

Public Transport Planning System by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area

Pimploi Tirastittam, Phutthiwat Waiyawuththanapoom

Abstract—Nowadays the promotion of the public transportation system in the Bangkok Metropolitan Area is increased such as the “Free Bus for Thai Citizen” Campaign and the prospect of the several MRT routes to increase the convenient and comfortable to the Bangkok Metropolitan area citizens. But citizens do not make full use of them it because the citizens are lack of the data and information and also the confident to the public transportation system of Thailand especially in the time and safety aspects. This research is the Public Transport Planning System by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area by focusing on buses, BTS and MRT schedules/routes to give the most information to passengers. They can choose the way and the routes easily by using Dijkstra STAR Algorithm of Graph Theory which also shows the fare of the trip. This Application was evaluated by 30 normal users to find the mean and standard deviation of the developed system. Results of the evaluation showed that system is at a good level of satisfaction (4.20 and 0.40). From these results we can conclude that the system can be used properly and effectively according to the objective.

Keywords—Dijkstra Algorithm, Graph Theory, Shortest Route, Public Transport, Bangkok Metropolitan Area.

I. INTRODUCTION

THE traffic problem of Bangkok Metropolitan area has been directly affected the quality of life of the citizens of the area. The effect of the traffic of Bangkok Metropolitan area are the pollution in every aspect such as air, water or sound, the time wasting on the road and also the hydro-carbon fuel. Even though the number of the roads and expressways are increasing, but the traffic problem in Bangkok Metropolitan area is still occur.

Thai government and the other public agency is paying attention to the public transportation and promote the benefit of using the public transportation such as the “Free Bus for Thai Citizen” Campaign and the prospect of the several MRT routes. But the majority of Bangkok Metropolitan area citizens still do not pay enough attention to the public transportation due to the several issues such as the insufficient data and information of the public transportation, the confident in the safety of the public transportation and the lacking of the comfortable and speed of the public transportation.

P. Tirastittam is the lecturer in the Department of Management Information System for Business, Suan Sunandha Rajabhat University 1 U-Thong Nok Road Dusit Bangkok 10300(phone: +662-160-1701; fax: +66-160-1184; e-mail: pimploi.ti@ssru.ac.th).

P. Waiyawuththanapoom is with the Department of Logistics Management, Suan Sunandha Rajabhat University 1 U-Thong Nok Road Dusit Bangkok 10300(phone: +662-160-1186; fax: +66-160-1184; e-mail: phutthiwat.wa@ssru.ac.th).

In the Public Transport Planning System by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area, it will assist the public transportation user to the information and data which is essential for them and also provide the planning system to plan the route and transportation mode with the fare. The system includes the bus, MRT and BTS and will use the graph theory and Dijkstra Algorithm to calculate the most efficient route.

A. Research Objective

- a) To design the Public Transport Planning System by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area
- b) To evaluate the user’s satisfaction of the Public Transport Planning System by Dijkstra Star Algorithm

B. Research Hypothesis

The Public Transport Planning System by Dijkstra Algorithm will be able to operate and received the “Good” level of satisfaction from the users.

$$H_0: \mu \geq 3.51$$

$$H_1: \mu < 3.51$$

By assuming, μ = the satisfaction of the users to the Public Transport Decision Support System by A-Star Algorithm.

C. Research Limitation

- A. The system will use the Dijkstra algorithm of the graph theory to find the shortest route.
- B. The waiting time of the user will not count as a time on the process.
- C. The system will include the detail of buses, sky train and underground train in the Bangkok metropolitan area.
- D. The system will be develop in the “Web Application” which will include
 - a. Planning System
 - i. Selecting the mode of the transport.
 - ii. Selecting the shortest route.
 - b. Public Transport Information
 - i. BMTA bus information
 - ii. BTS sky train information
 - iii. MRT underground train information
 - iv. BRT bus Information
- E. The tools which use to develop the decision support system
 - a. Hardware
 - i. Computer that have CPU 2.8.0 GHz at least
 - ii. Hard Disk 500 GB at least
 - iii. RAM 1 GB at least
 - b. Software

- i. Operating system is Windows XP or higher
 - ii. Use SQL as the database management system
 - iii. Use the Hypertext Preprocessor, JavaScript, Ajax and jQuery as the development tool
 - iv. Use Adobe Dreamweaver to create and design the web page
 - v. Use Adobe Photoshop CS2 to decorate a web page
- F. Evaluate the decision support system by the Black-Box Testing with 30 normal users.

D. Definition

Bus (BMTA) [1] is the bus which operates by the BMTA (Bangkok Mass Transit Authority) which is the government enterprise under the control of the Ministry of Transportation. It has a mission to manage and organize all the bus that operate in the Bangkok metropolitan area and another 5 nearby provinces which are Nonthaburi, Pathumthani, Samut Songkram, Samut Prakarn and Nakorn Pathom.

Sky Train (BTS) [2] is the public transport sky train which operates by the Bangkok Mass Transit System Public Company Limited.

Underground Train (MRT) [3] is the public transport underground train which operates by the Bangkok Metro Public Company Limited.

Graph Theory [4] is the structure of the data which is used to solve the problems.

Dijkstra's algorithm was found by the computer scientist named "Edsger Dijkstra" in 1959 in the object to solve the shortest path problem for the positive linking graph. This algorithm will calculate the shortest path from one point to another point in the graph one by one until the condition was met.

II. LITERATURE REVIEW

In the development of this decision support system, the researcher did the primary research by searching the theory, framework and principle which related to this research which are

A. Graph Theory

Graph Theory is the study of graphs [5] which are mathematical structures used to model pairwise relations between objects from a certain collection. A graph in this context is a collection of vertices or nodes and a collection of edges that connect pairs of vertices. A graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be directed from one vertex to another.

Structure of Graph is a nonlinear data structure which is different from the Tree structure. Graph is a set of points and set of lines which each of them was linked to the other point or line. The point is called "Node" of graph and the line is called "Edge" but sometimes the node is called "Vertice" and the edge is called "Arc".

B. Dijkstra's Algorithm

Dijkstra's algorithm was found by the computer scientist named "Edsger Dijkstra" in 1959 in the object to solve the shortest path problem for the positive linking graph. This algorithm will calculate the shortest path from one point to another point in the graph one by one until the condition was met [6].

By set one node as an initial node and set the distance of node Y means the distance from the initial node to node Y. The Dijkstra algorithm will set the initial value into some node and will increase the distance step by step.

C. Other Literature Review

There was an applied research by using the GIS (Geography Information System) to create the application that will support the BMTA call center by Chavanit, 2002 [7]. The research was found that the need of the system can be separated into 4 needs.

- a) The need of the bus number from the start point to the destination point.
- b) The need of the bus routing information.
- c) The need of the bus number from the start point.
- d) The need of the nearest bus stop.

The result was analyzed and created the database by the Arc info 8.0 program to improve the user friendly. The program was able to find the bus number from the start point to the destination point, the detail of the bus stop nearby which satisfied the user very much.

Zhan and Noon [8] provide an objective evaluation of 15 shortest path algorithms using a variety of real road networks. Based on the evaluation, a set of recommended algorithms for computing shortest paths on real road networks is identified. This evaluation should be particularly useful to researchers and practitioners in operations research, management science, transportation, and Geographic Information Systems. The computation of shortest paths is an important task in many network and transportation related analyses. The development, computational testing, and efficient implementation of shortest path algorithms have remained important research topics within related disciplines such as operations

Peter W. Eklund, Steve Kirkby, Simon Pollitt [9] also discuss the implementation of Dijkstra's classic double bucket algorithm for path finding in connected networks. The work reports on a modification of the algorithm embracing both static and dynamic heuristic components and multiple source nodes. The modified algorithm is applied in 3D Spatial Information System (SIS) for routing emergency service vehicles. The algorithm has been implemented as a suite of modules and integrated into a commercial SIS software environment. Genuine 3D spatial data is used to test the algorithm on the problem of vehicle routing and rerouting under simulated earthquake conditions in the Japanese city of Okayama. Coverage graphs were also produced giving contour lines joining points with identical travel times.

Shulz et al. [10] also did the research about the Dijkstra in the public railroad transport. Traffic information systems are among the most prominent real world applications of

Dijkstra's algorithm for shortest paths. There was a consideration the scenario of a central information server in the realm of public railroad transport on wide area networks. Such a system has to process a large number of online queries for optimal travel connections in real time. In practice, this problem is usually solved by heuristic variations of Dijkstra's algorithm, which do not guarantee an optimal result [11]. In this study, various speed up techniques for Dijkstra's algorithm were analyzed empirically. This analysis was based on the timetable data of all German trains and on a snapshot of half a million customer queries.

III. RESEARCH METHODOLOGY AND OPERATION

A. Research Methodology

- a) Study the principle of the decision support system and graph theory to find the shortest route
- b) Study and analyze the problem statement in the research
 - i. Study the problem and analyze the need of the system.
 - ii. Study the process of the system
 - iii. Study the tool to develop the system
- c) Data collecting
- d) System design
 - i. Overview design
 - ii. Graphic design
 - iii. User interface design
- e) System development
- f) System testing and evaluate

B. Research Operation

In the development process of the Public Transport Planning System by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area, the researcher has divided the research operation into 4 stages.

- a) Data Collection Process
- b) Analyze and Design Process
- c) System Development Process
- d) Evaluate Process

1. Data Collection Process

The data can be sorted in 4 types which are system data, public transport in Bangkok metropolitan area, routing data and system development data which can be detailed as

- a) Collect the need from the system and the performance that the user will needed.
- b) Collect the public transport information in bangkok metropolitan area from the related government agency.
- c) Study the development of the system and divide the process into 5 stages which are analyze, design, develop, testing and evaluation.
- d) Study the tool that will be used to develop the system.

2. Analyze and Design Process

A. Define the requirement of the system

- a. System requirement
 - i. CPU speed is 2.8 GHz at least
 - ii. Hard Disk is 150 GB at least
 - iii. Operating System is Windows XP or higher

- iv. SQL Database management system
- v. Adobe Dreamweaver is installed
- b. System capability
 - i. System development as a web application
 - ii. The system will be able to show the data to the user
 - iii. The system will be able to select the shortest route and bus number.
 - iv. The system will be able to show the information of the public transport.
- B. Structure design and data presentation
 - a. Use Case Diagram will show the activities in the related domain between the activities and the relationship of the activities and the others. There will be 2 parties which are the user and the admin. There is also 6 sub-functions which are searching and examining route, Route calculation for suggest the route, add/remove the data, BTS sky train data expression, MRT underground train data expression and BMTA bus data expression as shown in Fig. 1.

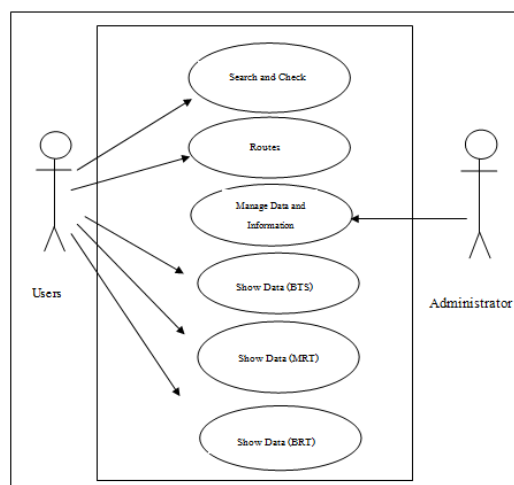


Fig. 1 Use Case Diagram

- b. Sequence Diagram which will simulate the overview picture in the system and will describe the process of the use case diagram which is searching and examining route, Route calculation for suggest the route, add/remove the data, BTS sky train data expression, MRT underground train data expression and BMTA bus data expression.

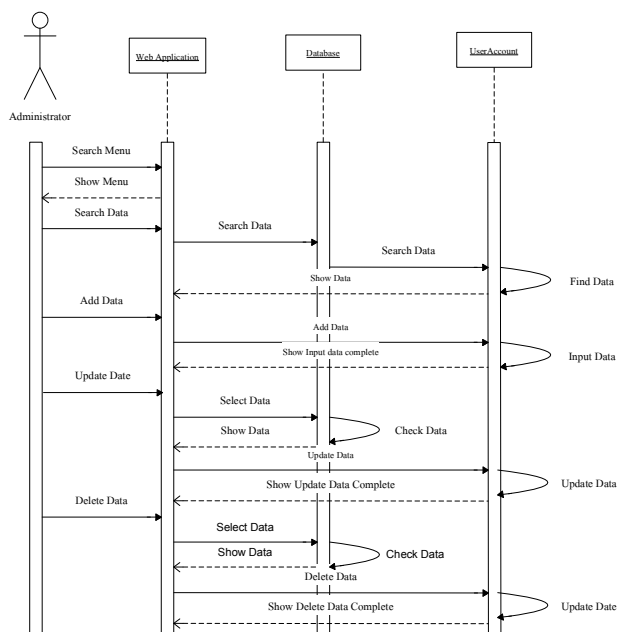


Fig. 2 Sequence Diagram

3. System Development Process

In the development process of the system, the researcher designed the database to collect the data about the public transport by using the MySQL database which will use to develop the A-Star algorithm of graph theory to calculate the shortest route. The system will be developed by using PHP to create the script and connect with the database to develop the program.

4. Evaluate Process

In the testing and evaluating process of public transport planning system by Dijkstra Algorithm, the researcher used the alpha testing process to test the system in order to reduce the error of the system. After using the alpha testing, the researcher used the black-box testing with 30 normal users and evaluates the system then separates the result in 4 aspects.

- Functional Requirement Test
- Function Test
- Usability Test
- Security Test

In the evaluate process, the researcher has set the range of the score in the evaluation form into 5 range as the Table I.

TABLE I
RANGE OF SCORE

Score	Meaning
4.51 – 5.00	The develop system has a very good quality
3.51 – 4.50	The develop system has a good quality
2.51 – 3.50	The develop system has a moderate quality
1.51 – 2.50	The develop system has a low quality
1.00 – 1.50	The develop system has a very low quality

Statistics tools which use for analyzing the data is mean. Mean is the sum of the data from the evaluation process and divided by the number of the sample as (1):

$$\bar{X} = \frac{\sum X}{N} \quad (1)$$

Assuming

- \bar{X} = Mean of the evaluation
- $\sum X$ = Sum of the evaluation result
- N = Number of the normal user

Standard Deviation is the value which shows how much variation exists from the average as (2):

$$S.D. = \frac{\sqrt{\sum(X-\bar{X})^2}}{N} \quad (2)$$

Assuming

- S.D. = Standard Deviation
- X = Result of the evaluation
- \bar{X} = Mean of the evaluation
- N = Number of the normal user

IV. RESEARCH RESULT

In this part the research will discuss about 2 issues of public transport planning system by Dijkstra Algorithm: Case Study Bangkok Metropolitan Area which are the result of system development and result of the satisfaction of the user.

A. Result of System Development

The design and development as a web application use PHP language and MySQL as a database management system. The main page of the program is shown below as Fig. 2 and the user interface of the program was shown below as Fig. 3-5:



Fig. 2 Main page



Fig. 3 GUI for Bus Finding



Fig. 4 GUI for Bus Finding with condition

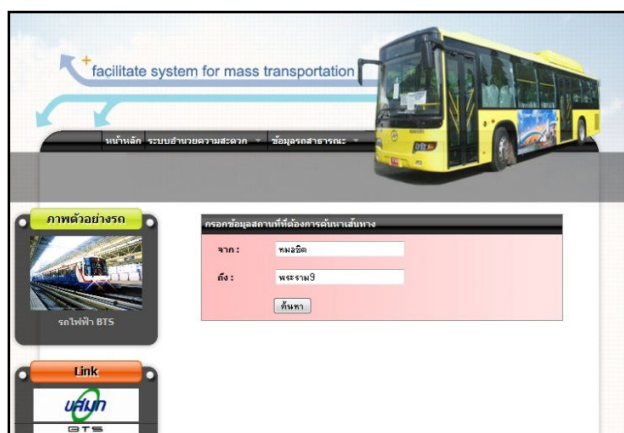


Fig. 5 GUI for route finding (Enter origin point and destination point)

B. Result of the Satisfaction of the User

The functional requirement test is the test that will evaluate the developed system is correctly developed and how the user satisfies with the decision support system. There is 1 out of 4 that was rated as "Very Good" which is the usage of the system. The mean and standard deviation of the usage of the system are 4.57 and 0.57 respectively. The other three are rated as "Good" and the mean and standard deviation is as

shown in Table II.

The conclusion of the result evaluation of the system is "Good" with the mean and standard deviation equal to 4.20 and 0.40 respectively. So the result and the hypothesis that public transport planning system by Dijkstra Algorithm is be able to adopt to use in the real world in Bangkok metropolitan area.

TABLE II
THE TABLE OF EVALUATION RESULT

List of Evaluation	Result		
	\bar{X}	SD	Range
1. System Performance Match with the User Needs	3.57	0.82	Good
2. Accuracy of the System	4.03	0.67	Good
3. Usage of the System	4.53	0.57	Very Good
4. Security of the System	4.40	0.51	Good
Overall	4.20	0.40	Good

V. RESEARCH SUGGESTION

After the evaluation process, the researcher has concluded the suggestions from the researcher and the user to enhance the public transport decision support system which is

- The public transport decision support system should have more flexibility.
- The public transport decision support system should have more condition in finding the public transportation.

The public transport decision support system should show the distance to the user so the user will be able to make a decision by himself.

ACKNOWLEDGMENT

The authors of this research would like to thank you the Suan Sunandha Rajabhat University for funding this research and also assist authors in every aspect. The authors also need to thank the family and friends who are so encourage the author. Lastly, the authors would like to thank you to the population of this research.

REFERENCES

- Bangkok Mass Transit Authority (2011), Bangkok Mass Transit Authority, 28 August 2011 from Bangkok Mass Transit Authority: http://www.bmta.co.th/th/about_history.php/.
- Bangkok Mass Transit System Public Company Limited (2011), Bangkok Mass Transit System Public Company Limited, 19 August 2011 from Bangkok Mass Transit System Public Company Limited: <http://www.bts.co.th/customer/th/main.aspx/>.
- Bangkok Metro Public Company Limited (2005), Bangkok Metro Public Company Limited, 25 August 2011 from Bangkok Metro Public Company Limited: <http://www.bangkokmetro.co.th/>.
- Biggs N., Lloyd E., and Wilson R., (1986), "Graph Theory", Oxford University Press, P.1736-1936.
- Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L.; Stein, Clifford (2001). "Section 24.3: Dijkstra's algorithm". *Introduction to Algorithms* (Second ed.). MIT Press and McGraw-Hill. P.595–601. ISBN 0-262-03293-7.
- Dijkstra, E. W. (1959). "A note on two problems in connexion with graphs". *Numerische Mathematik Vol.1* P. 269–271.
- Lursinsap C., Analysis and Design of Algorithms, Bangkok, School and University Media Publishing, 2000.

- [8] Zhan F.B. and Noon C.E. (February 1998). "Shortest Path Algorithms: An Evaluation Using Real Road Networks". *Transportation Science* Vol.32 (1): P.65–73.
- [9] Eklund P.W., Kirkby S., Pollitt S., (1996) "A Dynamic Multi-source Dijkstra's Algorithm for Vehicle Routing", *Intelligent Information Systems* P.329-333.
- [10] Schulz F., Wagner D., Weihe K., (2000), "Dijkstra's algorithm on-line: an empirical case study from public railroad transport", *Journal of Exponential Algorithmics* Vol.5.
- [11] Epp S.E., *Discrete Mathematics with Applications* 3rd Edition, Belmont CA, Thompson Publishing, 2004.