the shortest route trip is:
(Sentul – Cibinong – Ciluer – Babakan Madang – Citeureup – Sentul) atau (Sentul – Citeureup – Babakan Madang – Ciluer – Cibinong – Sentul).
D. Communication between objects in the system is described in a Sequence Diagram. There are six sequence diagrams in the design. Namely: sequence login, customer data input, input transaction data, input authorization data, the input set scheduling, TSP distance recommendation.

![Sequence Diagram TSP Distance Recommendation](image1)

**Figure 8. Sequence Diagram TSP Distance Recommendation**

E. Database design describes the relationships between tables, namely the relationships between tables used in a database that was created [6]

![Database Relations](image2)

**Figure 9. Database Relations**

3. Result and Discussion

1. Making and Implementing Information System
Web information system was developed using Microsoft window 8 Professional, Adobe Photoshop CS 5, Sublime Text 2.0.2, Internet browser google chrome, Xampp package version 1.8.1, PHP version 5, and MySQL version 5.0.10 with the main display as in Figure 7.
Several pages are generated, such as Customer Input page which is a page to enter all customer data into the application. The ring input page which is a page to enter customer distances divided into kilometers based on distance travelled. The input area page is the relationship between customer area data and ring data. The vehicle input page is an entry for the vehicle (fleet) which will later be included in the delivery schedule. The driver input page is the driver data input in the application, which is vehicle driver data. The helper input page is the helper data that is entered into the application. Salesmen input page is a page for entering salesman data. The fleet management page is a page for entering vehicle data (Fleet) related to drivers and helpers. Authorization page is used to authorize customer order data that is accepted or rejected by the supervisor. The order transaction page is an input page for customer order data. The delivery scheduling page is used to manage schedules in the application. The set distance page is a page for entering distances between areas and comparing with other areas. The TSP page is a page to view and recommend the closest distance that must be travelled by a vehicle (fleet).
and authorized by the supervisor before being included in the scheduling, and then customer orders are included in the division of the fleet. The route that can be taken is obtained from a system that issues a recommendation for the shortest distance according to the schedule made using the calculation formula from the Heuristic Traveling Salesman Problem method.

2. Structural and Functional Testing

Structural testing is intended to check the conformity of the output as expected and has been functioning correctly by running each menu. This checking stage is carried out by displaying the pages in the system. Functional testing includes checking the system buttons and processes, whether they are running well or not. The results of checking the structural and functional testing can be seen in Table 2.

| Table 2. The Results Structural and Functional Testing |
|---------------------------------------------|
| Menu File | Sub Menu | Structural Button | Functional Button | Results |
| Login | acceptable | link login | achieved |
| | | login | achieved |
| Logout | acceptable | link logout | achieved |
| | | logout | achieved |
| Area | acceptable | tab | achieved |
| | | insert | achieved |
| | | update | achieved |
| | | delete | achieved |
| | | reset | achieved |
| | | detail | achieved |
| TSP system | Armada | acceptable | insert | achieved |
| | | update | achieved |
| | | delete | achieved |
| | | reset | achieved |
| | | detail | achieved |
| | Drive | acceptable | insert | achieved |
| | | update | achieved |
| | | delete | achieved |
| | | reset | achieved |
| | | detail | achieved |
| | Helper | acceptable | insert | achieved |
| | | update | achieved |
| | | delete | achieved |
| | | reset | achieved |
| | | detail | achieved |
| Service          | Action | Achieved |
|------------------|--------|----------|
| Customer         |        |          |
| Insert           | achieved|
| Update           | achieved|
| Details          | achieved|
| Delete           | achieved|
| Reset            | achieved|
| Detail           | achieved|
| Insert           | achieved|
| Update           | achieved|
| Details          | achieved|
| Ring             |        |          |
| Insert           | achieved|
| Update           | achieved|
| Delete           | achieved|
| Reset            | achieved|
| Detail           | achieved|
| Insert           | achieved|
| Update           | achieved|
| Details          | achieved|
| Sales            |        |          |
| Insert           | achieved|
| Update           | achieved|
| Delete           | achieved|
| Reset            | achieved|
| Detail           | achieved|
| Insert           | achieved|
| Update           | achieved|
| Details          | achieved|
| Customer Type    |        |          |
| Insert           | achieved|
| Update           | achieved|
| Delete           | achieved|
| Reset            | achieved|
| Detail           | achieved|
| Insert           | achieved|
| Update           | achieved|
| Details          | achieved|
| Arrange Transportation |    |          |
| Insert           | achieved|
| Update           | achieved|
| Delete           | achieved|
| Reset            | achieved|
| Action       | Status   |
|--------------|----------|
| Autorotation | acceptable|
| detail       | achieved |
| insert       | achieved |
| update       | achieved |
| details      | achieved |
| option accept| achieved |
| option reject| achieved |
| option wait  | achieved |
| applied      | achieved |
| reset        | achieved |
| details      | achieved |
| Scheduling   | acceptable|
| calendar     | achieved |
| dialog form  | achieved |
| option data  | transaction achieved |
| save         | achieved |
| update       | achieved |
| delete       | achieved |
| cancel       | achieved |
| Transaction  | acceptable|
| insert       | achieved |
| update       | achieved |
| delete       | achieved |
| reset        | achieved |
| detail       | achieved |
| insert       | achieved |
| update       | achieved |
| details      | achieved |
| arrange distance | acceptable|
| insert       | achieved |
| update       | achieved |
| delete       | achieved |
| reset        | achieved |
| detail       | achieved |
| insert       | achieved |
| update       | achieved |
| details      | achieved |
| TSP          | acceptable|
| route        | achieved |
| details      | achieved |

4. Conclusion
The TSP (travelling salesman problem) heuristic method can be applied to the web-based scheduling information system in the case study of bottled drinking water delivery so that data and information can be obtained quickly. Delivery schedules can be done regularly. The results of designing using the waterfall method are also able to build applications with structural and functional testing, which are declared appropriate and function for further application.

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