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Using Dijkstra's Algorithm for Public Transportation System in Yangon Based on GIS

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Abstract: In modern life, everyone needs to reach their destinations in time. For people who rely on the public bus transportation requires to get the reliable bus information that can help them to reduce their waiting time at the bus stops. In the age of digital transformation, smart phones, laptops, other digital devices are changing the world very day lives. Among them, GIS is one of the players. In a modern urban region, public transportation network such as bus, train, taxi and etc. are become so large that why passengers lack sufficient information. In order to solver that we will app that will guide user shortest route to reach the destination. In this paper, we will use GIS and Dijkstra's Algorithm to calculate the shortest path. The system is implemented using free and open source technologies including open source GIS tools. A prototype application is designed and implemented based on short distance bus routes in Yangon city bus routes.

Keywords: Dijkstra's Algorithm, GIS database, GIS, Shortest path, Public Transportation

1. INTRODUCTION

The traffic problem of Yangon area has been directly affecting the quality of the citizens of the area. The effects of the traffic of Yangon area are the pollution in every aspect such as air, sound, the time wasting on the road and also the hydro-carbon fuel. Even though the numbers of the roads are increasing, the traffic problem in Yangon area is still occurring. In advanced public transportation systems, the shortest path computation plays an important role and has been extensively studied. This paper helps in showing the best way to travel from one point to another and in doing so, the shortest path algorithm was made. The shortest path and the alternative path is computed based on the problem of getting the shortest path based on traffic conditions and it also gives alternative paths and the traffic count. This plays an important role in navigation systems as it can help to make sensible decision and time saving decisions. To solves the shortest path problem of a graph with nonnegative edge costs, gives shortest path tree, Dijkstra's Algorithm is used. This algorithm is mostly used in routing and other network connected protocols. For a given vertex in the graph, the algorithm gets by finding the costs of shortest way from one source vertex to one destination vertex, once the shortest path reach to the destination vertex has been found the algorithm is then stopped. For example, if the edges show driving distances of connected cities by a direct road and vertex of the graph shows cities, to find the shortest path between one city to other cities, Dijkstra's algorithm can be used.

Through abstract large number of works is done on finding shortest paths. Dijkstra's algorithm is used to find shortest path, which can be apply on a graph which is directed and got the edges with non-negative weights. If we implement Breadth First Search algorithm (BFS), it can solve the problem of undirected graph with edges un weighted or with negative weight. We will later know that with unbound nonnegative weights, Dijkstra's algorithm is the fastest well known for directed graph sin shortest path algorithm. These are the basic things that will help to know further more about the Dijkstra's algorithm. Yangon public transportation was changed to new system (called YBS). The eleven agencies (YRTA, OMINIFOCUS etc.) is operating the over 100 bus line. YBS bus network is getting bigger and bigger so that in this paper, we will give information to passenger, we will develop mobile application to give information very the internet by using GIS.

This study prototype provides sufficient information required by a passenger to decide which bus routes to take when travelling from a known source to a destination, considering such constraints. Possible bus route combinations, the travel bus stop and travel distance are provided by using Dijkstra's Algorithm.

2. RELATED WORKS

In navigational assistance for such type of client presents more challenges not seen by guidance systems, due to the self-nature of the interactions [3]. The algorithms are part of all Navigation Indoor Models that provide guidance to indoor environments that are unknown. To work on an "Intelligent Map" path planning uses the Dijkstra's shortest path algorithms, that is based on a new data structure termed "cactus tree" which is shown on the relationships between the different objects that show an indoor environment. They need to design an application for the visually impaired when to-date 'positioning and tracking' system cannot offer proper position information that is mostly required by this type of application as this research find. We saw that the nature of transfer is that it needs more costs from one edge to its adjacent edge , this is the best-path problem for public transportation systems [4]. To store the scattered information related to transfer in indirect adjacent edges lists, it brings the space storage structure. Thus, it solves the issue of complex network graphs storage and to solve transit issue of the data model so it designs a new shortest path algorithm. We introduce a prior to simple graph depends on the Dijkstra's algorithm in terms of space and time as algorithm analysis exhibits. The complex road network finds a better route [5] from one location to another location by a non-trivial task, as now a day there is increased in traffic. There are many search algorithms that have been proposed to solve the problem of shortest path, and the most well-known algorithm are Dijkstra's algorithm.In this paper, both uninformed and heuristic search to examine depend on some major cities. To decrease the travelling distance and transportation costs, routing algorithms is used effectively. The proposed model is tested with sample dataset and we have simulated this on different working and traffic conditions. Several algorithms exit for finding suitable paths between two known locations, based on different requirements. Shortest path algorithm like Dijkstra's algorithm, A* algorithm etc. is used in most of the application. Although these algorithms are optimum, they are not capable of dealing with certain real scenarios. Dijkstra's algorithm is very efficient as it works only with a smaller subset of the possible paths through a graph. After each node is solved, the shortest path from the start node is known and all subsequent paths build upon that knowledge. Dijkstra's algorithm is often used to find real-world shortest paths, such as for navigation and logistics. It is better performance than Depth- and Breadth-First Search.

In this paper, the way of finding shortest path is provided by using Dijkstra's algorithm. The remainder of this paper is structured as follows. Section 3 describes road network representation. Section 4 describes system methodology used in the proposed system in details. The System Overview is described in section 5 and in section 6 shows the experimental result. Finally, we conclude this paper in section 7.

3. ROAD NETWORK PRESENTATION

A public road network is composed by some nodes (bus stop) in this paper, the links connecting two nodes and bus lines. Define a public road network as G, G= {N, E, R}, where N={0,1,2,..,n, n ∈ N} denotes the set of all nodes, and n is the number of nodes; the origin node and the destination node is O, D respectively. E= {0 ≤ e ≤ m} is the set of all transit links, and m is the number of links; R= {0,1,2,..,n, n ∈ N} is the set of all bus lines and u is the number of links. In this paper, algorithm employs two functions that relate bus stops and bus routes. We use the distance on the road network as the cost in this paper. In Yangon, roads are made up of one-way, two-way roads. To design system, data structure that will used in this prototype is graph data structure unlike tree structure, graph there can be more than one path i.e. graph can have uni-directional or bi-directional paths (edges) between nodes. The overall graph data pattern is as following figure 1.

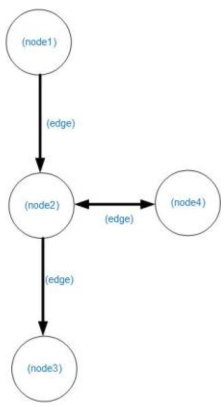


Figure 1. Overall Graph Data Pattern

A geographic information system (GIS) may be a computer system designed to capture, save, treatment, analyze, manage, and display all kinds of spatial or geographical data [1]. Geographic information system (GIS) is a robust tool and has the capability to handle and treatment spatial data in a massive volume. GIS becomes a common technique that may produce maps, integrate info, visualize and solve issues, and develop valuable solutions [2]. Network analysis remains one in all the foremost important and protracted analysis and application areas in the geographic data system. Networks can perform an alternative datum for locations in the context of linear referencing and support a set of tools for the graphical present. Many network location problems are the most troublesome to solve in terms of their combinatorial complication. The shortest path analysis is not only one of the major network operations in GIS analysis, transportation manufacture and many other fields but also the foundation of other network analysis, such as the most credible path problem, maximum capacity path problem etc. The graph nodes are link with GIS spatial data, also known as geospatial data or geographic information is data that identifies the geographic location of features and boundaries on Earth. Spatial data describes the physical location and shape of geometric objects such as countries, roads, or lakes. Two classes of GISs in term of data structure, the raster-based systems and the vector-based systems. Vector is mainly used in this system.

4. SYSTEM METHODLOGY

4.1 Dijkstra's Algorithm

Dijkstra's Algorithm was developed by Dutch computer scientist Edsger Dijkstra in 1956 and published in 1959. It is based on graph search, the edge and vertex, gives the shortest path between two vertex .For a given source vertex (node) the graph, the algorithm finds the path with lowest cost (i.e. the shortest path) between that vertex and every other vertex. It can also be used for finding costs of shortest paths from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined [6].

The algorithm is represented in brief as below:
G = (V, E)
Where, **V** is a set of vertices and **E** is a set of edges.

Dijkstra's algorithm keeps two sets of vertices:
S = the set of vertices whose shortest paths from the source have already been determined.
V-S = the remaining vertices.

The other data structures needed are:
D = array of best estimates of shortest path to each vertex
Pi = an array of predecessors for each vertex

The basic mode of operation is:

1. Initial is **d** and **pi**,
2. Set **S** to empty,
3. While there are still vertices in **V-S**,
    a. Sort the vertices in **V-S** according to the current best estimate of their distance from the source,
    b. Add **u**, the closest vertex in **V-S**, to **S**,
    c. relax all the vertices still in **V-S** connected to **u**

Pseudo code for Dijkstra's Algorithm:

Distance [s] ←0 (distance to source vertex is zero)

for all v ∈V–{s}
do distance [v] ←∞ (set all other distances to infinity)
S←∅ (S, the set of visited vertices is initially empty)
Q←V (Q, the queue initially contains all vertices)
while Q ≠ ∅ (while the queue is not empty)
do u ← min distance (Q, distance) (select the element of Q with the min. distance)
S ← S ∪ {u} (add u to list of visited vertices)
for all v ∈ neighbors[u]
do if distance [v] > distance [u] + w(u, v) (if new shortest path found)
then d[v] ← d[u] + w(u, v) (set new value of shortest path)
(if desired, add trace back code)
return dist

4.2 Haversine Formula

Haversine formula is suitable in calculating distance for spatial data because it provides better accuracy. It assumes the earth to be spherical and ignores the ellipsoidal effects. It provides the good results in mathematically and computationally.

Let lat1, lon1 be latitude and longitude of current location of bus and lat2 , lon2 be latitude and longitude of the nearest bus stop respectively.

deta(lat)=lat2-lat1
deta(lon)=lon2-lon1
a=(sin(deta(lat)/2))^2+cos(lat1)*cos(lat2)*(sin(deta(lon)/2))^2
c=2*atan2(sqrt(a),sqrt(1-a))
d=R*c

Where,

a=the square of half of the straight-line distance between the two points
c=the great circle distance in radians
d=the distance between the two points
R=radius of the earth(R=6371.01km)

In the proposed system, Haversine distance formula is used for measuring the distance form source or target to its nearest bus stop. The reason of choosing haversine is the calculation based on ellipsoid geometry. The calculation result is more precise than Euclidian geometry calculation distance on earth's surface.

5. SYSTEM OVERVIEW

The system is allowed to be accessed via mobile access on android mobile phones. This is aimed at reaching wide audience. Mobile phone is considered as the most suitable mode to reach the general public due to its wider acceptance of general public. The prototype will design to search shortest path from source to destination that user want to go with the YBS route. The source is user location anywhere within the Yangon and destinations is anywhere that user want to go. The user can search the suggested shortest route can get by mobile smart. The mobile will send the latitude and longitude of source and destination to web server using (REST API). Several processes of calculation the shortest path are nearest bus stops measure form source and destination. The google map is used as the based map of the system. For the web API, ASP.NET MVC framework is used for implementing system. For the mobile side, android platform is used. The database store and act as the centralized database.

With so many handheld devices such as smart phone, digital watch, GIS , IoT supporting applications that include GPS and mapping functionality, geographic data often needs to be stored in a relational database. There are several types of enterprise geo databases such as Oracle, Microsoft SQL Server, IBM DB2, Postgre SQL that are support spatial data type supported. In this paper, MSSQL is used as geo database because it is very easy to use.

In Figure 2 system design for proposed system is described. The proposed system is composed with four main layers. Data layer stores spatial and non–spatial data relates to routes and services. Server logic layer is web server. Application logic layer Dijkstra's, searching and other core functionalities are handled by this layer. User interaction handing layer is Android application user interaction mode works based on the results issued by application logic layer.

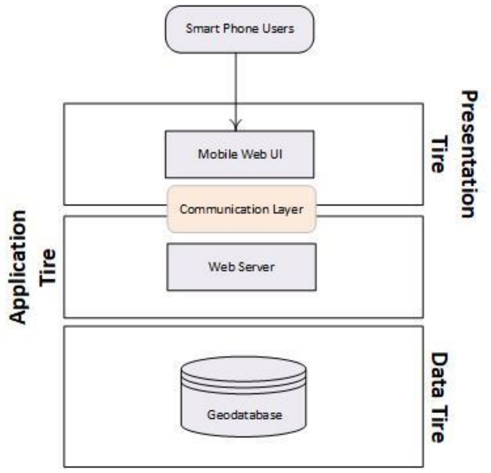


Figure 2. System Design Layer For proposed System

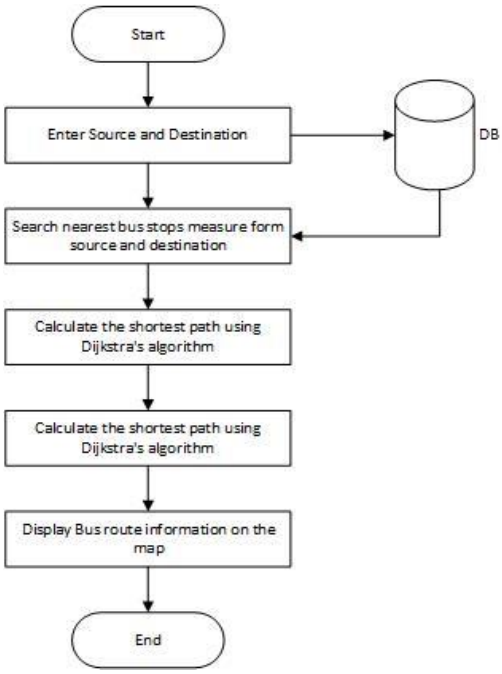


Figure 3. Flowchart for Proposed System

The flow chart of the proposed system is as shown in figure 3. Android will post the source and destination that user want travel to the server. The application layer will accept data and process it.

Taking a nearest bus stop from sources and destination using have rsine distance. The result of nearest bus stops used to search the shortest route by Dijkstra's algorithm within Yangon complex bus stop connection network.

The result route and sum all the distance between each transit send back data the presentation layer as xml format. The result will display on the base map.

5. EXPERIMENTAL RESULT

5.1 Study Area

For study area, Yangon public transportation was changed to new system (called YBS). There are eleven agencies (YRTA, OMINIFOCUS etc.) which are operating the over 100 bus lines. YBS bus network is getting bigger and bigger so that in this thesis, we will give bus line, bus route and bus stop information which the bus user wanted to know to passenger. We will develop mobile application to give these information very the internet by using GIS. The map shown in Figure 4 is the Yangon map for study area.

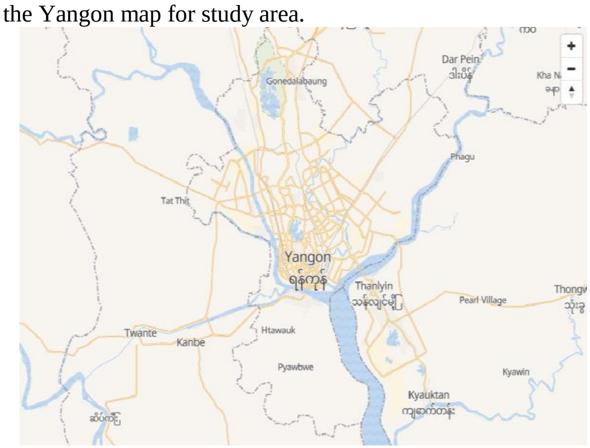


Figure- 4. Yangon Map for Study Area

5.2 Data Processing

When the bus lines dataset shown in Figure 6 is loaded on Google Map, all bus route of the Yangon Region can be shown in Figure 5.

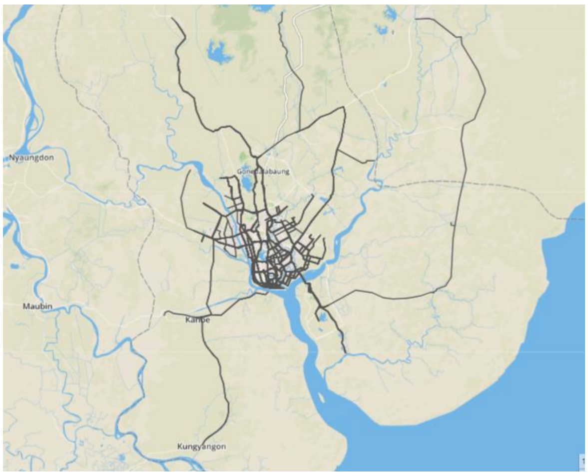


Figure- 5. All Bus Lines in Yangon for Study Area

1	route_id	agency_id	route_long_name
2	R1	YRTA	(၁) လှည်းကူးဈေးရှေ့ - ဇဝန
3	R2	YRTA	(၂) ယုဇန(ခိုင်ရွှေဝါလမ်း) - အောင်မင်္ဂလာအဝေးပြေးဝင်း
4	R3A	YRTA	(၃ တာမွေ) ယုဇနဥယျာဉ်မြို့တော် - မင်္ဂလာဈေး - လမ်း၅၀
5	R3B	YRTA	(၃ သုဝဏ္ဏဈေး) ယုဇနဥယျာဉ်မြို့တော် - လမ်း၅၀
6	R4	YUPT	(၄) ယုဇနဥယျာဉ်မြို့တော် - ဆူးလေ
7	R5	YRTA	(၅) ရိုးမရိပ်သာ - ဗိုလ်ချုပ်အောင်ဆန်းလမ်း
8	R6A	GYCT	(၆-က) တောင်ဒဂုံ သိမ်ချောင်း - လှိုင်သာယာ
9	R6B	GYCT	(၆-ခ) တောင်ဒဂုံ (၇၀/၇၁) ဈေး - လှိုင်သာယာ
10	R7A	YUPT	(၇ စက်မှုဇုံ (၂)) တောင်ဒဂုံ (၇၀/၇၂)ရပ်ကွက် - မဟာဗန္ဓုလလမ်း
11	R7B	YUPT	(၇ မောင်မကန်လမ်း) တောင်ဒဂုံ (၇၀/၇၂)ရပ်ကွက် - မဟာဗန္ဓုလလမ်း
12	R8	YUPT	(၈) လမ်းမတော် - တောင်ဒဂုံအင်းဝသိမ်ရာ
13	R9	YRTA	(၉) တိုင်းရင်းသား နည်းပညာတက္ကသိုလ် - ကျောက်တိုင်
14	R10	YUPT	(၁၀) တိုင်းရင်းသားကျေးရွာ - ဒဂုံတက္ကသိုလ်
15	R100	GYCT	(၁၀၀) မင်းရဲကျောင်းပုံလမ်း - ဗိုလ်တစ်ထောင်
16	R11	YRTA	(၁၁) အောင်မင်္ဂလာအဝေးပြေး - ရွှေတိဂုံဘုရား
17	R12	BDL	(၁၂) အရှေ့ဒဂုံ - ဆူးလေ
18	R14	BDL	(၁၄) ပါရမီ (ညောင်ပင်) - သခင်မြပန်းခြံ
19	R15	YRTA	(၁၅) ဒဂုံတက္ကသိုလ် - တညင်းကုန်း
20	R16A	YRTA	(၁၆ တောင်ငူလမ်း) ရွှေပေါက်ကံ - ဒဂုံဧရာအဝေးပြေးဝင်း
21	R16B	YRTA	(၁၆ ဗိုလ်တေဇလမ်း) ရွှေပေါက်ကံ - ဒဂုံဧရာအဝေးပြေးဝင်း

Figure 6. Sample Bus lines Data

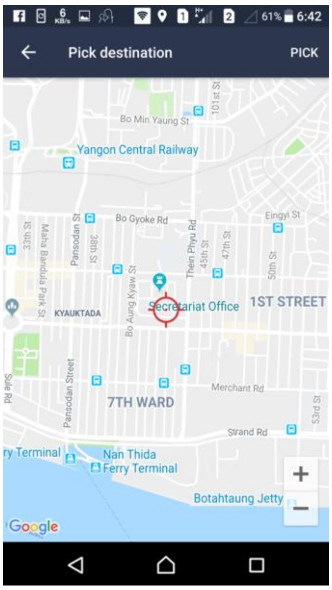
id	svc_name	sequence	stop_id	name_en	name_mm	road_en	road_mm	township_en	township_mm	lat	lng
105	2	26	929	Kone Padayth	ကုန်ပဒေသာ	Pyi Htaung S	ပြည်ထောင်စု	North Dagon	မြောက်ဒဂုံ	16.8842	96.2006
106	2	27	881	Yone Shae	ရုံးရှေ့	Pyi Htaung S	ပြည်ထောင်စု	North Dagon	မြောက်ဒဂုံ	16.8875	96.1988
107	2	28	927	Khun/ Shit Lai	(၇/၈) လမ်းဆုံ	Pyi Htaung S	ပြည်ထောင်စု	North Dagon	မြောက်ဒဂုံ	16.8923	96.196
108	2	29	935	Lay-sae-nga H	(၄၅) မှတ်တိုင်	Pyi Htaung S	ပြည်ထောင်စု	North Dagon	မြောက်ဒဂုံ	16.8948	96.1947
109	2	30	1019	Lay-sae-chaul	(၄၆) မှတ်တိုင်	Pyi Htaung S	ပြည်ထောင်စု	North Dagon	မြောက်ဒဂုံ	16.8984	96.1927
110	2	31	931	Kyar Hmat Tai	ကြားမှတ်တိုင်	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8977	96.1907
111	2	32	903	Ba Htoo Zay	ဗထူးဈေး	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8958	96.187
112	2	33	905	Banyardala	ဗညားဒလ	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8948	96.1851
113	2	34	917	Kyaung Lay Sh	ကျောင်းလေးဧ	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8937	96.183
114	2	35	919	Lay-sae-lay La	(၄၄) လမ်းဆုံ	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8927	96.1811
115	2	36	915	Kyan Mar Yae	ကျန်းမာရေး	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8915	96.1787
116	2	37	899	Kyaung Kwae	ကျောင်းကွေ့	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8895	96.175
117	2	38	901	Phyo Sabei	ဖြိုးစံပယ်	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8875	96.1709
118	2	39	897	Khay Mar	ခေမာ	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8858	96.1677
119	2	40	894	Gandar Yon	ဂန္ဓာရုံ	Bo Hmu Ba H	ဗိုလ်မှူးဗထူးဝ	North Dagon	မြောက်ဒဂုံ	16.8866	96.1641
120	2	41	1822	Gate Haung	ဂိတ်ဟောင်း	Industrial Ro	စက်မှုဇုန်လမ်း	North Okkalapa	မြောက်ဥက္ကလာပ	16.8938	96.1576
121	2	42	891	Yone Thit	ရုံးသစ်	Khaymarthi I	ခေမာသီလမ်း	North Okkalapa	မြောက်ဥက္ကလာပ	16.8959	96.1559
122	2	43	797	May Dar Wi	မေဓာဝီ	Khaymarthi I	ခေမာသီလမ်း	North Okkalapa	မြောက်ဥက္ကလာပ	16.8991	96.155
123	2	44	801	Oakkar	ဥက္ကာ	Khaymarthi I	ခေမာသီလမ်း	North Okkalapa	မြောက်ဥက္ကလာပ	16.9026	96.1546

Figure 7. Sample Dataset used in System Database

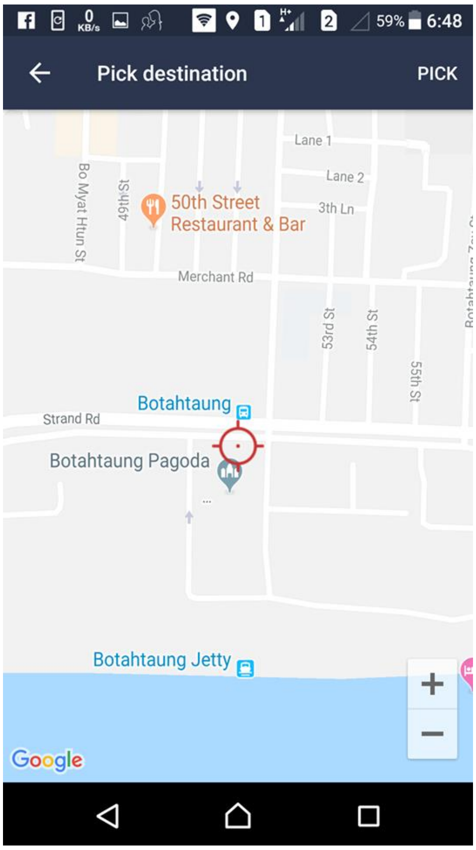
This bus lines, bus stops and bus sequences data are pre-processed to use in the proposed system. The some sample datasets are shown in Figure 7. These datasets required for the proposed system are stored in MSSQL database.

5.3 Result

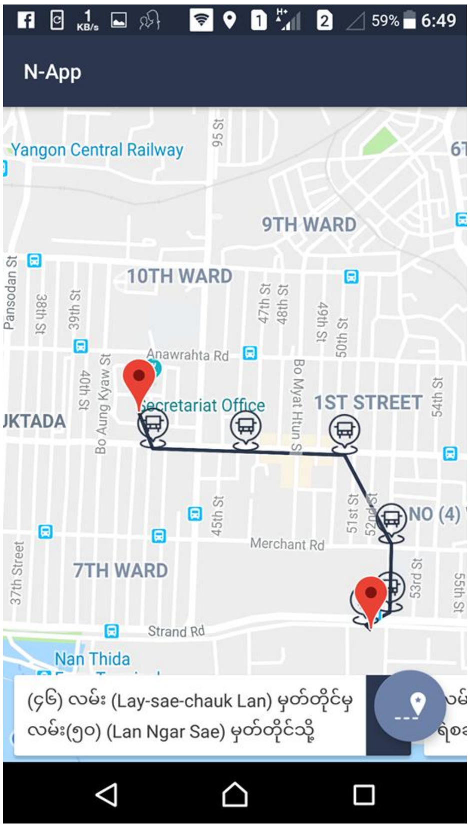
The user can get the information for the shortest path from his location to his desired destination easily, by opening the android application of the proposed system.The proposed system was tested in which user's desire for the data in Yangon Bus Transportation System.



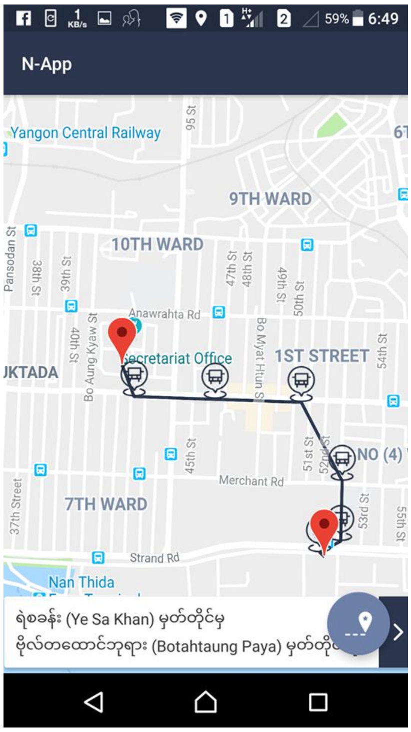
(a)



(b)



(c)



(d)

Figure 8. (a)user location, (b)user destination, (c)user's location nearest bus stop and (d)user's destination nearset bus stop

In the system, the user's location is Secretariat Office in Botahtaung Downship. And he want to go to Botahtaung Pagoda. By using the system application shown in figure, he may know his nearest bus stop (Lay-sae-chauk-Lan) of his location and shoretest path to arrive the Botahtaung Pagoda. And then shown in Figure he may know the nerest bus stop (Ye-sa-khan) of his desired location.

6. CONCLUSION

Public bus transportation system by Dijkstra's algorithm apply in Yangon downtown area will assist the bus transportation user to the information and data which is essential for them and also provide the planning system to plan the route and transportation mode with the fare. Dijkstra's algorithm is better when we know both starting point and destination point. As a future work, the time or other factors such as waiting time at the bus stop, walking time to the bus stop will be used as weight for road network in the whole Yangon area.

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