Jeddah City Ride-hailing Company Bus Routes Planning by Using Traffic Neural Network Design

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Abstract: This study aims to discover the relationship between neural systems and their use and nature in optimizing public transportation in real life. As neural networking system in the human body represents a smooth delivery and reception of data between the neural joints, in similarity to public transportation delivering public to multiple points/zones. Today's simulation systems depend on simulating real life to help us find an optimized solution but never the ultimate optimization. Applying an intelligent design like the human neural system into real life will deliver an ultimate solution to such a problem. Applying a neural networking system to Jeddah's traffic platform allowed us to reach an optimized map/network for the public transportation services with clear stations/stops numbers and real-life path/lane to be followed.

Keywords: Neural Network Design, Public Transportation, Optimization, Bus Routes Planning.

I. INTRODUCTION

Neural Networking System, defined as the system modeled on the human brain, has a similar process to the neural system operating in the brain. Today, the neural system is applied in multiple sectors and is used to solve real-life problems as it optimizes the solution in the simplest needed form. In public transportation, neural networking is used to optimize the final layout of stations and lanes used in the public transportation project. It helps minimize the number of less needed stations or enhance the most used lanes. This paper shows a specific description of using a neural networking system in Jeddah City. Saudi Arabia as a ride-hiling company bus project routing plan is based on the optimized layout of the neural networking system. This study aimed at analyzing and understanding the positive impact of using new technologies and problem-solving methodologies such as neural networking systems in providing solutions for real-life problems. Also, how the application of the neural networking system helps routing a clear map for the public transportation sector in Saudi Arabia in general and Jeddah city.

Recently, The Ride-hailing Transportation Company has decided to expand its services by providing a new product and giving the consumers high quality, safe, and affordable transportation methods to help with cutting the daily costs. This product is labeled as "Bus." Since the beginning of the project, there have been challenges facing the company in implementing the product, stated as follows:

a) The start of the program is based on launching the service in Jeddah City. Designing the routes were arbitrarily placed, and it was built on ill-conceived assumptions because of the data restrictions. This process resulted in a significant loss in the budget during the initial month after the trial/testing period. This bus service does not offer door-to-door pickups, which means the line's design is sensitive

to target a more significant number of commuters. The company wanted a reliable implementation of creating stable routes to expand the service in different cities in the Saudi Kingdom, followed by all markets.

b) One major challenge was studying the investment areas where the company could gain the desired passengers who are willing to use the service. This studying approach wasn't straightforward due to the unfamiliarity of the Saudi marketplace and culture with public transportation services, limiting the expansion of this service. Like any city worldwide, they are categorized by areas based on the living standards to promote the service in certain areas that have affirmative acceptance based on habitat needs and lifestyles.

c) Another major challenge was time, as the drivers were requested to cover a specific shift, including peak hours. But different factors affected the operations as the demand was fluctuating between weekdays and weekends. Also, prayer times had shown different demand rates in different areas. Scheduling is a need with a new scope of flexibility and control to assure the success of the day-to-day operations.

The purpose of this research is to achieve the following objectives:

- Implement a reliable methodology to create bus routes.
- Study the impact of different factors affecting the provided service.
- Reach the optimized process and utilization of each bus.
- Promote the use of public transportation/increased awareness.
- Improve day-to-day operations performance.
- Adapt to extraordinary changes or a large event.

They consider the accelerated pace of work in all sectors in Saudi Arabia, including the public transport sector, to achieve the vision 2030 of Saudi Arabia. If not yet widespread, there is a growing trend that aims to add improvements to public transportation network planning to diminish car dependence and raise the quality of transport services and strategies to establish attractive, livable, and ambitious cities. This research attempts to apply scientific approaches and experimenting with them in possible terms such that they can be used to design bus routes and networks. The research outcomes will be used to help bus service be profitable to the company and provide a reliable alternative transportation option. The study will provide a clear vision that helps in building the infrastructure. The result will be used to expand the service to other markets flatly — this study aimed to clarify the positive impact of public transportation network planning.

II. LITERATURE REVIEW

a) Public Transportation Planning

Public transportation is generally defined in several ways. According to Walker [1], public transport includes vehicle trips that are regularly scheduled, accessible to all paying individuals, a capacity to transport people whose journeys might have various destinations, origins, and purposes. Walker believed that its planning elements examine such a definition; as by regularly scheduled trips, Walker stated that a form delivers transportation of vehicle, which functions on a regular pattern or schedule with a possibility for several variations in schedules and routes. In its essence, public transportation planning must be anticipated in the order that individuals can plan around it without having to liaise with each other directly. According to Walker, such an aspect is important as it is the

main difference between transportation and other forms of sharing a vehicle. Regarding "accessible to all paying individuals, the term "public" in public transportation indicates being accessible to all people with the ability to transport many of them in on single means of transport, which is the trait of transportation and the most important measure of its quality and effectiveness [1].

Research on public transportation indicates that the concepts of "transit" and "transport" are interchangeable when mentioning the systems that incorporate coaches, buses, heavy and light trains, ferries and trams, as well as private cars and taxis employed for public use [2]. These systems are mostly seen by engineering planners as essential to the liveability of urban regions for many environmental, social, and economic advantages such as reducing the congestion of traffic, ensuring accessibility to services and activities, reducing emissions of carbon, and increasing productivity [3].

These urban regions are places characterized by a concentration and accumulation of economic activity, a high level of capital, and multifaceted structures of spaces supported by modern transport systems. The urban population in 2008 has surpassed that of rural regions, which was a first in the history of humankind [4]. Donovan and Munro [5] believed the urban regions' population might increase twofold over the coming 30 years. This shows that transportation is an essential aspect of accessing various societies' day-to-day routines such as work, education, shopping, healthcare, and entertainment. Public transportation, around the world, has various forms; however, the common forms of transportation are rails, buses, or trains. These vehicles' ownership can be both public and private. Public transportation is considered favorable for dependent families, low-income individuals, and tourists in some countries, as it is the most or only accessible method of mobility [6].

The transportation sector, public and often private, comes with several advantages to the societies it serves as it creates employment, supports societies' infrastructure, and establishes the ground for future development. Regions with good planning methods and infrastructure for public transportation and transit systems are more suitable for business windows as these regions offer location benefits with logistics strategies that can be beneficial for such businesses. This aspect of transportation is considered an efficient implementation of energy and limited city space and an attractive alternative for long-distance journeys. Furthermore, these systems reduce the emissions of Co2 as societies are currently heading to the public transportation sector as an alternative to vehicles, which leads to less energy and oil consumption [7].

Regardless of their demographic or social characteristics, people generally use transportation for a broad range of daily goals and destinations. Litman [8] suggested that travel demand refers to the type and amount of travel that individuals would choose in certain situations. It is considered qualitative, distinguished according to a certain period in a day or week, travel motive, and importance of frequency and speed. Therefore, transport planning or demand is rather challenging to forecast and analyze as this process is generally a derived demand instead of an end in itself. The planning process is significantly controlled by provided space; thus, spaces must be considered in most designing cases [9].

The general increase in the field of public transportation planning, mobility, and travel demand results from urbanization, which allows the access of goods, products, and societies [10]. Dealing with the frequent need for transportation and transportation planning in urban regions is primarily a modern dilemma faced by most authorities in urban areas. According to researchers, this is why the planning process of public transport has been regarded as an essential constituent in the planning and administering of urban regions and as sustaining fundamental human life in urban regions. On the other hand, public transportation is beneficial in promoting certain practices for individuals, such as

saving money in their daily travels in more cost-efficient transportation means [11]. Nonetheless, the current section mainly discusses bus routes planning in Jeddah City by the ride-hailng company by identifying the system design, optimization, models, and quality of the implemented transportation systems in the Kingdom of Saudi Arabia in general and Jeddah City in particular.

b) Public Transport System Design

The essential signifier of mobility is the practice of moving individuals and materials between certain locations within a single city or several cities, in specific places or towns on earth. Mobility is a fundamental aspect of planning, facilitating, and preserving economic development and social relationships and bonds. Mobility planning and strategic design provide important elements between regions and be a needed activity around the world [12]. Rodrigue et al. [4] argued that public transportation system design brings a complicated interaction of society's forces together, which relate to the general activity of such society and being a key aspect in determining the size, location, structure, and form of urban regions. Each element of such a design is created to offer a specific design of routes, frequencies, or services offering mobility. Among the defining elements of public transport network design are frequency, capacity, costs, the distance between stations, and flexibility. Based on these elements, public transport systems are classified into coaches, buses, private hire vehicles, taxis, light rail, tramways, metro, and heavy rail [13]. The following presents a brief overview of public transport design and services provided for urban regions.

c) Public Transportation Planning in Jeddah City

In general, transport networks in Saudi Arabia are facilitated through a network of railways, roads, and seaways that have started construction after the oil discovery in 1952in the Eastern Province. After that, the Kingdom has started many development projects of its infrastructure across the Kingdom. The extensive development of the public transportation system supported several economic and have shown dependency on car-based travel among the cities due to the continued growth in the economy [14].

These major cities predominantly view the use of cars as an obvious and easy mode of urban transit. Though cars and fuel prices are cheaper their; the undesired results of higher ownership of private cars including congestion of traffic and compromised public health, all of which require a strategy for a sustainable system of public transportation in the urban region [15].

The Kingdom has had privately-owned automobile as the dominant form of urban transport; yet recently, the government declared mega projects to develop modern and integrated public transport systems in the Kingdom's major cities; staring by establishing the Saudi Public Transport Company (SAPTCO) and presenting several projects designed for the railway infrastructure that link the Kingdom's different cities [16]. Thus, urban transport designers are struggling to optimize the presence and quality of public transport to match the overgrowing aspirations and needs of commuters in the Kingdom. For every single journey, passengers have the choice of distinctive aspects with their pros and cons. Since people's endeavors are of paramount importance in the success of a public transport system, the design of such a system must be according to the needs of those people [17].

As the second-largest region in Saudi Arabia, Jeddah is a busy region; transport network developments and expansions are in constant progress. The city is located on the Kingdom's west coast in the middle of the Red Sea's eastern shore (Shown in Figure 1) and highly dependent on privately-owned vehicles as the primary means of transportation [18].

Nonetheless, public transport has been the key issue for many social needs to travel within a reliable transportation system. The dramatic changes that the Kingdom and Jeddah both faced in the economy and population growth helped better realize the relationship between transportation networks and urban growth. The public transportation systems are a fundamental aspect of urban development by presenting mobility that affects economic growth [19].

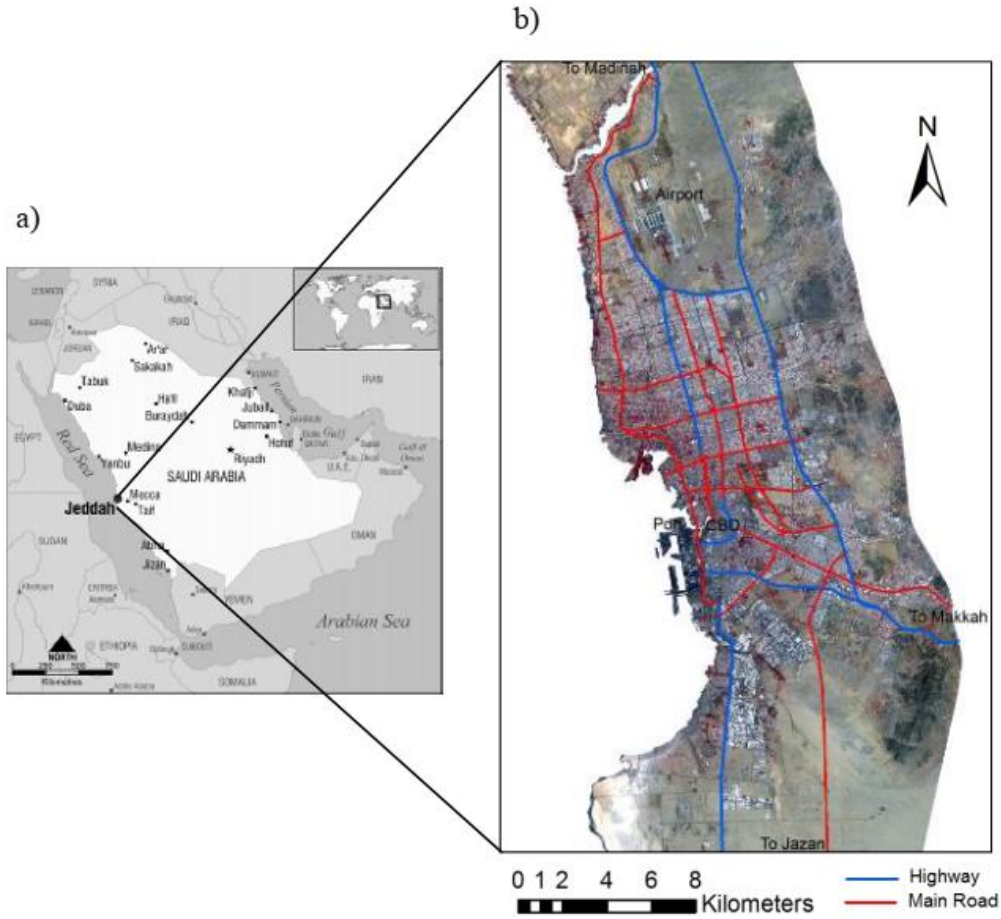

Figure (1): (a) Jeddah's geographic location and (b) Jeddah city Highway road [20].

Cycling and public transport represent 5% of the total movement in the city [20]. Two key systems represent the system of public transport in the city:

(1) SAPTCO; operating the regulated bus networks; The company-regulated bus network includes around (90); operating on eight service lines; covering nearly 150 km (Shown in Figure 2).
(2) Unregulated Coaster buses services operating in 10 service lines, coving nearly 160 km (Shown in Figure 3). This service includes (1730) old buses (With a 19-21 individual capacity) from 1972-1982 [74].

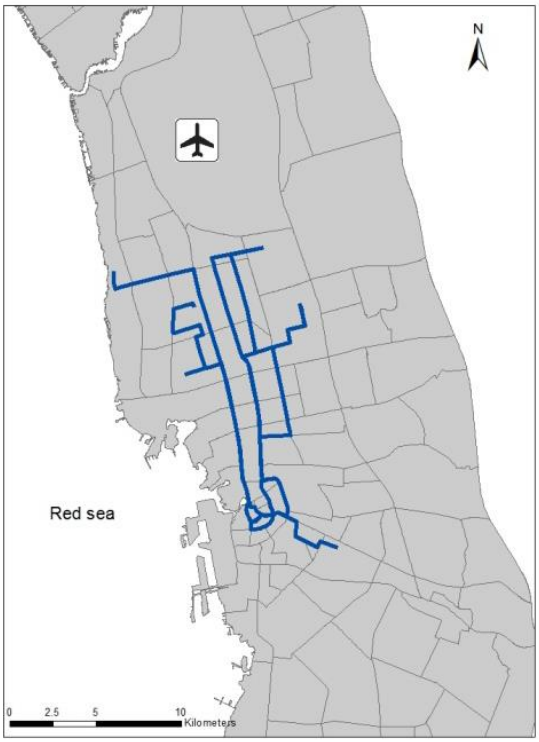

Figure 2: SAPTCO service lines [20].

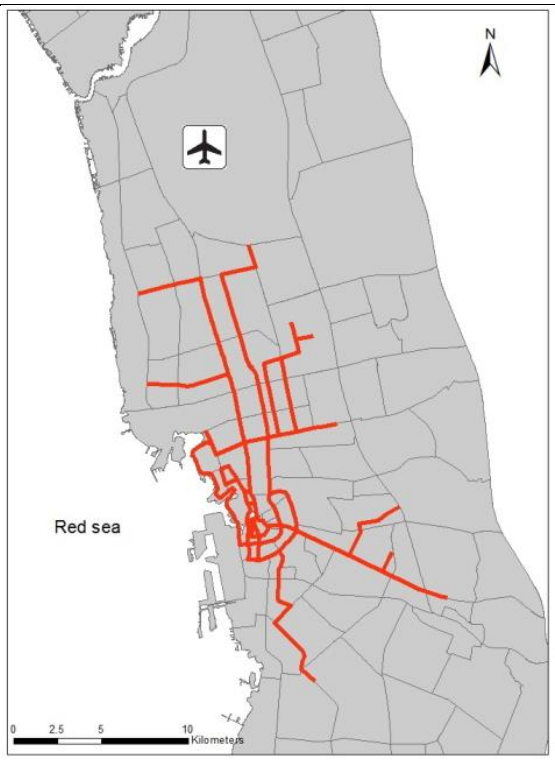

Figure 3: Service lines of unregulated coaster buses [20].

Improving public transport applications is particularly essential in fulfilling the obligations of social mobility, lessening the negative effect of many private automobiles, and ensuring a sustainable and constantly developed transportation system. Sustainable transportation systems can reduce a country's endeavors to negative social, climate, and environmental change effects. This depends on several aspects of the system's optimization and the infrastructure to accommodate the requirement of a certain society [21]. For Jeddah, there is an increasing demand for the expansion and development of the public transport infrastructure; where no organized system of public transport is established in Jeddah, and the utilization of public transport continues to stay minimal in the Kingdom in general, which has caused an increase in car ownership. The Kingdom's government has initiated a strategy to develop a public transport system comprising buses, metro, and ferries, investing SAR50 billion in the coming few years [22].

All bus and rail projects in Jeddah are being constructed by Metro Jeddah Company (MJC), a public-private establishment owned by the Jeddah Development and Urban Regeneration Company. The company designed the upcoming systems of the metro network, Jeddah Metro, which will comprise (4) lines spanning together for (150) km, covering (85) stations. The fare system will be established with smartcards and integrated ticketing. Furthermore, the Light-rail transit (LRT) system will also be established and will include (3) lines that are planned to be extended the distance of (37) km, while the bus system will include routes of (400) km with Bus Rapid Transit (BRT) system containing (724) bus stops [23].

Literature shows that the public system of transport is under-utilized in the Kingdom. For instance, Alotaibi and Potoglou [24] conducted in-depth surveys and interviews with experts and officials in transport on the importance of presenting public transportation systems and services in Riyadh. The participants concluded that this helps create employment opportunities, improve mobility, and reduce travel time in the Kingdom's capital. Alotaibi and Potoglou [25] examined whether the policy measures of transport in the Kingdom could encourage the implementation and development of public transport.

The researchers found that affordable parking charges, improved infrastructure, proper transit-oriented sites' development, improved provision, and facilities of separate carriageways are effective methods to increase the use of public transport. [25] also analyzed the reason behind the growth in car ownership and its impact on public transport use in Riyadh. The researchers concluded that based on the analysis of historical and future improvements of Riyadh, there was a requirement to surpass engineering solutions and analyzing the whole system, including society, culture, and community participation, to reverse the effects of such a phenomenon.

d) Models for Public Transportation Planning

Neural Networks

Dating back to the 1950s, the neural network is a system and a computational model inspired by deep neural networks. Biological neural systems have been applied in several fields, not just the ones challenging to solve with conventional machine learning algorithms (i.e., image classification) but relatively modern fields as well, such as language modeling and bioinformatics. The earliest applications of the neural network had another concept, perceptron [26].

Perceptron

In 1957, Frank Rosenblatt [27] developed a perceptron as a biological neuron imitation. This form of the algorithm was considered a binary classifier approximator with a purpose mapping (x), input vector, too (y), binary output, as follows [28]:

$$y = f(x) = \begin{cases} 1 & w \cdot x + b > 0 \\ 0 & otherwise \end{cases}$$

Where w is real-valued weights of vector and b, seen in Figure (4), is the bias. This process of computation is essentially an affine transformation [28].

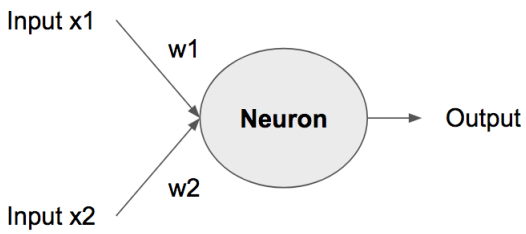

Figure. 4: An illustration of Perceptron [28].

In geometric concepts, $f(x)$ is viewed as a linear decision boundary for the vectors of its input. If the data of training is not separable linearly, then convergence is not guaranteed.

Non-Linearity

Non-linearity is presented by making each neuron's output nonlinear. This needs nonlinear aspects and functions. These nonlinear aspects are usually known as the functions of activation. However, certain features of a nonlinear function of activation can be found to be more suitable for a neural

network's training. For example, such a function is preferred when it is differentiable and continuous. The most commonly used functions of non-linearity are rectified linear unit (ReLU), hyperbolic tangent function (Tanh), and sigmoid function (Logistic function). The mathematic functions' formats are [28]:

$$tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}$$

$$ReLU(x) = \begin{cases} x & x > 0 \\ 0 & otherwise \end{cases}$$

$$sigmoid(x) = \frac{1}{1 + e^{-x}}$$

Modern neural systems tend to include many layers. [26] proposed that ResNet has (152) layers, which are (8) times deeper than VGG nets [29]. Some characteristics of nonlinear functions (Hyperbolic and sigmoid tangent function) add more challenges, making the process impossible to be implemented in modern training of the neural network. The numeric ReLU stability makes it a suitable choice [29].

Loss Functions

A neural network is generally implemented as a supervised algorithm of learning. The supervised process of training requires both input data (X) and the labels (y). The neural network's output is compared to the labels (ground truth). In the machine learning algorithm, it is better to know an algorithm's state of wrong is rather than measuring if it is correct or not [30]. The state of the output is analyzed by a given cost function or loss function, which is the essential function to be reduced.

$$L(\theta) = L(y, \hat{y}; \theta)$$

θ Represents the target function's parameters, y is the ground truth, and the output is the $\hat{y}$ [31].

Backpropagation

Usually, the training process of the neural system is a system's feedforward algorithm and function, where the flow of computation goes from one end to another, from the input to output (Presented in Figure 5). No loop can be found inside the architecture, as when a loop of feedback is created, the architecture of such a network is usually known as RNN (Recurrent Neural Network) [32].

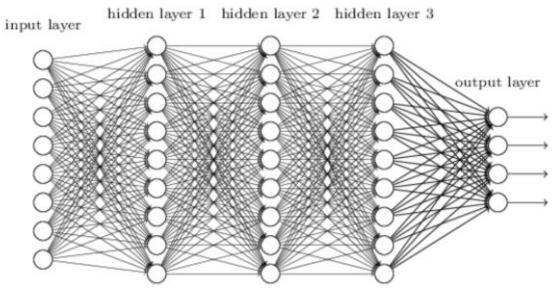

Figure. 5: A fully connected network of feedforward function [32].

Intrinsically, neural networks' training aims to locate a set of neuron weights to minimize the corresponding functions of loss. The loss (Which is the error that explains the bad state of a given

network) will be calculated once the flow of control reaches the end of it. An effective instrument to reflect the accurate weights' value numerically and if it needs adjustment can be backpropagation. Backpropagation (A short version of Backward Propagation of Error) was developed by Rumelhart et al. [31] and showing its significance regarding neural networks training (Such as updating each neuron's weights in a certain network). The general implementation of backpropagation made neural systems and nets useful for finding solutions to insoluble challenges. Nowadays, the algorithm of backpropagation has been the main key to training in neural systems. The feedforward backpropagation and function combined can be as [33-34]:

- Take input through the system until the output layer.
- Calculate the functions based on the loss.
- Adjust the neurons' weights on all intermediate layers until the first, which is done from the backward of the output layer.

III. ABOUT THE COMPANY

A local Ride-hailing Company App-based is a vehicle-for-hire corporation and the subsidiary of the American corporation Uber. The company headquarters is based in Dubai, UAE, with operations in more than (100) cities within (15) countries spreading in Africa, the Middle East, and South Asia. The company was co-founded by Magnus Olsson and Mudassir Sheikha, who had worked together at McKinsey & Company as management consultants [35]. The company began operating in July of 2012 as a website service for corporate bookings of transportation means such as cars. With time, the company evolved into a vehicle-for-hire service with car hire for routine applications and activities [35].

The company is a platform of the internet for the Middle East region. Throughout the years, the company had become a pioneer of the ride-hailing economy of North Africa and the Middle East, expanding its services across all online platforms to include delivery, mass transportation, and payments. The company's current mission is to improve and simplify the lives of citizens by creating a lasting corporation that provides free mobility and transportation access.

The company then acquired Abdulla Elyas and a Saudi-based company in 2015 for home service. Furthermore, the company announced a course to hire more female workers and extend maternity leave in 2017. In the same year, the company started operations in several countries, including Palestine, as part of a commitment that the company aims to create employment through offering one million jobs in North Africa and the Middle East regions by 2018. In 2018, the company became the first ride-hailing and mobility service to start its operations in Baghdad, Iraq, with other Erbil, Najaf, and Iraqi Kurdistan [36].

The company’s initiatives have been many; as announced in 2018, the company acquired a restaurant food and listing ordering platform, Round Menu, which operates in several cities in the Arab region. In the same year of 2018, the company said they would be kicking off bus services, beginning with Egyptian cities. Moreover, the company announced the company's acquisition of Cycle, a UAE-based bike-sharing startup enterprise in 2019, which will be Bike. The company also announced that soon it would be launching a digital wallet app called Pay to replace payments in cash [37].

With these business deals, the company started by receiving $1.7 million, as seed money, in a round led by Ventures of STC in 2013. After one year, the company received $10 million funding in a round of Series B by STC Ventures and Al Tayyar Travel Group. The company announced a Series

C investment round of $60 million in 2015 by The Abraaj Group. The company reached an agreement in 2016 with the regulators in UAE; whereby users can book all limousines and taxicabs operating in Dubai through the mobile app of the company [37]. Based on a $1 billion valuation. The company raised US$350 million in 2016 in a Series D round. In such a round, Saudi Telecom invested its funding round in 10% shares in the company. In the final quarter of 2018, the company secured funding reaching $200 million from its current investors. Following these events, Uber agreed in 2019 to acquire the company for $3.1 billion. This transaction included $1.4 billion cash and $1.7 billion in convertible notes.

The company's efforts to launch several service apps, from food delivery (Now) to delivering pharmaceuticals, show the company's plans for service expansion in Saudi cities such as Jeddah and Riyadh [38].

Following the successful initiative in Egypt of BUS in 2018, the company has expanded operations to Saudi Arabia, beginning with a direct link of bus services connecting Makkah and Jeddah for SR25 fare. The Dubai ride-hailing platform company that Uber acquired for $3.1 billion has established and launched direct bus services in Jeddah. For many, the service comes as part of the company's ongoing commitment to solving transportation challenges, enhancing mobility, and creating employment. The system designs of the transportation routes have been approved by the Public Transport Authority of Saudi Arabia [39].

This service, Bus, is the first mass transportation app of bus service in the Kingdom; as it operates through a separate app from the ride-hailing app and is available for individuals to pick the bus that suits their time best and can track the movement of the bus and its location, the same as when ordering a taxi from the original app. The buses are presented in partnership with given vendors who were paying them a fixed salary every month. The collected fares by the Bus drivers (Captains) go to the company, while the company pays the vendors a fixed amount every day, regardless of the trips' value or number [40].

The service will initially start with 13-seater buses. Based on the feedback from customers, the service will look to add to its offerings to provide the easiest transport and mobility options for people in the Kingdom. Customers will be able to check the availability of the bus via the app, monitor its arrival, and secure a seat. Walk-on passengers will also be accepted. The service is currently cash-only, but soon passengers will be able to pay via several payment methods, such as the wallet on the app or by a registered credit card.

The following, figure (6), shows the routes currently operating in the BUS app in Jeddah [39]:

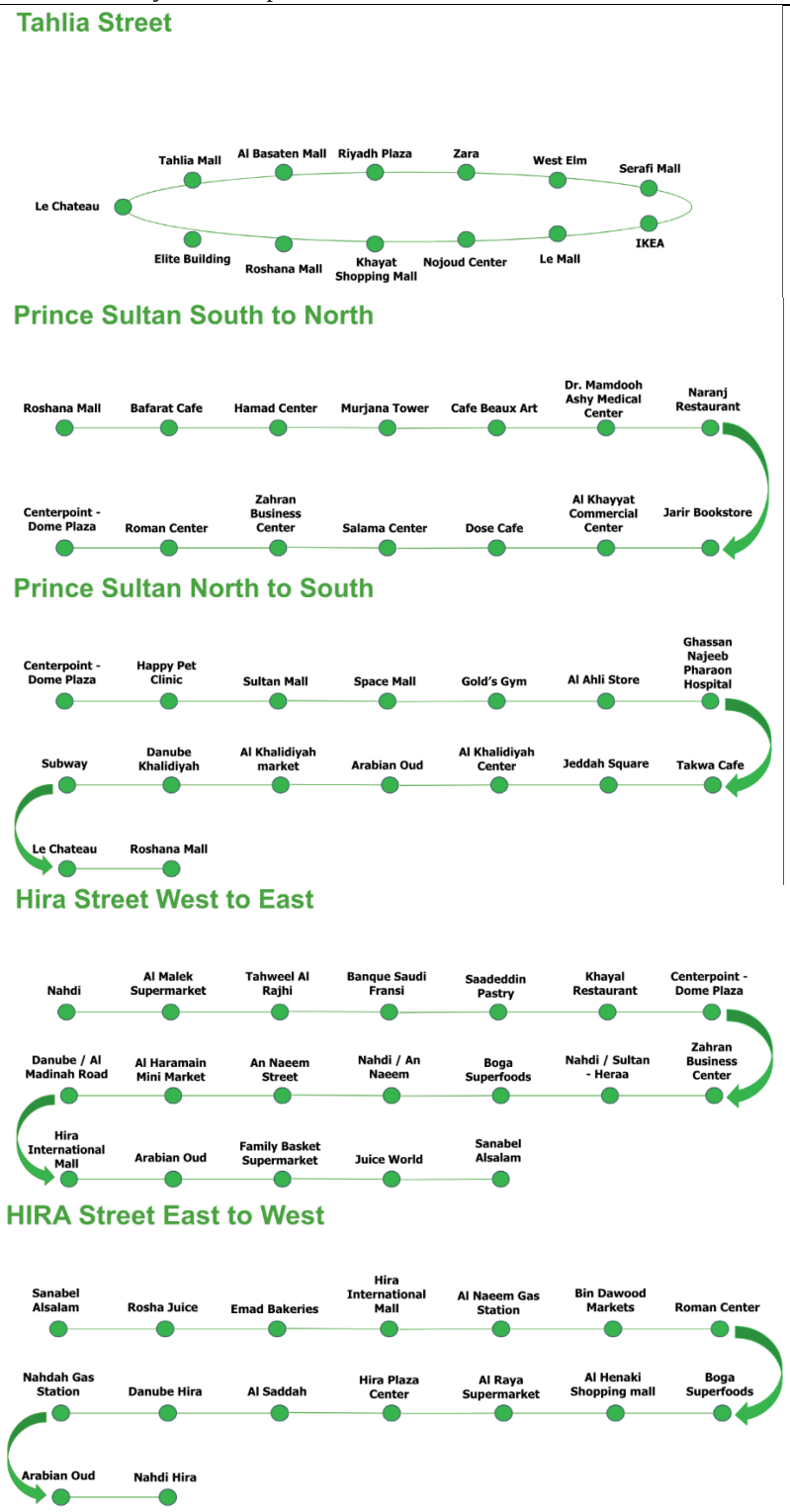

Figure 6: Operational routes in Jeddah [39].

Many believe that the introduction of the bus services, BUS, will help the Kingdom with Vision 2030 for Smart Cities in Riyadh and Jeddah, contributing to the app-based transport integrated options. Furthermore, this helps the Kingdom's government achieve its goals and ambitions in reducing environmental pollution and ease traffic congestion as every Bus can cover nearly (13) cars [41]. The "Bus" service, in the opinion of several reports, will evolve the mass transportation in the Kingdom of

Saudi Arabia: bringing a modern level of development, sophistication, and price. This service has been a significant success in Egypt, resulting in easing traffic flows and offering an efficient and safe way to travel [42].

In conclusion, the introduction of similar services and initiatives will help the Kingdom of Saudi Arabia with its Vision 2030 implementation and providing the path to develop and expand the systems and networks of the Kingdom's transportation sector.

IV. METHODOLOGY

The questionnaire aimed to collect people's opinions of the current public transport network in Jeddah city and reveal some weaknesses and strengths from the viewpoint of its users. The survey consisted of two main parts. One is to explore society demography, such as gender, age, education, and income level, etc.

The other part of the questionnaire included the extent of usability of the public transport network by the community. The survey also examined the effectiveness of the current system and explored society's acceptance of using public transportation.

Given that, the respondents were asked to determine their personal opinion by answering the included thirteen questions in the survey. These questions were divided into four main sections to study the individual's viewpoints of the public transportation system in Jeddah City:

- Socio-economic characteristics.
- Favorite transportation style.
- The comfort of using public transportation.
- Frequency of using public transportation.

Each question was divided into several close-ended multiple-choice and checkbox questions.

The questionnaire was designed to take 3-5 minutes to complete to increase the rate of the respondent. The survey was conducted between May 16th and June 27th, 2020. And was distributed online.

A total of 1288 responses have been collected. The survey had a completion rate of 85.7%; 184 responses were partially filled out, while 1104 responses were fully completed. Only the fully completed responses were considered in the analysis.

Table 1 describes the respondents' socio-economic questions. A different socio-economic characteristic of the respondents was noticed in the considered sample of the questions.

The majority of the respondents, 35.6%, are between 18 and 24 years, and 34.96% are between 25 and 34 years, as shown in Table 1, while about 0.82% of the respondents are under 18 years old. Respondents between 25 and 44 years are about 15.04%, whereas about 7.52% accounted for respondents between 45 and 54 years, and about 4.8% for respondents between 55 and 64 years; and about 1.27% respondents aged 65 years and above. The results indicate the Saudi society has a large number of youth individuals.

Table (1): Socio-economic characteristics

Socio-economic Questions	Responses	Percentage
Age		
Under 18	9	0.82
18-24 Years	393	35.6
25-34 Years	386	34.96
35-44 Years	166	15.04
45-54 Years	83	7.52
55-64 Years	53	4.8
65 Years and above	14	1.27
	1104	
Gender		
Male	532	48.19
Female	572	51.81
	1104	
Nationality		
Saudi	899	81.43
Resident	205	18.57
	1104	
Occupation		
Student	374	33.88
Working	423	38.32
Working and Study	142	12.86
Unemployed	165	14.95
	1104	
Work Entity		
Government	220	38.8
Semi-government	45	7.94
Private sector	259	45.68
Entrepreneur / freelancer	35	6.17
Other	8	1.41
	567	
Average income		
Under 5,000 SAR	425	39.06
Between 5,000 and 10,000 SAR	262	24.08
Between 10,000 and 15,000 SAR	178	16.36
Between 15,000 and 20,000 SAR	112	10.29
Between 20,000 and 25,000 SAR	47	4.32
Between 25,000 and 30,000 SAR	26	2.39
Over 30,000 SAR	38	3.49
	1088	

Table 1 also shows that the answers are closer to equality between males and females; 48.19% are males, and 51.81 % are females. On the opposite, results expose that the sample is dominated by Saudi nationality, wherein 81.43% of the respondents are Saudi, while 18.57% are residents.

Profession level results show a diversity of occupation of the respondents as in Table 1. The majority of respondents are 38.32% for workers and 33.88% for the students, while about 12.86% of the respondents are workers and students at the same time. Unemployed respondents make up a ratio of 14.95%.

On the other hand, the work entity has shown a difference in the percentage as most of the respondents are 45.68% and are working in private sectors. While 38.8% are working in the government sector, and 7.94% are in the semi-government sector. Fewer respondents were from entrepreneurs and freelancers at a ratio of 6.17%. In contrast, 1.41% of the respondents have unlisted work entities.

Finally, the monthly income level results turn out to be an inverse relationship—the greater the rate of income, the less interest in the use of public transport. Table 1 respondents with income level under 5,000 SAR have 39.06%, while about 24.08% were between 5,000 and 10,000 SAR. About 16.36% earn between 10,000 and 15,000 SAR, whereas about 10.29% earn between 15,000 and 20,000 SAR. Respondents with monthly income between 20,000 and 25,000 SAR have a ratio of 4.32% and about 2.39% for those who earn between 25,000 and 30,000 SAR. And about 3.49% of the respondents earn more than 30,000 SAR.

Respondents were asked to choose their favorable and the most used transportation style. A large portion of respondents, 734 (66.49%), preferred to use their owned cars. The male category was 480 (65.40%). At the same time, the female result was 254 (34.60%). This is due to the high average income in Jeddah. Respondents who chose Personal driver were 197 (17.84%), the majority were female 191 (96.95%), and 6 (3.05%) were male. 109 (9.87%) prefer to use Ride-hailing apps. The analysis showed 93 (85.32%) were female while 16 (14.68%) were male.

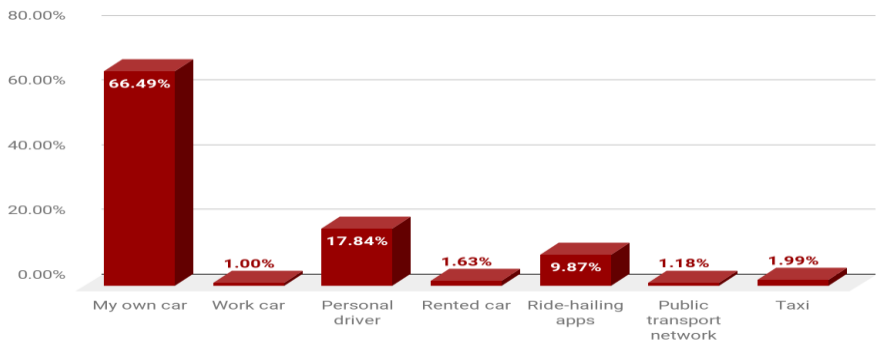

Figure (7): Favourite transportation style

On the other hand, a small portion of respondents prefers to use Work car 11 (1%) while 18 (1.63%) selected Rented cars. Results also show 13 (1.18%) and 22 (1.99%) with Public transport networks and taxis.

Table 2 shows the participant's distribution according to their support for using the public transport network (Buses), 811 (73.5%) support the use of public transport networks, while 293 (26.5%) do not support their use.

Table (2): Comfort of Using Public Transportation

Are you in favor of the use of the public transport network, Buses?	Responses	Percentage
Yes	811	73.5
No	293	26.5
	1104	

Table 3 shows the participants distribution according to the number of times they use the bus, 324 (40.0%) use the bus a few times a week, 206 (25.4%) use the bus every day, 136 (16.8%) use the bus once a month, 93 (11.5%) use the bus a few times a month, while 52 (6.4%) use the bus about once a week. The percentage of those using the busy days in encouraging are given a strong motivation for the company to consider planning techniques.

Table (3): Frequency of Using Public Transportation

How often would you be using the Bus?	Responses	Percentage
Every day	206	25.4
A few times a week	324	40.0
About once a week	52	6.4
A few times a month	93	11.5
Once a month	136	16.8
	811	

Table 4 shows the participants distribution according to the purpose of using the bus mostly, 276 (34.0%) using the bus for the commuting from/to university or school, 213 (26.3%) using the bus for the commuting from/ to work, 192 (23.7%) using the bus for the commuting from/ to malls, 32 (3.9%) using the bus for the visiting family/ friends, while 98 (12.1%) using the bus for other purposes. The high percentage of employees and students who use public transportation periodically indicates the need for giving them a priority while planning for the routes of buses.

Table (4): Purposes of using the bus service.

What would you be using the Bus mostly for?	Responses	Percentage
Commute from/to university or school	276	34.0
Visit family/friends	32	3.9
Commute from/to work	213	26.3
Commute from/to malls	192	23.7
Other	98	12.1
	811	

Figure 8 shows the distribution of participants' responses according to the reasons for using public transport (Bus), 517 (46.83%) due to avoiding crowded places and no parking, 378 (34.24%) due to the low price of the service, 289 (26.18%) due to reaching their destination Quickly, 163 (14.76%) because they do not own a car, 139 (12.59%) because of high car maintenance costs. In comparison, 91 (8.24%) use public transportation for other reasons.

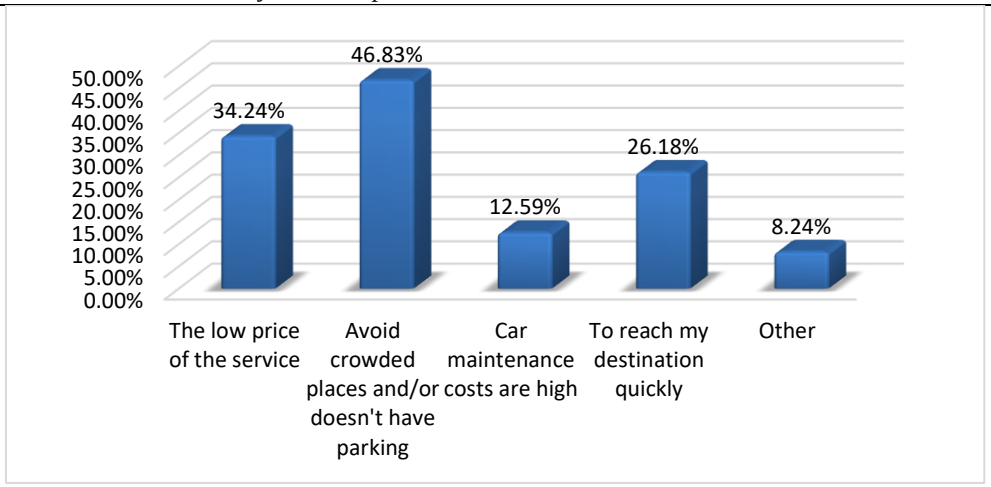

Figure (8): Reasons for using public transport.

Figure 9 shows the distribution of participants' responses according to the reasons for not using public transportation, 588 (53.26%) due to their ignorance of the station locations, 509 (46.11%) due to the difficulty of reaching the pickup area, 473 (42.84%) due to the low bus serves and quality, 359 (32.52%) because they prefer to transport privately, 351 (31.79%). After all, they do not know that there is a public transportation network,304 (27.54%) because of the long waiting time for the bus, 189 (17.12%) because there are no seats intended for families, 109 (9.87%) Because their social status does not allow them to use the bus, and 114 (10.33%) do not use public transportation for other reasons.

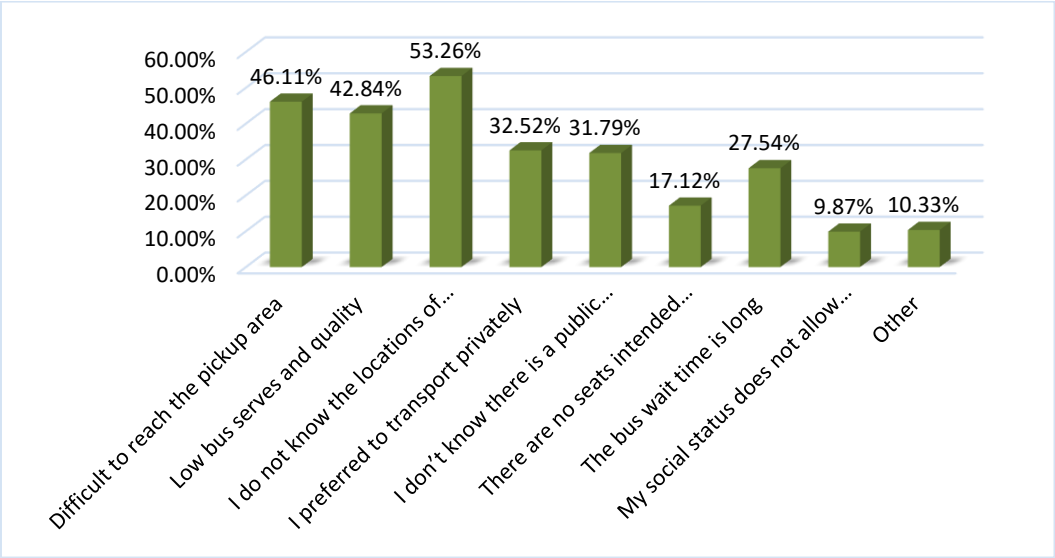

Figure (9): Reasons for not using public transport.

The value of transit has increased in recent years. Planners have begun to recognize that new bus routes are flourishing near growth. After this discovery, many places, particularly Saudi Arabia, realized that transit was linked to growth, especially during the Hajj and Umrah season. The interest of transport companies operating in Saudi Arabia to develop means of transport and communications is an integral part of their work, especially since most of this company operates during the Hajj and Umrah seasons.

The study results provided an overview of Saudi society's tendencies towards using public transportation and its relationship to their social and financial situation. The results showed that most public transportation users are students and employees. The researcher attributes this result to the ease

of using public transportation by students and employees, especially the buses have fixed and known routes on the roads. Besides, through the answers provided by the participants, it is evident that there is an inverse relationship between the use of public transportation and the financial situation of citizens where those of high income prefer using their cars and even have a special driver. The researcher believes that using a personal car is rooted in Saudi society, where it is linked to their perception of it as a form of prestige. The reluctance of Saudi women to use public transportation also appears. This is linked to the religious aspects and customs and traditions of Saudi society, which stipulate the necessity of having a companying man from the woman's relatives during travel or movement.

Regarding public transportation, there is a good percentage of people who use public transportation daily, and this percentage is encouraging for public companies to maintain them and attract more people through them. the company can attract more people to use the buses by remapping the bus routes to avoid congestion and reduce travel time. Several participants said that they do not know the bus stop location; this is blamed on the companies and their limited presence in the market. Bus companies must also relocate stations to be in the vicinity of citizens' houses and the routes they frequently take.

The results indicated that the respondents are unsatisfied with the quality and comfortability of the buses where the public transportation companies can handle this issue by evaluating the quality of the buses from inside and improving the quality of the services provided. The results also show that buses are not suitable for family transportation. Therefore buses can be developed to suit the number of families who wish to travel, and this is a matter that needs good study in order to ensure its success.

In conclusion, the researcher believes that there is a golden opportunity for the success of public transport companies. Still, they need to develop the quality of services provided and redraw the routes that buses take to become more suitable for citizens, thus motivating them to use them more frequently.

Development of Research Questionnaire

For this part of the study, the questionnaire was used to go beyond the community awareness of the factors contributing to bus network usage and facilitate the arrangements for identifying the routes of buses. The data retrieved from the questionnaires contributed to the factors considered when developing the system.

The researcher developed a close-ended questionnaire circulated online to the research sample; the company's customers were random people. The researcher decided on the type of data collected while considering the targeted population, sample attributes, response rate, questions type, time, and cost [1].

The online surveys were used to administer the questionnaire because it is advantageous in reaching a large population, greater samples, reduced time, and cost-effectiveness. Nevertheless, it could obtain fewer representative samples. It could be difficult to generate a randomized sample from the whole population; complex skip patterns could solve this problem [2].

For testing the research hypo paper, the quantitative technique was utilized to analyze the filled questionnaires. It enables the researcher to quantify the measures while collecting and analysing the research data and facilitating testing the theories used in the study [3]. Additionally, the quantitative research approach properly explains the research findings using quantified data analysis and provides solutions for the research problem as the data is grounded on specific research variables [4].

The survey method followed the positivist research philosophy and, hence, preserved its supposition. Furthermore, the researcher found that the quantitative research strategy fits the current study. The research problem arises from a wide research field where previous studies support predictors of research results. Also, the used strategy involves collecting data in quantifiable formats, which explain both dependent and independent research variables whereby correlations will be established to find factors contributing to the design of the neural network-based system for planning the company's bus routes .

The research sample included customers who use the company's bus services, which are the focus of the current study. All required permissions were retrieved from the company and the customers following the retrieval of an official explanation letter from the university to facilitate the research task at the workplace. Following the social distance measurements in Saudi Arabia, the data collection process involved no direct interaction between human beings. The research sample was given sufficient time to fill the questionnaires online and submit them to the researcher using surveymonkey.com. All required contact was through phone and official e-mails.

Development of Bus Planning System

For this part of the study, a traffic simulation model was developed to capture the complicated dynamics of bus transportation networks in Jeddah using the available traffic data. The current systems are intended to predict the Origin-Destination (OD) matrix of the road network used by the company's fleet in Jeddah**.** As the name suggests, origin-destination (OD) data represents movement through geographic space, from an origin (O) to a destination (D). Sometimes also called 'flow data', OD datasets contain details of trips between two geographic points or, more commonly, zones (which are often represented by a zone centroid) (Leigh, 2020). This matrix uses flow rate information to predict the fleet behavior on the road network under different simulation scenarios. Traffic flow is defined as the number of vehicles that pass by a point in a given time period. This value is usually expressed as an hourly rate - for example, you can observe a flow of 500 vehicles per hour on a highway.

The system consists of an optimization-based OD matrix, an NN-based model trained for predicting OD matrices through the pattern of traffic flow, and a traffic simulator with a Dynamic Traffic Assignment (DTA) scheme to predict fleet behavior. Traffic simulation models have been proven to be suitable tools for evaluating intelligent transport systems (ITS), such as advanced traffic management systems and adaptive traffic control systems. The applicability of traffic simulation strongly depends, in most cases, on computing performance. Off-line applications, such as those employed in testing ITS strategies and planning studies, are best served by fast-running traffic simulation because of their iterative nature. Models that are faster than real-time are requisites for online applications, such as those that support decision-making in real-time traffic management. A key aspect in evaluating ITS strategies is the impact on driver's behaviors, namely concerning path choice. The DTA model simulates drivers' decision-making processes.

The system was tested on the roads used by the bus fleet to ensure its effectiveness in simulating the impact of some real-world scenarios on the routes of buses, i.e., parking, lane closure, and so on.

Estimating the OD matrix from flow measurement was difficult because there was not a one-to-one map from the flow rate to the OD matrix; in this case, the OD matrix could lead to different patterns of flow. In OD matrix, let/be a function defined on a set A and taking values in a set B. Then f is said to be an injection (or injective map, or embedding) if, whenever $f(x) = f(y)$, it must be the case that $x = y$. Equivalently, $x \neq y$ implies $f(x) \neq f(y)$. In other words, f is an injection if it maps distinct

objects to distinct objects. An injection is sometimes also called one-to-one. Accordingly, it was assumed that the drivers tend to behave according to the dynamic traffic assignment.

Following this assumption, the map between the OD matrices and flow rates becomes one-to-one, making it possible to estimate the OD matrices from flow rate patterns. After that, the microscopic traffic model was implemented (the model developed in this study is a microscopic one since it considers individual vehicles' interaction) to represent a simulation of the real-world traffic network. Using the OD matrices as inputs, the simulator (using excel – annex 1) uses the previously explained DTA to identify the routes for each of the OD pair, from which the traffic flows in each link could be gathered.

Since the DTA is founded on reasonable behavior of the drivers on the road, the routes are assumed to be close to the ones chosen by the drivers. Given the Knowledge of OD matrices, the simulator provided traffic flows that are close to real ones.

The simulator was another base for validation. The OD estimate could only be compared according to generated traffic flows because it, unlike other estimation processes where estimated variables are known previously, could be directly compared. More specifically, there was a need for functions to map the OD matrix to different flows to evaluate how good an OD estimation is. Furthermore, NN was used to estimate an OD matrix based on the traffic flows. The neural networks were used to set the layers of change in the traffic flow, optimization, and change in the traffic speed, as shown in section IV. Figure (1) summarizes the entire OD matrix estimation method.

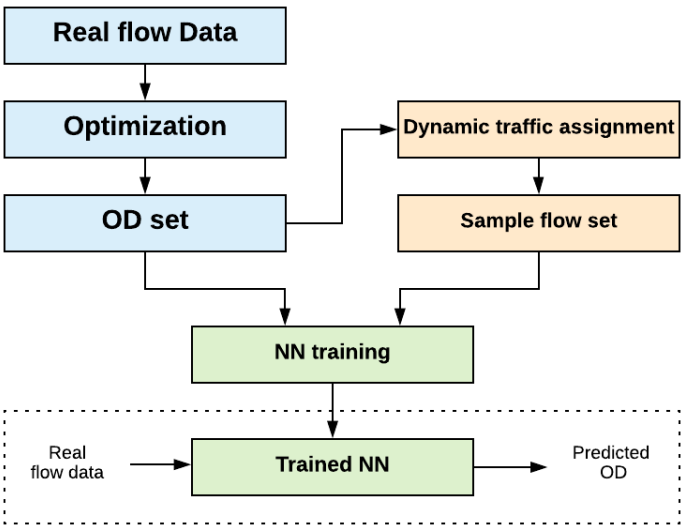

Figure (1): OD matrix estimation method

Sensors were used to collect data from the buses on the traffic network. Based on the real flow data, an optimization formulation was constructed with the flow conservation constraints. The solution achieved to use a set of OD matrices that are feasible given the real-world flow data (explained in the Process of Solution section in section IV).

The OD matrices generated by solving the optimization problem were feasible only according to the flow data, which were measured using the developed equations. This means that the OD matrix or flow rate was not guaranteed to follow the dynamic traffic assignment assumption or other routing behavior.

After that, the OD matrices were fed into the simulator (excel simulator – annex 1), which adopt a dynamic traffic assignment pattern to estimate the traffic flows in response to the input of the OD matrix. Using the OD matrices achieved by solving the optimization problem and the corresponding traffic flow generated by the simulator via dynamic traffic assignment, the NN system was trained on the traffic flows as input and the OD matrices as output. The equations were inserted into excel functions to show the Δbus passengers/hour, Δ cars-hour, and Δcars-km based on the data collected; this means that the NN system is trained to mimic the inverse process of dynamic traffic assignment that generate the compliant OD matrices following a set of flow measurement.

Furthermore, to improve the system's design, it is essential to develop the artificial neural network model.

ANN is a type of model that simulates the behavioral characteristics of a human neural network. It is a mathematical model that is based on distributing parallel information processing. This network relies on the complexity of the system. It achieves the purpose of processing information by adjusting the internal connection between a large number of nodes. This model has the ability of self-learning and self-adaptation.

For the current study, since no clear maps showing the routes of the buses, the factors – financial cost for the users of personal cars, the travel time for the users of personal cars, reduction of transit time for users will be used for developing the model of study.

The following optimization function could present the trade-off between those factors:

$$OF = f\,(\Delta C_{car},\ \Delta\, T_{car},\ \Delta T_{bus})$$

Where,

ΔC_{car} : the rise in financial cost for the users of personal cars.
$\Delta\, T_{car}$: the rise in the travel time for the users of personal cars.
ΔT_{bus} : reduction of transit time for users

The choice behavior of car drivers has been simulated through the Dynamic due date assignment method DUE. Besides, the impact of busways on bus travel speed has been evaluated by a neural network, allowing for several road attributes. The positive impact of the modal shift on public welfare has also been considered by assigning a suitable weight to the time saving for bus passengers. Iterations of a greedy algorithm have been used to determine the optimal set of busways.

V. APPLICATION AND RESULTS

To estimate the OF, it should be broken down into the following:

$$\Delta C_{car} = [SAR\ per\ car\text{-}km\ .\ \Delta cars\text{-}km];$$

$$\Delta T_{car} = [SAR\ per\ car\text{-}hour\ .\ \Delta cars\text{-}hour];$$

$$\Delta T_{bus} = [SAR\ per\ passenger\text{-}hour\ .\ \Delta bus\ passengers\text{-}hour].$$

Where,

- *Δcars*-km: variation of cars-km variable resulting from the busways. Such quantity stands for the personal car number that moves on the network and the distances they cover.
- *Δcars*-hour: the variation in the cars-hour that arises from a certain pattern of bus lanes. This component is intended to measure the transit time of private cars.
- *Δbus* passenger-hour: the difference in the passenger-hour component that arises from a specific pattern of bus lanes. This component is intended to measure the transit time of the bus.

To determine the *Δbus* passengers-hour, two components need to be evaluated: the speed of public transport for the roads under analysis, which are the bus routes' potential location, including the number of the bus's passengers.

A multilayer perceptron neural network has been used particularly to predict the speed of public buses. More specifically, a three-layer structure has been used:

- Input layer: includes several neurons that equal the number of components observed for the generic road section. This layer uses linear mathematical functions to send the input data to the processing layer.
- Hidden layer: this represents the core computer of the neural network that includes a set of neurons identified by the pruning approach and utilizes the tanh transfer function.
- Output layer: it estimates the bus travel speed using a neuron.

The data in table (5) hypothesized by the researcher after consulting some specialists in multiple transportation companies (Metro Jeddah and SAPETCO).

This artificial intelligence-based tool processes the empirical data of the road attributes that are (La Franca et al., 2004):

- Availability of busway (Y/N).
- Number of traffic lights junctions.
- Number of bus stops.
- Number of side roads.
- Number of crossings for pedestrians.
- Parking possibility (Y/N).
- Parking rules transgression (Y/N).
- Shop's presence (Y/N).
- Road capacity.

Based on the above variables, the roads under analysis were divided into homogenous sections. Furthermore, the road data were normalized to make them processable by the neural networks, e.g., comparable inputs and dimensionless. Table (5) show the data before normalization. The researcher hypothesized the data after consulting some specialists in the Saudi Ministry of Transportation. The data in the table are taken from a vehicle on the roads. King Abdullah Street includes four lanes, Tahliyah Street includes three lanes, and Madinah Road includes four lanes.

To identify the passengers' number, the origin-destination matrix representing the public transport demand at Jeddah street during the peak hours was assigned by hyperpath minimum algorithm (the averages of bus speed and peak hours) considering the rising speed of buses following the selection of new lanes. The application of the algorithm aimed at identifying the best lane for the buses to take

following the best speed, as shown in table (6). the table shows the range in the bus speed when taking the lanes randomly. More precisely, the distribution of buses according to the lanes on the roads increases their speed and gives shorter travel time.

Table (5): Data before normalization.

Road	Lanes #	Length (km)	Bus speed with bus lane (km/h)	Bus speed without bus lane (km/h)
King Abdullah Street	1	0.15	14.58	6.57
	2	0.25	7.57	7.07
	3	0.25	6.32	6.31
	4	0.2	15.06	7.88
	3	0.25	7.96	6.31
	4	0.2	15.06	7.88
	3	0.25	7.04	6.31
	2	0.25	6.98	7.07
	1	0.15	13.65	6.57
	4	0.2	15.06	7.88
Tahliyah Street	1	0.15	10.35	6.28
	2	0.25	6.91	7.00
	3	0.3	10.02	6.98
	3	0.3	10.46	6.98
	3	0.3	8.90	6.98
	1	0.15	11.25	6.28
	3	0.3	10.46	6.98
	2	0.25	7.10	7.00
	1	0.15	12.03	6.28
	1	0.15	13.75	6.28
Madinah Road	1	0.24	9.77	6.31
	2	0.7	8.16	6.52
	3	0.35	16.37	14.12
	4	0.5	15.94	15.09

To evaluate the *Δcars*-km and *Δcars*-hour, the matrix representing the demand of private transport in Jeddah during the peak hour was assigned using the *DUE method* (using excel ranking methods) to the corresponding graph (Figure 11) while considering the space reduction of car movements. The comparison shows that if buses are properly distributed according to the lanes, their speed will be more than the speed of cars.

Table (6): Output of Neural Network

Road	Lanes #	Length (km)	Bus speed with bus lane (km/h)	Bus speed without bus lane (km/h)
King Abdullah Street	1	0.15	14.58	6.57
	2	0.25	7.57	7.07
	3	0.25	7.96	6.31
	4	0.2	15.06	7.88
Tahliyah Street	1	0.15	13.75	6.28
	2	0.25	7.10	7.00
	3	0.3	10.46	6.98
Madinah Road	1	0.24	9.77	6.31
	2	0.7	8.16	6.52
	3	0.35	16.37	14.12
	4	0.5	15.94	15.09

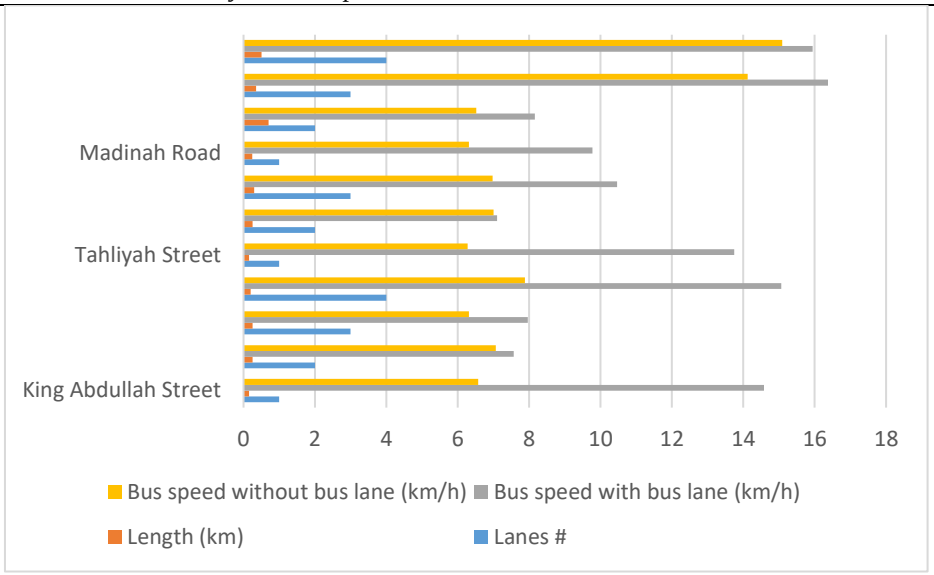

Figure (11): Changes in the bus speed following taking the bus lane.

The current part of the study shows the results achieved through the greedy algorithm that was applied to identify the optimal set for bus routes for public transport systems. The heuristic constructs mentioned in table (5) represent the bus lane design problem which could be figured out using step-by-step optimization methods where the followed function was applied – the researcher developed this function:

$$WF = \alpha\ (\Delta bus\ passengers\text{-}hour - \Delta cars\text{-}hour) - \beta\ \Delta cars\text{-}km$$

Where:

- WF: Welfare Function
- α: time value, 15 SAR per passenger-hour.
- β: cost of private transportation, 6 SAR per km.

The time value featuring the transportation system in Jeddah could be about 8 SAR per hour. Considering the positive environmental impact and the need for turning *Δcars-hour* into *Δcar passengers-hour*, the value (8) should be multiplied by 1.1 (this value is based on the researchers' knowledge). Accordingly, the function will be

WF = (8 SAR per hour) * 1.1 * (*Δbus passengers-hour* − *Δcars-hour*) - (6 SAR per care-km) * *Δcars-km*.

The sequential technique was used to build the optimal set of the buses at all stages t (t=1,2, ..., N) within the available road in critical transport frequency (between 14 and 27 buses per hour). The algorithm below identified the optimal WF by introducing an additional bus lane as follow as shown in table (7):

The above equations are developed to identify the best lanes to be taken by the buses to Overspeed the cars and decrease the travel time. If the company considers the distribution of their buses on the identified lanes, the travel time will decrease, and citizens will be more encouraged to take the public buses.

Table (7): Optimal lanes

Road	Lanes	Currently used lanes	Lanes – according to the model
King Abdullah Street	1	Suggested Lane	Suggested Lane
	2	-	Suggested Lane
	3	-	Suggested Lane
	4	Suggested Lane	-
Tahliyah Street	1	-	Suggested Lane
	2	Suggested Lane	Suggested Lane
	3	-	-
Madinah Road	1	-	Suggested Lane
	2	-	Suggested Lane
	3	Suggested Lane	-
	4	Suggested Lane	Suggested Lane

The results indicated that the buses need to take new road lanes to reduce the travel time and be more reachable by the passengers. In addition, the cost of the transportation should be reconsidered and fixed to be more convenient for the passengers who use their cars.

VI. CONCLUSION AND RECOMMENDATION

This study aimed to implement a reliable methodology for creating bus routes using traffic neural network design. The study is also intended to enhance the day-to-day operations performance of the bus network. The study took the ride-hailing company buses as a sample for applying the developed system. Besides, a questionnaire was developed and distributed among Saudi citizens to identify the main factors influencing their choice for using public transportation. Participants provided one thousand one hundred four responses. It was found that additional efforts are needed to promote public awareness of the significance of using public transportations. This part of the study aimed to know the Saudis perception of public transport services and know the most important factors affecting their willingness to use public buses. Based on this part of the research data, which showed the need to redraw the bus routes and reallocate the bust stations, Traffic neural network design was used to develop a system that would determine the most routes that buses take and the destination they take. Thus it is possible to determine the locations of the bus stations according to their proximity to places the citizens move back and forth.

The study showed that few Saudis use public transportation, and even very few of them know the location of bus stations. In addition, the results showed that there is an inverse relationship between monthly income level and usage of public transportation—the greater the rate of income, the less interest in the use of public transport. Furthermore, the results showed that many Saudi have private cars and prefer moving using their cars. Most Saudi women have private drivers and prefer using private cars for transportation. The results showed that the majority use their cars to avoid congestion. The irony here is that the frequent use of personal cars leads to more congestion than buses.

The researcher believes that increasing the use of public buses would reduce the use of personal cars and thus reduce air pollution resulting from their use, preserve the environment, and achieve environmental sustainability. Achieving sustainability is an important part of the Saudi Vision 2030 vision, which stipulates the need to pay attention to sustainability and environmental preservation. The Saudi government is supposed to organize public awareness campaigns to motivate the citizens to use public transportations services. Besides, the government can benefit from the spread of social networks to spread the culture of using public transportation.

Finally, the potential researchers can focus on the challenges facing the public services companies and provide solutions for such challenges. Besides, they can conduct further studies on using other technological techniques to plan the movement of buses for one company but several companies.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical statement: The authors declare that they have followed ethical responsibilities.

REFERENCES

[1] Walker, J. Human Transit: How clearer thinking about public transit can enrich our communities and lives. Island Press. 2012. Vol, 3:1.
[2] Redman, L., Friman, M., Gärling, T., and Hartig, T. Quality attributes of public transport that attract car users: A research review. Transport Policy 2013. 25. Pp., 119-127.
[3] Daniels, R., and Mulley, C. Explaining walking distance to public transport: The dominance of public transport supply. Journal of Transport and Land Use. 2013. 6:2. Pp., 5-20.
[4] Rodrigue, J., P., Comtois, C., and Slack, B. The geography of transport systems. 2013. Pp., 12-26. Routledge.
[5] Donovan, S., and Munro, I. Impact of urban form on transport and economic outcomes. Wellington, New Zealand: NZ Transport Agency. 2015. Vol, 1:1.
[6] Alotaibi, Omar. Potential demand for public transport in Riyadh City, Saudi Arabia. Cardiff University. 2017. Pp., 9-25.
[7] Alotaibi, Omar, and Potoglou, Dimitris. Introducing public transport and relevant strategies in Riyadh City, Saudi Arabia: a stakeholders' perspective. Urban, Planning and Transport Research. 2018. 6. 35-53. 10.1080/21650020.2018.1463867.
[8] Litman, T. Evaluating public transit benefits and costs: Best practices guidebook. Victoria Transport Policy Institute. 2017. 13.
[9] Scheiner, J., and Enoch, M. Sustainable Transport, Mobility Management and Travel Plans. JSTOR. 2013. 21:4.
[10] Jansson, K., Andreasson, I., and Kottenhoff, K. Public Transport in the Era of ITS: Forms of Public Transport. Modeling Public Transport Passenger Flows in the Era of Intelligent Transport Systems. Springer. 2016. Pp., 29-83
[11] Javid, A., Okamura, T., Nakamura, F., Tanaka, S., and Wang, R. Public Attitudes towards Travel Demand Management Strategies (TDM) in Lahore, Pakistan: Importance of Lifestyles, Social and Travel Related Beliefs. 13th World Conference on Transport Research. 2013. 15-18.
[12] Khalilikhah, M., Habibian, M., and Heaslip, K. Acceptability of increasing petrol price as a TDM pricing policy: A case study in Tehran. Transport Policy. 2016. 45. Pp., 136-144.
[13] Tai, T., Ngah, R., Shah, M. Z. and Al Ali, M. Modelling Travel Demand Management Measurements towards Travel Behaviour with Psychosocial, Trip Chain Attributes and Quality of Life: A Conceptual Paper. 2016. Vol, 5:1.
[14] Khodeir, M., Shamy, M., Alghamdi, M., Zhong, M., Sun, H., Costa, M., Chen, C., and Maciejczyk, P. Source apportionment and elemental composition of PM2.5 and PM10 in Jeddah City, Saudi Arabia, Atmospheric Pollution Research. 2012. 3. 331-340.
[15] Maskey, V., Strager, P., and Bernasconi, C. Managing a sustainable transportation system: Exploring a community's attitude, perception, and behaviour of the morgan town public rapid transit (PRT). Journal of Management and Sustainability. 2013. 3:2. 56-67.
[16] Dano, L., and Alqahtany, A. ISSUES UNDERMINING PUBLIC TRANSPORT UTILIZATION IN DAMMAM CITY, SAUDI ARABIA: AN EXPERT-BASED ANALYSIS. Journal of Sustainability Science and Management. 2019. 14. 157-171.
[17] Ji, J., and Gao, X. Analysis of people's satisfaction with public transportation in Beijing. Habitat International. 2010. 34. 464-470.
[18] Aljoufie, M., Zuidgeest, M., Brussel, M., and Maarseveen, M. V. Spatial–temporal analysis of urban growth and transportation in Jeddah City, Saudi Arabia. Cities. 2013. 31, 57-68.
[19] Alhazmi, A., and Nyland, B. Contextualization of Saudi International Students' Experience in Facing the Challenge of Moving to Mixed Gender Environments. American International Journal of Contemporary Research. 2015. 5:2. Pp., 87-97.
[20] Deweik, A., and Nayer, A. Initiating a smart Transportation system in Jeddah. Real Corp Proceedings/Tagungsband. 2016. 891-897.
[21] Miralles-Guasch, C., and Domene, E. Sustainable transport challenges in a suburban university: The case of the Autonomous University of Barcelona. Transport policy. 2010. 17(6), 454-463.

[22] Gately, D., Al-Yousef, N., & Al-Sheikh, H. M. The rapid growth of OPEC′ s domestic oil consumption. Energy Policy. 2013. 62, 844-859.
[23] Global Mass Transit. Public transport in Saudi Arabia: Priority sector for government investment. 2016.
[24] Alotaibi, O., and Potoglou, D. Perspectives of travel strategies in light of the new metro and bus networks in Riyadh City, Saudi Arabia. Transportation Planning and Technology. 2017. 40(1), 4-27.
[25] Alotaibi, O., and Potoglou, D. Introducing Public Transport and Relevant Strategies in Riyadh City, Saudi Arabia: a Stakeholders' Perspective. Urban, Planning and Transport Research. 2018. 6(1), 35-53.
[26] Domingos P. A few useful things to know about machine learning. Communications of the ACM. 2012. 55(10). 78-87.
[27] Rosenblatt F. The perceptron: a probabilistic model for information storage and organization in the brain. Psychological review. 1958; 65(6):386.
[28] Hurford JR. Exclusive or inclusive disjunction. Foundations of language. 1974; 11(3):409–411.
[29] Simonyan K, Zisserman A. Very deep convolutional networks for largescale image recognition. arXiv preprint arXiv:14091556. 2014.
[30] Tsapakis I, Cheng T, Bolbol A. Impact of weather conditions on macroscopic urban travel times. Journal of Transport Geography. 2013; 28:204–211.
[31] Rumelhart DE, Hinton GE, Williams RJ. Learning representations by back-propagating errors. Nature. 1986; 323(6088):533.
[32] Hecht-Nielsen R. Theory of the backpropagation neural network. In: Neural networks for perception. Elsevier; 1992. p. 65–93.
[33] Werbos PJ. Backpropagation through time: what it does and how to do it. Proceedings of the IEEE. 1990; 78(10):1550–1560.
[34] Riedmiller M, Braun H. A direct adaptive method for faster backpropagation learning: The RPROP algorithm. In: Neural Networks, 1993. IEEE International Conference on. IEEE; 1993. p. 586–591.
[35] Kamran, H., Rehman, Z., Chaudhri, A., and Farrukh, S. Ride-Sharing Apps and Privacy in Pakistan: A Detailed Study on the Practices of Uber and Careem. Digital Rights Foundation (DRF). 2019. Vol, 5:1.
[36] Arabianbusiness. Careem eyes potential expansion to 250 cities in MENA. Arabianbusiness. 2018. Available Online: https://www.arabianbusiness.com/transport/397038-careem-eyes-potential-expansion-to-250-cities-in-mena.
[37] Farber, Madeline. Uber's Middle East Rival Just Got a $1 Billion Valuation". Forbes Magazine. 2016.
[38] Arnold, T., and Carvalho, S. Uber faces pressure in Dubai as regulator signs deal with rival. Reuters. 2016.
[39] Careem. Careem BUS Jeddah routes. 2019. Available Online: https://blog.careem.com/en/careem-bus-jeddah-routes/.
[40] Arab News. Careem launches bus service between Jeddah and Makkah. 2019. Available Online: https://www.arabnews.com/node/1497611/corporate-news.
[41] Hasan, R., Oh, J.S., and Kwigizile, V. The Impacts of Socio-Cultural Dimensions on Active Transportation Mode Choice across Several Countries Case Study of Kalamazoo (USA), Seoul (South Korea), Jeddah (Saudi Arabia), and Samarra (Iraq). Journal of Transport & Health. 2019. 14.
[42] El-Sawy, N. Careem starts bus service from Jeddah to Makkah. 2019. Available Online: https://www.thenational.ae/business/technology/careem-starts-bus-service-from-jeddah-to-makkah-1.861540.

