CHAPTER I

INTRODUCTION

I.1 Overview of Project Area

Paris Metropolitan is the major transport systems that serving millions of commuters everyday in metropolitan areas. The networks are a high frequency service established mainly in underground tunnels or on elevated tracks separated from other traffic. There are 16 lines that are mostly in underground railway tunnel with 214 km in length and 301 stations which 62 of them to facilitate transfer to another line. Paris metro is also the second busiest metro sytem in Europe after Moscow. Wikipedia, 2012 explained Paris metro runs the surface consists of the viaduct sections within Paris (on lines 1, 2, 5, 6) and the suburban ends of lines 1, 5, 8, and 13. The system's tunnels are relatively close to the surface due to the variable nature of Paris's earth which doesn't permit deep digging; exceptions include parts of line 12 under the hill of Montmartre and line 2 under Menilmontant. The width of the carriages, 2.4 metres across, is narrower than that of newer French systems (such as the 2.9 metres carriages in Lyon, one of the largest in Europe) and lines 1,4, and 14 have capacities between six and seven hundred passengers; against two thousand six hundred on the Altéo MI 2N trains of RER A. The size of the Metro cars (and tunnels) was deliberately chosen by the City of Paris to prevent the running of French mainline trains in the Paris Metro system; the City of Paris and the nation of France had historically poor relations. In contrast to many other metro systems (such as those of the New York, London, and Boston), all of Paris's lines have tunnels and operate trains with the same dimensions. Five Parisian lines (1,4,6,11, and 14) are capable of running on a rubber tire system developed by the RATP in the 1950s; later exported for use on the Métros of Montréal, Santiago and Mexico City. The number of cars in each train varies line by line from three to six; most have five and eight is possible on the new line 14. Just two lines, 7 and 13, have branches at the end, and trains serve every station on the line except when they are closed for renovations.

The first train leaves the terminus at either end of each line at 5:30 am, although, on some lines, additional trains may also start from an intermediate station. The last train, often called the "balai" (broom) because it sweeps up remaining passengers, arrives at the terminal station at 1:15 am, except on Fridays, Saturdays, and on nights before a holiday, when the service ends at 2:15 am.

Paris and the existing railway companies were already thinking by 1845 about an urban railway system to link inner districts of the city. The railway companies and the French national government wanted to extend existing mainline railroads into a new underground network in Paris, whereas the Parisians favoured a new and independent network and feared national takeover of any system it could build. The disagreement lasted from 1856 to 1890. Meanwhile, the population became more dense and traffic congestion grew massively. The deadlock put pressure on the authorities and gave the city the chance to enforce its vision.

Prior to 1845, Paris's urban transport network consisted primarily of a large system of omnibus lines, consolidated by the French national government into a regulated system with fixed and unconflicting routes and schedules. The first concrete proposal for an urban rail system in Paris was put forward by engineer named de Kerizouet. This plan called for a surface cable car system. In 1855, civil engineers Edouard Brame and Eugene Flachat proposed an underground freight urban railroad for Paris, due to the high rate of accidents on surface rail lines. On November 19, 1871,the General Council of the Seine commissioned a team of 40 engineers to plan an urban rail network. This team proposed a network with a pattern of routes "resembling a cross enclosed in a circle" with axial routes following large boulevards. On May 11, 1872, the Council endorsed the plan, but the French national government turned down the plan. After this point, a serious debate occurred over whether the new system should consist of elevated lines or of mostly underground lines; this debate involved numerous parties in France (including Victor Hugo, Guy de Maupassant, and the Eiffel Society of Gustave Eiffel) and continued until 1892. Eventually, the underground option emerged as the preferred solution because of the high cost of buying land for rights-of-way in downtown Paris (required for building elevated lines), estimated at 70,000 francs *per meter* of line for a 20 meter-wide railroad.

I.2 Background

Mass Rapid Transit in tunnel system is one of the major mass transportation in most of the countries around the world. With the increasing of population, commercial activities, industrial, and social activities turns out to the demand of safe, comfortable and reliable railway sevice. Any delays and interruption on railway service can bring a city to a standstill that may occur to a significant economic loss. One of the major problems in the subway system is the operational cost that cause by the energy consumption need to be reduce. The reducing of energy consumption also leads to the "green transportation" and stakeholders (major of the city) could use the budget for the transportation to another field like education, rural area development, etc.

I.3 Project

The author starts from evaluating the effectiveness and efficiency. Efectiveness in engineering terms means "do the right things" that related to the service quality. Sevice quality itself in this research related to the end user. Efficiency in engineering terms means "do the things right" that related to the energy consumption. The typical interstation run out, a train accelerates from a station to maximum speed and maintains the train speed as much as possible until it is necessary to brake to a halt for the next station. Usually, the running time is the shortest and the energy consumption is the highest as the train is running close to the maximum permissible speed throughout the trip. The traction motors are allowed to turn off once the train accelerates above a certain speed if coasting is allowed. With the application of coasting, the momentum of the train carries it through and the brake is still needed to bring the train to stop at the next station. Interstation run time is longer but the energy saving can be achieved because the train spends less time on motoring.

I.4 Intellectual Challenge

Most of the research or books are focus on the interstation with the single link but at the real world problem, we face a railway network with multiple link. This book also examines the energy consumption by the multiple trains and taking interactions as the consideration. This research will use genetic algorithm integrated with simulation is designed to seek the approximate optimal coasting control strategies on the railway network. The control strategies that will be examine is network-based strategy which on other research examine link-based coasting strategy.

I.5 Objectives

There are 3 objectives for this research which is:

1. To know the performance and the amount of the energy that could be reduced.
2. To know the performance and the travelling time that could be reduced with the proposed approach.
3. To know the Carbon and CO_2 reduced with the proposed approach.

I.6 Scope and Limitations

There are several assumptions which is:

1. The railway network systems are on the flat ground without deviation degree.
2. There is no disruption on the Mass Rapid Transit systems. One example for the disruption is there is no people entering the train at the time when the door will be close because it will disrupt the system because the door will be open again and it will takes time to close the door again and the train has to move

faster in order to reach the punctuality on the next station which means there are more energy consume at that time.

There are several limitations which is:

1. There are not enough time to study the correlation between the tunnel systems with the energy that being used for the air-conditioning system.
2. This book doesn’t include the assessment of the proposed approach control strategy.
3. This proposed approach of this book is only focus on the control strategy while in the planning systems, we can try to simulate and decide where is the best stop for the metro, so that the persons can easily access to this transportation.

CHAPTER II

LITERATURE REVIEW

Mass Rapid Transit (MRT) systems are major transportation that serving millions of population in most of countries around the world. Wong, K.K & Ho, T.K. explained to maximise the capacity of the rail line and provide an eliable service for passengers throughout the day, regulation of train service to maintain steady service headway is essential. On their research they present an application of classical measures to search for the appropriate coasting point to meet a specified interstation run time and they can be integrated in the onboard Automatic Train Operation (ATO) system and have the potential for on-line implementation in making a set of coasting command decisions. The main idea is to identify the coasting point for real time train scheduling control. Two bi-section methods, Golden Section and Fibonacci search, are highlighted, and the idea of how to fix the necessary coasting point with the gradient method is also presented.

The Golden section search algorithm on coasting control to regulate the train schedule, the fitness of two initial coasting points are determined in advance. These two values will then be useful for further search of new coasting point. The basic idea of the Golden section search is that the solution space is divided into two unequal parts, the ratio of the larger of two segments to the total length of the interval should be the same as the ratio of the smaller to the larger segment. If the coasting points are placed with this fractional spacing from either end on the solution space, the solution space will then be reduced to a length of 0.618 times the previous of uncertainty of interval. It is obvious that one of the two evaluations of coasting point is available for the next step by the virtue of the golden ratio. Thus only one additional "golden-spaced" evaluation is required to reduce the solution space by 0.618 fraction. The process is repeated again and the uncertainly of interval is further reduced by the golden ratio until the obtained coasting point satisfies the expected train operational requirement in an interstation run. To achieve the maximum reduction in the subsequent solution space, the evaluations should be placed symmetrically about the centerline of the solution space. When this is done, a new evalutaion provides an additional reduction in the solution space.

The Fibonacci search is very similar to the Golden section search. The main different of the reduction ratio on the solution space in each iteration is fixed at 0.618 with the Golden search, whilst the reduction ratio varies with the previous uncertainty of interval in Fibonacci search. Fibonacci search provides a better reduction ratio on the solution space in each iteration if the maximum number of iterations is predetermined in advance. The gradient method uses the derivative as illustated in equation II-1 to locate the necessary coasting point. Similarly, the fitness of two initial coasting point are predetermined and the search direction of the updated coasting point depends on the polarity and the magnitude of the gradient.

Gradient = $\frac{\Delta\, Run\ time}{\Delta\, Coasting\ location}$ ....(II-1)

Then the step length can be calculated by,

Step length = $\frac{Runtime_{flat-out} - Runtime_{expected}}{\Delta\, Gradient}$ ....(II-2)

And the new coasting point =

Old coasting point + Step length……....................……………....(II-3)

In general, the step length becomes larger when the run-time of the current coasting location is far away from the expected one, or vice versa.

Feng, Xuesong explained the minimalization of the energy saving by optimization of target speeds. In their paper explained according to Hay (1982), Andrews (1986), Mao, et al. (2008), when the maximum speed is raised, higher traction effort is required which implies different patterns of energy consumption. It is then necessary to investigate how the traction enegy cost of a High-Speed Railway (HSR) train changes under a range of taget speeds, taking into account the effect of inter-stop transport distances, traction characteristics of HSR trains and gradients, curvatures, etc. of the rail lines. In particular time-saving may be achieved by various target speeds and the cost to attain such an improvement through highspeed operation should be evaluated. Furthermore, when the target speed of a HSR train is connected to both energy saving and transport efficiency, the setting of its target speed to improve both of them is essential to the service quality and operation cost. The difference in their research is the ability to provide quantitative evaluations of both energy and time saving with respect to target speeds of trains under different inter-stop transport distances, traction equipment characteristic and rail lines gradients, curvature, etc. By analyzing the effect of these factores on the Traction Energy Cost (TEC) and Technical Operation Time (TOT) per 10,000 passenger-kilometres (p-km), Feng proposes to optimize the target speeds of HSR trains in a quantificational manner from the perspectives of both traction energy saving and transport efficiency improvement.

The whole trip of the train from one stop to the next is simulated in successive intervals. The lengths of the calculation intervals are equal to 1 s in the simulation work of their research. The traction force, speed, and operating condition (i.e. motoring, coasting or braking) of the train are considered to be unchanged in one calculation interval. The train at a station is started up with its full traction power towards the target speed. With the first achievement of the target speed by the sustaining acceleration of the train from its startup, the train commences to coast till the difference between its speed and the target speed reaches a pre-set value, which is 10.00 km/h in this work, thereafter accelerate with its full traction power to the target speed alternately. In order to ensure accurate and safe stopping at stations, the train begins to decide whether brakes are necessary or not in a calculation interval when the train arrives at a rail site where there is a certain distance away from the next stop. This is decided according to the speed (v_1) of the train and the permitted speed (v_2), which is determined based on the braking performance of the train and the transport distance from the site of the train at the beginning of this calculation interval to the next stop.

There are 2 conditions:

1. If $v_1 \geq v_{2,}$ the train brakes to decrease its speed as soon as possible to a comparatively very small value, which is able to ensure absolute safety of its stop in