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REVIEW OF LITERATURE

2.1 INFORMATION TECHNOLOGY AND TRANSPORTATION:
The 20th century is rightly characterized by the industrial revolution and the information explosion would characterize the 21st century. The modern information technology has three components: the computer, the communication technology and the software. The innovation and the development in each of these fields are contributing towards the growth of information technology. In terms of computing power, the present day small personal computer easily outperforms large mainframe machines of yesteryears.

The modern communication technology permits seamless integration of computers separated across large geographical areas. The greatest phenomenon of this system is to be found in the terms of the Internet. It is thus possible to a user of Internet to access all the computers on the worldwide network of computers.

The most significant area of software development relevant to the field of transportation system analysis is database management system. The convention of various data processing approaches can be seen in the development of various types of decision support system. The application of the decision support systems like pavement management system, safety analysis systems, etc was limited to attribute data only. Recent advances in software engineering
it is now possible to incorporate spatial, graphic images in the database. This has facilitated many types of application analysis in the field of transport engineering. Geographic information system is one such emerging technology, which is based on the advances in relational database management techniques. The growth of GIS has been largely computer driven with emphasis on the storage, transformation and presentation of geographic data.

2.2 GIS APPLICATION IN TRANSPORTATION:

With the advent of GIS technology, limitations that have been previously imposed by data availability and quality will begin to diminish and creativity of the end user coupled with management support will gradually govern the applications environment. GIS is being applied in wide areas of applications, including urban planning, geography, geology, mapping, defense planning. The applications of GIS in fields outside transportation industry has proved to be successful. Comparing with other GIS applications, GIS in transportation is considered relatively new. However, the applications in transport suggest many potential benefits in using GIS in transportation. There are tremendous applications in transportation that uses GIS. In general, applications are limited by the lack of digitized transportation networks and the lack of a full set of transportation systems and related database attributes. The gateway to economic development and subsequently, a healthy economy, transportation infrastructure represents one of the largest and most critical investments made in any nation. Similarly, for many firms in the transportation industry,
profitability and a strong competitive position depends on a safe and reliable system.

2.3 GEOGRAPHY MATTERS TO TRANSPORTATION:
In the transportation industry geographic analysis is the key to making better decisions. Whether monitoring rail systems and road conditions, finding the best way to deliver goods and services, tracking fleet vehicles, or maintaining transportation networks. Understanding these issues from a geographic perspective is crucial to deploying or spending resources wisely refer figure below.

![Figure 2.1: Geography Matters to Transportation](image)

GIS technology serves three distinct transportation needs: Infrastructure management, fleet and logistics management and Transit management. Transportation professionals can use GIS to integrate mapping analysis into decision support for network planning and analysis, vehicle tracking and routing, inventory tracking, route planning and analysis and everything in between.
2.4 GIS BASED TRANSPORTATION STUDIES:

Transportation agencies are facing increasing pressures to manage transportation programs with fewer resources. The potential role of information system technology could play an important role in providing more productive program management. Such management information systems have become an important element of today's management process. Although the level of importance varies from one agency to the other, depending on the type and magnitude of implementation. Geographic information systems (GIS) provide an important enhancement to these information systems, especially for organizations like transport agencies, that deal extensively with spatially defined services and facilities.

2.4.1 Public Transportation and GIS:

Hillman R and Graham Pool in their Article [1] "GIS Based Innovations for Modeling Public Transport Accessibility" say that GIS provides an excellent environment for the modeling of accessibility. Transport data is inherently spatial in nature and GIS provide access to additional data such as geodemographic and land-use-data-sets. This enables the planner not only to look at the basic travel times between points, but also to access the utility of specific destinations to specific user groups. The study also examines how a software system called ACCMAP has been implemented to measure the accessibility for local authorities and operators. Data issues in developing and maintaining database are investigated. Accessibility modeling also requires public transport data. These include,
1. Accurate stop locations.

2. The service information, which must hold, services frequencies at various time periods.

3. The stop which are used by each services and the sequence and times between stops on each route.

In our study we are not including issues related to accurate stop location. We are considering only routing.

Patkar N.V and D Sampathkumar [2] considers GIS as a multipurpose tool for bus transport system management, in India. The study explains the functional elements of GIS. GIS in particular is found to be a multipurpose tool that can be employed for a variety of tasks related to bus transport, whether operated by public sector or private sector. Further, the capabilities of GIS to organize spatial and attribute data, to assimilate planning models and to present the output in different forms services all those concerned with bus transport system. Interfacing of GIS with appropriate models from operation research would offer much needed decision support system for bus transport management. With GIS software’s, which are now available at cheaper prices in the local markets, it is therefore practical for even small bus companies to implement a number of GIS based applications. Due to the generic nature and flexibility in operations GIS would be useful to the small agencies or large state owned public transport organizations. One notable point is that the same database can be employed to assist the bus operators and users. Installation of such a GIS driven bus information system with suitable user interface and
display arrangement at the major bus stops or terminals would be immensely benefit the community at large.

Javid. M and Jay Aguilar [3] in their article “Application of Geographic Information Systems in planning Transit Services for people with Disabilities”, explains the application of a GIS to perform necessary computations. Further it is shown that information such as block group populations and percentages of people with disabilities, which is available from census records and general travel characteristics of people with disabilities can be combined to arrive at reasonable estimates of demand for transit services. The use of the GIS for scheduling demand-responsive services where fixed route services are unavailable is also demonstrated.

Dr. Praveen Kumar, Dhanunjaya Reddy and Varun Singh [4] have developed Intelligent Transport System using GIS. Advanced Traveler Information Systems (ATIS) is one of the user services provided by Intelligent Transport System (ITS). With Advanced Traveler Information Systems (ATIS) information, drivers make informed decisions and are better equipped to plan their route and estimate their travel time. Route planning is an essential component of ATIS, aiding travelers in choosing the optimal path to their destinations in terms of travel distance and travel time. Advanced traveler information system for Hyderabad has been developed in GIS environment. This user-friendly system provides complete information of Hyderabad city such as road network, tourist places within the city limits, hospitals,
government and private offices, stadium, bus and railway stations. This system provides shortest path and path to closest facility based on distance and drive time. A facility consisting of city bus routes with bus numbers, origin and destination points, and all intermediate stations have been included in the system. The arrival and departure timings with services names of buses, trains and flights have been incorporated to facilitate the user in traveling. The developed package can be used in the bus stands, railways stations, airports, and tourist’s information centers, in personal computers to give information to the travelers. In this study we are generating alternatives to the best route. We are using GIS as a tool not just to display the routes but for decision-making.

R. Narayanan and C Sentil Prakash [5] in their development of “Advanced traveler information system using GIS- A case study of Chennai city” have vexed the question of road congestion in town may in parts be rescued by the application of Advanced Traveler Information System (ATIS). The function of ATIS is to assist the travelers with planning, perception, analysis and decision making to improve the convenience and efficiency of travel. ATIS technologies include,

1. On-board display of maps and road way signs.
2. On-board route guidance systems.
3. On-board traffic hazard warning system

ATIS provides drivers with information and congestion, alternate routes, to find the closest facility, to find the optimum route between many points, to find
the most direct path between two points, to build service areas, to find drive
time analysis, to find out the actual location and status of the vehicle and
roadway conditions through audio and visual means in the vehicle. Dr. S.
study “GIS based Transport Information Management System” have dealt with
the following,

1. To demonstrate the capabilities of GIS, which facilitates the
   integration and visualization of data.

2. To show the map information like road network, railway lines, river
   boundary and zone maps.

3. To provide information to the passengers such as the location of
   places of interest, other importation like hospitals, educational
   institutions and city bus routes.

4. To show the minimum path between two selected points based on
distance and travel time.

This study deals with the use of Visual Basic 6.0 as a GIS development tool.
Further the focus is on the data acquisition and storage. All topographic details
in the network, such as nodes, X and Y coordinates, connectivity, link and link
width are stored in text file format. The coordinate system is used for data
collection. Dijkstra’s algorithm is used for determining the shortest distance
from a specified vertex to a final vertex. In this study we are not only
determining the shortest (best) route but also determining the alternative routes
to the best route. We are trying to use these alternate routes as inputs in spatial
decision support system for making pricing decisions. Peter B. Keenan [7] in
his paper titled “Spatial Decision Support System for Vehicle Routing” deals with the effective decision support for vehicle routing problems with synthesis of appropriate algorithms and a GIS based computer system. Routing problems typically have a requirement for customers at known locations to be supplied with their demand by a set of vehicles, subject to limitation on the capacity of vehicles, the duration of the routes and the time at which the customer receives a delivery. Useful contribution can be made, by GIS techniques, to the design of a decision support system for vehicle routing. Such a system would be a Spatial Decision Support System (SDSS). General purposes GIS will not allow the decision maker easily interact with the algorithms needed for complex multi-vehicles routing problems. A spatial decision support system is needed to combine appropriate routing algorithm with the use of GIS spatial data handling techniques.

R. Sankar, J. Kavitha and S. Karthi [8] in their study on “Optimization of bus stop locations using GIS as a tool for Chennai city- A case study”, have stated that the optimal bus stop would reduce the precious travel time of commuters and also the even more valuable commodity in urban areas i.e. the land. Another solution obtained is the optimal location for creation of new bus stop, that would serve the population that earlier suffered. GIS can be used in all ways to carefully analyze all the criteria and successfully give good solution that is acceptable to everyone. Talat Munshi, Walid Belai and Martin Dijst [9] in their paper have developed a model, which models a public transport
network by creating links between stops and connecting these links to build the network. Attributes of speed, stop type and stop time are attached to the links between stops; waiting time for each route is attached to the route attributes. The model uses the least cost algorithm to generate path between a set of origin and destination points. D. Thirumalaivasan and V. Guruswamy [10] in their article “Optimal route analysis using GIS” have stated that Geographic information system can be used to address the objectives of finding the optimal route between the given origin and destination. It can be used to find out the routes involving shortest distance as well as shortest travel time. However in order to achieve realistic results, the volume of traffic data has to be real time. In this study we have considered different travel speed for calculating the time to reach form A to B using the best route. We are trying to use travel speed as a proxy to traffic data.

Vivek N. Patkar and D. Sampath Kumar [11] in their study on “GIS – A Multipurpose Tool for Bus Transport System Management” have worked on a pilot application of GIS for bus system for a limited area in the “P” ward of greater Mumbai. The BEST undertaking operates a number of bus routes in this area. In this application attribute details of one selected road like its status, location and type are displayed in pop-up window. Bus operators can make use of this information to access the quality of road network and potential customers to design alternatives bus routes and type of services. They have said that GIS in particular is found to be a multipurpose tool that can be employed for a variety of tasks related to bus transport. Further the capabilities of GIS to
organize spatial and attribute data, to assimilate planning models and to present
the output in different forms serve all those concerned with bus transport
system. We can use price, cost and profit as geo-coordinated and integrate them
in GIS to develop a good heuristic model for business decision-making.

Mezyad Alterkawi [12] in his paper “Application of GIS in Transport Planning- The Case of Riyadh, the Kingdom of Saudi Arabia” has used GIS to identify deficient facilities that are tolerable, moderate, moderate to heavy and heavy road deficiencies in the vital area within Riyadh’s ring road. Further integration of GIS into travel demand analysis process helps to identify future areas of congestion. Shortest path and travel time allocation of major activity centers analysis are also investigated.

Dr. Issa M. and El-Shaair [13] in their paper “GIS and Remote Sensing in Urban Transportation Planning- A case study of Birkenhead, Auckland” have used geographic information system and remote sensing in two specific aspects of transportation planning in Birkenhead region, Auckland, New Zealand. These two aspects are bus routes and bus stop facilities and they have found that GIS tools namely buffering, shape arc and identity are powerful tools and proved to be very useful. They feel that GIS and remote sensing can be effectively used in urban road mapping and in urban transportation planning. In our study we are not using the buffering tool. However buffering tool can be used to identify various utilities within a given buffer zone. Spear and Lakshmanan [14] discussed how organizations involved in transportation planning utilize computerized transportation models to forecast the impact of development patterns, transportation systems, and demographics upon regional travel demand. According to spear and
Lakshmanan these models are complex, data-intensive formulations of assumptions that are founded on the spatial organization of residences, places of employment, and location of commercial activity. Results from these models enable transportation planners to predict the level of usage at activity centers as a function of location, distance to urban population centers, and socio-economic composition of the surrounding community.

Foresman and Millete [15] explained the use of Landsat TM in conjunction with GIS to obtain land use and other spatial data for regional planning of 25 towns in Vermont USA. Image processing techniques and manual interpretation were used to achieve their objective. They implied the notion that transportation planners can utilize satellite images for land use identification purposes. We are not planning to use satellite imageries in our study.

Waters [16] in his chapter on Transportation GIS gave a brief introduction to the main characteristics of Geographical Information Systems in Transport (GIS-T) field. An interesting part of Water’s chapter “Transportation GIS: GIS-T” is his elaborations on the four-step urban transportation model system that includes,

1. Trip generation and trip attraction (How many trips?)
2. Trip distribution (Where do they go?)
3. Modal split (By what travel mode do they move?)
4. Traffic or network assignment (Which route they take?)
Walter’s concludes that

1. There is a sufficient use of GIS and remote sensing in urban transport planning.

2. Urban transportation planners and government agencies continue to need up-to-date land use information in order to predict the location and type of growth within metropolitan areas.

3. Most planning organizations tend to include in their activities several urban issues; the issue of transportation is considered an important one.

4. Urban roads mapping by means of GIS and satellite images is a promising direction in future.

This proves GIS is a very important tool for decision-making.

“Multi-Criteria Approach in Designing Bicycle Tracks”. By Suja Thambiraj, Weng-Tat Chan, [17] suggests a procedure for using GIS to design bicycle routes within the University campus. The procedure includes determining the origin-destination points, defining pertinent physical constraints and evaluation functions, developing the raw GIS layer into relevant raster layers, on which spatial analysis can be performed and verifying the aggregated results through a feasibility study in the form of a field investigation. GIS is shown to be very effective tool for the design of bicycle routes through the implementation of the procedure developed for National University of Singapore (NUS).

The potential of GIS as a decision making tool is limited when used as a standalone tool; hence we need to integrate it within a decision support system for maximum benefits.
G. Arampatzis, C.T. Kiranoudis, P. Scaloubacas, and D. Assimacopoulos [18] in their paper “A GIS-based Decision Support System for Planning Urban Transportation Policies” have presented a model in which a decision support system (DSS) is integrated in a Geographical Information System (GIS) for the analysis and evaluation of different policies. The objective of the tool is to assist transport administrators enhance the efficiency of the transportation supply while improving environmental and energy indicators. Road transport suffers, as manager’s application of GIS in decision-making is limited. GIS as a decision making tool can be used to come out with pricing policies.

Anjaneyulu, Prahallada and Nagaraj [19] in their paper “Development of spatial information system for transportation planning in Calicut urban area” have developed a computerized spatial data base system for Calicut city and to use that for identification of missing links in the road network based on travel demand. Travel demand is not static. It is time based and seasonal in nature. Pricing has not been used as a tool for improving capacity utilization. There is scope for research and that is what this researcher is intended to do. After a travel has been made few collect travel response. Road transporter can use this feedback for designing better offerings. This provides a feed for travel information systems.

Al-Deek [20] explained the development of framework for evaluating the effect of advanced traveler information systems. The framework uses a
composite traffic assignment modal, which combines a probabilistic traveler behavior modal of route diversion and a queuing modal to evaluate Advanced Traveler Information Systems impacts under incident conditions. The findings indicate that the overall system performance, measured by average travel time, improves marginally with increased market penetration of Advanced Traveler Information System under incident conditions are expected to be marginal when there is more information available to traveler through their own observation radio. Specifically, delay information received through radio and from observation of incident-induced congestion induces people to divert earlier causing the network to operate closer to system optimal user equilibrium. Thus it is important to generate alternatives, so that in case of congestion on one route the driver can divert to other route.

Thompson (2000) [21] in his article looks at how GIS is used to market bus services in Northeastern Illinois. Pace, the suburban bus service, serves six county suburban areas in Chicago through 240 fixed bus routes. To target potential feeder bus riders, the GIS is used to identify individuals who park at the Metra through license plate surveys. The surveys provide Pace with the total spaces, the number of spaces occupied, and license plate information showing the address, state and zip code of the car registration. Potential feeder bus passenger origins are mapped in a GIS to display the market that Pace can target through rescheduling or locating new bus stop or routes. The Fairfax County [22] DOT has developed two application areas for its bus system: Analysis of boarding and alighting activities, and Route distance and running
time. The former allows the user to query a bus route for the number of boarding and alighting activities and the number of persons on board. A table is generated with heavy and light boarding activities, helping planners to decide whether buses should run more or less frequently. Boarding and alighting data may be collected through visual observation collected fares, or on board sensors. Route distance and running time are calculated using dynamic segmentation tools along with length, speed and delay characteristics. Access to route statistics and ridership data and complaints help planners to assess whether the schedule and routes provide adequate service, or whether alternate routes can offer faster, more efficient services. **Marcus, L. and R. Cruz. (2003)** [23] in their paper "Applying GIS Technology to Improve Transit Accessibility" have described the strategy utilized by the City of Rockville, MD to address congestion by the promotion of alternative modes of transportation by improving public transit service options. By applying GIS, laptops, Pocket PCs and GPS technologies, City staff evaluated existing transit service, using three performance goals: 1) maximize walk-accessible transit service to City residents, 2) increase the number of residents within a 10 minute travel time to a Metro rail station using local bus service, and 3) maximize the transit frequency of service. GIS and GPS technologies are useful during the data compilation stage, and also permit staff to continue to apply this information to address transportation issues and problems as they arise.

**Miller, H.J. and Y. Wu. (2000)** [24] in their paper "GIS software for measuring space-time accessibility in transportation planning and analysis" has
focused on the use of GIS in transportation to improve accessibility. The authors report on the development of GIS software that uses space-time-accessibility measures (STAMs), which reflect the benefits that the individual receives from the transportation system. Space-time-accessibility measures are easily interpreted with respect to changes in accessibility. These space-time-measures are also comprehensive since they take into consideration the locations and travel rates imposed by the transportation system in the context of an individual’s daily activity schedule.

Murray, A.T. and X. Wu. (2003) [25] in their study on “Accessibility tradeoffs in public transit planning” have examined two important components of public transit planning accessibility: of access and geographic coverage, with the recognition that the two elements can at times conflict with one another. The authors apply two complex mathematical modeling approaches for addressing accessibility concerns which consider both access and geographic coverage in an integrated fashion, with the aim of optimizing accessibility. For urban areas striving to promote use of public transit, the ability to evaluate and improve transit accessibility is valuable.

O'Sullivan, D., A. Morrison, and J. Shearer [26] in their paper “Using desktop GIS for the investigation of accessibility by public transport an isochrone approach” have worked on a desktop GIS application that can automatically generate isochrones for travel by public transport (In this paper an isochrone refers to a line joining a set of points at equal travel time from a
specified location). Isochrones provide an easily understood method for examining accessibility by public transport. The authors report that the most useful function of the desktop GIS application is the immediate location of the generated isochrones in relation to any other available data in the region of interest. In other words we are trying to say that graphic representation can give better service to customers. Pathan [27] in his study “Optimization of Transportation Routes using GIS techniques” has evaluated the possibilities of optimization, in which the optimum routes, travel time, travel distance and cost for defined paths and for the optimum paths was determined for few transport services. Steven (2003) [28] in his paper “Optimization of multiple route feeder bus service - an application of GIS” has developed a genetic algorithm to optimize a bus transit system serving an irregularly shaped area with a grid street network. The total cost function is minimized subject to realistic demand distribution and street pattern. Crowson[29] in his study “A GIS for public transit” has developed a geographic information system that includes the street maps for the three-country service region, the route system, and the bus stop locations. These maps are used together with US census block and block group information to perform communication, analysis, planning and service assurance.

Zhong-Ren Peng and Ruihong Huang (2000) [30] in their study “Design and development of interactive trip planning for web-based transit information systems” present a web-based transit information system design that uses
Internet Geographic Information Systems (GIS) technologies to integrate Web serving, GIS processing, network analysis and database management. A path finding algorithm for transit network is proposed to handle the special characteristics of transit networks, e.g., time-dependent services, common bus lines on the same street, and nonsymmetric routing with respect to an origin/destination pair. A unique feature of the reported Web based transit information system is the Internet-GIS based system with an interactive map interface. This enables the user to interact with information on transit routes, schedules, and trip itinerary planning. Some map rendering, querying, and network analysis functions are also provided. Marius T. [31] in his paper "Modeling Commuter Trip Length and Duration within GIS: Application to an O-D Survey" has presented modeling and simulation procedure to evaluate optimal routes and to compute travel times for each individual trip of an OD survey database. Postal codes provide accurate locations within street blocks for each trip beginning and end point. Using TransCAD GIS software, the procedure finds the best routes through a topological road network. Each road is characterized by a maximal speed related to the functional class of the road, to its location in rural or urban areas, and to the distance from the nearest school. Turn and transfer penalties govern movements at the intersections. Moreover, the procedure calculates the number of persons traveling on every road to estimate traffic congestion. Through study it is concluded that it is possible to combine GIS and transportation modeling to estimate travel time of urban commuters. This could help measuring temporal constraints of
households in planning their daily activities. Passenger’s traveling pattern data can be used for making pricing policies.

Papacostas C. [32] in his study “GIS application to the monitoring of bus operations” has developed a route structure specification scheme that can form the basis of a comprehensive GIS framework for fixed-route bus systems. The proposed specification requires a relatively sophisticated software package that allows for dynamic segmentation and provides programming functionality. This paper also described an initial implementation of this framework and a GIS application to fixed-route bus system schedule adherence monitoring. The extension of this prototype to the charting of passenger boarding and alighting activities, as well as to the plotting of running times, along transit routes is relatively straightforward. The same framework can enhance other applications, including the efficient identification of complex transit paths, improved scheduling and run-cutting procedures, and the extraction of abstract networks at various levels of aggregation as required by regional travel demand analyses and forecasts. By retaining the integrity of the base transportation network, the framework described in this paper can reduce coding redundancies. It can also facilitate database integration with other transportation-specific applications.

C.D. Tarantilis, C.T. Kiranoudis [33] in their study “Using a Spatial Decision Support System for Solving the Vehicle Routing Problem” present a SDSS to coordinate and disseminate tasks and related information for solving the
vehicle routing problem (VRP) using a metaheuristic method termed: Backtracking Adaptive Threshold Accepting (BATA). Its architecture involves an integrate framework of Geographical Information System (GIS) and a Relational Database Management System (RDBMS) equipped with interactive communication capabilities between peripheral software tool.

Ruben Ruiz, Concepcion Maroto, Javier Alcaraz [34] in their paper “A Decision Support System for a Real Vehicle Routing Problem” have discussed a new two-stage exact approach for solving a real problem, along with decision-making software. In the first stage, all the feasible routes are generated by means of an implicit-enumeration algorithm; afterwards, an integer-programming model is designed to select in the second stage the optimum routes from the set of feasible routes.

Sotiris P. Gayialis, Ilias P. Tatsiopoulos [35] in their paper “Design of an IT-Driven Decision Support system for Vehicle Routing and Scheduling” have presented the development of a decision support system used by an oil downstream company for routing and scheduling purpose. The utilization of advanced IT systems supports effectively the planning and management of distribution operations. The combination of supply chain management (SCM) application with a geographical information system (GIS) integrated with an enterprise resource planning (ERP) solution resulted to this innovative decision support tool. The objectives of this new tool are: optimum use of distribution network resources, transportation cost reduction and customer services.
improvement. C.D. Tarantilis, D. Diakoulaki and C.T. Kiranoudis [36] in their paper “Combination of Geographical Information System and Efficient Routing Algorithms for Real Life Distribution Operations” have presented a decision support system (DSS) employing a metaheuristic algorithm called BoneRoute, for solving the open vehicle routing problem (OVRP). The OVRP deals with the problem of finding a set of vehicle routes, for a fleet of capacitated vehicles to satisfy the delivery requirements of customers, without returning to the distribution center. The computational performance of the Bone Route algorithm for the OVRP was found to be very efficient, producing new best solutions over a set of well-known published case studies examined. Technical and managerial issues aroused from the ad hoc connections between the geographical information system (GIS), the routing techniques used for calculating shortest paths and the BoneRoute algorithm for finding the optimal sequence of customers, were faced successfully.

Guy Desaulniers, June Lavigne and Francois Soumis [37] in their study “Multi-depot Vehicle Scheduling Problems with Time Windows and Waiting Costs” have stated that the multi-depot vehicle-scheduling problem with time windows (MDVSPTW) consists of scheduling a fleet of vehicles to cover a set of tasks at minimum cost. Each task is restricted to begin within a prescribed time interval and different vehicles are supplied by different depots. This paper breaks new ground by considering costs on exact waiting times between two consecutive tasks instead of minimal waiting times. This new and more
realistic cost structure gives rise to a nonlinear objective function in the model. Optimal and heuristic versions of the algorithms have been extensively tested on randomly generated urban bus scheduling problems (UBSP) and freight transport scheduling problems (FTSP). The result show that such a general solution methodology outperforms specialized algorithms when minimal waiting costs are used, and can efficiently threat the case with exact waiting costs. Tadeo H. Schultz [38] in his article “New Trends and Applications in GIS Based Routing” has stated that GIS based routing solutions have proven to be one of the most popular and cost effective GIS application of recent years. Typically these systems will find a least cost path among a series of nodes on a linear network against a series of constraints. Allocation and optimization components, which are used to solve problems such as scheduling, can typically be found as a part of larger GIS based routing applications. Another powerful and popular combination is the integration of GPS and vehicle tracking technology with routing components. The paper also reviews the various styles of routing solutions currently in vogue as well as the technology behind them. Traditional approaches such as the Dijkstra algorithm, which is typically used to solve the classic ‘traveling salesman’ (least cost path) problem, are contrasted against some of the newer developments such as the adaptive swarm-based distribution method. In addition new novel GIS routing applications are presented and guidelines for integrating GIS based routing component with other systems are discussed.
Md. Shahid Uz Zaman, Yen-Wei Chen and Hayao Miyagi [39] in their article “GIS Oriented Platform for Solving Real World Logistic Vehicle Routing Problem” have said that logistics optimization problems related with vehicle routing such as warehouse locating, track scheduling, customer order delivery, wastage pickup etc. are very interesting and important issues to date. Many Vehicle Routing and Scheduling Systems (VRSS) have been developed / proposed to optimize the logistics problems. But majority of them are dedicated to a particular problem and are unable to handle the real world spatial data directly. The system developed for one problem may not be suitable for other due to inter-problem constraint variations. The constraints may include geographical, environmental and road traffic nature of the working region along with other constraints related with the problem. So the developer always needs to modify the original routing algorithm in order to fulfill the purpose. In this study a general -purpose platform by combining GIS road map and Database Management System (DBMS) is proposed, so that VRSS can interact with real world spatial data directly to solve different kinds of vehicle routing problems. Using the features of the developed system, the developer can frequently modify the existing algorithm or create a new one to serve the purpose.

Dr. ir. L.A. Tavasszy, Dr. M.J.M. Vnader Vlist and Dr. C.J. Ruijgrok [40] in their model have described the background and the intermediate results of a project aimed at the development of a new decision support system for public
and private decision makers in the transport and logistics sector. The model was constructed as joint effort of the Transport Research Centre of the Ministry of Transport and the research organizations NEI (Netherlands Economic Institute) and TNO Inro. The name of the model is SMILE (Strategic Model for Integrated Logistic Evaluation). The applicability of this model for exploring the possible effects of transport policy and changes in logistic organization of firms and through this on the corresponding freight flows is discussed. Also, the design of the information system is explained, covering the specification of the underlying models, the graphical interface by means of which scenarios in SMILE can be prepared and the databases.

Wang [41] has conducted a study on GIS base Transit- Network design Model for Taipei. He presented a GIS based transit network design model that covers an integrated approach for traffic management and network performance evaluation. The model examines Taipei metropolitan transit network alternatives by various traffic management stages, such as exclusive bus lane network and downtown bus grid network. This GIS based model presents both the characteristics of network infrastructure and spatial distribution, where traffic control strategies and network assignment methods can be applied on this platform together. The effects of changes on transit network infrastructure and transit operations methods will be investigated with the above data; consequent impacts on network performance issues and intersection level of service (LOS) can be examined. An improved transit assignment method has
been developed, that will alleviate the shortcomings of traditional All-Or-Nothing (AON) method on transit assignment. Bailey [42] made a case study on the City of Newton in Creating a Municipal GIS for Transportation. Building simple transportation tool directly within a general GIS package may be an appropriate avenue for smaller agencies without the support of multi-package solutions. Greater sophistication has been included in the routing programmes of the traveling salesman problem applications. The purpose of the initiative thus far has been to plan the general feasibility and value of developing transportation tools within a GIS package rather than merely to link them to a GIS. Naturally there will be many applications for which more sophisticated and dedicated tools will be required. Routing is one of the most important applications developed in GIS. GIS can be used to analyze various other customer preferences like for instance a customer would like to know exactly at 10 clock where would he be on the highway and the available utilities nearby so that he can plan for his lunch. A service provider can use buffering to identify where to locate his unit. Neil [43] deals with Transit Services Areas using GIS. The transit route location and analysis problem requires the estimation of a population within the service area of a route. The route’s service area is defined using walking distance or travel time. Service area population data integrated with the demographic profile will help decision maker to decide on, which routes to operate. The study made by Adams [44] attempts to explain GIS in Fine Tuning Transportation Networks. On a daily basis, GIS is used for simple query functions such as highlighting areas, which
are currently poorly served by public transportation. Such areas can be found by searching the GIS for locations, which are farther than 400 meters from a bus stop. These queries supply the information needed for the planners to fine-tune the details of the new routes they have devised. Many transportation planning projects, however, are much more complicated than simply finding a street corner that needs a bus stop. They often require weighing multiple social and geographic variables that can influence—or be influenced by public transportation. The output from these models must be considered in terms of cost and benefit, which is where the GIS play an important role.

All the fine-tuning is from operational optimizing. Integrating customer preference to understand what customer is prepared to pay makes business sense. This is not covered in any of the earlier papers. In my research we are attempting to convert business variables like cost, profit, price based on customer preferences into geo-coordinate and use GIS to do analysis for route selection and pricing policy.

Study made by Hartgen and Yuanjun Li [45] on Geographic Information System Applications to Transportation Corridor Planning, deals about GIS applications to large transportation corridor planning. A wide variety of GIS procedures—data display, buffering, opinion surveys, traffic statistics, land use patterns, and traditional modeling were found to be applicable, explaining how the use of GIS added value to decision-making, at reasonable investment in time and effort by agency and support staff. Study made by Simkowitz [46] on
Geographic Information Systems—An Important technology for Transportation Planning and Operations explain why GIS technology is important to transportation people, describes how a number of transportation agencies are using GIS, and provide insight on how to participate in this technology. Transportation agencies are still in their infancy with respect to exploiting the power and capabilities offered by GIS technology. The usefulness of spatially integrated data to transportation is examined and the distinction is made between GIS and other database systems that use spatial data. Kim [47] reviewed the “Application of GIS Technology and Its Role” has concluded that GIS plays two important roles in transportation planning and analysis. Firstly, the use of GIS in processing geographically related data; and secondly the use of GIS for performing spatial analysis, not only for obtaining new information, but also to augment decision support by allowing the development of what-if scenarios. In addition to these two primary roles, the application of GIS to transportation planning and analysis can be grouped into three broad approaches.

1. To include GIS functions within transportation planning and analysis models.

2. To incorporate transportation analysis functions in GIS.

3. To build an interface between GIS and transportation models

GIS-based innovations for modeling public transport accessibility. In this study we are applying “what-if” query to different difficulty parameters and costs in terms of rupee value. This helps us to analyze the effect on price and profit for varying combinations.
Vikas Khitha and Sanjay Govil [48] in their paper “GIS in public transportation” have developed a model which in addition to depicting all bus routes passing via the respective bus stop, an inset in the map also covers a four square kilometer area around the bus stop in the level of detail of building footprints and building names. Last mile directions to commuters searching for a particular building are provided. In our study we are not including details of various utilities like hospitals, government and private offices, hotels etc. The focus is only on route generation and differential pricing based on passenger’s preferences. Zhongzhen Yang and Zhuo Sun [49] in their paper “A road traffic management system for Dalian based on GIS and WebGIS” have stated that commuters can manage road traffic information more systematically and scientifically with the system developed by them. Especially with the visualized operations, commuters can grasp and use the system easily.

2.5 CONCLUSION AND NEED FOR STUDY:

It is very important to note here that research works using geographical information systems is relatively a new area of research and hence limited number of studies have taken place in the area of GIS (SDSS) and still fewer studies have taken place on Transportation area as a whole and Public Transportation being specific.

GIS is one of the fastest growing technologies of present time. It has emerged as powerful and sophisticated means to manage vast amounts of geographic data. It provides a mechanism by which information on location; spatial interaction and geographic relationship of various facilities can be assessed and
viewed in moments. It provides an opportunity to effectively view and access geographic data and thus to improve decision-making process [50].

From the literature review it can be seen that researchers have worked with GIS for modeling public transport accessibility, which include accurate stop location, development of ATIS, etc. GIS has been made use to develop spatial decision support systems for:

1. Optimizing of bus location,
2. For routing analysis,
3. For developing urban transport policies,
4. To address the problem of congestion,
5. Shortest route generation between an origin and destination,
6. Providing site tour of a city,
7. Providing information about city bus services from any origin to any destination,
8. Providing Inter-City bus services information,
9. Intercity Railway services (Train name, arrival time, departure time, etc) Information to travelers,
10. Developing web based transits information systems using Internet GIS technique for monitoring of bus operations.

GIS has been widely used in the field of development of spatial decision support systems for solving vehicle routing and scheduling problems. In all the above case one can find route generation between OD (Origin-Destination) as an integral part of any GIS based transport application. Secondly all researchers
in their articles have identified that GIS offers huge potential for spatial analysis. Researchers have identified in their articles that there are other methods to find the shortest path between a origin and destination like 'C' based Moore’s algorithm, K-Tree algorithm, the Simulated Annealing algorithm, Genetic algorithm, Swarm based algorithm, Inbuilt path finding module (shortest path module) available in Esri’s Arc Info Ver. 3.2 A or using spatial analysis extension of ArcGIS but most of the researchers have supported the use of Dijkstra algorithm for generating the shortest path between the origin and destination. Very few research articles have dealt with the problem of road congestion using GIS.

It is also important to note here that earlier research works have addressed the shortest route problem first and then have solved the other issues. However there is hardly any mention of generating alternate routes between an origin and destination other than generating the shortest route, because shortest route does not always translate into shorter travel time. This is true because the shortest route may be narrow in width, or it may have higher volume of traffic, or more number of traffic signals or more number of turns. Generating alternative route to the best path is important because: In pre-trip planning, for example drivers often want to be provided with one path for their outbound trip and an alternative path for their return. Another example could be users of in-vehicle guidance systems often wants to be provided with several alternative paths that they can use to avoid particular facilities. Alternate paths allows a
user to prefer a particular path because of light traffic, few boulevard stops, etc. or avert using a particular path because of frequent delays, high tolls, etc. Finally we can see in all research papers, researchers have used GIS as tool for obtaining operational optimization. Transportation is not just ‘x’ and ‘y’ coordinates on a map but is a business. We in our research are attempting to convert business variables like cost, profit and price based on customer preferences into geo-coordinates and make business decisions. That is we are trying to make use of GIS for business decision-making and not just for operational efficiency. In almost all the research article we can see the usage of ESRI’s Arc Info / Arc View/ ArcGIS as the most popular GIS tool for spatial analysis and hardly few have used MapInfo and MapBasic as tools for spatial analysis and for customization. Thus there is wide scope for research work, where in GIS can be used to display route network, the shortest route and the alternate routes between an origin and destination and also make pricing decisions based on passenger’s choice of difficulty he is willing to take when he plans to travel. We are using MapInfo and Microsoft Visual Basic as a tool for developing spatial decision support system. Customers decide the route and its implications therefore take responsibility of its outcome. Logistics Company’s job is to ensure the service delivered using differential pricing. To substantiate the necessity and usefulness of such a system a survey using a structured questionnaire is conducted to understand the attitudes of commuters of public transport towards such a system.
2.6 VISUAL BASIC 6.0 AS A FRONT-END TOOL:

With Visual Basic, the program is written by assembling the objects that will be used for screen display and interacting with the user, adjusting the properties of those objects, determining which event should be responded to, thinking through the variables needed for holding data and for passing information from one part of the program to another, and writing the command lines that will run when events are activated. At each stage of development, any aspect of the program may be added or changed.

2.6.1 Components of Visual Basic:

The main components of Visual Basic project are Forms, Controls, Module, Project and Procedure.

The form is the central display unit in visual Basic. It is a window on which controls to create screen or printer display with associated properties, events and methods pasted. Controls are the objects ranging from labels, for display of text, picture boxes for graphic images, buttons, check boxes, dropdown lists and other menus, to file management utilities and spreadsheet style grids. They are objects associated with forms, with their related properties and methods.

Modules are the collection of sub-procedures or sub-functions whose code can be reached from any form in the program. There may be several modules in one program and each is saved as a separate file with a .BAS extension.
The projects are collection of forms, modules. Project file has .MAK extension. The ultimate goal of any programming project is to provide a usable and useful executable application. The user would be able to launch the program directly from windows without having the Visual Basic software in the system. An executable file is a window based application with an .EXE extension that can run outside the Visual Basic development environment.

2.7 MAPINFO PROFESSIONAL 7.8:

Among several GIS systems, MapInfo is commonly used. Factors such as lower hardware requirements, easy to learn and master, high quality and low cost makes MapInfo become a popular system. MapInfo Professional provides data visualization, including step-by-step thematic mapping and three-linked view of data that is Maps, Graphs and Tables. MapInfo Professional supports raster map registration and imports a variety of standard raster formats and vector formats. Maps can be digitized to create vector images and edited using several functions.

MapInfo Professional can be visualized to create thematic maps using ranged shading, bar charts, pie charts, dot densities, graduated symbols and individual values. Range classification of maps can be based on equal count, equal range, inflection point, natural break, standard deviation, quartile and user defined. Thematic option can be combined to create maps that display multiple

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variables from many tables. Thematic joints can be based on count, sum, value average, weighted average.

This software provides multiple data view, user can overlay various projections and convert between projections. It also supports geo-coding to street address, locations and user-defined match options. MapInfo supports standard mathematical, statistical, logical, measurement, conversion, sorting and aggregation function. It provides direct access to spreadsheet and database data. It supports geographical queries to remote database server containing point data. New maps or tabular database can be created based on new information or results of queries and edits. MapInfo Professional provides tools for managing database fields. MapInfo can also generate HTML image maps that can be included in web pages.
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