Managing public buses transportation considering environmental emissions

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Abstract.
Transportation systems and the environment are conflicting issues in nature with the main factor behind emissions of most pollutants and their impacts on the environment. The public transportation contributes by reducing negative effects of traffic and environmental pollution, as well as, its positive effects on the total transport economic costs. The aim of this paper focuses on managing the transportation network for public buses, by implementing some scientific planning techniques such as, working networks to reach maximum flow of the passengers, and minimum path method to choose the shortest way. Three parameters are considered in the problem solution these are; the maximum flow of passengers, the minimum distance and the minimum CO2 emissions. The case study of the research focuses on two main crowded areas in Baghdad governorate and theirs group transportation lines to be managed; these areas are The University of Technology and Al Mustanseria University in Baghdad/ Al Risafa. The flows of passengers between the two campuses were studied with the aim of getting minimum distance and maximum flow of passenger. Distance in kilometers and Population Density for each path were studied to calculate CO2 Emissions in Tons to fulfill the third parameter. The results shows that for minimum distance the best route is route no.15; while for maximum passenger flow, the best route is route no.10. For minimum CO2 emissions, the best route is route no.15. The conflicting results emphases on the choice for the most important target according to the governorate strategies decisions.

Keywords: Transportation, Maximum flow, environmental pollution, Linear Programming, Network, CO2 emissions.

1. Introduction
Centering on the relation among transportation and environment that got great changes due to the modes of related environmental matters and transportation, the 21st century is called “Century of Environment”. Transportation offers a wide range of matters viz. crowding, accidents, air pollution, noise and transportable time. It is obvious from the current information that air pollution controls are a recent priority in the native environment and present a major potential to regulate gas emissions [1]. In developing republics and Eastern Europe, however, with the possibility of great increase in car ownership and use, these countries adopt measures now to prevent transport-related air pollution problems which are severe in the 21st Century [2]. In this work the target of reducing pollution is studied within applying network transportation method focusing on shortest path and maximum flow. Linear programming is the illustration of networks to solve the shorter route and the maximal flow problem. The obvious advantage is that the efficiency of computations may be improved drastically when network formulation is used. Literature and articles review do not state if any general theory of network construction exists [3]. Cork City Council [4] for example, has applied a strategic plan, with a stress on public transport improvement as a city center access. The facility of vehicle paths, such as the Corridors of the Bus, the location of automatic vehicle and...
integration of ticketing besides other means for public transportation, increase the using of buses with decreasing car usage which lead to reduce emissions.

2. Literature review

Many researchers studied transportation techniques and some of them take into consideration environmental impacts as a view point. Ramirez and Seneviratne (1996) [5] suggested a method for path network design constructed on GIS. The method allocated an element of impedance for all probable paths and nominated the set of paths minimizing impedance. Pattnaik et al. (1998) [6] defined a procedure for detecting optimum paths and facility occurrences employing genetic algorithm. Particularly, they applied two phase process: firstly, set of practicable paths were created to be followed by genetic algorithm that was adopted to choose optimal path [7]. Sharm and Kumar (2012) [8] concluded that transport has an extensive range of ecological externalities, certain ones are reasonably evaluated but others are typically assumption. Externalities occur in different scales of topographical; overlapping over some may be occur. For example, using fuel effective means of transportation which decrease ecological externalities may lead to positive ecological, social and economic imports. The problem is still about which approaches are the most positive in totally ecological. Recently a research [4] by Interface Europe carpet manufacturer focus on the transportation emissions impacts from their shipping supply such as establishment cars and air traveling were the most significant and far when comparing with energy consumption of the production processes, solid waste disposal and waste discharges. Doddy Yuono (2019) focus on the sorting scheme and alternate road hierarchy which are a primary phase in studying the urban transport scheme. The road networks provide accommodations to the road functions and usage for integration with the road’s users [9]. Thota and Raja (2020) in their paper suggested a routine, namely, zero average routine for solving fuzzy transportation problems by assuming a decision maker is uncertain upon the accurate prices of the transportation costs, demand, and supply; then a numerical case is resolved to examine it. The suggested routine is easy for understanding and applying in real-life transportation problems [10]. Ogryzek, Adamska-Kmie´c Klimach (2020) in their article adopts sustainable transport codes and guides that can lead cities to an efficient transportation network. They took into consideration parameters such as public transport signs, and the number of trips. The results show direction for Vilnius to improve a sustainable traffic network. Analyses and regulation were centered on adopting geographic information system (GIS) tools to get the best reliable outcomes [11]. Wang et al. (2020) in their study consider technological developments to validate the simulation model and evaluate the risk model depending historical scenarios to determine the CO2 emissions for 2004–2014 concentrating on urban areas, and the records were matched with the bottom-up emission. They found that CO2 emissions might exceed 250 million tons in the end of 2020 due to the current policies [12].

3. Transportation and pollution

The decisions of ecological strategy [13] and transportation division strategy are not separated. City air pollution due to the movable causes is a by-product of city transportation facilities. Such facilities are vital to the commercial health of a town and for the safety of its populations. Therefore, balancing strategy must be considered in its different extents locally and nationwide. Main line of comparison approaches stresses on ecological effect caused by transportation such as air emissions and their resultant effect like health affecting [14]. The influence for transport related six main areas which are environment, health, noise, accidents, earth usage and the harm of ozone. Transportation [13] is known as a cause of various air pollutants. The World Health Organization (WHO) named the following six air pollutants which are the “classic” ones:

- Lead which is formed mainly by the burning of toxic leaded gasoline.
Suspended particulate matter (SPM), which is a mix of several of contaminants that happen in liquid and solid forms.

- Ozone (O3) is linked with transient properties on man respirational system; it reduces lung function.
- Carbon monoxide (CO) is the major suppliers of vehicles fueled with gasoline. CO prevents blood from carrying oxygen to tissues and muscles.
- Sulfur dioxide (SO2) is produced directly as a sulfur amount of fuel; it affects lung function and causes asthma and worsens breathing indications.
- Nitrogen dioxide (NO2) likewise damages lung function.

To control CO2 emissions in transportation division is commonly harder than to control emissions in other divisions of industrial republics. Ireland [4] is a country with almost the maximum ranks of annual car usage and lowermost ranks of public transportation usage in the Europe, although public transportation is effective in energy efficiency rather than cars for a passenger per kilometer.

4. Graph Theory

For problem solving in a network of transportation, the graph scheme is essential in mathematics. Graph term mathematically takes double dissimilar meaning. A graph is firstly a relation or a function. Secondly, it is commonly associated with the Graph theory, which is a group of vertices or nodes and, links or ends [7]. Graph theory is normally related to the application and it’s firstly using is credited in transportation; where it is normally adopted studying routing problems and networks as follows:

4.1. Routing

It is a method for representing roads and intersections as a graph for illustrating relationships and cross-sections of paths to the problem under study. The followings are the most used routs problems; the problem of Konigsberg Bridge, the problem of the road with one way, the problem of Chinese postman and the problem of travelling salesman which will be introduced shortly as follows:

a. The problem of one way street is adopted in the towns for controlling the traffic flow by asking about the possibility of converting two way roads into one way roads [15]. As an example taking double triangles in a case through a bridge i.e. connect of the edges and in an additional case with no bridge as shown in figure 1.

b. The problem of Konigsberg’s bridge demonstrates the seven bridges in the city, where its societies required knowing the ability of starting at a point to cross all bridges once and return to the initial point.

c. The problem of the Chinese postman is adopted to find the shortest delivery path taking into consideration to start at a point.

d. Problem of travelled salesman is adopted to deal with the salesman’s desires for visiting N different towns, once each, and returning to the initial point, aiming for cost minimization. The use of graphs is for problem formulating. The towns are represented by vertices or symmetric edge. The edge’s arcs are denoted with a weight that represents the costs between towns.
e. The problem of the shortest path seeks to find the shortest path between two vertices or towns in a network. Solving such problem by focusing on graph network placing weights on the arcs to indicate the length.

4.2. Network problems

The network modeling is used in economic a long time ago. Quesnay (1758), Cournot (1838) and Pigou (1920) work embedded it [17]. Latter considered the network structure for transport network that was consisted of two paths and indicated that the system optimization solution was different from the user optimization solution. More recent it was coined in the efforts of Samuelson (1952) [18], Takayama and Judge (1971), and Dafernos and Nagureny (1984) [19] who recognized the similarity between the problem of network stability in traffics and the problems of three-dimensional stability. The followings are the most used networks problems; the shortest path network problem, the maximum flow problem, the minimum cost flow problem. These networks are usually adopted in the transportation problem. The followings demonstrate them shortly to focus on solving them using graph theory.

4.2.1. Shortest-path network problem. This network model is adopted for finding minimum distance between two points depending either the shortest route or minimum time according to the speed for the case in the road under study. Moreover, these models are commonly varies. The followings are the most relevant variant of each model.

Time expanded model: In this model all node are corresponded for a certain time departure or arrival, where all edges have constant time of travel [20]. All edges are weighted with simple values which give the advantage for this model to be simple for using.

Time-dependent model: This model lessens the node’s number compared with the time expanded model that presented performance difficulty [21].

Station graph model: This model adopts only one node for a location for least transfer periods. Berger et al. introduce [22] this model by abbreviating time dependent model.

The Vehicle Routing Time-dependent: Here a procedure is provided which expands the calculation huge traveling time tables for the time dependent state. Vehicle routing problem (VRP) is a problem widely regarded in operations research, [27], with capabilities increasing consideration from the process area [23]. It is NP-hard due to its generality of the problem of traveling salesman.

Time-dependent Graph: computing all paths is to be done before creating a graph depending a timetable according to the time-dependent model.

4.2.2. The maximum flow problem. Transportation planning and materials’ Logistics deal with a significant problem that focuses on finding the material amount to be shipped among two localities by transport channels usage with restricted capacity. As an example in the designing of transport paths for a company that seeks to know the maximum number of passenger to be transported from a location to another daily. In such problems the starting location is a source, while the receiving location is called the sink; the source and sink might be with unlimited capability for the convenience of problem solving. Linear Programming is used for problem modeling, however Simplex method is used as a solver; but focusing on a graph theory is more effective.

In this paper the maximum flow problem is adopted for finding the path to transfer passengers from the source to the sink. In search assistance of the following flow path, convenience is by keeping track for the remaining of the capability for each edge. Stages are dependent for solving problem and to add additional flow in all stages, then to be represented in the network of the graph. This technique is used for solving flow network design problems for liquid materials and transportation to achieve maximum passenger flow for two ways networks according to the problem under study.
The maximum flow capacity with networking is applicable in recent logistic management. Automatic system widely uses computerized programs to solve maximum flow problems. The maximum flow problems develop an approach to design bus’s network upon demand in the small and medium cities.

Maximum flow focuses on finding feasibility of flow with a single source and sink network. Maximum rate of an s to t flow equals the minimum rate of an s to t cut in the network. An (s, t) flow as shown in figure 2, is maximize when no augmentation is admitted in the s-t chain.

Figure 2. S-T Flow Problem [16]

4.2.3. The minimum cost flow problem. Minimum cost flow problem focusing on finding the possible cheapest way to send a definite sum of flow from a source s to a sink t within the network. No negativity capacity on all arc and no negativity cost are essential in this problem which can be adopted in Transportation problem. The minimum cost flow problem will not be used in this paper.

5. Transportation Network Types in large cities

Representation for transportation network is formally uses number of links and number of nodes. The link joins two nodes and a node joins two or additional links. Two links are said to be parallel when connecting the identical nodes’ pair in a same direction. Loops are links of a same node in both ends [24]. Different origins and destinations may exist that form alternative paths. Other representation may be the grid network for a city that consist number of blocks.

A link used in the transportation networks’ analysis has different features, some of interest features are demonstration below:
- Length of a link may be in meters or in typical number of means of transportation.
- Cost of link may be as travel time or linear grouping of distance and time.
- Capacity of link which means the maximum flow [24].

The following steps determine the maximum flow between the source and the terminal to be followed in the case study in this paper.

Step 1: determine a chain connecting S and T such that the next flow in the chain is positive in the direction \( S \rightarrow T \). If no such chain exists, go to step 3 otherwise go to step 2.

Step 2: let \( \bar{C}_{ij} \) be capacities of the arcs of the chain \((S, T)\) in the direction \( T \rightarrow S \).

Step 3: determine the maximum flow in the network.

6. Environmental Impact and CO2 emissions

One of the greenhouse effective gases (GHG) is carbon dioxide (CO2). Participants of Kyoto Protocol focus on GHG actions and obligations denoted by them. To calculate the CO2 Emissions various CO2 emission programmers are presented in Internet, which may be realistic for the emissions generated by transportation vehicles. PlanetAir is recommended to compute the emissions released cars, buses, and air travels [25].

Regulations are obligatory according to United state Environmental Protection Agency (EPA), [26] Occupational Safety and Health Administration (OSHA), [27] and National Institute for Occupational Safety and Health (NIOSH) [28]. Quantifiable factors are well-defined and are updated frequently. The
series of ISO 14000 standards [29] are considered to assist meeting and improving ecological managing system requirements. Motivation are due to the necessity to well accomplish compliances with ecological rules, according to the search for transportation effectiveness, customer needs, community or ecological drive of public pressure, or even for being noble corporate residents by eliminating CO2 emissions ($C_e$).

The carbon emissions in the transportation from one point to another location based on formula below which computes the total carbon emissions occurring during the transportation.

$$C_{ei} = \sum_{i=1}^{n_p} M \times d \times E_{fm}$$

Where: $M$: Mass or Quantity

$E_{fm}$: Emission factors for the type of transportation mode used

$d$: The destination travelled of required line.

This is the carbon dioxide (CO2) emission. Table 1 shows the CO2 Emission amount per one kilometer for each passenger related on the means of transportation.

| foot   | bicycles | Animal | rickshaw/trishaw | Moped | motorcycle | auto rickshaw | Ice mechanisms |
|--------|----------|--------|-------------------|-------|------------|---------------|----------------|
| Electric cars | 0        | 0.043  | 0.073             | 0.094 | 0.061      | 0.094         |                |
| Small cars | 0.11     | 0.133  | 0.183             | 0.84  | 0.069      | 0.069         | 0.055          |
| Medium cars | 0.183    | 0.183  | 0.84              | 0.17  | 0.069      | 0.069         | 0.055          |
| Big cars | 0.073    | 0.073  | 0.094             | 0.061 | 0.094      | 0.094         |                |
| Hybrid Cars | 0.183   | 0.183  | 0.094             | 0.061 | 0.094      | 0.094         |                |
| taxi | bus      | Mini bus |                |       |            |               |                |
| Electric train | Electric train | 0.065 | 0.065 | 0.042  | 0.115 | 0.53       |                |
| Boats | Fast boats |                |       |            |               |                |

7. Studying a public transportation line in Baghdad city /Case Study

The problem of public transportation in Baghdad city is the case study in this work; taking into consideration two main crowded areas in Baghdad governorate and theirs public transportation lines. These areas are The University of Technology and Al Mustanseria University in Baghdad/ Al Risafa. The flow of passengers between the two centers are studied with the aim of getting minimum distance or earlier reaching time and maximum flow of passenger to calculate the CO2 emissions effects. The passenger’s number may vary each day and each hour according to different variables.

The assumptions of the specialty for this case in public transportation are:

- Only one start point nod ($M$) and one end point nod ($T$)
- The capacity of the different arcs in the direction $M \rightarrow T$ along the selected chain is dynamic; the data for the going trip $\neq$ the data of the coming trip.
- The capacities of the arcs of the chain ($M, T$) in the direction $M \rightarrow T$ various in the direction $T \rightarrow M$

7.1 The problem demonstration of the research

The problem of the research for the chosen case study is demonstrated using network approach explained early in this research. To illustrate the routes reality Google maps programme is used and the areas and the routes of the selected case study are shown in the grid in figure 3.
Figure 3. Map showing the routes of the grid

Figure 4 shows both the routes on the grid and the population density of the named areas under study in the network taking into consideration different points of view for the places and areas to be constructed in the network graph. The figures 3 and 4 show the Google maps of the Baghdad city area studied in this case study. 14 neighborhoods are named and coded with its population density M in Table 2 and depended on constructing the network graph in figure 5 showing the codes of the neighborhood and all possible routes.

Figure 4. Map showing the route of the grid and population density

Table 2. Residential neighborhoods

| No. | The name of the neighborhood      | Short code | Population density M |
|-----|-----------------------------------|------------|----------------------|
| o   |                                   |            |                      |
| a   | University of Mustansiriyah      | UOM        | 20                   |
| b   | 14 July                           | 14 J       | 40                   |
| c   | Quarter 508                       | Q508       | 22                   |
| d   | Al-Mustansiriyah Neighborhood     | MUS        | 10                   |
| e   | Palestine Street1                 | P1         | 10                   |
| f   | Palestine Street2                 | P2         | 32                   |
| g   | Al-Eqari                          | EQ         | 12                   |
| h   | Nile 503                          | N503       | 50                   |
| i   | Quarter 505                       | 505        | 20                   |
| j   | Al-Idrisi 507                     | ID507      | 65                   |
| k   | Zayona 1                          | Z1         | 30                   |
| l   | Zayona 2                          | Z2         | 36                   |
| m   | Zayona 3                          | Z3         | 36                   |
| n   | Zayona 4                          | Z4         | 80                   |
| o   | Zayona 5                          | Z5         | 60                   |
| p   | Zayona 6                          | Z6         | 54                   |
| q   | Al-Gadeer                         | GD         | 15                   |
| r   | Al-Gilani                         | GI         | 8                    |
The different routes are named as paths according to the nodes numbers with their distances in Kilometers and the population density besides the influence areas numbers and illustrated in table 3.

![Network Graph](image_url)

**Figure 5.** The primary network graph of the routes

**Table 3.** Distances and population density of paths

| No. | Path      | Distance (Kilometers) | Population density M | Influence area (No.) |
|-----|-----------|-----------------------|----------------------|---------------------|
| 1   | 1 – 2     | 5.39                  | 30                   | o, a                |
| 2   | 1 – 3     | 2.45                  | 103                  | b, e, c, f          |
| 3   | 1 – 4     | 1.31                  | 15                   | e, d                |
| 4   | 4 – 5     | 2.18                  | --                   |                     |
| 5   | 3 – 5     | 1.65                  | 28                   | h, f, g             |
| 6   | 3 – 6     | 1.93                  | 135                  | h, j                |
| 7   | 3 – 2     | 2.81                  | 21                   | c, j                |
| 8   | 6 – 2     | 0.98                  | 15                   | i                   |
| 9   | 5 – 7     | 1.51                  | --                   | --                  |
| 10  | 6 – 7     | 1.85                  | 8                    | r                   |
| 11  | 2 – 8     | 1.79                  | --                   | --                  |
| 12  | 8 – 9     | 1.72                  | --                   | --                  |
| 13  | 6 – 9     | 2.10                  | --                   | --                  |
| 14  | 9 – 10    | 1.12                  | --                   | --                  |
| 15  | 7 – 14    | 4.05                  | --                   | --                  |
| 16  | 10 – 13   | 0.92                  | 36                   | l, j                |
| 17  | 9 – 12    | 0.72                  | 66                   | m, k                |
| 18  | 12 – 11   | 2.97                  | 104                  | n, p                |
| 19  | 12 – 13   | 2.72                  | 96                   | --                  |
| 20  | 13 – 14   | 1.86                  | --                   | --                  |
| 21  | 8 – 11    | 3.13                  | --                   | --                  |
| 22  | 11 – 14   | 2.90                  | 35                   | q, s, j, o          |

To calculate shortest path the scientific network graph is constructed showing the paths demonstrated previously in figure 5 with the distances in kilometers for each path as shown in figure 6. Figure 7 shows Network graph of the routes showing Population density M for each path as mentioned in table 3 inorder to calculate the maximum flow. For more accuracy and time minimization (POM-QM) program is used. (POM-QM) is a package usually adopted to assist in the Decision Skills comprehensive platform; in form three, the software is directed for Windows produces into unique creation.
7.2. Research problem solution for routes transportation

The research problem solution considers two sub-solutions; the solution using Min path method and the solution using Max flow method adopting algorithms discussed in the theoretical part of the research. To calculate the shortest path and maximum flow, the scientific network graph is further analyzed by dividing the total routes of the network graph into eight stages as shown in figure 10 illustrating the solution for shortest path.

Figure 6. Detailed scientific network graph of the routes showing the paths’ distances

Figure 7. Detailed scientific network graph of the routes showing Population density M for each path

POM packages for Networks is used to calculate the shortest path and displayed in figure 8. This shortest path is illustrated in the network in figure 9; it is the path 1 – 4 – 5 – 7 – 14.

Figure 8. Networks for POM packages / shortest path display
Figure 9 shows Network graph of the routes showing Population density M for each path with after adopting the eight stages with the solution of maximum flow. Distance in kilometers and Population Density M for each path will be depended to calculate Co2 Emissions in Tons to fulfill the objectives of this research in calculating these three parameters.

![Network graph of the routes showing shortest path](image)

**Figure 9.** Network graph of the routes showing shortest path

Figure 10 shows the maximum flow of passengers and demonstrated in the network graph of the paths.

![Network graph of the routes showing maximum flow](image)

**Figure 10.** Network graph of the routes showing maximum flow

To calculate Co2 Emissions for all possible paths further calculations are conducted to fulfill the main objective of this research in reducing environmental pollution; Table 4 is arranged for all possible paths. This table includes the distance in kilometers and the population’s density according to the previous networks shown.

| Route No. | The Route | Distance (kilometers) | Population Density M |
|-----------|-----------|-----------------------|----------------------|
| 1         | 1 – 2 – 8 – 11 – 14 | 13.21                 | 65                   |
| 2         | 1 – 2 – 8 – 9 – 12 – 13 – 14 | 14.2 | 192                  |
| 3         | 1 – 2 – 8 – 9 – 10 – 13 – 14 | 12.8 | 66                   |
| 4         | 1 – 3 – 2 – 8 – 11 – 14 | 13.08                 | 159                  |
| 5         | 1 – 3 – 2 – 8 – 9 – 12 – 13 – 14 | 14.07 | 280                  |
| 6         | 1 – 3 – 2 – 8 – 9 – 10 – 13 – 14 | 11.75 | 124                  |
| 7         | 1 – 3 – 6 – 2 – 8 – 11 – 14 | 13.18                 | 288                  |
| 8         | 1 – 3 – 6 – 2 – 8 – 9 – 12 – 13 – 14 | 14.17 | 415                  |
| 9         | 1 – 3 – 6 – 2 – 8 – 9 – 10 – 13 – 14 | 11.05 | 216                  |
| 10        | 1 – 3 – 6 – 2 – 8 – 9 – 12 – 11 – 14 | 15.46 | 458                  |
| 11        | 1 – 3 – 6 – 9 – 10 – 13 – 14 | 10.38                 | 201                  |
| 12        | 1 – 3 – 6 – 9 – 12 – 13 – 14 | 11.78                 | 327                  |
| 13        | 1 – 3 – 6 – 7 – 14 | 10.28                 | 173                  |
| 14        | 1 – 3 – 5 – 7 – 14 | 9.66                  | 58                   |
| 15        | 1 – 4 – 5 – 7 – 14 | 9.05                  | 15                   |
Table 5. Calculated Co2 emissions according to distances and population density

| Route No. | Distance (kilometers) | Population Density M | Co2 Emissions (Tons) |
|-----------|-----------------------|----------------------|----------------------|
| 1         | 13.21                 | 65                   | 0.03                 |
| 2         | 14.2                  | 192                  | 0.11                 |
| 3         | 12.8                  | 66                   | 0.03                 |
| 4         | 13.08                 | 159                  | 0.08                 |
| 5         | 14.07                 | 280                  | 0.16                 |
| 6         | 11.75                 | 124                  | 0.06                 |
| 7         | 13.18                 | 288                  | 0.15                 |
| 8         | 14.17                 | 415                  | 0.24                 |
| 9         | 11.05                 | 216                  | 0.10                 |
| 10        | 15.46                 | 458                  | 0.50                 |
| 11        | 10.38                 | 201                  | 0.08                 |
| 12        | 11.78                 | 327                  | 0.15                 |
| 13        | 10.28                 | 173                  | 0.07                 |
| 14        | 9.66                  | 58                   | 0.02                 |
| 15        | 9.05                  | 15                   | 0.01                 |

7.3. Calculation of the CO2 Emissions
PlanetAir software (http://planetair.ca/index.php?sel_lang=english) is adopted in this research to calculate the Co2 emissions generated using public buses for transportation according to the different paths calculation in table 4, and the results are shown in Table 5.

8. Conclusions
After investigating the three parameters for the case under study; which are the maximum flow of passengers, the minimum distance and the minimum Co2 emissions. The results for these parameters are shown in table 5 for fifteen different paths. For minimum distance the best route is route no.15; while the longest route is route no.10. For maximum passenger the best route is route no.10, while the minimum flow of passenger is in route no.15. For minimum Co2 emissions the best route is route no.15; while maximum Co2 emissions are with route no.10. The conflicting results emphases on the choice for the most important target according to the governorate decisions to choose the most required path. If the governorate priority is reducing the environmental impact them the choice is route no.15. But according to the transportation requirement of meeting the pupils and the staff of the universities targets to reach their destinations the route no.10 is chosen. It is noticed that route no.9 for example could have an acceptable requirements with 11.05 km, 216 passenger and 0.10 tons of Co2 emissions. Of course the flow of passengers may vary according to the days of the week and the hours of rush which might lead to different path choice. Further analysis depending AHP (Analytic Hierarchical Process) or LCA (Life cycle assessment) could be adopted for minimize environmental impact. Future work suggestion is to take into consideration two ways transportation lines with time table for line scheduling.

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