Project Eirin: A Fast-Paced Courier System Utilizing Every Integrated Railway in the Philippines

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Abstract

The sudden strike of Covid-19 has brought many Filipinos to the brink of unemployment with a huge portion of the workforce being affected by the pandemic. In contrast to this, the rise of e-commerce and online businesses are notable when the pandemic started since individuals cannot leave home and now began to rely on digital shopping to purchase goods, which in turn increased the demand for logistical services, thus increasing the problematic traffic issues The Philippines already faces. An idea was proposed to utilize the railways as a new medium for logistics to travel on, but there are no proper navigation algorithms to fit the train system. This paper introduces Project Eirin, a logistics algorithm that allows rail passengers to become part-time or full-time couriers that deliver goods across the rail lines of the Philippines. The paper focuses on the proposed algorithm that aims to provide a backbone for an idealized system of metro railway logistics within the current Philippine railway transits available to aid the flow of logistics congested in road traffic. An algorithm was formulated tailored specifically to fit a train line's route with the necessary parameters like travel time, capacity management, and efficient package drop-offs, was simulated to show its planned functionality, and was compared with the A* pathfinding algorithm. Further study and development of Eirin is recommended alongside the development of a program that can incorporate the algorithm and be applied for live test runs in actual train transportation rides.

Keywords: Courier Service; E-Commerce; Traffic Congestion; Railway Station

1. Introduction

(Wherein COVID 19 has struck, so has unemployment taken the livelihoods of many Filipinos with a whopping 90% of the labor force nationwide being affected (Khatibi, 2021). Most people have either been laid off from work or suffer fewer working hours, hence less pay, which affects the amount of income they bring home to sustain themselves and their families.

Nevertheless, a rise in commerce, specifically, e-commerce has been notably observed as people are restricted from going to their malls or stores to buy goods for themselves. Because of this, people are now relying on couriers more than ever in the pandemic situation to deliver their purchases at their doorsteps (Dones, Young, 2020).

However, Traffic Congestion has been one of the recurring problems that Filipinos struggle against in their daily lives. Not only does it pose an inconvenience to one's time, but it also serves as a huge setback for the entire Philippine economy as we lose a whopping 3.5 billion Pesos a day in delayed goods and services ("PH loses ₱3.5B a day", 2021).

According to TomTom, a Dutch geolocation service provider (Tomtom.com, n.d.), Manila ranks as the 4th worst city in the world when it comes to traffic congestion due to the sheer number of vehicles that have taken over the road, causing it to get clogged.

To answer the demand and problems, we propose a new courier system like the existing ones that utilize The Philippines' existing railway systems as a new channel for the flow of goods across urban areas within the scope of the existing stations. This system is named Project Eirin, short for "Every Integrated Railway in The Philippines." Its' main function is to efficiently deliver goods under one-way trips along the railway within the passenger or courier's time limit and carrying capacity to create more job opportunities with lesser requirements (e.g., owning your own vehicle to be qualified as a courier) and contribute to faster logistical solutions for businesses and clients alike.

This paper focuses on developing the algorithm, giving emphasis on creating the backbone of a system in the future to be applied.

1.1. *Research Related Literature*

We designated the relevant literature into three branches: Pandemic and e-commerce, Philippine Logistics, and traffic in the pandemic, Inventory routing logistics, and algorithms.

1.1.1. *Pandemic and E-commerce*

E-commerce's share in the market has steadily increased in the past years. In fact, the total online e-commerce retail shares have increased from 16% in 2019 to 19% in 2020 ("Global e-commerce jumps", 2021). A large part of it is due to the incessant covid restrictions imposed on people. The two most famous e-commerce websites in the Philippines, Lazada, and Shopee have seen increased users during the pandemic times, especially the first two. As a result, the percentage of global retail sales increases, and is projected to reach an increase of almost twenty-five percent of its total sales by 2025("Global Ecommerce Sales Growth.", 2021) In a survey conducted by Rakuten Insights, among their respondents, 44% of their respondents have confirmed that they have begun buying products digitally in the Philippines during the pandemic. While only 16% of the respondents aged 25 to 54 years old do not have a bearing on their online purchase (M. Flores et al., 2021).

1.1.2. *Philippine Logistics and Traffic in the Pandemic*

Logistics is a vital element of a functioning supply chain, which can directly affect the number of sales and profits of businesses. It is the driver of countries and firms/business competitiveness which is fundamental to job creation and economic growth. Efficient logistics connects businesses/firms to every element of the market, which affects the competitiveness of a country's economy (Reyes, 2021). It is also noted that e-commerce will be a major driver in the growth of logistics due to it being the consumer platform of choice for many Filipinos (Reyes, 2021). In the survey done by the students at Lorma Colleges Senior High School, 96.7% of their online seller respondents agreed that there was an impact on the distribution of their products and services due to the pandemic (M. Flores et al., 2021). Which is the result of the quarantine restrictions that are imposed on logistics, the economic freeze due to the closing of a lot of businesses also contributes to it. Now that the covid restrictions are lessening, the state of traffic is going to go back to normal. This means that traffic congestion is coming back on the Philippine roads. In addition to this, the lack of proper urban planning in Metro Manila aids the increasing problem of traffic congestion. Traffic congestion has a lot of impacts on our society, and most of those are negative (Tomtom.com, n.d.). From wasting people's time, environmental pollution, resource consumption, and may also cause accidents, etc. This may further increase when no other solutions are placed. Fortunately, the current rise of Philippine Railways in accordance with President Rodrigo Roa Duterte's "Build Build Build" program ("Build Build Build Projects", 2021) is an opportunity up for grabs to develop a new algorithm that can make use of the expansion of rail travel and utilize it as a new channel for the flow of goods. Rail freight was already a proposed topic within the Philippines (Yee, 2021), but up until now, there is no news of it being used in the daily expanse of our logistical status. The railway mode of transportation removes a lot of factors that are relevant to road transportation. An example of it is accidents. It is said that 70% of road accidents in Thailand, Cambodia, and Laos involve motorcycles and three-wheelers (Kitamura et al., 2018).

Deliveries in retail e-commerce usually use motorcycles as their mode of transporting parcels. By using a railway mode of delivery, it reduces motorcycles on the road, less time is spent on roads because railways are faster which in turn has a positive impact on the economy and traffic congestion. A case study in Indonesia named "Proposed Customer-based Brand Equity (CBBE) Strategy for Railway Courier Service" is like what transportation medium we are using in our study. In the year 2019, KAI, a local railway transportation service in Indonesia launched a railway courier service that aims to support the logistics sector (Rahman & Garnida, 2021). In which, despite the numerous advantages that the railway gives as opposed to roads, it does not achieve tremendous success due to the low marketing done by KAI (Rahman & Garnida, 2021).

1.1.3. *Inventory Routing Logistics and Algorithms*

The inventory routing problem (IRP) tackles inventory management and vehicle routing, which are the two components of a logistics value chain ("Inventory routing", n.d.). The inventory routing problem with logistics ratio (IRP-LR) on the other hand is a variant of the IRP. Where, instead of the total distribution cost, the ratio between the total distribution cost and the total delivered quantity is minimized, giving rise to a fractional objective function (Archetti et al., 2019). The objective of the Inventory Routing Problem is to minimize the total cost between the distribution and inventory holding, as opposed to the logistic ratio variant of the IRP where the only cost of interest is the delivery cost (Archetti et al., 2017). The ratio between the total distribution cost and total delivered quantity is minimized in the IRP-LR variant, it can also be called the Logistic Ratio (Archetti et al., 2019). In short, it is the average cost of delivering one unit of a commodity to the customers (Archetti et al., 2019). An Exact algorithm is made to solve the IRP-LR (Archetti et al., 2019). The algorithm stresses the inventory and capacity management of both supply and courier capability to ensure that package delivery is as efficient as possible without causing logistic and inventory problems across all points of delivery. It should be noted that the Exact algorithm does not have some side constraints that are imported into real-world applications, such as time and minimum packages to be delivered to achieve efficiency (Archetti et al., 2019). The A*, which is also called the A-Star algorithm, is one of the pathfinding algorithms. It analyzes inputs and generates the most efficient path. It is a computer algorithm that is used extensively in graph traversal and the search for paths along with the efficient path planning process around the points called nodes (Permana et al., 2018). The A* Pathfinding is considered one of the best and most popular techniques in pathfinding problems (Permana et al., 2018). It is more optimal compared to similar algorithms like Dijkstra and BFS (Permana et al., 2018).

1.2. *Methodology*

1.2.1 *Algorithm Analysis*

Currently, there are no existing algorithms or systems that are specifically built to cater to railway deliveries, mainly because the railway travels in a singular direction across the rail route. As such, to determine the fittest algorithm in our railway project, the term fitting is in a sense that meets a lot of factors that are related to our railway project, we used the SWOT (Strengths Weaknesses Opportunities Threats) analysis.

Table 1. SWOT Analysis for A* Algorithm

Strength	Weakness	Opportunity	Threat
It is the most popular shortest route algorithm, and it is as fast or faster as any other pathfinding algorithm	It is simple and only has two variables	Due to its simplicity, it is applicable to any other project ideas that deal with paths	As opposed to an opportunity, its simplicity makes it not applicable to more complex ideas.

The A* algorithm is the most famous and preferred algorithm regarding pathfinding topics because of its speed, which refers to the running time of the algorithm, and its simplicity. While its simplicity is a notable feature, it acts as a double-edged sword. Complex situations such as parcel delivery engage in a lot of factors that can affect the whole path process. Therefore, we have improved an existing algorithm and tailored it according to the factors that are essential in our railway project.

These are the following variables Eirin's Algorithm takes into consideration to generate a route and package assignment to couriers:

Parameters:

C_{st} = Courier's Starting Destination
C_{ed} = Courier's End Destination
C_{cap} = Courier's capacity
C_t = Courier's time allotment
t = Travel time between 2 stations
w = Wait time before boarding a train in a station
$P\alpha$ = Packages picked up at starting station
$P\theta$ = Packages picked up on stations en route to the destination
$P\Omega$ = Packages dropped off at visited stations

Equations used for the Algorithm:

Time Efficiency:

$$C_t >= \Sigma t + \Sigma w \quad (1)$$

Capacity Management:

$$C_{cap} >= P\alpha + \Sigma (P\theta - P\Omega) \quad (2)$$

Package Efficiency:

$$P\alpha + \Sigma (P\theta + P\Omega) \quad (3)$$

In comparison to most delivery algorithms that are more focused on finding the quickest and most efficient routing to combat factors like traffic, the proposed algorithm focuses on efficiency scoring in package delivery while considering the factors that the courier-commuter has (as shown in Ccap and Ct).

Since Eirin is an improved algorithm, we will create a side-by-side comparison between Eirin and the A* algorithm which is commonly used as a navigational algorithm for pathfinding in the logistics sector based on common factors such as point-to-point navigation and factors that affect pathing (traffic, etc.)

1.2.2 *Running a Short Simulation within a Set Scenario*

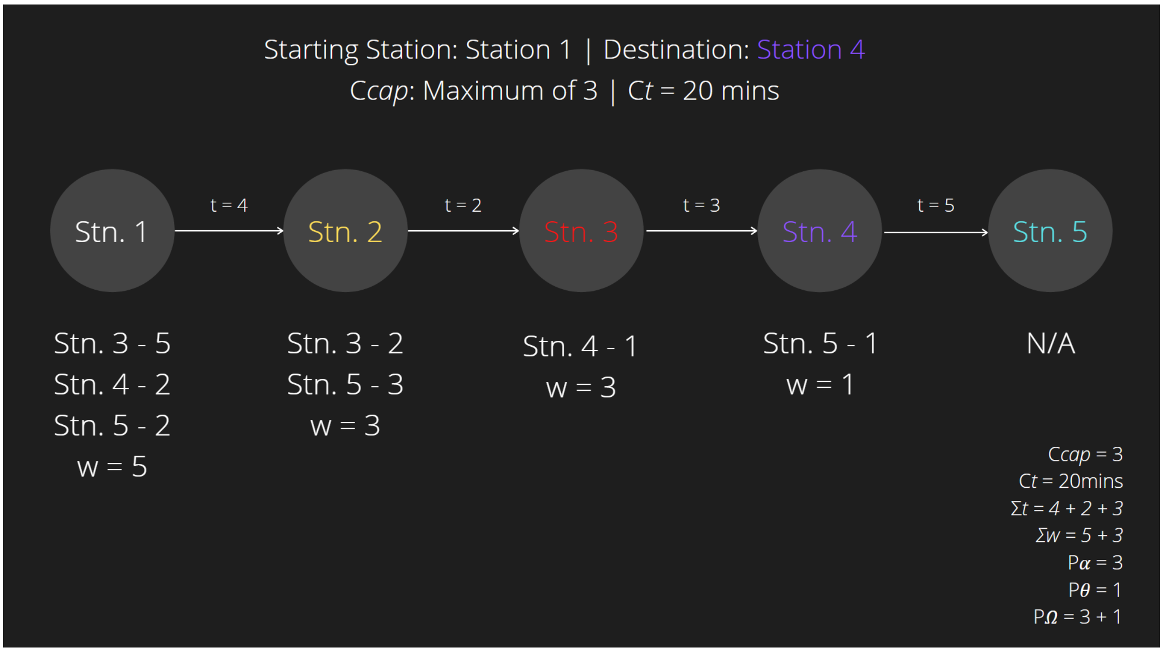

Fig. 1. Simulation Scenario

The lower right part of figure 1 shows the optimal pathing parameter. The Set Scenario as shown in Figure 1 will be used for a simulation test of Eirin's Algorithm. It shows the number of packages in each station and their corresponding destinations to be delivered, the travel time per destination, and the wait time for a train to come along each station. The numbers used in this simulation, especially on train waiting times and travel times, are used only as a placeholder for data.

User-Inputted parameters:

Starting Point: Station 1
End Point: Station 4
Courier Capacity: 3
Courier Time Frame: 20 mins

Eirin's Algorithm

1. Start
2. Courier Enters Variables for C_t, C_{cap}, C_{st}, and C_{ed}
3. C_t = **20 minutes**
4. C_{cap} = **3 packages max**
5. C_{st} = **Station 1**
6. C_{ed} = **Station 4**
7. Receive data, calculate possible routes
8. System Database fills out variables for *t*, *w*, $P\alpha$, $P\theta$, *and* $P\Omega$.
9. ***DO:***
10. **If** $C_t < \Sigma t + \Sigma w$
    a. *Recalculate route*
11. ***Else if*** $C_t >= \Sigma t + \Sigma w$
    a. *Continue*
12. If $C_{cap} < P\alpha + \Sigma (P\theta - P\Omega)$
    a. *Recalculate route*
13. ***Else if*** $C_{cap} >= P\alpha + \Sigma (P\theta - P\Omega)$
    a. *Store route*
    b. *ctr ++*
14. ***While*** *ctr! = 3*
15. *If ctr = 3*
    a. *Compute for Package Efficiency on 3 routes taken*
    b. *Compare which has the highest Package Efficiency Score*
16. *Output Route for courier*
17. ***If*** *courier accepts route*
    a. *Update Database, mark packages as 'for delivery' under courier ID*
18. ***Else***
    a. *Return to start*
19. *End*

Fig. 2. Eirin's Pseudocode

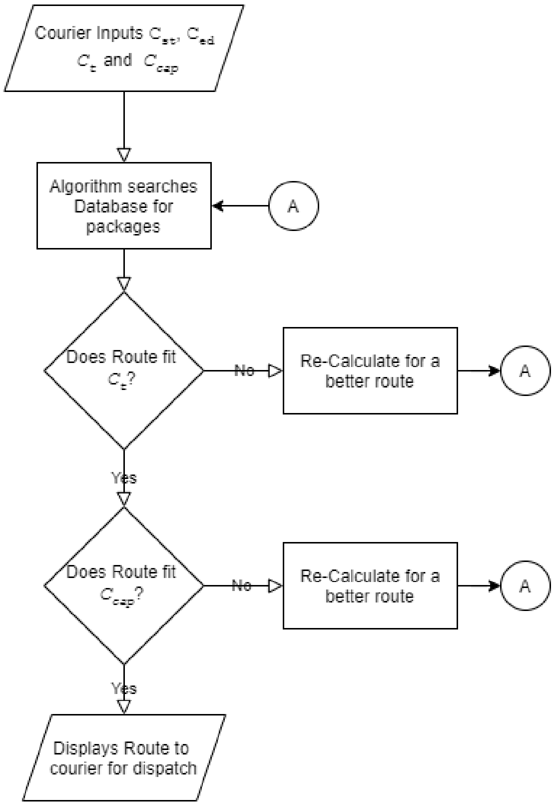

Fig. 3. Flowchart of Eirin's Process

Figures 2 and 3 show the process of how Eirin computes the best possible routes under the time and capacity a courier has. In Figure 2, steps 1 to 6 are all courier-input data, steps 7 and 8 scan the database of packages in each station covered by the courier's start and endpoint(refer to Figure 2) and gather said data, steps 9 to 12 ensure that the route is under the given capacity and timeframe the courier is capable of, step 13 and 14 is a loop that gathers the 3 best routes under the courier's data, step 15 compares all the routes on which has the highest package efficiency, and step 16 is the actual outputted route for the courier to take, giving them the packages they need to pick up and deliver to target stations. The courier may take or refuse the given route at their discretion.

2. Results and Discussions

2.1 Simulation Results

Below the following are the results of simulating the proposed algorithm from Section 3.2

Sample scenarios:

- Time Efficiency:

20 >= Σt (4stn.1 + 2stn.2 + 3stn.3) + Σw (5stn.1) (14 mins.)

- Capacity Management:

3 >= Pα(3stn.1) + Σ[Pθ(1stn.3) - ΣPΩ(3stn.4)]

- Package Efficiency:

Pα(3stn.1) + ΣPθ (0) + ΣPΩ(3stn.4) = 6

Fig. 2 Simulation A (Fits courier data, less efficiency score)

In Fig. 4, Simulation A, the process shows as follows:

- The starting station is Station 1, the destination station is Station 4
- The courier has a time limit of 20 minutes and is capable of handling 3 packages at a time.
- The courier took 3 packages to Station 1 bound for Station 4.
- Courier waits for the train (5 mins)
- Courier boards the train and travels through Station 2 (4 mins), then to Station 3 (2 mins) and to Station 4 (3 mins), for a total of 14 minutes.
- Courier drops off the packages at the station.
- The total time traveled is less than the time limit, making it a valid route for the courier
- The total efficiency score of packages transported is 6.

- Time Efficiency:

20 >= Σt (4stn.1 + 2stn.2 + 3stn.3) + Σw (5stn.1 + 3stn.3) (17 mins.)

- Capacity Management:

3 >= Pα(3stn.1) + Σ[Pθ(1stn.3) - ΣPΩ(1stn.3 + 3stn.4)]

- Package Efficiency = Pα(3stn.1) + ΣPθ(1stn.3) + ΣPΩ (1stn.3 + 3stn.4) = 8

Fig. 3 Simulation B (Fits courier data, best efficiency score)

In Fig.5, Simulation B.

- The starting station is Station 1, the destination station is Station 4
- The courier has a time limit of 20 minutes and is capable of handling 3 packages at a time.
- The courier took 2 packages in Station 1 bound for Station 4, and 1 package bound for Station 3.
- Courier waits for the train (5 mins)
- Courier boards the train and travels through Station 2 (4 mins), then to Station 3 (2 mins).
- Courier drops 1 package bound for Station 3 and picks up 1 package bound for Station 4.
- Courier waits for the train at Station 3 (3 mins) and travels to Station 4 (3 mins) for a total of 17 minutes.
- Courier drops off the packages at the station.
- The total time traveled is less than the time limit, making it a valid route for the courier
- The total efficiency score of packages transported is 8.

Eirin's algorithm will acknowledge both routes as valid routes but will compare the two with their package efficiency scores, hence, Simulation B's route will be the one given to the assigned couriers with the given parameters.

2.2 *Algorithm Comparisons*

Table 2. Table Comparison of Eirin versus the A* Algorithm

Algorithm	A*	EIRIN
Vehicle Used	Road Vehicles	Train
Affected by Road Traffic?	Yes	No
Can travel exclusively from point A to Point B?	Yes	No
Can it calculate travel through multiple stops?	No	Yes
Can it calculate for dynamic package changes along the route?	No	Yes

The major advantage Eirin will possess is that it is unaffected by any road traffic, which is one of the significant problems of logistics it is trying to alleviate. Studies involving the A* pathing (Wang et al., 2015) (Liu et al., 2019) using the A* algorithms for automated guided vehicles in logistics show that they are still affected by traffic and road problems in their factors, in which Eirin's algorithm does not need to take in consideration anymore due to being in a separate path away from the main road.
The A* algorithm normally calculates the route from Point A to Point B exclusively, finding the fastest route it can to avoid traffic as much as possible. In some cases, it can also compute for multiple stops and deliveries along the desired routes to efficiently deliver a set amount of goods. However, it is still affected by road traffic, and even if the best route had been set as the fastest and most efficient, it may still be heavily clogged due to the volume of vehicles present on the roads.

3. **Conclusions**

Project Eirin's algorithm is tailored to the dynamic changes of package deliveries across the railway stations that the route can encounter in comparison to the A* algorithm whose main goal is to get from Point A to Point B at the shortest route possible, which does not apply considering there are many points of travel to be encountered along the way. Development of the system for prototyping is highly recommended, and it is advisable to start within one metro line for test runs, preferably LRT line 1 where the construction of the southbound extension is partially operable by Q4 of 2021. Further study of the system's feasibility when applied in real-time scenarios is recommended, the feasibility of the system in post-pandemic situations to see if the demand for the service will persist like Indonesia's courier service "PT Kereta Api Indonesia" (Rahman & Garnida, 2019) as well as studying the train's travel time and wait time intervals as the data used above are just approximations used. Further study is also recommended regarding traffic statistics and the flow of goods in logistics once Project Eirin is implemented to see if the system has helped with the decongestion of traffic and an increase of daily delivery of goods per day.

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