Green Light Please: An Algorithm-Based Public Motility System for Batangas City

"This is no different from the other day," Vera murmured to herself matter of factly, feeling the heat outside her office window as she gazed at the bumper-to-bumper traffic below. Until a few days ago, Vera had been the director of the management information systems department, which designed a comprehensive Batangas City, Philippines roadmap and deployed the city traffic light system. The mayor then appointed her transportation development regulatory officer, tasking her with finding solutions to the city's traffic problems.

Today, Vera's frustration was being pushed to the limit. With a master's degree in computer science, she decided to use algorithms to find ways to ease the city's traffic situation, which had worsened with the collapse of the western portion of the Bridge of Promise that spanned the Calumpang River and served as the main conduit for going to SM Mall, the biggest mall in Batangas City.

Batangas City

Located approximately 108 kilometers south of Manila, Batangas City is one of 144 cities in the Philippines and home to 324,116 residents. It was proclaimed a city on July 23, 1969 and was later classified as a regional growth center and identified as a regional agro-industrial center and special

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economic zone as mandated by the Medium Term Philippine Development Plan and the Ecozone Act of 1995. Based on the area's existing endowments, agro-industrial enhancement was seen as the take-off point for the immediate development of the area. It was one of the nation's top revenue earning cities and the site of one of the biggest refineries in the Philippines. The city was also host to the first three power plants in the country, which used natural gas with a combined capacity of 2,700MW.[1]

Transportation Options in Batangas

With the implementation of the city's new traffic ordinance, public utility jeepney (PUJ) parking areas and terminals had been designated for the various routes throughout the city.[2] (See **Exhibit 1**).

Exhibit 1

Jeepney

Tourism in the Philippines. <http://www.tourisminthephilippines.com/transport/>.

Jeepneys originated from U.S. military jeeps that were used in the Philippines as a means of transporting troops during World War II. After the war, the Americans left hundreds of these jeeps behind. Through the years, the jeepneys' design evolved. Metal roofs were added for shade and the sides and hoods were decorated. Two long parallel benches to seat passengers were built in at the jeep's rear portion. The jeepneys' routes were posted on the front and sides of the vehicles. As the years passed, the jeepneys touring the major thoroughfares increased in size, length, and capacity.[3]

Jeepneys could access many inner-city roads that were off-limits to buses. Jeepneys were color-coded and took standard routes. White and yellow jeepneys took the north city routes, green jeepneys were for the east routes, red jeepneys ran through the northern outskirts, while blue jeepneys ran through the western outskirts of the city.

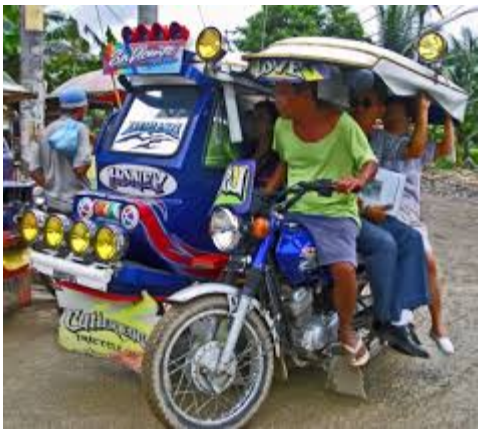
Like PUJs, tricycles also operated through a color coding system. Also called "trikes," tricycles provided point-to-point service. Passengers rode in the side car or sat behind the driver. Tricycles were not allowed on the main roads of the city, so they used the back roads. In 2013, according to the Land

Transportation Office, there were 2,164 tricycles operating in the city, but only 1,394 units obtained the mayor's permit and paid the necessary fees (see **Exhibit 2**).

The Transportation Development and Regulatory Office in Batangas City strictly imposed the law against colorum tricycles, prohibiting tricycle drivers to operate without the required franchise. The law was part of Article IV, Section V and Article 10, Section 46 of the Revised Tricycle Franchising Ordinance.

Exhibit 2

Tricycle



Real Life Philippines

In an effort to address the worsening traffic problems in Batangas City, the city government together with the MIS Department had installed traffic signals at the seven major intersections. The city's traffic signals were upgraded with LED lights and electronic timers in 2010.

As in many cities in the Philippines, 80% of Batangas City residents used public PUJs and tricycles, but private vehicles occupied most of the narrow roads when major car dealers offered a minimal down payment of less than 100,000 Philippine pesos. This created many problems: traffic congestion, air and noise pollution, long travel times, and greenhouse gas emissions, among others.

Batangas City and the City of Suseonggu, which was a part of the Daegu Metropolitan City in South Korea officially established a sister city relationship in November 2009. The mayor on his trip to Suseonggu, had a chance to meet the ecology office director and discussed his concerns over air pollution. He realized that many small changes could make a big difference to provide a good quality of life for every Batangas City citizen. He dreamed of putting a bicycle lane in so bikers wouldn't be at risk while they were exercising. He also envisioned converting the southern part of the plaza, the recreational park, into a venue for aerobics and Zumba activities for women wellness enthusiasts and to decongest traffic on the major roads.

Rapid population and economic growth after Batangas' cityhood in 1969 had resulted in heavy congestion on roadways, especially during peak hours in the morning when students and employees rushed to school and work and in the afternoon when they returned home.[4]

Vera nervously wrung her fingers, knowing too well that she had to present the best solution to the city's traffic problems to the mayor in two weeks. She circled her office and sat at her drawing table with

her computer to start her task. She recalled from memory the different algorithms she learned in college and in her post graduate studies, knowing these would help her.

It is well-known that smoother traffic flow leads to lower emission rates in general. Given a gridlock situation, the algorithms would tell the moves each car made and in which order the cars moved, so that the congestion could be eliminated.

Vera realized she needed to create a system capable of following a trial and error process, leading to the combination of inputs that would give the best output. This could be less expensive than adding a lane.

Could she use the ant colony algorithm, an algorithm for finding optimal paths based on the behavior of ants searching for food?

At first, the ants wander randomly. When an ant finds a source of food, it returns to the colony leaving "markers" or pheromones that show the path with food. When other ants come across the markers, they are likely to follow the path with a certain probability. If they do, they then populate the path with their own markers as they bring the food back. As more ants find the path, a couple of streams of ants traveling to various food sources near the colony are formed. Shorter paths are more likely to be discovered when the ants drop pheromones every time they bring food.

Examples of the Ant Colony algorithms are as follows:

1: for each colony do

2: for each ant do

3: generate route

4: evaluate route

5: evaporate pheromone in trails

6: deposit pheromone on trails

7: end for

Rank Based Ant System (RBAS)

1: for each colony do

2: for each ant do

3: generate route

4: evaluate route

5: end for

6: verify for global or local optimum

7: evaporate pheromone in all trails

8: generate an elite from current colony

9: deposit a Y amount of pheromone on elite trails

10: deposit an X amount of pheromone on best global route

11: end for[5]

Would the traffic problem be rectified by using the Dijkstra's Algorithm, which determines the shortest path?

The shortest path algorithm finds a path between two vertices (nodes) on a given graph, such that the sum of the weights on its constituent edges is minimized. Dijkstra's algorithm was developed by the computer scientist named Edsger Dijkstra in 1959 to solve the shortest path problem for the positive linking graph. This algorithm calculated the shortest path from one point to another point in a graph one by one until the condition was met by setting one node as an initial node and setting the distance of node Y the distance from the initial node to node Y. The Dijkstra algorithm would set the initial value into some node and will increase the distance step by step.[6]

Would the genetic algorithm which mimics the survival of the fittest process to generate an increasingly better path be the best option for Batangas City's traffic problem?

The road traffic control method for reducing traffic congestion with a genetic algorithm is a system which should control the routes of all vehicles in a certain area. The system need to optimize the routes of all vehicles. The genetic algorithm to be used in this problem will encode the route of all vehicles to a fixed length chromosome. To improve the search performance, a new genetic operator called "path shortening" must be designed.[7]

Vera was a little nervous knowing too well that her time to study all options and prepare her proposal to the city mayor was quite short. She lost herself among the keyboard keys when she started pounding on her computer.

Endnotes

1 Official Website of Batangas City, Philippines. “All About Batangas City.” 2014. Accessed 26 Oct 2015. <http://batangascity.gov.ph>.
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