Analysis of Excessive Cost of Overlapped Bus Route System in Bangkok

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Abstract

Bangkok, as the capital of Thailand, has been drastically growing in economic aspect and population. It has also been ranked as one of the top destinations over the past decades. It therefore attracts more immigrants from the rural areas and tourists from several parts of the world. One of the main drawbacks in Bangkok is public transportation system. Unlike other capitals of the developed and some developing countries, public transportation in Bangkok is not fully organized. Bus transportation is the core of the current system and it is operated by the Bangkok Mass Transit Authority (BMTA). According to the BMTA annual report 2011, it operates 108 bus routes and has been suffered from an accumulated loss of over 5 billion baht (approximately 160 million dollars). Three key causes of such loss include bus routes, policy conflicts and its quality of services. Most of the bus routes managed by BMTA are long and overlapped. There are plenty of buses on the same routes, especially in the city centers. Further, long route decreases the number of operating cycles, generating less income. The BMTA provides transportation services to the public and it also aims for profits. Ticket prices have to be maintained as long as possible in order to minimize the impacts, especially to the low-income. The investment has been temporarily ceased which has crucial effects to its quality of services. The passengers usually have to wait for their buses for an unknown period

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of time and the buses do not provide acceptable comfort. Therefore, the "BMTA ex-passengers" gave up and arranged to own personal vehicles. The number of private vehicles is increasing and it results in an increased severity of traffic-jam problem in Bangkok. Such effects undoubtedly worsen the BMTA's crisis.

Overlapped bus routes directly affect the BMTA's operations as they increase the number of vehicles in the traffics and decrease the number of operating cycles. This case presents an analysis of the effects of the overlapped bus route operated by the BMTA. Current situations including operating and financial aspects of the BMTA, together with its plans are provided. A computerized system has been developed to support data input, processing and output – both reports and graphical representations. The bus route is simulated by the graph theory where a node represents main bus stop or junction and an edge represents bus route. The results demonstrate degree of the existing overlaps and their corresponding costs. Further, several feasible policies on bus route adjustments and the feasible corresponding impacts are introduced.

Keywords: Public Transportation System, Computerized System, Overlapped Bus Route

การวิเคราะห์ต้นทุนอันเนื่องมาจากการทับซ้อนของเส้นทางการเดินรถของระบบรถโดยสารประจำทางในเขตกรุงเทพมหานคร

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บทคัดย่อ

กรุงเทพมหานครซึ่งเป็นเมืองหลวงของประเทศไทย กำลังเติบโตทั้งในมิติด้านเศรษฐกิจและจำนวนของประชากรที่เพิ่มขึ้นอย่างต่อเนื่อง ได้รับการจัดอันดับให้เป็นหนึ่งในเมืองชั้นนำสำหรับการท่องเที่ยวในช่วงทศวรรษที่ผ่านมา ส่งผลให้เกิดการย้ายถิ่นฐานของประชาชนในประเทศและดึงดูดนักท่องเที่ยวจากทั่วโลก จุดอ่อนที่สำคัญประการหนึ่งของกรุงเทพมหานคร ได้แก่ ระบบขนส่งมวลชนซึ่งยังมีการดำเนินงานที่ยังไม่เป็นระบบอย่างสมบูรณ์เฉกเช่นเดียวกับเมืองหลวงของประเทศที่พัฒนาแล้ว หรือบางประเทศที่กำลังพัฒนา ในปัจจุบัน การเดินรถโดยสารประจำทางเป็นระบบขนส่งมวลชนหลักและดำเนินงานโดยองค์การขนส่งมวลชนกรุงเทพ (ขสมก.) โดยข้อมูลจากรายงานประจำปี 2554 พบว่า ขสมก. ดูแลเส้นทางการเดินรถโดยสารทั้งสิ้น 108 เส้นทาง และประสบกับปัญหาขาดทุนกว่า 5,000 ล้านบาท โดยมีสาเหตุหลัก 3 ประการ ได้แก่ เส้นทางการเดินรถ การขัดแย้งของนโยบาย และคุณภาพของการให้บริการ เส้นทางการเดินรถโดยสารประจำทาง ส่วนใหญ่มีระยะทางที่ยาวและทับซ้อนประกอบไปด้วยสายรถประจำทางจำนวนมากโดยเฉพาะอย่างยิ่งในบริเวณกลางใจเมือง ส่งผลให้จำนวนรอบของการให้บริการลดลงเนื่องจากเวลาในการเดินทางยาวนานขึ้นจากการจราจรที่คับคั่ง และรายได้ที่ลดลง หน้าที่หลักของ ขสมก. คือ การให้บริการด้านการขนส่งแก่ประชาชนและต้องแสวงหาผลกำไร

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ราคาตั๋วโดยสารต้องถูกตรึงไว้ให้นานที่สุดเพื่อลดผลกระทบต่อประชาชนที่มีรายได้น้อย รวมถึงต้องชะลอการลงทุนชั่วคราวส่งผลให้คุณภาพการให้บริการลดลง โดยปกติแล้วผู้โดยสารไม่สามารถคาดคะเนระยะเวลาในการรอรถโดยสารได้ อีกทั้งยังไม่ได้รับความสะดวกสบายเท่าที่ควร ดังนั้น ผู้โดยสารจำนวนไม่น้อยจึงเลิกใช้บริการของ ขสมก. และหันไปซื้อยานพาหนะส่วนตัวแทน ส่งผลให้จำนวนยานพาหนะในระบบเพิ่มสูงขึ้นและมีผลกระทบต่อ ขสมก. อย่างหลีกเลี่ยงไม่ได้

การทับซ้อนของเส้นทางการเดินรถโดยสารประจำทางส่งผลกระทบโดยตรงต่อการดำเนินงานของ ขสมก. เนื่องจากเพิ่มปริมาณยานพาหนะบนท้องถนนและลดจำนวนรอบของการให้บริการ กรณีศึกษานี้นำเสนอการวิเคราะห์ผลของการทับซ้อนของการเดินรถโดยสารประจำทางของ ขสมก. โดยกล่าวถึงสถานการณ์ด้านการดำเนินงาน การเงิน และแผนงาน ระบบคอมพิวเตอร์ได้ถูกพัฒนาขึ้นเพื่อรองรับกระบวนการรับข้อมูลเข้า การประมวลผล และการนำเสนอผลลัพธ์ ทั้งแบบรายงาน และแบบกราฟิก ทั้งนี้ ทฤษฎีกราฟได้ถูกนำมาใช้ในการนำเสนอเส้นทางการเดินรถโดยโหนดแสดงถึงจุดหยุดรถหรือทางแยกที่สำคัญ เส้นขอบแสดงถึงเส้นทางการเดินรถ ผลลัพธ์ชี้ให้เห็นถึงระดับการทับซ้อนและต้นทุนที่เกี่ยวเนื่องกัน นอกจากนี้ ยังนำเสนอถึงนโยบายที่เป็นไปได้ในการปรับเส้นทางการเดินรถโดยสารประจำทาง รวมถึงผลกระทบที่อาจเกิดขึ้น

คำสำคัญ: ระบบขนส่งมวลชน ระบบคอมพิวเตอร์ การทับซ้อนของเส้นทางการเดินรถโดยสารประจำทาง

Bangkok Mass Transit Authority (BMTA)

History

Bangkok has been the capital of Thailand for over 200 years. As being the center of economical, cultural and societal aspects of the country, Bangkok is expanding in terms of population size and is attracting tourists across the globe. According to the report of the Institute for Population and Social Research as shown in IPSR (2014), Bangkok has the population size of 7.98 million in June 2014 or approximately 12.30% of the entire population in Thailand. Moreover, regarding the report by The Nation (2013), Bangkok has won the "World's Best City Award" for 4 years (2010-2013) where the criteria used were tourist attractions; culture and customs; food hygiene and taste; shopping availability; hospitality; and monetary worthiness. Several key infrastructures are therefore required in order to support the future growth and development of Bangkok.

Public transportation is crucial in all cities to facilitating mobility. In Bangkok, bus is the major public transportation system and it is operated by the Bangkok Mass Transit Authority (BMTA). The history of BMTA was started in 1907 where the horses were initially used to save costs and attract the feasible operators. However, the service was not satisfied by the customers in terms of travelling delay and short path. The engines were then used in 1913 together with extended route. Such improvement resulted in better feedbacks. Bus transportation was expanded to celebrate the 150th Anniversary of the Rattanakosin Reign in 1932. Moreover, the first bridge over the Chao Phraya River which connects the districts Phra Nakorn and Thonburi, The Memorial Bridge (Phra Putta Yodfa Bridge), was opened. This resulted in more mobility requirements and in total of 28 companies operated bus transportation. The problems of bus transportation arose due to two main reasons. Firstly, there were many companies which tried to get passengers on the overlapped bus routes. Secondly, the fuel cost was high during the post World War II period. The operators could not increase the fairs, faced losses and stopped the operations. The government saw the opportunities to organize the existing services by establishing a government enterprise. The firm was then transformed to a service-oriented government agency and named "Bangkok Mass Transit Authority" on October 1st, 1976.

Situation

BMTA has been running bus transportation in Bangkok and metropolitan areas for 38 years. According to its 2011 annual report, BMTA owns 1,659 regular buses and 1,850 air-conditioned buses (in total of 3,509 buses). There are 108 bus routes which are grouped into 8 stations. The stations are not categorized regarding their territory meaning that a bus line can travel across one or more stations. As BMTA provides fundamental services, it should maintain the ticket fares while achieving the business goals – making profits and avoiding losses. Unfortunately, such tradeoff cannot be handled. BMTA has been struggling from accumulated losses over years. According to BMTA (2011), BMTA had an income mainly from ticket sales of 4,088 million baht (approximately 127.75 million dollars) while two key expenses included salary and fuel of 3,105 (approximately 97.03 million dollars) and 3,092 million baht (approximately 96.63 million dollars), respectively. In conclusion, BMTA lost over 5,125 million baht (approximately 160 million dollars) in such year.

The monetary situation of BMTA becomes worse for two reasons. Firstly, there are more travelling alternatives, such as vans and motorcycles, offered by several private firms. Operational costs of such companies are significantly lower. Regarding the study of Thongsuk (2013), the operational costs of BMTA are approximately three times higher than those of the private firms. One of the key causes is diesel instead of gas usage. Several policies are also stated such as fuel substitution, early retirement and overlapped route decrement. Secondly, the passengers have not been serviced properly. The results shown in Rujikiatkumjorn and Wangjiranirun (2013) demonstrate the difference between public transportation and private drive travelling expenditures is insignificant whereas that of travelling times is considerable. Moreover, the cost of public station is more highly susceptible to the fuel prices than such of private car. According to the survey on passengers' satisfaction conducted by Buakitti (2007), service-based qualities in terms of tangibles, reliability, responsiveness, assurance and empathy are rated at "Fair" level. Similar results were obtained except the cleanliness of staffs' uniforms which is "Good" regarding Tuntivasinchai (2002). Furthermore, Buakitti (2007) indicates that up to 40% and 30% of the passengers take only one ride and take the buses during the rush hours, respectively. The observed number of rides reflects convenience required by the passengers. However, the duration taken by each journey is not reported in the study.

As the results of uncomfortable services gained, the “BMTA ex-passengers” gave up and arranged to own personal vehicles. Figure 1 sourced by Department of City Planning (2012) shows the number of BMTA passengers from 1992 to 2010. The number of passengers of regular buses (dark blue line) have been decreasing from almost 4 million to 0.5 million over 18 years. In the case of air-conditioned buses (pink line), they attracted more passengers only from 1992 to 2000. Furthermore, the number of private vehicles is increasing and it results in increased severity of traffic-jam problem in Bangkok. Such effects undoubtedly worsen the BMTA’s crisis. In order to reduce the operating expenses, BMTA decides to maintain its current status. Figures 2 and 3 demonstrate the numbers of vehicles and routes operated by BMTA and other firms from 1997 to 2011, respectively. The number of BMTA buses is shown in pink in Figure 2 while the number of its routes is illustrated in cyan in Figure 3. According to both figures, BMTA did not buy more buses and manage to increase its routes. On contrary, vans have become the most popular.

Have been facing all difficulties for years, BMTA is trying to make its situation better by proposing a rehabilitation plan proposed in BMTA (2012). Three strategies are summarized as follows:

- Expense reduction – by natural gas substitution, transforming the existing air-conditioned buses for natural gas usage, hubs improvement, launching electronic ticket system, organization reform, early retirement, business unit establishment, debt management and routes improvement. BMTA states that the exiting bus routes are too long and complicated. These result in an increase in travelling and waiting times.
- Income increment – by efficiently managing the affiliated-bus companies and asset management.
- Quality improvement – by developing GPS-based tracking system, human capital management and applying quality assurance approaches such as ISO (International Standards Organization).

Analysis

World Bank (2007) points out several key problems and challenges regarding transportation aspects in Bangkok as follows:

- The quality of public transportation in Bangkok is lower than some cities in the same region. The ongoing rail systems were separately built – not fully connected to the bus systems.
- Existing systems do not provide connection among themselves and to the society.
- The passengers usually take a plenty of travelling time and cost. They cannot predict the travelling time due to uncontrolled traffic conditions.
- Road surfaces are mainly occupied by private vehicles.
- Lack of proper logistics application.

Two urgent improvement policies include connection among public transportation systems (especially bus and rail systems) and bus re-route, and operation (to offer better service and to obtain more passengers). The Economic and Social Commission for Asia and Pacific (ESCAP) also suggests four policies in ESCAP (2012) on transportation system improvement as follows:

- Encourage non-motorized vehicle usage by improving corresponding environment and providing facilities.
- Improve bus transportation system.
- Develop rail systems.
- Manage and improve public transportation services.

Hence, bus transportation system improvement is one of the most crucial policies in order to tackle traffic congestion and associated problems (such as air pollution). Like other main cities, Bangkok has been suffering from the worsen traffic problems. Limited road surfaces have to support over 17 million journeys per day. The number of journeys is increasing and it is estimated to reach 26.2 million in 2021. BMTA conducted self-assessment and reported in BMTA (2011). Both external and internal impacts on its loss are addressed as follows:

External factors

- Conflicts between policies and objectives defined by Ministry of Transport (service oriented) and Ministry of Finance (profit oriented), which bring difficulties to management and planning.
- Insufficient budget supported and ticket price controlled by the Thai government, which result in accumulated losses.

- Traffic congestion in Bangkok, which negatively affects both journey time and fuel consumption.
- Unorganized and inefficient bus operation such as routing and scheduling. Most of the bus lines cover too long journey. Only some parts face high demands during peak hours. Hence, scheduling is difficultly controlled. Furthermore, the routes are not properly planned and adjustable regarding passengers' requirements.

Internal factors

BMTA can be considered as a governmental organization which is usually bureaucratic. It outsources private companies for bus maintenance and it also pays rent for the sub-station offices.

What Next?

The previous sections state several problems of the BMTA which cause accumulated losses in the past years. This study focuses on an analysis of the impacts of overlapped routes by means of scientific modeling and computerized simulation. The process follows traditional system development approach which includes requirement analysis, object-oriented analysis and design, implementation and testing. This case can thus be used in several subjects such as object-oriented analysis design and development, computer simulation and computational science.

The key reason of analyzing the overlapped route is in twofold. Firstly, such issue is also concerned by both BMTA and international institutes as addressed earlier. Secondly, preliminary results based upon current operations should be made in order to be used as a tool for feasible route adjustment. However, additional domains cannot be avoided. For example, Buakitti (2007) suggests that an acceptable number of connections should be investigated as most of the BMTA passengers take only one ride to reach their destinations. Details of computerized system development together with corresponding output and analyses are described in the following sections.

Bus Transport Simulation System

Analysis, Design and Development

The key suggestions provided in World Bank (2007) and ESCAP (2012) are quite similar. Bus transportation system should offer better services to keep and attract more passengers. An overlapped bus route causes traffic congestion and inefficient resource usage. Bus route should be therefore revised to address passengers' requirement mainly in terms of convenience (such as shorter waiting time). However, current bus route should be studied and analysed prior to the proper route adjustment. Computerized simulation is one of the promising approaches which requires less cost and provides useful results.

System requirements

In this case study, bus transportation system is simulated by developing a computer system (application software). The system has requirements as follows:

- Data input (bus transportation details) support by manually using the keyboard or pre-formatted binary file using spreadsheet. The input data consists of several fields based on Graph Theory such as node (important place or intersection where one or more buses pass on), edge (demonstrates bus route connecting two nodes), and distance between nodes and bus line.
- Data processing capability in order to yield the output, which illustrates overlapped bus routes. Different colors are used to depict the degree of overlap at the nodes and edges. The distances between nodes are summed to obtain the distance of each bus line. The impacts of overlapped route can then be pointed out.
- Data management, which include insertion, deletion and update. Database management system (DBMS) is used in the computer system. The DBMS acts as an intermediate component between the front-end system (where the user interacts) and the data.
- Result or output representations in textual or graphical formats. The node's location can be automatically shown by the program or specified by the latitudes and longitudes. Several reports are generated including overlap (source, destination and bus line), distance of the bus line and total distances (specified by users).

System design and development

Bus transport simulation system is designed and developed based on an object-oriented concept where each component is considered as an object.

Each object consists of several attributes (characteristics of the object) and methods (functionalities of the object). Figure 4 shows the use case diagram of the bus transport simulation system. The use case diagram depicts the interactions between users (BMTA staffs) and the services offered by the system. According to Figure 4, the system has five services as follows:

- Manage Data – The user is able to insert, delete and update bus transport data.
- Search Path – Upon user's request, the system provides bus route details.
- Path Report – The system shows the distances between the chosen nodes.
- Bus Report – Total distance of the selected bus line is calculated and shown.
- Overlap Report – For the selected overlapped route, the system shows the list of bus lines together with their sources and destinations.

Class diagram of the bus transport simulation system is shown in Figure 5. Each class has its own attributes and methods. All classes work together in order to achieve the predefined requirements and services. The system consists of three classes including Bus, Node and Relation.

- Bus – This class represents the bus in the system and includes key attributes such as bus code, source and destination. It also explains route type – regular or express way. Main methods include attribute management (insert, delete and update) and report generation.
- Node – It represents an important place, bus stop or intersection. Its attributes include node id, node name, latitude and longitude. Standard methods (insert, delete and update) are also found in this class.
- Relation – This class results from the relationship between Bus and Node classes. It demonstrates the edge which is the connection between two nodes and there is at least one bus line travelling along such edge (route). Key attributes from Bus and Node classes are included. The overlap report method is in this class.

Java is used for system development as it is one of the most widely used object-oriented programming languages. Apart from the set of commands or program, database is employed for data storage and management. MySQL is the chosen DBMS in this case study. It is freely distributed and widely used in both academic and industrial communities. The database consists of three tables as follows:

- BUS – Consists of five data fields including OBJECT_ID (automatically generated record ID), BUS_CODE, BUS_NAME, SOURCE and DESTINATION.
- NODE – Consists of five data fields including OBJECT_ID (automatically generated record ID), NODE_CODE, NODE_NAME, NODE_LATITUDE and NODE_LONGITUDE.
- SOURCE_DESTINATION_RELATION – Consists of five data fields including OBJECT_ID (automatically generated record ID), BUS_CODE, NODE_CODE_SOURCE, NODE_CODE_DESTINATION and DISTANCE

Program and Output

This section aims at describing some key output from the bus transport simulation system – both screens and reports. Figures 6 and 7 show the main screen and sub-menus within each menu, respectively. Three main menus include File, Report and Manage. The File menu consists of two sub-menus including New (start the program) and Exit (end the program). The Report menu consists of four sub-menus including Bus Report (add bus line to the system for further analyses), Overlap Report (generate overlapped bus route in the ascending order), Bus Distance Report (show details of the bus lines) and Bus Path Report (show distance between nodes). Finally, the Manage menu facilitates data management of the bus, node and relation. The input data may be prepared by spreadsheet software and then imported to the MySQL as shown in Figure 8.

The main objective of this case study is to obtain the overlapped bus routes. Such output can be shown in graphical or textual format. In the case of graphical representation, the nodes can be automatically placed by the program or by their exact locations regarding latitudes and longitudes as shown in Figures 9 and 10, respectively. Furthermore, different colors are used to illustrate the overlap degree by determining the number of bus lines, both at node and edge. Two colors are applied at the node – 'red' for at least five incoming bus lines and 'pink' for less than five. In total four colors are used at the edge – 'red' (15 or more), 'purple' (more than 10 but less than 15), 'green' (more than 5 but less than 10) and 'black' (5 or less). The program also provides several useful reports including overlap, bus path and bus distance reports as shown in Figures 11, 12 and 13, respectively.

Analysis of Overlapped Route and Distance

There are two sources of input data of this study – from BMTA website and map as shown in Figure 14, and the Siamtraffic website (www.siamtraffic.net). The main reason is that BMTA provides bus transport data mostly in textual format while Siamtraffic generates more graphical representations. Prior to analyze the impacts of overlap bus route, correctness of the result is determined. The bus distances obtained from the system are manually compared to those from BMTA. The comparative results are shown in Table 1.

According to Table 1, up to 90% of the bus lines have their total distances (from source to destination) computed from the program with at most 10% error. The total distance of the whole bus system is 3,405.04 kilometers (km.) which is 2.98% greater than that of BMTA (3,306.35 km.) Hence, the results demonstrate an acceptable accuracy of the program.

The next step is to consider the number of overlapped routes. The processes begin with data retrieval and then count the number of edges which have similar source and destination. There are distinct 1,032 routes in the database. Figure 15 shows the numbers of overlapped bus routes. Two routes have 11 bus lines running on them. In total 387 out of 1,032 routes (or 37.50%) are overlapped and the average overlap is 1.87 bus lines. Apart from determination of the number of overlapped routes, the distances of such routes are also focused. The non-overlapped distances are 1,681.83 km, thus the percentage of overlapped distances is (3,405.04 – 1,681.83) × 100 / 3,405.04 or 50.61. This means that about half of the current operating distances are overlapped.

Analysis of Excessive Cost due to Overlap

The results from the previous section demonstrate significant overlap in routes and distances which considerably affect the cost of operation. According to BMTA (2011), three main costs include salary (41.68%), fuel (41.67%) and others such as depreciation (16.65%). Therefore, fuel and gas account for the cost of BMTA and it increases with the travelling time induced by traffic congestion. The total distance of 3,405.04 km includes the effects of overlap. It is reduced to 2,203.02 km if the overlap is excluded. Therefore, BMTA can save fuel cost of (3,405.04 – 2,203.02) × 100 / 3,405.04 or 35.30% if it re-routes the bus line to avoid the overlap.

Another problem of BMTA which affects the service quality is condition of the bus. The passengers prefer new and comfortable buses whereas BMTA has stopped investing to get new ones. Nowadays, BMTA has 3,509 buses which are grouped into 108 bus lines and cover 1,032 routes. Hence, an average number of buses per line is (3,509 / 108) or 32.49 which averagely cover (1,032 / 108) or 9.56 routes. Furthermore, there are averagely (32.49 / 9.56) or 3.40 buses in each route. An adjustment of the number of bus lines (maintain the number of buses) is useful for revision of the policies. Equation (1) and (2) demonstrate the effects of the number of bus lines (x) on the average numbers of buses (n) and routes (p), respectively and the results are shown in Figure 16.

$$n = 3{,}509 / x \tag{1}$$

$$p = 1{,}032 / x \tag{2}$$

The number of bus lines greatly affects the average numbers of buses and routes, especially when x is equal or less than 20. Such impacts decrease with an increasing number of bus lines. Moreover, many bus lines result in more complicate management as additional staffs and corresponding budgets are required.

Apart from the effects of the number of bus lines, those of overlap on each route are also considered. Recalling that there are averagely 3.40 buses on each route and BMTA has the fuel cost of 3,104 billion baht (approximately 97 billion dollars). Assuming that the passengers do not change the buses during their journeys or neglecting the effects of bus lines on the overlap. Figure 17 shows the impacts of the average number of buses per route on the fuel cost. Linear relationship between fuel cost and the average number of buses per route is observed in Figure 17. An increase in the overlap on each route should be avoided. Figure 18 addresses the impacts of the average number of buses per route on the percentage of change in fuel cost. If there is only one bus on each route, up to 70% of the cost can be saved. However, such analyses do not include travelling timeframe. Fewer buses undoubtedly affect the passengers' convenience as they may wait for their buses longer. On the other hand, more buses require higher fuel cost but decrease the waiting time.

Suggested Policies based on the Results

Bus is one of the main public transportation systems in Bangkok. BMTA, who is responsible for bus transport system, has been suffering from accumulated losses. The problem is becoming worse as more passengers have turned to alternative travelling mode or arranged to have their own vehicles. Traffic congestion is therefore worsened. One of the feasible approaches for tackling such crises is bus re-route. Based upon previous analyses which demonstrate the impacts of overlap, several suggested policies are addressed as follows:

- Make the distance of each bus line shorter in order to increase the number of operation cycles (more frequent trips). Passengers' satisfaction will be increased as waiting time is shorter.
- Decrease the bus line on each route (overlap) to reduce the traffic congestion, especially in the city centers.
- Clearly locate the terminals (hubs) together with adjust the stations in order to offer better services to the passengers. The terminals should be fully connected to the others and the stations should cover only one main area.
- Offer new ticket system to support single journey comprised of unlimited bus changes and within a predefined timeframe. Encourage the use of daily or monthly ticket system in order to relieve the travelling costs.

Affected Issues due to Proposed Policies

Several policies suggested in the previous section are solely based upon the simulation results and the data provided by BMTA. The key is to reduce the number of overlapped routes and to provide convenient hubs. New ticket system is also crucial in order to relieve additional travelling costs due to more connections.

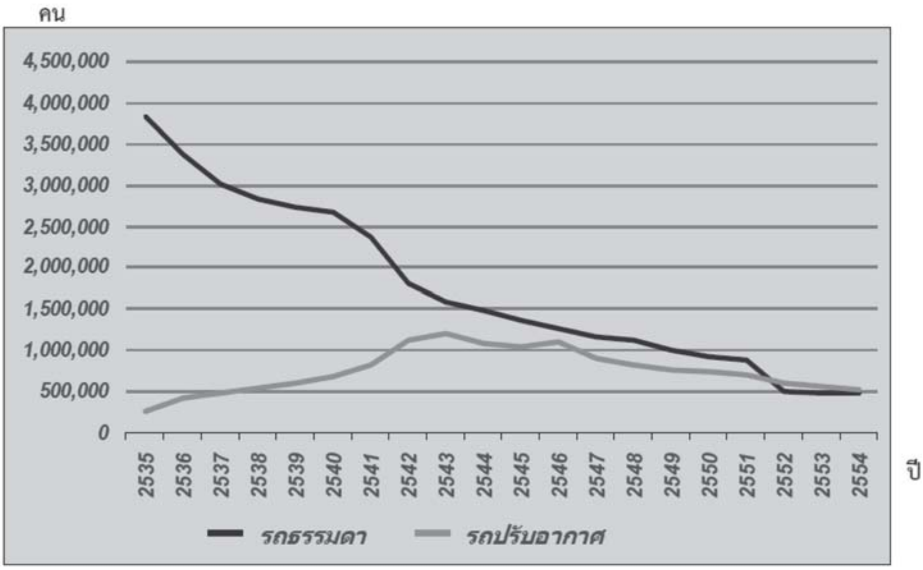
However, feasible side effects should be noted. Firstly, with current pricing model, the passengers must pay for additional travelling costs due to more connections. New ticket system may be one of feasible solutions. Secondly, an increase in connections may violate the passengers' satisfaction. According to Buakitti (2007), up to 40% of the current passengers take only one ride to reach their destinations. More connections may lead to inconveniences, especially the elderly and the disabled people. Terminals or hubs with several facilities may be required under such circumstances. Considerable amount of budgets is desired and the BMTA should carefully determine. Thirdly, waiting time may increase if there are fewer buses available on the specific road.

BMTA should get the passengers' opinions and carefully consider all possible pros and cons of the re-route policies. A plenty of time and effort are undoubtedly required to complete such analyses. Bus re-route approach should be carefully studied and implemented as it considerably and broadly affects both people and society. Passengers' requirements and opinions should be surveyed to obtain the most optimal scheme. Finally, referendum should be conducted.

Conclusion

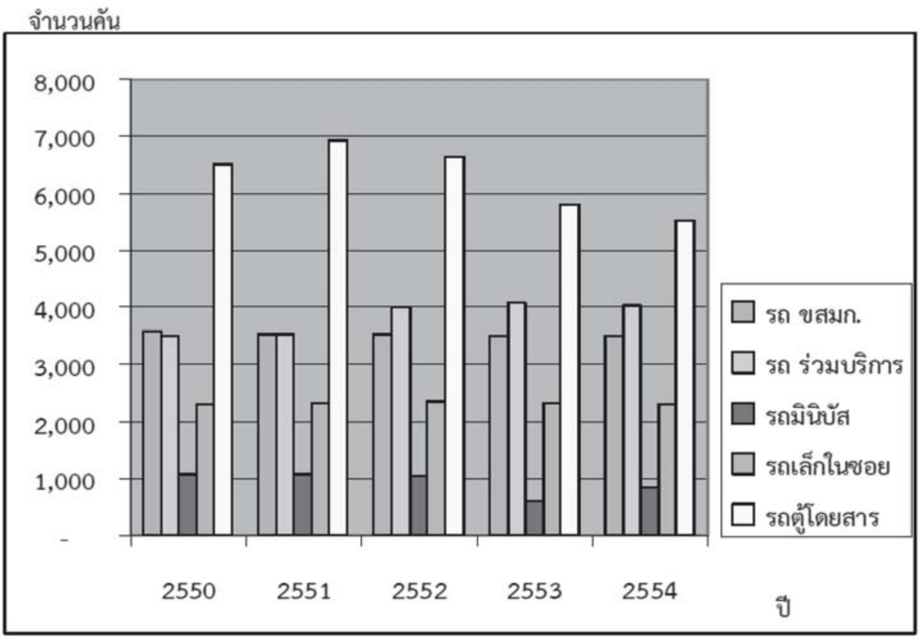
Bangkok Mass Transit Authority (BMTA) has been struggled for accumulated losses since its establishment. Three key causes of such loss include bus routes, policy conflicts and its quality of services. An optimal solution between making profit and providing good service is still impractical. Most of the bus routes managed by BMTA are long and overlapped. This case focuses on the overlapped route which is regarded as one of the key causes and improvements by the BMTA. A computer program is developed in order to simulate the current data from BMTA map and a public transportation guide to yield both textual and graphical reports. The results demonstrate degree of the existing overlaps and their corresponding costs. About half of the current operating distances are overlapped. If there is only one bus on each route, up to 70% of the cost can be saved. However, such analyses do not include travelling timeframe. Several preliminary policies based upon bus re-route are suggested and their side effects are also stated. Moreover, bus re-route approach should be carefully studied and implemented as it considerably and broadly affects both people and society. Passengers' requirements and opinions should be surveyed to obtain the most optimal scheme.

Exhibits



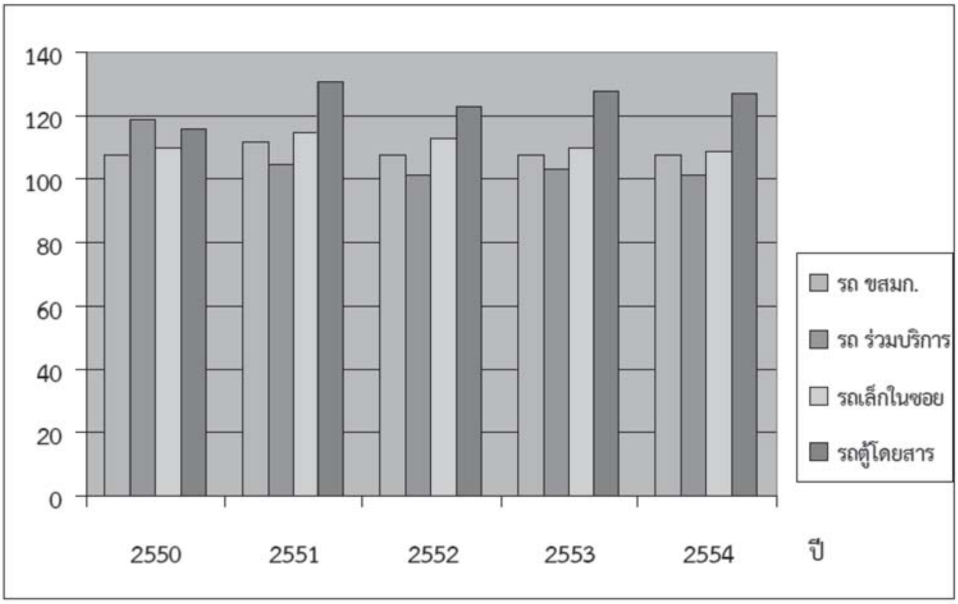
Source: Department of City Planning (2012)

Figure 1: Number of BMTA Passengers from 1992 to 2010



Source: Department of City Planning (2012)

Figure 2: Number of Vehicles operated by BMTA and Other Firms from 1997 to 2011



Source: Department of City Planning (2012)

Figure 3: Number of Routes operated by BMTA and Other Firms from 1997 to 2011

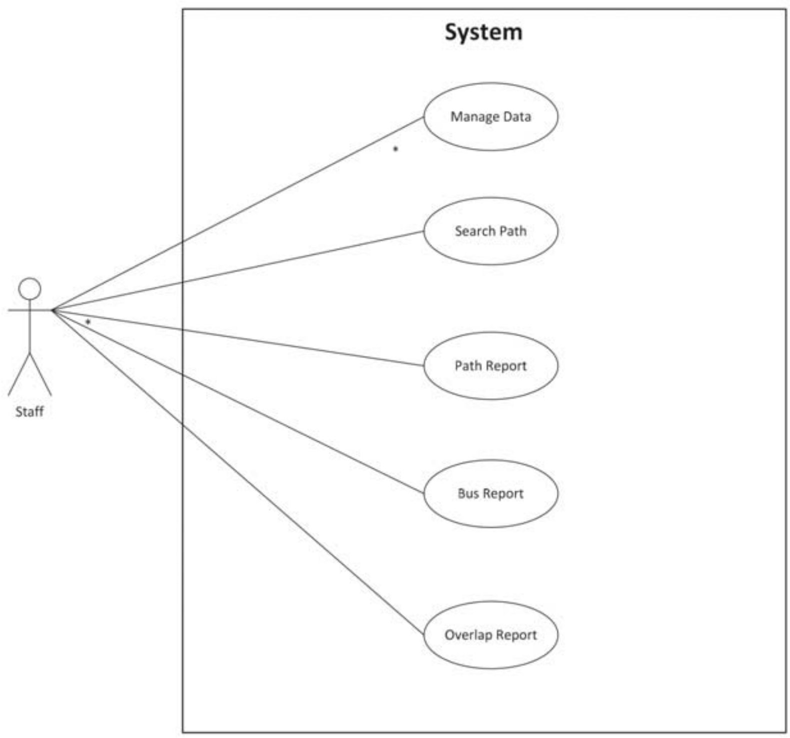


Figure 4: Use Case Diagram of the Bus Transport Simulation System

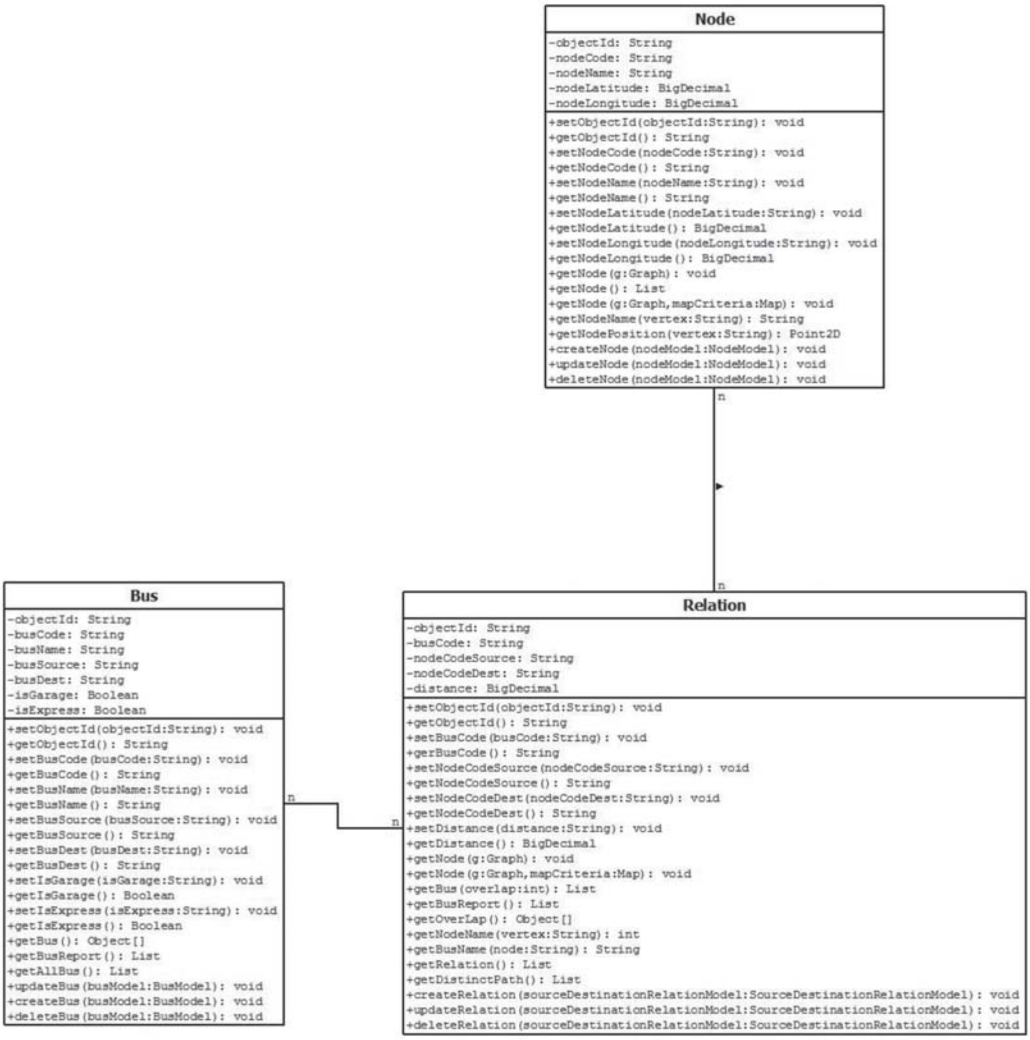


Figure 5: Class Diagram of the Bus Transport Simulation System

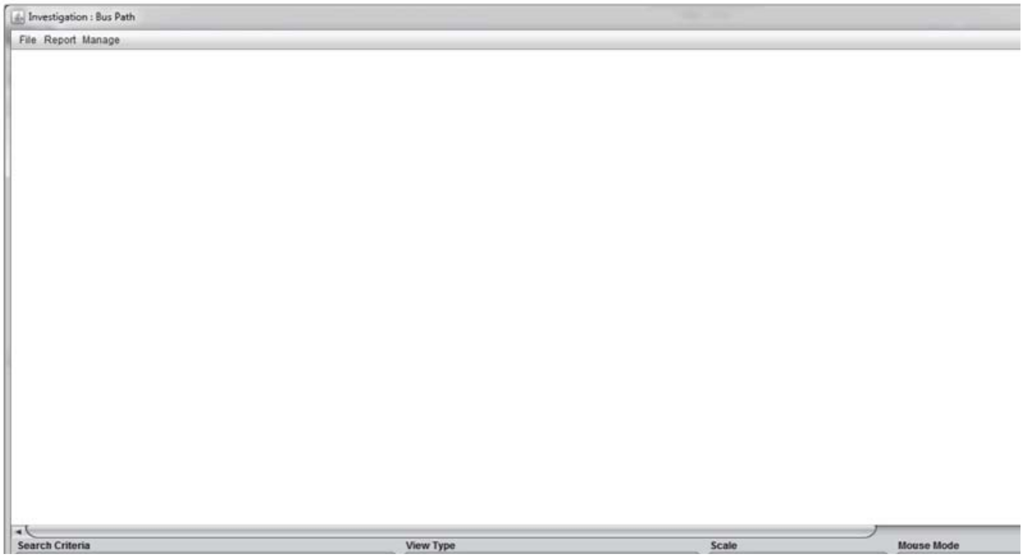


Figure 6: Main Screen of the Bus Transport Simulation System

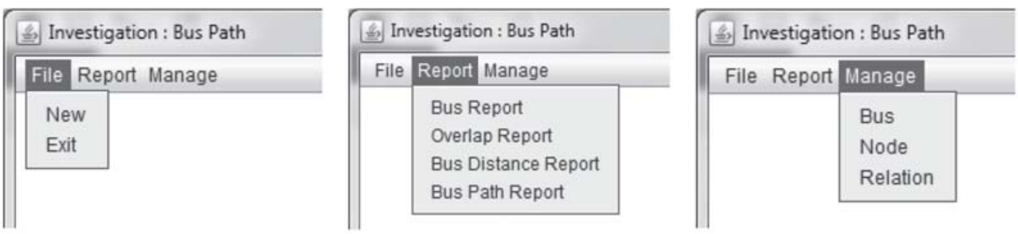


Figure 7: Sub-menus of the Bus Transport Simulation System

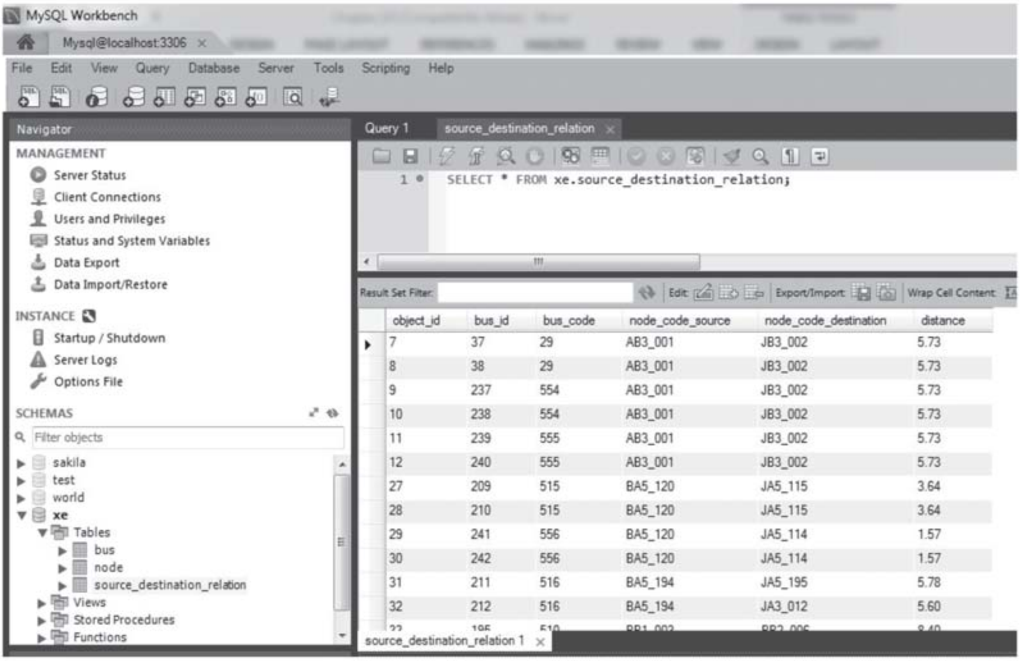


Figure 8: Database Management Using MySQL

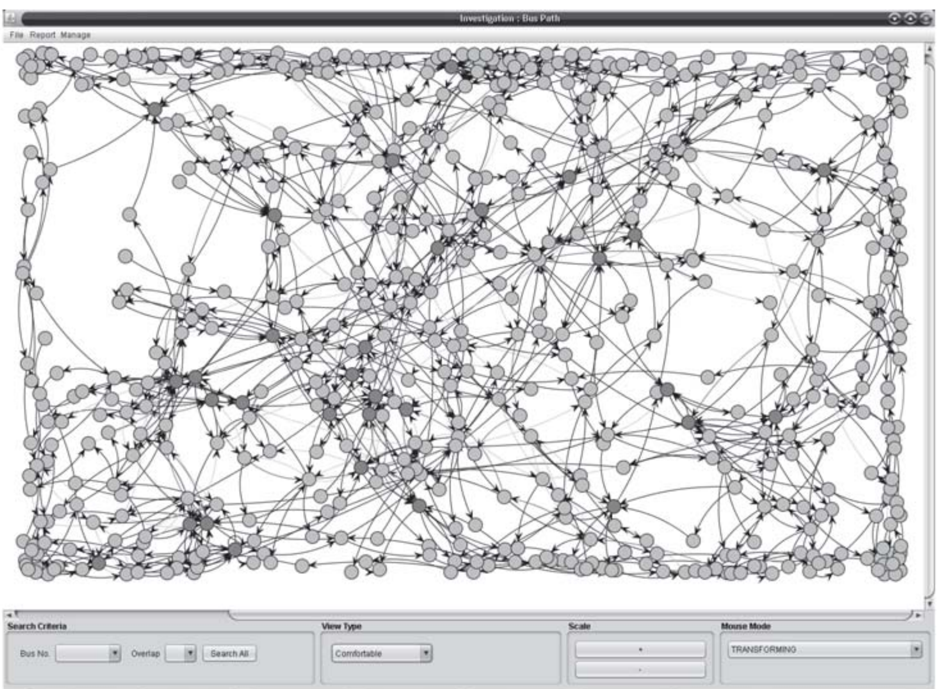


Figure 9: Graphical Representation of the Overlapped Routes where Nodes automatically placed by the Program

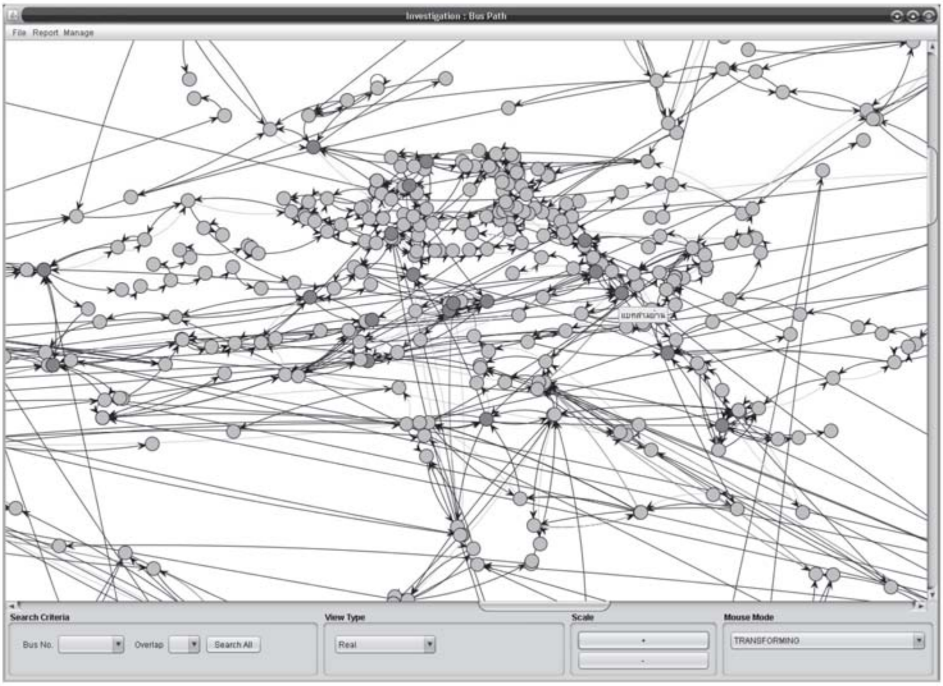


Figure 10: Graphical Representation of the Overlapped Routes where Nodes placed by considering their Latitudes and Longitudes

Overlaping Report

University of the Thai Chamber of Commerce

สายรถเมล์	ชื่อสายรถเมล์	จุดที่ทับซ้อน
11 คัน		
204	กทม.2-ท่าน้ำราชวงศ์	แยกสะพานควาย - แยกซอยอารีย์
27	มีนบุรี-อนุสาวรีย์ชัยสมรภูมิ	แยกสะพานควาย - แยกซอยอารีย์
29	รังสิต-หัวลำโพง	แยกสะพานควาย - แยกซอยอารีย์
34	รังสิต-หัวลำโพง	แยกสะพานควาย - แยกซอยอารีย์
39	ตลาดไท-อนุสาวรีย์ชัยสมรภูมิ	แยกสะพานควาย - แยกซอยอารีย์
502	มีนบุรี-อนุสาวรีย์ชัยสมรภูมิ	แยกสะพานควาย - แยกซอยอารีย์
503	สนามหลวง-รังสิต	แยกสะพานควาย - แยกซอยอารีย์
510	ตลาดไท-อนุสาวรีย์ชัยสมรภูมิ	แยกสะพานควาย - แยกซอยอารีย์
59	รังสิต-สนามหลวง	แยกสะพานควาย - แยกซอยอารีย์
63	อตก.3-อนุสาวรีย์ชัยสมรภูมิ	แยกสะพานควาย - แยกซอยอารีย์
97	นนทบุรี-โรงพยาบาลสงฆ์	แยกสะพานควาย - แยกซอยอารีย์
204	กทม.2-ท่าน้ำราชวงศ์	แยกซอยอารีย์ - แยกราชครู
27	มีนบุรี-อนุสาวรีย์ชัยสมรภูมิ	แยกซอยอารีย์ - แยกราชครู
29	รังสิต-หัวลำโพง	แยกซอยอารีย์ - แยกราชครู
34	รังสิต-หัวลำโพง	แยกซอยอารีย์ - แยกราชครู
39	ตลาดไท-อนุสาวรีย์ชัยสมรภูมิ	แยกซอยอารีย์ - แยกราชครู
502	มีนบุรี-อนุสาวรีย์ชัยสมรภูมิ	แยกซอยอารีย์ - แยกราชครู
503	สนามหลวง-รังสิต	แยกซอยอารีย์ - แยกราชครู

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Figure 11: Overlap Report

Bus Path Report

University of the Thai Chamber of Commerce

ป้ายรถเมล์	ถึง	ระยะทาง
BTS พญาไท	แยกราชเทวี	0.64
BTS ราชเทวี	แยกปทุมวัน	0.65
BTS สนามเป้า	แยกโยธี-พญาไท	1.36
BTS สยาม	แยกอังรีดูนังต์-พระราม 1	0.27
BTS อารีย์	แยกราชครู	0.40
การไฟฟ้าธัญบุรี	ห้างโลตัสธัญบุรี	2.17
การไฟฟ้าย่อยเคหะธนบุรี	แยกสุขสวัสดิ์ ซอย 27	10.51
การไฟฟ้าย่อยเคหะธนบุรี	ท่ารถสาย 105 มหาชัยเมืองใหม่	12.68
การไฟฟ้าย่อยลาดพร้าว	แยกถนนสังคมสงเคราะห์-นาคนิวาส	1.13
คลอง 2 (ลำลูกกา)	แยกลำลูกกา	0.93
คลอง 3 (ลำลูกกา)	คลอง 2 (ลำลูกกา)	3.22
คลอง 4 (ลำลูกกา)	คลอง 3 (ลำลูกกา)	0.61
คลอง 5 (ลำลูกกา)	คลอง 4 (ลำลูกกา)	0.76
คลอง 6 (ลำลูกกา)	ต่างระดับลำลูกกา	1.51
คลองหลอด	จราจรกลาง	0.66
จราจรกลาง	วัดสุทัศน์	0.36
ดินแดง (ด่านทางด่วน)	แยกสามเหลี่ยมดินแดง	0.98
ตลาดมีนบุรี	แยกถนนเจริญพัฒนา-รามอินทรา	3.54
ต่างระดับคลองหลวง	ต่างระดับรังสิต	8.40
ต่างระดับงามวงศ์วาน	แยกโรงกรองน้ำ	9.27

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Figure 12: Bus Path Report

Bus Distance Report

University of the Thai Chamber of Commerce

สายรถเมล์	ชื่อสายรถเมล์	ระยะทาง
เที่ยวไป		
1	ถนนตก-ท่าเตียน	42.85
101	วัดม่วง-บางมด	18.96
102	ปากน้ำ-เซนทรัลพระราม 3	16.72
105	มหาชัยเมืองใหม่-คลองสาน	22.25
107	อู่บางเขน-คลองเตย	17.90
111	บคคโล-เจริญนคร	16.50
114	ตลาด อตก.3-ลำลูกกา	26.27
117	กทม.2-ท่าน้ำนนท์	11.40
129	บางเขน-สำโรง	30.11
13	หวัยขวาง-คลองเตย	12.30
134	หมอชิต 2-บัวทองเคหะ	32.08
136	กรมศุลกากร-หมอชิต 2	64.68
137	วงกลมรามคำแหง-ถนนรัชดาภิเษก	26.67
138	หมอชิต 2-พระประแดง	22.99
140	อนุสาวรีย์ชัยสมรภูมิ-อู่แสมดำ	29.68
141	อู่แสมดำ-ม.จุฬาฯ(ออกเมือง)	60.94
141	อู่แสมดำ-ม.จุฬาฯ(เข้าเมือง)	60.94
142	เคหะฯธนบุรี-อู่ฟาร์มจระเข้	30.21

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Figure 13: Bus Distance Report

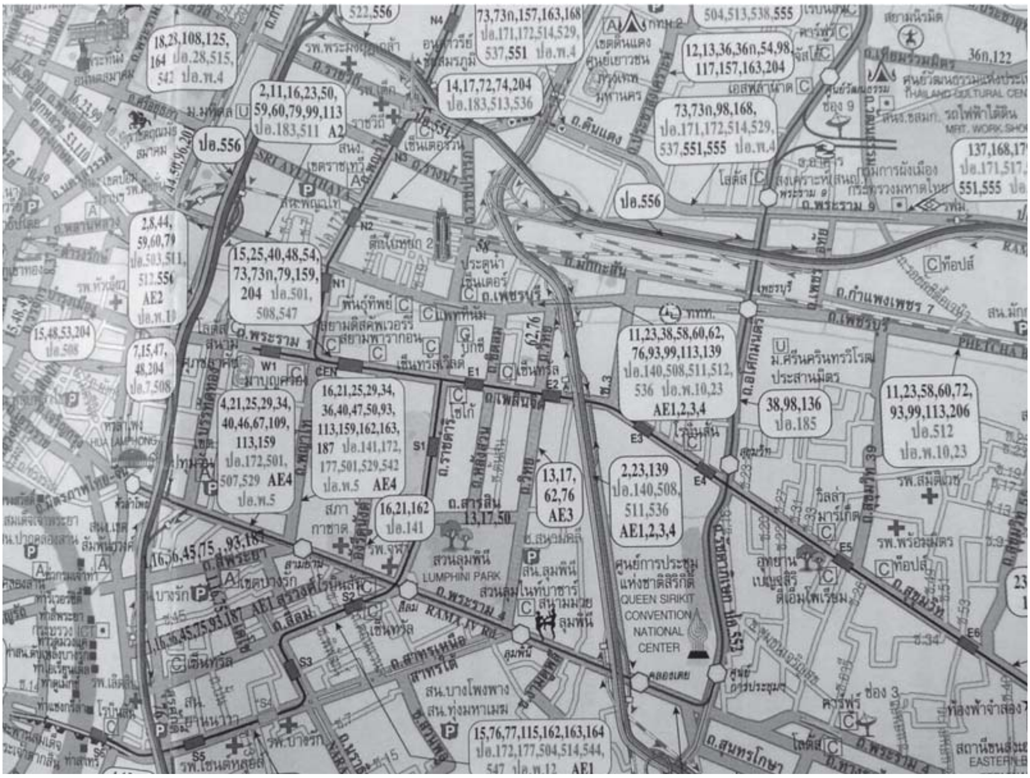

Figure 14: BMTA Map

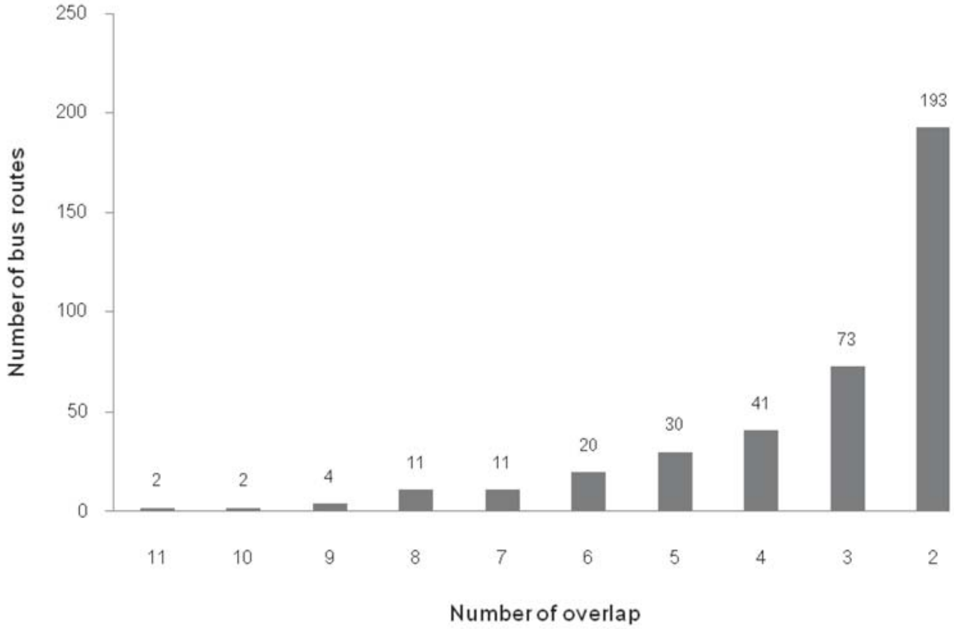

Figure 15: Number of Overlapped Bus Routes

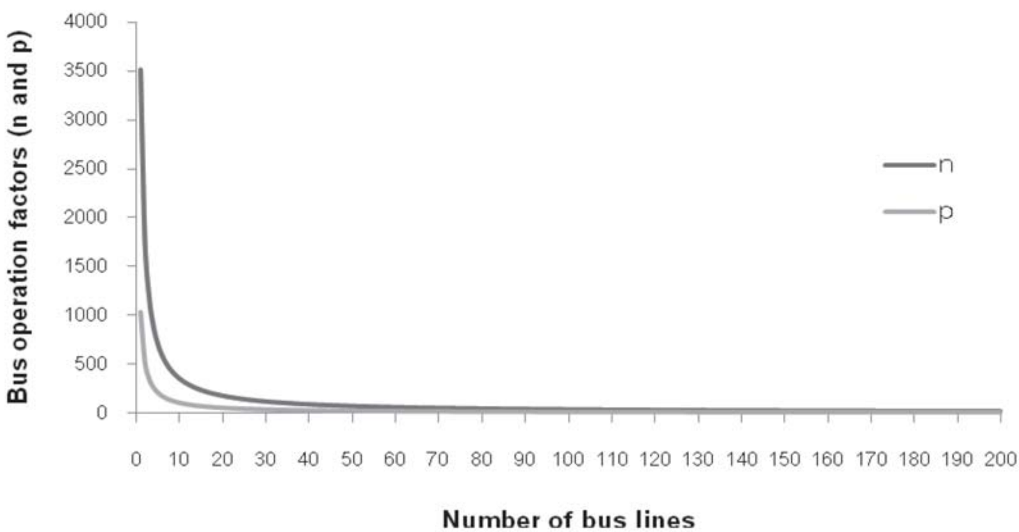

Figure 16: Impacts of the Number of Bus Lines (*x*) on Bus Operation Factors including the Average Number of Buses (*n*) and the Average Number of Routes (*p*)

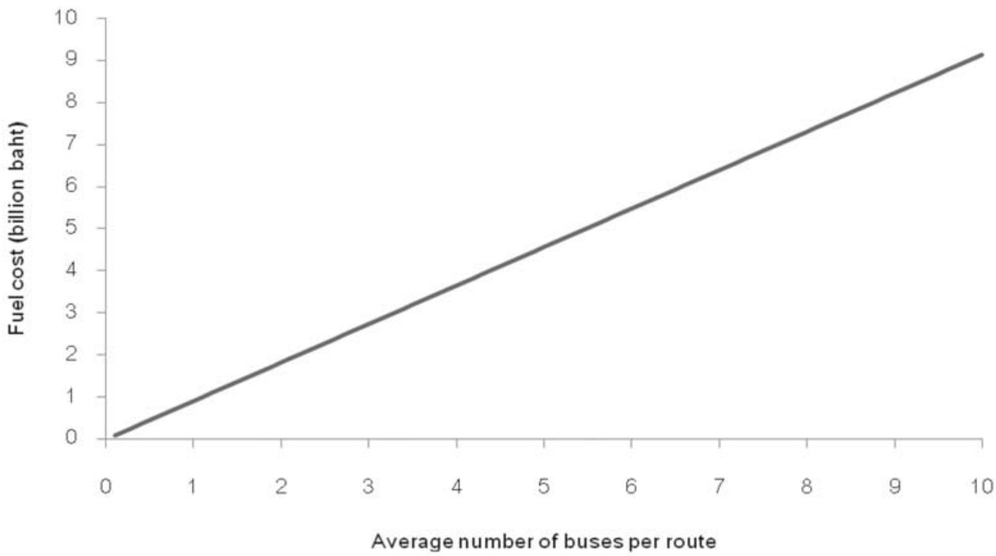

Figure 17: Impacts of the Average Number of Buses per Route on Fuel Cost

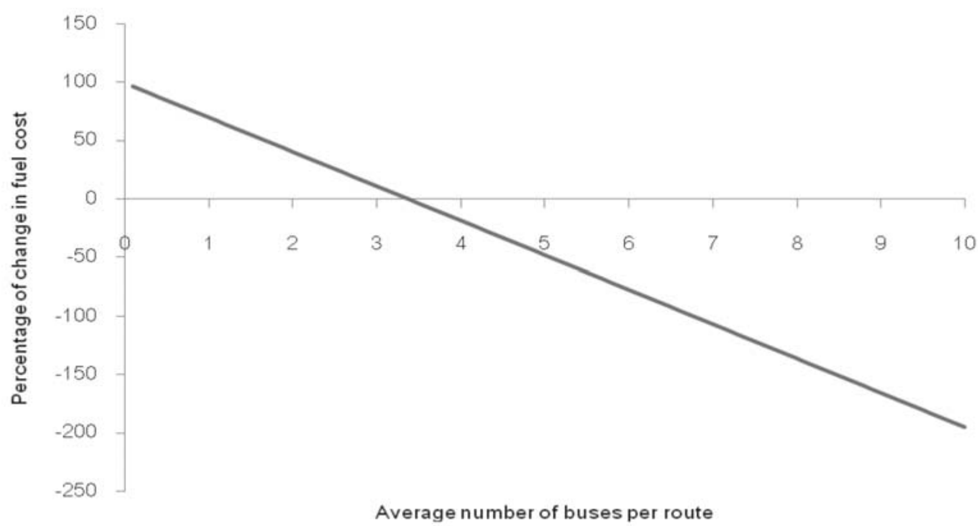

Figure 18: Impacts of the Average Number of Buses per Route on the Percentage of Change in Fuel Cost

Table 1: Comparative Results between the Distances obtained from the Program and those from BMTA

	Percentage of the Number of Buses		
Error (%)	**Greater than BMTA**	**Less than BMTA**	**Total**
21-25	1.85	0	1.85
16-20	0.93	1.85	2.78
11-15	3.70	0.93	4.63
6-10	122.04	10.19	22.23
1-5	37.04	31.48	68.52
0	0	0	0

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