

WORKING PAPER NO.252

**Routing Strategies for BMTC Buses
Decision Evaluation Using Simulation**

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January 2007

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Routing Strategies for BMTC Buses – Decision Evaluation Using Simulation

Abstract

The Bangalore Metropolitan Transport Corporation (BMTC) operates public bus services in the Bangalore metropolitan region. BMTC owns over 3500 buses and operates through six depots spread across the city. On an average 30 lakh passengers are carried and BMTC runs over 10 lakh bus kilometers per day. This generates a daily revenue of Rs. 1.5 crores. Over the last 10 years the city has seen tremendous growth. BMTC has responded to the public demand for bus services for the newer areas by starting point-to-point routes. Despite this the organization is unable to meet the growth in demand. The increase in the services has been reactionary rather than in a planned manner and it is desirable to look into the possibility of rationalizing the routes and schedules with the objective of improving service efficiencies.

BMTC currently provides point-to-point services throughout the city. This routing practice usually results in low frequency of service and low service levels characterized by large waiting time, number waiting and total travel time.

It is felt that routing based on a hub and spoke orientation may result in better service levels. The Jayanagar sector in the city is studied for evaluating potential benefits of such an orientation. The Jayanagar bus stand is taken to be the regional hub in the Jayanagar sector and it serves seven demand centres in the region. This hub is connected to three hubs across the city, namely, KR Market, Shivaji Nagar and Kempegowda Bus Station.

Simulation models are developed to simulate the current and proposed routing systems and field data is used to compare the two. Analysis is carried out for various scenarios to compare the waiting times, number waiting, travel time and number of buses required. The results suggest that the hub and spoke routing strategy provides better service levels to the commuters for the various scenarios generated. Moreover, this can be done using fewer buses.

The proposed routing system will entail change of buses at the hubs. A sample field survey of 165 commuters was undertaken in the Jayanagar sector to understand willingness to change buses for different levels of savings in total travel time. The survey results indicate that the percentage of commuters willing to change buses is substantial.

The results from the simulation models can be used to assist BMTC officials in making a decision on adopting a hub and spoke system of routing as well as for evaluating various decisions with respect to frequencies on the routes.

Key Words: Routing, Public Transport, Simulation, BMTC

Routing Strategies for BMTC Buses – Decision Evaluation Using Simulation

Introduction

The urban population in India has increased significantly from 62 million in 1951 to 285 million in 2001^[2] and is estimated to grow to around 540 million by the year 2021. Although circumstances differ considerably across cities in India, certain basic trends that determine transport demand (such as substantial increase in urban population, household incomes, and industrial and commercial activities) are the same. These changes have placed heavy demands on urban transport systems, a demand that many Indian cities have been unable to meet.

Public transport systems have not been able to keep pace with the rapid and substantial increases in demand over the past few decades. Bus services in particular have deteriorated, and their relative output has been further reduced as passengers have turned to personalized modes and intermediate public transport (such as three-wheelers and taxis), adding to traffic congestion, which has had its impact on quality as well. It is often thought to be in egalitarian to provide special services such as air-conditioned buses, express buses, and premium or guaranteed seats in return for higher fares. In other words, variety is usually curbed. Experience shows that the public welcomes a wide choice of transport, but despite the clear need for greater variety in public transport, there is a tendency in established monolithic corporations to offer very limited choice. The city cannot afford to cater only to the private cars and two-wheelers and there has to be a general recognition that without public transport, cities would be even less viable. Much needs to be done if public transport is to play a significant role in the life of a city. Measures need to be taken in the short-run to enhance the quality of public transport service and to impose constraints on the use of private vehicles in cities. In the long-run, there needs to be effective land use planning and the introduction of new transit systems to keep the city moving. It must not be forgotten that cities are the major contributors to economic growth and movement in and between cities is crucial for improved quality of life.

Banaglore has seen a phenomenal growth over the past decade. The estimated passenger trips were 39 lakhs in 1994 (ILFS Ltd), 50 lakhs in 2002 (RITES) with an annual growth rate is 3.5%. Among personal vehicles, two wheelers are estimated to grow at 9.02% CAGR and four wheelers at 9.87% CAGR (Ravichandar). Good public transport is a must for the city. TERI's guidelines in its report on *Restructuring Options for Urban Public Transport in India* (TERI) recommend that a good public transport system should provide good connectivity, adequate frequency (<5 minutes during peak hours), reasonable waiting time, public conveniences such as toilet facilities at major bus stops, easy access to information, reliable service, riding comfort and a good grievance redressal system.

Like other major cities, transportation infrastructures have not kept pace with growth, resulting in increased congestion and pollution in Bangalore. The main traffic corridors in the city are Bangalore – Madras National Highway (NH-7): central to Northeast; Bangalore – Thane National Highway (NH-4). The same highway also enters the city from Tumkur: this highway passes through the city entering from the Northwest and leaving it in the Southeast; Bangalore – Kanakapura: central to the south of the city; Bangalore – Anekal: central to the south of the city; Bangalore – Mysore: central to the southwest of the city; Bangalore – Bellary: central to north. Apart from these, several internal roads have heavy traffic. The ring road is one of these. The Anand Rao Circle, the Hudson Circle, West of Chord Road, Old Madras Road, Magadi Road, etc., are a few others. The current form does not have any orbital corridor which means that most traffic moves through the congested core of the city. Bangalore has a population of five and a half million and about 1.3 million vehicles, of which almost 80% are two-wheelers. The buses owned by the Bangalore Metropolitan Transport Corporation, account for only 0.2 % of the total vehicular fleet but caters to almost 65% of the total passenger trips generated in the city.

Bangalore Metropolitan Transport Corporation (BMTC)

The Government of Karnataka (GoK) has created an independent urban public bus transport corporation called BMTC (Bangalore Metropolitan Transport Corporation) to take care of the commuting needs of the people in the city of Bangalore. BMTC owns over 2300 buses and operates 57000 trips per day, carrying 30 lakh passengers and covering 8 million-bus kilometers. The Corporation generates a daily revenue of Rs. 120 lakhs.

BMTC, at present, is the major mode of public transport in the city. Although BMTC is the only Municipal Transport Undertaking to make accounting as well as economic profit, when compared to its counterparts, its total revenue exceeds its total cost by just around 5%. One of the main reasons for this being the expansion of the transportation network without the integration of entire system, leading to underutilization of resources and descent in service levels.

The operation of the corporation is categorized into city and suburban services. BMTC has 1063 routes and the average route length has increased from 19.45 km in 1998 to 19.66 km in 2000.

TABLE 1: Bus Statistics

Parameters	1997/98	1998/99	1999/2000
Number of routes	1036	1048	1063
Avg. route length (km)	19.45	19.54	19.66
Number of trips	1934	2030	2121
Daily schedule km	442953	472289	500553

The volume of total passenger travel demand in Bangalore is expected to grow 3.9 times (from 14 to 54 billion passenger kilometres) while on a per capita basis, over a 20 year period, that is, from 1990/91 to 2010/11, the average annual growth rate in travel demand daily would be around 3.6% in Bangalore (from 9.5 km to 19.3 km per day). As in Delhi, in spite of a very large fleet size of private vehicles, buses cater to a very high volume of travel demand.

Table 2 shows that buses in Bangalore currently meet about 65% of the total passenger travel demand and would reduce steadily to 59% by 2010/11. Among the Intermediate Public Transport (IPT) modes, the role of three-wheeler autorickshaws in meeting passenger travel demand in Bangalore will increase by about 3.5 times in 2010/11.

TABLE 2: Year wise statistics of percentage usage of various modes of transport

Year	2-wheeler	3-Wheeler	Car/Jeep	Taxi	Bus	Total passenger bpkm*
	%					
1990/91	19.57	5.23	15.96	0.83	58.4	14.11
1995/96	15	7.41	10.21	0.46	66.92	25.48
2000/01	13.77	11.5	9.16	0.54	65.04	33.02
2005/06	10.85	18.45	8.56	0.66	61.49	40.28
2010/11	8.31	25.13	6.57	0.66	59.33	54.07

*bpkm: billion passenger kilometer

The various problem areas can be summarized as follows:

- Stumpy assimilation of services in the system
- Enfeebled frequency of buses at any point of time, at any particular stage, resulting in higher waiting times for the commuters
- Undesired performance indicators like docile utilization of particular schedules, lower Load Factors, resulting in dwindling revenues
- Suboptimum allocation of buses resulting in additional expenditures
- Inefficient routing and scheduling of transporters, done with unplanned methodologies
- Dissatisfied commuters taking other modes of transport leading to loss of revenue
- Finally, disgruntled service for a commuter, with either higher waiting time or higher cost.

Current Routing Pattern of BMTC Buses

The current practice followed by BMTC is to provide point-to-point services throughout the city. Whenever new demand centers evolve due to growth, additional schedules from such demand points to all stations and sub-stations are introduced. Buses are routed point to point, implying that from a given major origin there are buses for all other major destinations. This usually entails low frequency of service due to point-to-point demand being low and/or the constraints on fleet strength. Low frequencies result in low service levels characterized by large waiting time, number waiting and total travel time.

This study is to understand the impact of alternate methods of routing on service levels and operational efficiencies. In the present operations the focus is on point-to-point service. We feel that this results in frequency of services being low and turn around times being high leading to large waiting time for commuters. It is, therefore felt that the resources are not being used optimally.

The proposed method of routing is to have a hub and spoke orientation providing high frequency services between nodal centers (hubs) identified in different areas of the city. The nodal center (hub) in each region will be connected with the demand points in that region. In addition, it will also be connected to the other hubs identified across the city. Though this routing strategy entails transshipment at the nodal centres, the commuter waiting time and total travel time will be reduced. BMTC will benefit from the resulting improvement in vehicle utilization and personnel productivity.

The Jayanagar sector in the city is studied for evaluating potential benefits of such an orientation. The Jayanagar bus stand is taken to be the regional hub in the Jayanagar sector and it serves seven demand centres in the region. This hub is connected to three hubs across the city, namely, KR Market, Shivaji Nagar and Kempegowda Bus Station.

Methodology

The methodology adopted to carry out the study:

- ***Interactions with BMTC Officials***

Discussions were held with officials from the BMTC to understand the operations, their concerns and collect pertinent information and data for the study.

- ***Identifying the regions to be covered under this study:***

The size of the entire operations of BMTC throughout the city being large, it was necessary to identify the region that was to be taken up for the study. The region thus selected was meant to be closely representative of the entire system. Thus, operations in the Jayanagar sector are considered for the purpose of study, since this region involves all the intricacies resembling the entire system.

- ***Identifying the kind of data that is to be collected for the purpose of simulation:***

For the simulation results to be meaningful, it is important to have a clear idea of the kind of data to be input into the model. It is also necessary to have the available data in the precise form. With focus on the input parameters that would be required for running the model, a datasheet was prepared that would give the right kind of data in the right form.

- ***Data collection:***

Data regarding the schedules and passenger volumes was collected for one week in the required format from various depots for 192 schedules

- ***Data analysis and consolidation in the form that suits the simulation model:***

After the data was collected, it was collated and patterns in the movement of passengers between origins and destinations were identified.

- ***Model conceptualization:***

This entailed a study of the present system and conceptualizing a model logic using appropriate simulation modules to best imitate the real system. A second model was conceptualized for the proposed system.

- ***Building the model:***

For the purpose of simulation study, the working model was constructed using Arena® 8.0.

- ***Testing and debugging the model for errors:***

This step involved critically examining the model for errors and also determining whether the model gave meaningful results.

- ***Validating the model***

The results obtained from the model for the existing routing pattern were validated by comparing the load factors. The waiting time and number of passengers waiting could not be validated as such information is neither available nor possible to collect. stages. Comments and suggestions were incorporated into the final recommendations.

Data Collection and Analysis

To simulate the routing patterns it was essential to obtain comprehensive and structured data for the system under study. The volume of data involved is very large considering the number of buses that operate in this sector which necessitated that data collection was done by the BMTC. This was restricted to the Jayanagar sector alone.

In order to facilitate such a process, a Trip Information Sheet (Appendix 1) was prepared keeping in mind the various parameters that were to be collected. The various parameters identified were:

- Route taken by a bus
- No. of trips a bus makes
- Arrival and departure times of bus at every stage
- No. of passengers boarding and alighting the bus at every stage
- Stages covered by the bus
- Denomination wise sale of tickets
- No. of pass holders

After identifying these parameters, it was necessary to know for how long the data was to be collected. Ideally, the duration for which the data is required would be for long period of time over which the mean demand is quite stable.

Considering the time and other constraints involved and consultations with the BMTC officials, it was decided that the data would be collected for a period of one week.

Seven key origins, one nodal centre in Jayanagar (JBS) and three destinations or nodal centres across the city, as listed below, were identified for the Jayanagar region for the purpose of the study.

The 7 key origins identified were:

1. BTM Layout (BTM)
2. Banashankari (BSK)
3. Jayanagar 9th Block (JN9)
4. JP Nagar 3rd Phase (JP3)
5. JP Nagar 6th Phase (JP6)
6. Kumaraswamy Layout (KUML)
7. Padmanabhnagar (PBN)

The 3 major destinations (nodal centres across the city):

1. KR Market (KRM)
2. Kempegowda Bus Station (KBS)
3. Shivajinagar Bus Station (SBS)

Nodal Centre - Jayanagar Bus Station (JBS)

As per the current routing pattern there are 24 trunk routes in the Jayanagar sector i.e. from 8 key origins to 3 key destinations. These 24 routes were then considered for the study. The figure in Appendix 2 represents the current routing pattern for the Jayanagar sector.

For the proposed routing pattern direct services are provided from the 7 origins to the Jayanagar nodal centre (JBS) and from JBS to the three nodal centers across the city.

Data consolidation and analysis:

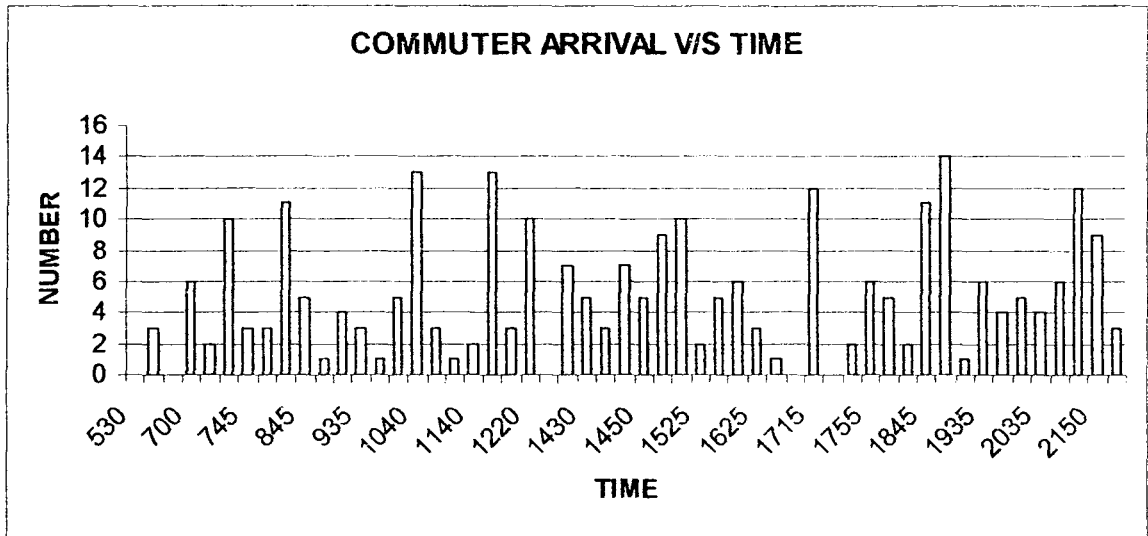
The contents in the datasheet were in terms of the denomination wise sale of tickets at every stage. This data was transformed into a From – To chart, which indicates the no. of commuters traveling from one stage to another at any time of the day.

The sample data consolidated for various stages for one day i.e March 14th is as follows:

TABLE 3: Commuters at ASKP on KBS route

STAGES	TIMES	MIN	CORP	MYS	KBS	PASS	IN	OUT	L	TL	OR
ASKP	530	0	0	0	0	0	0	0	4	4	8%
ASKP	545	0	2	0	1	0	3	0	14	14	28%
ASKP	625	0	0	0	0	0	0	0	6	6	12%
ASKP	700	0	0	0	6	7	6	1	17	24	48%
ASKP	705	0	0	0	2	0	2	2	19	19	38%
ASKP	720	0	4	0	6	10	10	4	20	30	60%
ASKP	745	0	0	0	3	6	3	1	19	25	50%
ASKP	815	0	1	1	1	0	3	4	20	20	40%
ASKP	830	0	1	1	9	5	11	0	24	29	58%
ASKP	845	0	0	1	4	10	5	6	24	34	68%
ASKP	900	0	0	0	1	15	1	6	47	62	124%
ASKP	915	0	0	0	4	6	4	7	20	26	52%
ASKP	935	0	0	4	2	0	3	9	10	44	88%
ASKP	1000	0	1	0	0	6	1	11	14	20	40%
ASKP	1015	1	0	0	4	10	5	7	34	44	88%
ASKP	1040	1	2	2	8	6	13	4	39	45	90%
ASKP	1105	0	0	0	3	10	3	5	23	33	66%
ASKP	1105	0	1	0	0	4	1	0	32	36	72%
ASKP	1140	1	0	0	1	0	2	10	29	29	58%
ASKP	1155	2	4	4	3	15	13	4	37	52	104%
ASKP	1205	0	0	0	3	10	3	5	12	22	44%
ASKP	1220	3	3	1	3	15	10	4	22	37	74%
ASKP	1240	0	0	1	3	3	0	7	3	11	22%
ASKP	1305	0	3	0	4	15	7	0	39	54	108%
ASKP	1430	0	3	0	2	5	5	5	19	24	48%
ASKP	1435	0	0	4	3	0	3	10	7	29	58%
ASKP	1440	1	5	1	0	3	7	5	22	25	50%
ASKP	1450	0	3	0	2	10	5	3	32	42	84%
ASKP	1505	0	2	1	6	6	9	1	19	25	50%
ASKP	1510	3	2	1	4	9	10	1	15	24	48%
ASKP	1525	0	1	0	1	3	2	1	11	14	28%
ASKP	1545	0	1	0	4	5	5	0	18	23	46%
ASKP	1550	0	1	2	3	3	6	3	24	27	54%
ASKP	1625	0	1	0	2	7	3	2	25	32	64%
ASKP	1640	0	0	0	1	5	1	6	19	24	48%
ASKP	1650	0	0	0	0	0	0	4	30	30	60%
ASKP	1715	1	4	3	4	7	12	4	43	50	100%
ASKP	1725	0	0	6	1	1	0	8	9	21	42%
ASKP	1740	0	0	1	1	10	2	14	16	26	52%
ASKP	1755	1	3	1	1	20	6	3	20	40	80%
ASKP	1755	0	3	0	2	0	5	1	24	24	48%
ASKP	1835	0	0	0	2	11	2	5	28	39	78%
ASKP	1845	1	2	1	7	0	11	1	22	22	44%
ASKP	1910	0	6	8	0	10	14	6	50	60	120%
ASKP	1930	0	0	0	1	7	1	7	19	26	52%
ASKP	1935	1	0	0	5	4	6	2	7	11	22%
ASKP	1935	0	0	2	2	1	4	0	32	33	66%
ASKP	2005	0	2	0	3	10	5	7	22	32	64%
ASKP	2035	0	4	0	0	1	4	5	22	23	46%
ASKP	2045	1	0	0	5	0	6	10	23	23	46%
ASKP	2130	0	1	0	11	5	12	0	24	29	58%

FIGURE 1: Commuter arrival pattern at ASKP on KBS route



This Process is repeated for all the selected routes.

Simulation Models

Simulation models were developed to understand the potential benefits of the proposed routing method. The first model simulates the current operations in the Jayanagar region using data provided by BMTc. Currently, 192 schedules (each schedule can have several trips through the day) on 99 routes are operated through this region. There are 12 demand centres in the region from which direct services originate for around 45 different destinations across the city. The second model simulates the proposed routing pattern. The models are used to determine the average commuter waiting time, average travel time, queue length and load factor for the existing operations.

Model Assumptions

The following assumptions were made with respect to the system under consideration:

- The commuters who enter the system use the buses as the only mode of transport to reach their destination.

Since in our model, we are considering the buses to be the only mode of transport, the commuters created in the system have to travel in these buses to move from one place to another.

- The arrival rate of commuters at their place of origin is said to follow a continuous distribution i.e. an exponential distribution

Since the arrival rate was found to be inconsistent, showing large fluctuations, with the future demand also being unknown, a theoretical distribution is assumed

- Breakdown of buses do not happen.
- The arrival pattern of the buses at various stations follows the predefined schedule.

- The route time for the buses is assumed to be constant.
- The total capacity of the bus is assumed to be 50
- The travel time for the commuter is the time elapsed since his arrival at the origin to his departure at his desired destination.

Scenario Analysis and Results

The simulation models are used to evaluate a number of scenarios. Each scenario is a combination of a specific frequency of 5, 10 or 15 minutes between spokes (demand points) to the nearest hub (nodal points) and between hub to hub of 3, 5 and 10 minutes. Each scenario results in different service levels and requires different fleet strength. Three scenarios were analyzed further as others were either poorer on the service level (such as 10_10) or required higher number of buses (such as 3_5) than are available. Table 4 presents the results for these three scenarios. The scenarios are listed as 3_10, 5_5 and 5_10 where the first number is the frequency from the Jayanagar hub to the three major hubs in the city and the second number is the frequency from spokes (7 demand centers in Jayanagar) to the Jayanagar hub.

TABLE 4: Service Levels for Different Scenarios

	3_10	5_5	5_10
Waiting Time Reduction	70%	71%	66%
Travel Time Reduction	42%	45%	40%
Number Waiting Reduction	54%	41%	35%

Table 5 below presents the number of buses required for the three scenarios and the resulting savings.

TABLE 5: Number of Buses Required for Different Scenarios

	3_10	5_5	5_10
Demand Centres to Jayanagar Hub	24	38	24
Jayanagar Hub to 3 Major Hubs	62	36	36
Total Required	88	74	60
Currently Used	92	92	92
% Savings	4.35	19.57	34.78

A comparison of the results from the two models indicates that the average commuter waiting and travel times are reduced by over 70% when a hub and spoke routing strategy

is used. The average queue length at the demand centers is reduced by over 50%. Thus the proposed strategy provides better service levels to the commuters for the given scenarios. These substantial improvements in service levels are achieved with lesser number of buses than are currently in use. This also implies improved bus productivity and greater revenue earned per bus.

The hub and spoke orientation will entail a change of buses at the Jaynagar hub in order to travel to other hubs in the city. This gives rise to two major concerns. First is the commuter's willingness to change and the other is the implication on the total fare to be paid by the commuter.

To address the concern regarding total fare we propose that a single ticket be issued from the origin to the desired destination so that the commuter does not have to purchase multiple tickets and does not have to pay a higher fare to complete the journey. This can be facilitated by the introduction of ticketing machines. BMTC officials have indicated that it is possible to introduce ticketing machines and implement a single ticket and single fare for the journey.

To address the concern regarding willingness of passengers to adopt the proposed routing pattern, we conducted a survey, details of which follow.

Commuter willingness survey

A sample field survey of 165 commuters was undertaken in the Jayanagar sector. For this a BMTC Commuter Survey was prepared (Appendix 3). Opinions of the commuters regarding their willingness to change buses at the Jayanagar hub were elicited for different levels of savings in total travel time. These were categorized by trip classification, vehicle ownership and classification of travel by day. Table 6-8 present the survey results.

TABLE 6: Commuter Willingness to Change at JBS by Trip Classification

Trip Classification	Time Saving						Total in Each Category
	<25%		25 - 50%		>50%		
	Number	%	Number	%	Number	%	
Student	15	0.20	24	0.32	62	0.84	74
Workers	27	0.36	30	0.40	54	0.72	75
Non-work related	1	0.06	2	0.13	6	0.38	16
Total	43	0.26	56	0.34	122	0.74	165
% Willing To Change	0.26		0.34		0.74		

The commuter trips are broadly classified into three categories namely, students, workers and persons making non-work related trips. It may be noted that 26% of the commuters are willing to change if the saving in travel time is up to 25%. This percentage goes up to 34% for travel time saving ranging between 25-50% and 74% if the travel time savings is

beyond 50%. The percentage of students willing to change for different levels of travel time savings varies between 20% to 84%. In the case of workers this percentage change varies between 36% to 72%.

TABLE 7: Commuter Willingness to Change at JBS by Vehicle Ownership

Vehicle Owned	Time Saving						Total in Each Category
	<25%		25 - 50%		>50%		
	Number	%	Number	%	Number	%	
2 wheeler	12	0.32	16	0.43	27	0.73	37
4 wheeler	0	0.00	0	0.00	3	0.75	4
2 and 4 wheeler	2	0.50	2	0.50	2	0.50	4
None	29	0.24	38	0.32	90	0.75	120
Total	43	0.26	56	0.34	122	0.74	165

Commuters classification on the basis of vehicle ownership includes four categories namely, persons owning two wheelers, four wheelers, both two and four wheelers and not owning any vehicle. The commuters owning no vehicle are ready to change at JBS varies between 24% to 75% for different levels of savings in travel time. The willingness to change in the case of two wheeler owners varies from a 32% to 73%. The sample size of 4 wheeler owners is small and indicates that willingness to change is limited to at least 50% reduction in travel time.

TABLE 8: Commuter Willingness to Change at JBS by Trip Type

Trip Type	Saving time						Total
	<25%		25 - 50%		>50%		
	Number	%	Number	%	Number	%	
Working days	36	28.80	40	32.00	98	78.40	125
Weekends	26	32.91	31	39.24	59	74.68	79
Occasional	4	11.11	3	8.33	20	55.56	36
Total	66	37.29	74	41.81	177	100.00	240
% Willing To Change	0.28		0.31		0.74		

The commuters are broadly classified into three groups namely, traveling on working days, traveling on weekends and persons undertaking occasional travel. 28% of all these commuters are prepared to change at JBS if the travel time saving is less than 25%. This percentage increases to 31% for travel time saving upto 50% and 74% for savings in travel time beyond 50%. Among commuters making trips on working days the percentage willing varies from 28.8% to 78.4%. Willingness among commuters traveling on weekends varies between 33% to 75%.

It can be concluded from the above analysis that the percentage of commuters willing to change buses is substantial.

Conclusion

Comparing the present and proposed routing strategies using the simulation models, it is evident that the proposed system benefits both the commuters as well as the BMTC. Based on the sensitivity analysis conducted on the proposed system, a 3 minute frequency of buses from the Jayanagar hub to the nodal centres and the 10 minute frequency between the origins in the region and the hub can be implemented with the existing number of buses. This can reduce the travel time by over 40% and the waiting time of the commuters by over 70% without requiring additional buses.

The benefits to the commuters can be summarized as:

- Lesser waiting times at the bus stop
- Improved frequency of buses
- Reduced total travel time
- More buses to travel within the sector
- Reducing the dependence on other modes of transport

The benefits to the BMTC include:

- Additional areas can be covered with the same number of buses
- Can cater to additional demand in these areas resulting in increased revenues.
- Providing higher service levels to the commuters
- Increased usage of buses by the commuters due to better service levels.

The results from the simulation models can be used to assist BMTC officials in making a decision on adopting a hub and spoke system of routing as well as for evaluating various decisions with respect to frequencies on the routes.

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Appendix 1: Trip Information Sheet

Trip Information Sheet

Date:

Route No :
 Stage 1:
 2:
 3:

From:
 4:
 5:
 6:

To:
 7:
 8:
 9:

Dept/Unit:
 10:
 11:
 12:

Trip 1 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 5 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 2 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 6 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 3 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 7 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

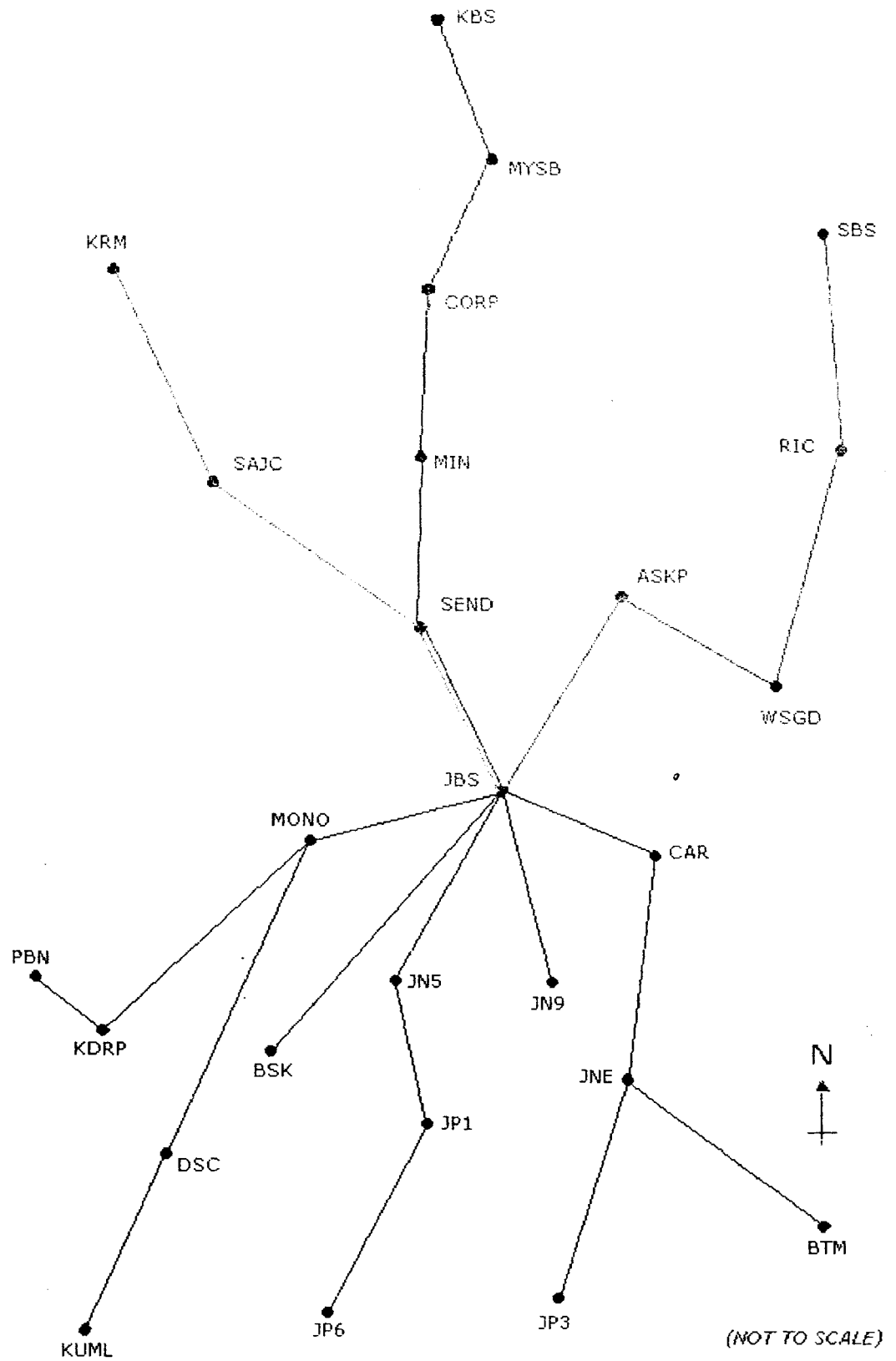
Trip 4 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Trip 8 From: To:
 Time: Time:

Stage:	Description and rate of Holes:						% of Filler
	2.00	4.00	6.00	8.00	10.00	12.00	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Appendix 2: Current Routing Pattern for BMTC Buses



Appendix 3: BMTC Commuter Survey : Perception and Opinion

A1. *Commuter profile*

a) Student

College High School Others

b) Workers

Office goers Business Others

c) Non-work related

Shopping Entertainment Religious Others

A2. Age

A3. Do you own a vehicle 2 Wheeler 4 Wheeler No

Reason for not using own vehicle:

B. *Trip information (Trips made during the last one week)*

1. (a) Do you travel on all working days? Yes No
(b) Do you travel on weekends? Yes No
(c) Are you an occasional traveler? Yes No

2. Trip details chart – ***please fill up the enclosed chart.***

C. If routing reduces total travel time (*please see below*), would you be willing to transfer at Jayanagar Bus Stand (JBS) to reach the destination?

Time Reduction Willingness to Transfer at JBS

Less than 25% Yes No

25 – 50% Yes No

50% and above Yes No

What if seating is assured? Yes No

D. Do you travel within JP Nagar, Jayanagar Banashankari and BTM Layout areas? If circular routes are introduced connecting these areas how many times are you or your family members likely to use them in a week?

Nil 1 – 2 3 – 4 5 – 6 More than 6

What if this requires change of buses?

Appendix 3: BMTC Commuter Survey : Trip Details Chart

Sl No. of trips	Origin	Final Destination	Purpose of trip (Fill appropriate no. 1 to 7)	Time of trip (Fill appropriate no. 1 to 4)	No. of buses taken to complete the trip	Total cost of trip (Rs.)/ DP/MP/SP	TIME (minutes)			No. of trips repeated in a week (1/2/3/4/5/>5)
							Waiting time	Travel time	Total Time	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

PURPOSE

1. Studies (student)
2. Office goers
3. Business trip
4. Shopping trip
5. Entertainment trip
6. Religious trip
7. Others

SP; Student Pass Holder
 DP: Daily Pass Holder
 MP: Monthly Pass Holder

TIME

1. Morning peak hours (0700 -1030Hrs)
2. Evening peak hours (1630 -1830Hrs)
3. Morning off-peak hours (Up to 1200 Hrs, other than 1 above)
4. Evening off-peak hours (Rest of 24 Hrs other than 1, 2, 3 above)