Public Transport Route Selection, Bus Stops Location and
Guidance to the Users in Dar Es Salaam

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ABSTRACT

Transportation planning is very important in improving quality of transportation which in turn improve quality of life but still this profession is not much appreciated in the society. Good planning make progress towards paradise while bad or no planning leave legacy of problems and disputers. Planners perform vital role by anticipating and resolving community conflicts. Good planning requires special skills and perspectives:

- Most people prefer to ignore problems until they become unavoidable. Planners are professional worriers who seek out potential problems so they can be mitigated.
- Most people look at a problem from a single perspective. Planners are responsible for considering multiple perspectives; they ask, “what is best for everybody overall?”
- Most people prefer simple problems and solutions. Planners learn to appreciate complexity, and search for deeper meanings and underlying causes. Planners learn to work with uncertainty and ambiguity.
- Most people consider compromise a sign of weakness and failure. Planners are passionate about compromise because it resolves conflicts and often leads to better solutions and justice to everyone and every situation.
- Most people prefer to consider one issue at a time. Planners apply integrated analysis, so individual, short-term decisions are consistent with multiple, long-term goals.

Despite the effort of planners to help in maintaining balance between the human and natural world, yet, planners often receive little respect. Our successes are taken for granted, and we are often blamed for failures beyond our control. As coordinators of public decision-making, planners are lightning rods to criticism. Our role as unbiased facilitators is often misinterpreted as heartless bureaucrats. Stakeholders frequently hold planners personally responsible when dissatisfied with outcomes. Planners need diplomatic skills and a thick skin: if we do our job well, we are criticized approximately equally by all sides.

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MOTIVATION OF THE PROJECT

As a person who most of the time whenever I want to go anywhere whether it for work, shopping, worshiping and recreation the first option on how to get there is by the use of public transport. For number of years in this city of Dar es salaam i experience several challenges like:

Every time I arrive at a bus stop I must ask whether i can get a bus heading to my destination and as a matter of fact not everyone is honest enough to give right answer, through this way I was forced to unnecessary use more than one bus to reach my destination.

Many times after reaching the final bus stop i was forced to use intermediate means of transport to get to my destination, and sometimes I used intermediate means of transport before boarding a bus to my destination. Too much waiting time at each bus stop leading to unnecessary.

CHAPTER ONE: INTRODUCTION AND BACKGROUND

Dar es Salaam formerly Mzizima is the former capital as well as the most populous city in Tanzania and a regionally important economic center. Located on the Swahili coast, the city is one of the fastest growing cities in the world. The most common form of transport in Dar es Salaam are the public buses, called *dala dala*, which are often found at the major bus terminals of Makumbusho, Ubungo, Mawasiliano, Mbezi mwisho and Gerezani, despite being the cheapest this means of transport is now facing serious competition from motorcycle transit business known as "Bodaboda", because most of the people prefer this type of transportation which allows them to get into the city faster compared to the minibuses which face a lot of delay due to presence of bus stops where buses must stop for purpose of taking off passengers who arrive at their destination and/or waiting for new passengers meanwhile there is significance number of passengers on board who are not yet to reach their destination but they have to wait anyway and that elapsed time is considered as a loss to them and traffic. Other types of transport include taxi and Bajaj which does not have bus stops meaning no time loss apart from traffic jam but its cost is considerable higher compared to public buses famous known as *dala dala*.

An efficient and cheap transportation system is critical for a country's development as it is a means of transporting goods and services from one place to another. Yet in a big city like Dar es salaam which is characterized by high-density urban areas with annual population growth of 4.3 percent (1) there is poor public transport management resulting in frequency complaining from users due to presence of traffic jam, frequency stops and start resulting in increase of travel time. There are updated research studies on transit and traffic system using microscopic simulation approach and by using intelligent transportation system technology (9, 10, 11).

Location of bus stops should also be considered seriously not because of their function of linking between people (users) and vehicles but also their location highly influence travel time and quality of transport, because if they are so close to each other will lead to increase in travel time due to frequency stop and start especially when there are so many, and when they are far apart will lead to increase walking distance from origin to bus stop and from bus stop to destination hence forcing people to use intermediate means of transport which is always very expensive (2).

In major growing cities like Dar es salaam (3) where population increase at a rate of 4.3 percent annually (1) together with urban migration which is common problem result in population increase this encourage government and other private sector to build new public services facilities in area where those services has never been there, this result in shifting of people movement and most of them use public transport also increase in population command government to divide regions and district for purpose of simplifying governing, this will result in building of new offices hence shifting of public movement is inevitable meanwhile there is no flexible system bus stops location to take care for either increase or shifting of demand (as SUMATRA press release of April 2013 is silent on in this issue) and only concentrate on rules for establishing fares charges depending on distance from origin to destination.

1.1 PROBLEM STATEMENT

In the city like Dar es salaam public transport route are so complex in a way that even to people who lived here for many years is still a nightmare, so every time people arrive at Bus Stop they will be asking questions like “can I get a bus going to my destination from here”, “how far is my destination”, “ how many intermediate stop to my destination”, “is there any alternative route”, and the worst part about asking questions is that it does not guarantee the right answer, because most of the time public transport users rely on bus drivers and their assistance (who always give answers on their favors) to get required information this create a lot of disturbance to the passengers as they may board a bus heading to a wrong destination, unnecessary boarding more than one bus to reach their destination or forced to use intermediate transport.

Also presence of bus stops so close to one another lead to increase in travel time due frequency stopping and starting (Mabibo hostelbus stop and Externalare just 400m apart, chama and buguruni bus stops are 200m apart mean while simu 2000 and darajani are 1800m apart leading to increase walking distance from origin to bus stop and from bus stop to destination).

Apart from problem mention above lack of proper system for route selection bus stop location lead to conflict between driver and traffic police when drivers decide to break the rules like using prohibited route for several reasons like to escape intersections and long distance route, stopping at any place to take in passengers.

Also, improper bus stop location lead to number of problems because if they are so close to each other will lead to increase in travel time due to frequency stop and start, when they are far apart will lead to increase walking distance from origin to bus stop and from bus stop to destination, when distance between bus stops vary to large extent (simu 2000 and darajani bus stops are 1.8km apart while darajani and riverside bus stop are 480m apart) this lead to irregularity in transport and it can also create redundancy. Redundancy occurs when the same

parcel is being served by multiple stops along the same route due to short stop spacing or is being served by multiple routes leading to the same destination.

1.2 OBJECTIVES OF THE PROJECT

Objectives of this project aiming at minimizing problems mentioned above are classified into two groups i.e Main and specific objectives.

1.2.1 MAIN OBJECTIVES

All these problems can be minimized or removed by having system which will perform the following functions.

1. Ensuring presence of bus stops near public service facilities like schools, hospitals and market and discouraging bus stops so close to each other.

Presence of bus stops near public service will minimize walking distance from origin to bus stop and from bus stop to destination, and uniformity in their distance apart lead to regularity in transport, also bus stops should not be so close to each other as this will increase delay due to frequency stop and start and lead to redundancy in transport.

2. Introduction to express buses in public bus transport (NON-BRT) famous known as dala-dala.

These are buses that does not stop in each bus stop hence reduction in travel time from origin to destination for long distance passengers, as one of the key factors that determine efficiency of public transport system is travel time from origin to destination, so much emphasis must be given to minimize it.

1.2.2 SPECIFIC OBJECTIVES

These are objectives that will pave a way to the completion of main objectives:

1. By using map to locate all present bus stops in selected routes i.e from Mawasiliano to Mbezi mwisho and Mawasiliano to Bugruruni
2. To determine time loss associated with presence of bus stops

Kind of Losses

Losses due to time taken for passengers to enter and/or leave the bus. Data to be collected was waiting time. Losses due to deceleration and acceleration at the bus stops was measures by travel speed of buses.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Public transport is one of factors that determine quality of life because it is a means of moving people from their home to their destination such as working places. Apart from carriageways which are considered more important and perhaps the sole factor that guide quality of transport system from obvious point of view and indeed they are very significance because it's through carriageways vehicles move and its quality determine smooth ride and comfortable journey.

2.2 Component of public transport

Apart from carriageways there are other key components of transport system like bus stops and public transport routes. *Bus stops* provide link between users and vehicles so their proper location which should consider easily accessibility and travel time can highly improve performance of public transport by trying to provide balance between passengers on board and those who are heading toward bus stops and eliminate any chance of providing redundancy in transport (redundancy is when one destination is served by more than one bus stop).

public transport route help in providing link between origin and destination and they must be careful chosen to minimize travel distance, minimize walking distance and if possible eliminate the need of intermediate transport and reduce redundancy (redundancy is when one destination is saved by more than one route).

2.3 Route selection

Human beings are natural effort minimizers, notably when it involves moving around. When given the opportunity, they will always try to choose the shortest path to go from one place to another. This behavior can easily be observed from pedestrians. When possible, a pedestrian will walk over a lawn, zigzag by cars in a parking lot, or cross a street sideways between intersections if the route selected enables to reach faster a destination.

Transportation, as an economic activity, replicates this process of minimization, notably by trying to minimize the friction of distance between locations. Shorter times and lower costs are looked upon by individuals as well as by multinational corporations. For an individual, it is often only a matter of convenience, but for a corporation it is of strategic importance as a direct monetary cost is involved. Under such circumstances, it is not surprising that numerous methods have been developed to deal with the often-complex issue of route selection. One such classic application is the "traveling salesperson" problem, where the shortest route has to be selected from a set of numerous combinations of possible paths. Route selection has two major dimensions:

- Construction. Involves activities related to the setting of transport networks such as road and rail construction. Among the basic considerations are factors such as distance and topography.

- Operation. Concerns the management of flows in a network. This is the most common route selection activity since it considers routes as fixed entities and therefore seek an optimal path considering existing constraints.

2.4 Evaluating the Route Selection Process

The choice of linking a location to another, and more importantly, the path selected is part of a route selection process which respects a set of constraints. Although route selection varies by mode, the underlying principles remain similar; in its most simple form, a route selection process (R) tries to respect these general constraints: $R = f(\text{minimum cost} : \text{maximum efficiency})$ Route selection thus tries to find or use a path minimizing costs and maximizing efficiency. There are obviously two major dimensions in this function:

- Cost minimization. A good route selection should minimize the overall costs of the transport system. This implies construction as well as operating costs. The most direct route is not necessarily the least expensive, notably if rugged terrain is concerned, but most of the time a direct route gets selected. It also implies that route selection must be the least damageable to the environment, if environmental consequences are considered.
- Efficiency maximization. A route must support economic activities by providing a level of accessibility, thus fulfilling the needs of regional development. Even if a route is longer and thus more expensive to build and operate, it might provide better services for an area. Its efficiency is thus increased at the expense of higher costs. In numerous instances, roads were constructed more for political reasons than for meeting economic considerations.

Route selection is consequently a compromise between the cost of a transport service and its efficiency. Sometimes, there are no compromises as the most direct route is the most efficient

one. At other times, a compromise is very difficult to establish as cost and efficiency are inversely.

2.5 Location of bus stops

There are several considerations in locating bus stops, travelling time and population density are few of them as described by different author like Transit Cooperative Research Program report 19.

Traveling time

Travelling time includes summation of the following:

1. Walking time to public transportation vehicle.
2. Time of getting on the public transportation vehicle.
3. Reputation time of an alternative movement of a vehicle for arriving to the next station consists of:
 - 3.1. Enough time for the vehicle to develop the acceleration to a constant speed;
 - 3.2. The time in which a vehicle moves between two stations;
 - 3.3. Enough time for a vehicle to get to the deceleration station.
4. Stopping time in the stations along the route.
5. Delay time and occasional delays.
6. Time of getting off the vehicle.
7. Time of walking to the destination or replacing transportation system or changing the public transportation vehicle.

Population density

The density and locations of bus stops are usually used to determine the accessibility of bus services, which significantly influences transit system performance and level of service. In a newly developed suburban region where a bus route is nearby, adding several stops into the bus route can stimulate ridership because of reduced access time. However, the corresponding user

in-vehicle time and supplier cost might increase due to the excess acceleration and deceleration delays incurred by buses serving the additional stops.

A number of previous studies by different author like (4) Optimization of bus stop locations for improving transit accessibility, Transportation Planning and Technology have focused on planning bus transit systems while considering the locations of bus stops. However, demand was distributed continuously along an existing transit route. The methods applied for analyzing transit system performance were based on the relationships between stop spacing, service headway, fleet size and round-trip travel time. The objectives of those studies were using these relationships to evaluate system capacity versus actual demand and required headway versus policy headway to minimize the total cost (the sum of supplier and user costs). It was believed that the performance of a transit system could be significantly improved if the spacing of bus stops was optimized. The review of past research for this study on optimizing locations of bus stops can be classified into three categories.

The first involved studies that focused on locating bus stops based on simplified demand distribution. A survey on bus stop design was conducted by (5). Findings from a survey on bus stop design. Journal of Public Transportation, 1997. Who developed guidelines for allocating bus stops considering bus patron's convenience, safety and access time (walking time from origin to bus stop), as well as the efficiency of transit operations. Based on given traveler preferences and budget constraints from the transit provider, Van Nes and Bovey (6) developed an analytical model that optimized stop spacing and line spacing, while a number of performance indices (i.e. travel time, operator costs, and patronage) were analyzed. Due to the fact that buses compete for right of way with other transportation modes, Brouwer et al. (7) optimized the locations of bus stops considering the costs incurred not only by bus passengers and transit suppliers, but also by other road users, local residents and businesses.

The second category focused on joint optimization of bus route and stop spacings for a bus system. Holroyd (12) analyzed a grid bus network with a given origin–destination demand that was uniformly distributed over an infinite plane. The route spacing and headway were optimized, which achieved the minimum total cost. Later Chien and Schonfeld (7) optimized a grid transit system in a heterogeneous urban area without oversimplifying the spatial and demand characteristics. An iterative algorithm was developed to minimize the total cost, while the bus route spacing, stop spacing and headways were optimized. (4) found the optimal number and locations of bus routes serving a residential area by minimizing the total cost using genetic algorithms. Since passengers were assumed to be able to access buses anywhere on the route (e.g. jitney service), the locations of the bus stops were not considered.

In the third category, several studies have considered temporal demand while optimizing a bus system. Gerrard and Hundle (13) optimized a service area by minimizing the total cost considering time varying demand. Bramel and Simchi-Levi (8) applied heuristic methods to solve a vehicle routing problem in which customers requested service with a certain probability during a given time period. Most of the aforementioned studies considered additive time cost while optimizing their objective functions. However, in the real world the cost of time is rarely linear. Thus, Chien et al. (4) evaluated various feeder bus systems considering probabilistic time-varying demand and nonadditive time costs. In this paper, a mathematical model is formulated to optimize the number and locations of bus stops that achieve the minimum total cost. A realistic demand distribution based on a general street configuration is considered. The concept of non-additive time cost is also applied in the development of the model.

2.6 Suggestion of bus stop spacing

After studying and understanding vital roles bus stops play in public transport it is time to consider suggestion of bus stops spacing as explained by different authors. In establishment place for bus stop we determine the place of bus stations mainly as per distance between stations, per model of the passersby movement and traffic production centre and determination of the distances between stations as per density of the population according to the kind of land use, and needs, the distance between the stations is determined for the city centre, as per change of the population density in different zones of the city. The following values are suggested for the distances between the stations:

1. The distance between stations in the city trade center, is determined from 750 to 250 m with population density of more than 3500 persons in every km².
2. The distance between stations in the city center, with an average density from 1000 to 3500 persons in every km², is determined from 200 to 300 m.
3. The distance between stations, in the suburb of city, with an average density of less than 1000 persons, in every km², is determined from 250 to 3000 m.

2.7 Accessing transportation system (bus stop)

For accessing to public transportation, one of the most usual methods is a walking one. It means the distance access in which a person covers the distance from the origin toward the station to get to the destination. This distance is considered about 500 m for the local buses and time for the passengers, normally and safely, cover this route vary accordingly to different factors like age and the disability.

CHAPTER THREE: METHODOLOGY OF CONDUCTING PROJECT

This study was conducted based on two approaches. The first approach is based on the field whereby using handheld GPS receiver, coordinates of the bus stops and public facilities were taken. The second approach is based in the office whereby study planning and processing of the route data were done. Details on the activities performed are as explained below:

3.1 Field based methodology

By beginning with field-based methodology, the following are the procedures which I classified them into three categories.

3.1.1 Collection of data for map preparation

The following are activities that was done during data collection for map preparation

- Moving along chosen routes i.e. simu 2000 to mbezi mwisho and simu 2000 to buguruni for the aim of:
 - i. Collecting coordinates and names of present bus stop and public services facility (including religious building) identifying.
 - ii. Identifying potential area for location of bus stops and places where bus stops are so close leading to redundancy in transport.

3.1.2 Collection of data for travel time

The following are activities that was done during data collection for map preparation

- Selecting time for conducting my study, because the aim of improving public bus transport is to save many people so I decided to conduct my study during peak hours i.e. from 4.00 PM to 8.00 PM and from 7.00 AM to 10.00 AM

- Taking a bus from origin i.e. Simu 2000 to destination i.e. either Buguruni or Mbezi mwisho and vice versa and recording the following:
 - i. Starting and finishing time
 - ii. Time taken excluding waiting time in traffic so as to have fair comparison.

3.1.3 Collection of data for time loss

The following are activities that was done during data collection for analyzing time loss

- Recording travel time for each route for the aim of knowing the current condition i.e. non express buses which will later on be used as a reference to compare with express buses.
- Choosing bus stops that will be used for express buses by considering several factors like presence of collector road near bus stops, presence of intersection and nearby public service.
- Choosing two bus stops to collect required data, these stops were chosen by considering several criteria like safety of workers during process of data collection and absence of bumps near bus stops.
- Recording time taken for buses to embark and disembark passengers at bus stops.
- Recording velocity of the buses and time taken to decrease it to zero and accelerate back to operating speed.

3.2 Office based methodology

On the other hand, office-based methodology has the following procedures

- Acquiring shapefile map of Dar es salaam
- Uploading obtained coordinates on google earth to confirm their location
- Creating shapefile of present Bus Stop and proposed ones, this can be done with the help of handheld GPS even though it has accuracy of 3 m it can save intended purpose.

- Digitization process to show present routes and alternative one.
- Establishing attributes table that will contain distance from origin to destination, number of intermediate bus stop, number of junctions and names of intermediate bus stop (popular ones).
- Preparing specific printed map/table for each terminal (simu 2000) indicating all necessary information as indicated above.
- Assembling and analysis of data by using Microsoft excel.

CHAPTER FOUR DATA COLLECTION AND ANALYSIS

Table I: Coordinates of bus stops and public service facility

COD	LATITUDE	LONGITUD	ALTITUD	NAME
E		E	E	
36	-6.78067	39.20303	94	Utawala
37	-6.78804	39.21611	52	simu 2000
38	-6.78929	39.20859	59	university road junction
39	-6.79206	39.20858	61	ubungo sheli
40	-6.79213	39.20896	62	ATM
41	-6.79219	39.20715	64	ubungo maji
42	-6.79184	39.20584	67	Tanesco
43	-6.79049	39.19666	96	Kibo
44	-6.79007	39.19173	100	kona
45	-6.79114	39.18686	113	kimara baruti
46	-6.78932	39.18214	102	kimara bucha
48	-6.78705	39.16642	91	kimara mwisho
49	-6.78737	39.15723	93	kimara stop over
50	-6.79134	39.14703	101	kimara suka

51	-6.79075	39.1386	122	Temboni
52	-6.79019	39.13194	113	kwa msuguli
53	-6.78315	39.12403	106	kibanda cha mkaa
54	-6.78605	39.11238	119	mbezi mwisho
55	-6.78607	39.19682	98	RC church
56	-6.79638	39.20732	46	Darajani
57	-6.79696	39.20682	48	Mosque
59	-6.79913	39.2063	48	riverside hall
60	-6.80036	39.20552	54	ubungo primary school
61	-6.80052	39.20683	49	riverside
62	-6.80461	39.20697	52	mabibo hostel
63	-6.80397	39.21067	45	mabibo hostel bus stop
64	-6.80529	39.22345	41	NIT
65	-6.80986	39.21392	47	KKKT church
66	-6.80743	39.21382	49	TFDA
67	-6.80616	39.213	46	mkapa

68	-6.80594	39.21372	48	external
69	-6.81143	39.21663	41	gereji
70	-6.81648	39.22237	32	mwananch i
71	-6.82048	39.22783	28	TOT
72	-6.82718	39.23443	31	matumbi
73	-6.83828	39.24328	38	chama
74	-6.83941	39.24402	38	buguruni
75	-6.8383	39.24419	37	buguruni primary school

Table II: Attribute table of bus stops

Table						
XYbus_stops						
FID	Shape *	LAT	LONG	ALT	name_dista	ab_na
0	Point ZM	-6.788024	39.216108	50	simu 2000 (0.00)	
1	Point ZM	-6.789269	39.208594	58	(1.00)	
2	Point ZM	-6.792197	39.207159	63	ubungo maji (1.63)	
3	Point ZM	-6.790509	39.196662	92	kibo (2.67)	
4	Point ZM	-6.790253	39.191448	101	kona (3.25)	
5	Point ZM	-6.79101	39.186544	113	kimara baruti (3.81)	
6	Point ZM	-6.789314	39.182294	101	kimara bucha (4.31)	
7	Point ZM	-6.787146	39.176844	113	korogwe (4.96)	
8	Point ZM	-6.787063	39.166539	134	kimara mwisho (6.16)	
9	Point ZM	-6.78731	39.157495	132	kimara stop over (7.22)	
10	Point ZM	-6.791012	39.149039	133	kimara suka (8.24)	
11	Point ZM	-6.790722	39.138573	158	temboni (9.40)	
12	Point ZM	-6.790234	39.132093	145	kwa msuguli (10.17)	
13	Point ZM	-6.78322	39.123944	136	kibanda cha mkaa (11.43)	
14	Point ZM	-6.786307	39.111968	141	mbezi mwisho (12.83)	
15	Point ZM	-6.796391	39.207322	53	darajani (1.80)	
16	Point ZM	-6.80053	39.206827	55	riverside (2.28)	
17	Point ZM	-6.80397	39.210661	45	hostel (2.88)	
18	Point ZM	-6.805905	39.213728	48	external (3.28)	
19	Point ZM	-6.8114	39.216664	38	garage (3.96)	
20	Point ZM	-6.816442	39.222403	30	mwananchi (4.83)	
21	Point ZM	-6.820488	39.227836	26	T.O.T (5.58)	
22	Point ZM	-6.827163	39.234448	31	matumbi (6.63)	
23	Point ZM	-6.838274	39.243267	35	chama (8.19)	
24	Point ZM	-6.839881	39.244333	36	buguruni (8.39)	

NOTE 1: Stops from field 1 to 13 correspond to mbezi mwisho route while the rest correspond Buguruni route

NOTE 2: The number in brackets stands for distance in kilometers from simu 2000 to respective stop for example kwa msuguli stop is 10.17 km from simu 2000.

Table III : Travel time from Simu 2000 to Buguruni

ROUTE NAME: SIMU 2000 TO BUGURUNI

COORDINATES:FROM 6°47'16"S,39°12'58"E TO 6°50'22"S,39°14'38"E

PASSING THROUGH: SAM NUJOMA AND NELSON MANDELA ROADS

TOTAL DISTANCE: 8.39 KM

NUMBER OF BUS STOPS: 9

DATE	START	FINISH	FINISH-START	TIME TAKEN (min)
Friday, April 26, 2018	4:20:00 PM	4:55:36 PM	0:35:36	26:36.0
Friday, April 26, 2018	5:10:20 PM	5:59:40 PM	0:49:20	24:06.0
Monday, April 30, 2018	6:01:05 PM	6:57:09 PM	0:56:04	33:20.0
Monday, April 30, 2018	7:05:50 PM	8:01:06 PM	0:55:16	37:19.0
Wednesday, May 02, 2018	6:02:20 PM	6:50:40 PM	0:48:20	32:14.0
Wednesday, May 02, 2018	7:01:15 PM	8:02:40 PM	1:01:25	35:02.0
Friday, May 04, 2018	6:04:20 PM	7:04:10 PM	0:59:50	29:01.0
Friday, May 04, 2018	7:10:26 PM	8:12:00 PM	1:01:34	30:04.0
Monday, May 07, 2018	5:10:01 PM	5:48:04 PM	0:38:03	28:17.0
Monday, May 07, 2018	6:02:40 PM	7:03:01 PM	1:00:21	31:01.0
Friday, June 01, 2018	7:02:00 AM	8:05:11 AM	1:03:11	29:01.0
Friday, June 01, 2018	8:14:20 AM	9:11:11 AM	0:56:51	27:06.0
Monday, June 04, 2018	7:10:14 AM	8:08:11 AM	0:57:57	34:01.0

Monday, June 04, 2018	8:20:14 AM	9:20:19 AM	1:00:05	26:14.0
Friday, June 08, 2018	7:08:00 AM	8:05:11 AM	0:57:11	27:42.0

mean time $\bar{X}$ = time taken/no. of data collected

$$= 450 \text{ min}/15$$

$$= 30 \text{ min}$$

standard deviation = $\sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$

standard deviation $S = 4 \text{ min}$

by using t-distribution

average travel time = mean $t_{(0.025, n-1)} S/\sqrt{n}$

$$= 302.145 \times 4/\sqrt{15}$$

= 302 min at 95% confidence interval

Table IV : Travel time from Simu 2000 to Mbezi mwisho

ROUTE NAME: SIMU 2000 TO MBEZI MWISHO

COORDINATES: FROM 6°47'16"S, 39°12'58"E TO 6°47'11"S, 39°06'43"E

PASSING THROUGH: SAM NUJOMA AND MOROGORO ROAD

TOTAL DISTANCE: 12.83KM

NUMBER OF BUS STOPS: 12

DATE	START	FINISH	FINISH-START	TIME TAKEN
Friday, April 27, 2018	4:15:42 PM	5:06:22 PM	0:50:40	32:29.0
Friday, April 27, 2018	4:10:15 PM	5:20:02 PM	1:09:47	33:27.0
Saturday, April 28, 2018	6:20:10 PM	7:30:02 PM	1:09:52	45:47.0
Saturday, April 28, 2018	7:35:20 PM	8:40:42 PM	1:05:22	41:23.0
Saturday, May 05, 2018	6:04:21 PM	7:06:04 PM	1:01:43	39:10.0
Saturday, May 05, 2018	7:10:00 PM	7:57:11 PM	0:47:11	35:14.0
Tuesday, May 08, 2018	5:11:04 PM	6:14:42 PM	1:03:38	37:01.0
Tuesday, May 08, 2018	6:20:04 PM	7:29:00 PM	1:08:56	40:20.0
Thursday, May 10, 2018	6:05:07 PM	7:06:01 PM	1:00:54	36:04.0
Thursday, May 10, 2018	7:20:47 PM	8:29:24 PM	1:08:37	42:27.0
Tuesday, June 05, 2018	6:57:00 AM	8:10:16 AM	1:13:16	44:20.0
Tuesday, June 05, 2018	8:18:26 AM	9:28:09 AM	1:09:43	38:42.0
Thursday, June 07, 2018	7:08:14 AM	8:18:15 AM	1:10:01	36:09.0
Thursday, June 07, 2018	8:29:14 AM	9:26:19 AM	0:57:05	41:48.0
Saturday, June 09, 2018	6:55:00 AM	8:05:16 AM	1:10:16	44:26.0

mean time $\bar{X}$ = time taken/no. of data collected

$$= 589 \text{ min}/15$$

$$= 39 \text{ min}$$

standard deviation = $\sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$

standard deviation $S = 4 \text{ min}$

by using t-distribution

average travel time = mean $\pm t_{(0.025, n-1)} S/\sqrt{n}$

$$= 392.145 \pm 4/\sqrt{15}$$

$\pm 392 \text{ min}$ at 95% confidence interval

Table V: Time losses for non-express buses from Simu 2000 to Mbezi mwisho

NAME OF ROUTE: SIMU 2000 TO MBEZI MWISHO

DATA COLLECTED AT: KIBO AND KIMARA STOP OVER

NUMBER OF EXTRA STOPS FOR NON-EXPRESS: 10

velocity (km/h)	time to deccerelate(s)	time to accereate (S)	decceralation(m/ s ²)	acceleration(m/ s ²)	waiti ng time (s)	distan ce (m)	time of expres s vehicle (s)	time loss(s)
44	9	9	0.38	0.38	82	110	9	91
40	6	6	0.51	0.51	60	67	6	66
28	8	8	0.27	0.27	50	62	8	58
40	7	10	0.44	0.31	72	94	9	81
39	6	6	0.50	0.50	60	65	6	66
50	9	9	0.43	0.43	68	125	9	77
30	4	4	0.58	0.58	50	33	4	54
50	6	8	0.64	0.48	90	97	7	97
40	8	8	0.39	0.39	60	89	8	68
46	9	9	0.39	0.39	90	115	9	99
42	9	9	0.36	0.36	92	105	9	101
48	6	6	0.62	0.62	102	80	6	108
50	10	10	0.39	0.39	74	139	10	84
38	7	7	0.42	0.42	80	74	7	87
45	11	11	0.32	0.32	96	138	11	107
44	9	9	0.38	0.38	58	110	9	67
37	6	8	0.48	0.36	84	72	7	91
34	6	6	0.44	0.44	76	57	6	82
48	8	8	0.46	0.46	67	107	8	75
36	7	7	0.40	0.40	72	70	7	79

KEY: Un-colored columns are the data recorded directly from field

Yellow colored columns are the data assisting calculation of final result

Green colored column is the final result

mean time $\bar{X}$ = time difference/no. of data collected

$$= 1640 \text{ sec}/20$$

$$= 82 \text{ sec}$$

standard deviation = $\sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$

standard deviation $S = 4 \text{ sec}$

by using t-distribution

average time loss = mean $t_{(0.025, n-1)} S/\sqrt{n}$

$$= 822.093 * 4/\sqrt{20}$$

$$= 822 \text{ sec}$$

total time loss for 10 stops = $820 \text{ sec} \pm 20 \text{ sec}$

$$= 13 \text{ min } 40 \text{ sec } \pm 20 \text{ sec at } 95\% \text{ confidence interval}$$

Table VI: Time losses for non-express buses from Simu 2000 to Buguruni

velocity (km/h)	time to deccerelate(s)	time to accerelete(S)	decceralation(m/ s^2)	acceleration(m/ s^2)	waiti ng time (s)	distan ce (m)	time of expres s vehicle (s)	time loss(s)
42	6	9	0.54	0.36	80	88	8	88
44	7	7	0.49	0.49	74	86	7	81
28	8	8	0.27	0.27	62	62	8	70
41	10	9	0.32	0.35	102	108	10	112
39	9	5	0.33	0.60	40	76	7	47
50	8	10	0.48	0.39	77	125	9	86
32	10	8	0.25	0.31	50	80	9	59
50	8	7	0.48	0.55	88	104	8	96
40	7	6	0.44	0.51	67	72	7	74
46	6	7	0.59	0.51	110	83	7	117
42	7	8	0.46	0.41	90	88	8	98
48	8	9	0.46	0.41	88	113	9	97
49	10	9	0.38	0.42	74	129	10	84
38	9	4	0.33	0.73	62	69	7	69
46	7	10	0.51	0.35	96	109	9	105
45	9	8	0.39	0.43	68	106	9	77
37	10	9	0.29	0.32	84	98	10	94
34	10	8	0.26	0.33	99	85	9	108
48	8	8	0.46	0.46	77	107	8	85
36	7	7	0.40	0.40	92	70	7	99

KEY: Un-colored columns are the data recorded directly from field

Yellow colored columns are the data assisting calculation of final result

Green colored column is the final result

mean time loss $\bar{X}$ = time loss/no. of data collected

$$= 1740 \text{ sec}/20$$

$$= 87 \text{ sec}$$

standard deviation = $\sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$

standard deviation $S = 2 \text{ sec}$

by using t-distribution

average time loss = mean $t(0.025, n-1) S/\sqrt{n}$

$$= 872.093 \cdot 2/\sqrt{20}$$

$$= 871 \text{ sec}$$

total time loss for 8 stops = $696 \text{ sec} + 8 \text{ sec}$

$$= 11 \text{ min } 36 \text{ sec } 8 \text{ sec}$$

CHAPTER FIVE: DISCUSSION OF RESULT

The results to be discussed here have been generated through analysis by using Excel spreadsheet and GIS. From data analysis by the help of excel spreadsheet the following is the summary of the result.

Table VII: SUMMARY OF THE RESULT

NAME OF ROUTE	TRAVEL TIME FOR NON-EXPRESS BUSES	AVERAGE LOSSES	TRAVEL TIME FOR EXPRESS BUSES	% OF TIME SAVED BY EXPRESS BUSES
SIMU 2000 TO BUGURUNI	302 min	11 min 36 s 8s	192 min	37%
SIMU 2000 TO MBEZI MWISHO	392 min	13 min 40 s 20s	262 min	33%

From data analysis by the help of excel GIS the following are the key points to be discussed:

1. Simu 2000 and Darajani stop (next stop) on Buguruni route are 1.8 km apart
2. Simu 2000 and Ubungo maji stop (next stop) on Mbezi mwisho route are 1.6 km apart.
3. Chama and Buguruni stop are 200m apart.

Explanations

The first two points bring problems to the passengers who originate or want to reach University of Dar es salaam and Maji university by increasing their walking distance to nearest bus stop and to their destination. The last point contributes to the unnecessary delay by increasing travel time.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

After data collection and analysis with the help of Excel spreadsheet we can conclude the following.

1. Non express buses (currently in operation) use 392 min to travel from Simu 2000 to Mbezi mwisho and 302 min from Simu 2000 to Buguruni.
2. The use of express buses can minimize travel time by 11min 36s 8s from Simu 2000 to Buguruni equivalent to 37% and by 13min 40s 20s from Simu 2000 to Mbezi mwisho equivalent to 33%.

NOTE: All these values have been calculated at 95% level of confidence.

6.2 Recommendations

For the sake of minimizing travel time and walking distance from origin to bus stop and bus stop to destination the following are my recommendations.

1. Introducing the use of express buses so as to minimize travel time by 37% for Simu 2000 to Buguruni route and 33% for Simu 2000 to Mbezi mwisho route.

2. Introducing bus stop at University of Dar es salaam junction for the sake of minimizing travel time for passengers who originate or want to reach at University of Dar es salaam and Maji University.
3. Express buses from Simu 2000 to Buguruni should only stop at Darajani and External stops.
4. Express buses from Simu 2000 to Mbezi mwisho should only stop at Ubungo maji and Kimara mwisho stops.

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