Application of Minimum Spanning Tree for Creating the Most Efficient Itinerary to Bali

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***Abstract*— Bali, also known as the Land of the Gods, appeals through sheer natural beauty of looming volcanoes, lush terraced and pristine beach. Bali has a lot of tourist's destination that can be visited. In order to attain best experience in Bali, an effective itinerary is needed. This paper proposes a hypothetical itinerary that can be used for tourist by using the minimum spanning tree. The minimum spanning tree can be obtained with Prim Algorithm**

***Keywords*— Bali, Itinerary for Bali, Minimum Spanning Tree, Prim Algorithm.**

I. Introduction

Bali, also known as the Island of Gods, is a province located in Indonesia. Bali was well known not only for it's beautiful landscape, but also for it's very unique culture. In these several years, Bali has been nominated and also chosen as the most visited island or the most search island by TripAdvisor.

Based on a data that was released by Bali's governance in 2016, there are 216 tourist destination that can be explored and visited. These tourist destinations are widely spread across all regions in Bali. Several popular tourist destinations are Kuta Beach, Kelingking Beach, Rice Terrace Jatiluhur, Rice Terrace Tenggalang, Mount Batur, Uluwatu Temple, and many more.

Huge amount of tourist destinations combined with their widely spread location makes tourist needs a lot of time and money to get full experience of Bali.If there is no algorithm included when creating an itinerary, tourists will not get their best experience, due to limited money and time. Therefore, this paper offers a solution or methods on how to create a itinerary that was efficient. The method that is used in this solution is by using prim algorithm to search minimum spanning tree of several tourist destinations in Bali.

The author of this paper sincerely hopes that this paper can help readers to create the most efficient itinerary, so they can get full experience on their holiday. The concept that is used in this paper can be applied not only for Bali, but also any places around the world. Hopefully, this paper can reduce the transportation cost for all tourists and make Bali become even more popular amongst the world.

II. Formatting Your Paper

A. Graph

Graph is a discrete set of vertices, which represent a stinct point and edges that connect two vertices. Graph can be used to represent discrete objects and the relation among those objects. Formally, graph can be described as a pair of vertices and edges

$$G = (V, E)$$

$$G : Graph$$
$$V : Finite\ set\ of\ Vertices\ \{V1, V2...., Vn\}$$
$$E : Finite\ set\ of\ Edges\ \{E1, E2, ..., En\}$$

Based on the existence of multiple edges and loops, graph can be divided into :

a. Simple Graph
   Simple graph has neither multiple edges nor loops
b. Unsimple Graph
   Unsimple graph can have multiple edges and/or loops. Furthermore, unsimple graph can be differentiated into :
   - Multi-graph
     Multi-graph is allowed to have multiple edges, as shown in Fig 2.1b, where vertices 1,3, and 4 has multiple edges. However, muti-graph is not allowed to have any loops
   - Pseudo-graph
     Pseudo-graph is allowed to have multiple edges and loops as shown in Fig 2.1c, where vertices 1,3, and 4 have multiple edges and vertices 3 has a loop.

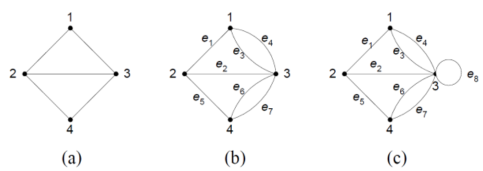


Fig 2.1 (a) simple graph, (b) multi-graph (c) pseudo-graph

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

Furthermore, there is another method to differentiate graph, by using the orientation of a graph. Based on the orientation, graph can be divided into 2 groups :

- Undirected graph

Undirected graph is a term that used to described a condition where graph's edges don't have any orientation or direction as shown in figure 2.2a. Since undirected graph doesn't have any direction, it is impossible to determine the start point and end point from a graph.

- Directed graph
  Directed graph is a term that used to describe a condition where all of graph's edges have orientation or direction as shwn in figure 2.2b. Direction/Orientation in directed graph can be used to determine the start point or the end point from a graph. For example, from figure 2.2b, it can be concluded that e is the starting point and e is the end point for edges that connect both of them.

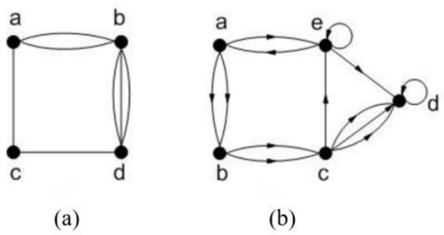


Figure 2.2 (a) Undirected Graph (b) Directed Graph

Source: https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

This paper will used a few common graph terminologies, such as :

a. Adjacent

Two vertices can be determined as an adjacent if and only if both of them are connected directly. For example, in figure 2.2a, vertices a and c can be said as an adjacent vertices since they are directly connected. But, vertices b and c is not an adjacent.

b. Incident

An edge $e = (u, v)$ can be said incident with vertices *u* and vertices *v* if *u* and *v* are the endpoints of edge *e*. For example, in figure 2.2a, edge (1,2) is incident with vertices 1 and 2.

c. Isolated Vertex

Isolated vertex is a term used to describe a condition where a vertex doesn't have any edge.

d. Null Graph / Empty Graph

Null graph is a graph that has zero edges, but it can contains vertices.

e. Degree

Degree of a vertex *u* is the total number of edges that are incident with *u*. A loop with both endpoints at *u*, will add 2 to the degree of vertex *u*.

f. Path

Path is a sequence of consecutive edges in a graph and the length of a path is the number of edges traverse.

g. Cycle or Circuit

Cycle or Circuit is a term used to describe path that has the same start and end point in a graph.

h. Connected

Two vertices, *u* and *v* can be said as a connected vertices if and only if there is a path that goes from *u* to *v* or *v* to *u*. Moreover, a graph can be determined as a connected graph if and only if for every pair of vertices V_1 and V_2, exists a path that goes from V_1 to V_2 or from V_2 to V_1.

i. Subgraph and Complement of a Subgraph

If there is a graph $G = (V, E)$ and $G1 = (V1, E1)$, G1 can be said as a subgraph from G, if and only if $V1 \subseteq$ V and E1 ⊆ E.

Complement of subgraph G1 towards G is G2 = (V2, E2), where $E2 = E - E1$ and vertices V2 are all vertex that incident with V2.

j. Spanning Subgraph

If there is a graph G = (V,E) that has subgraph G1 = (V1, E1), G1 can be concluded as a spanning subgraph if V1 = V or G1 has all vertex that G has.

k. Cut-set

Cut-set from a connected graph G is a set of edges that if removed, will make G no longer a connected graph.

l. Weighted Graph

Weighted graph is a graph in which each edge is given a specific value or weight. This value can represent anything in the real world, such as distance.

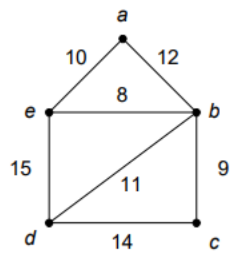
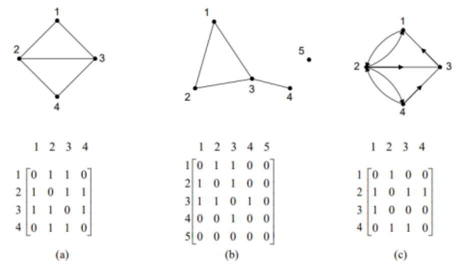


Figure 2.3 Weighted Graph

Source: https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

There are multiple ways to represent the graph, beside drawing them :

1. Adjacency Matrix
   Adjacency Matrix represent weighted graph by write the edge's value if two vertices are adjacent. If the two vertices aren't adjacent, the value will be written as infinite. For graph that doesn't have any weight, Adjacency Matrix will write 1 if two vertices are adjacent. If the vertices aren't adjacent to each other, Adjacency Matrix will write 0



	1	2	3	4
1	0	1	1	0
2	1	0	1	1
3	1	1	0	1
4	0	1	1	0

(a)

	1	2	3	4	5
1	0	1	1	0	0
2	1	0	1	0	0
3	1	1	0	1	0
4	0	0	1	0	0
5	0	0	0	0	0

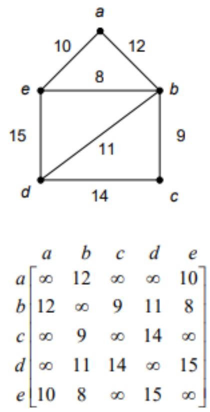
(b)

	1	2	3	4
1	0	1	0	0
2	1	0	1	1
3	1	0	0	0
4	0	1	1	0

(c)

Figure 2.5 Adjacency Matrix for non-weighted matrix

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

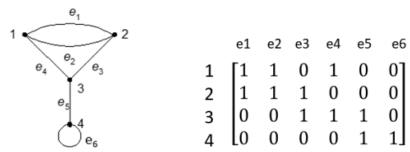


	a	b	c	d	e
a	∞	12	∞	∞	10
b	12	∞	9	11	8
c	∞	9	∞	14	∞
d	∞	11	14	∞	15
e	10	8	∞	15	∞

Figure 2.6 Adjacency Matrix for weighted matrix

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

2. Incident Matrix
Incident matrix represent graph by describing the relationship between all vertices and all edges. If an edge is incident with a vertex, then the value will be 1. If an edge isn't an incident with a vertex, then the value will be 0.

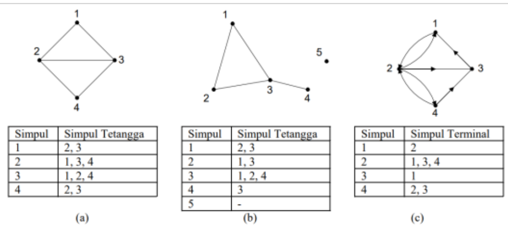


	e1	e2	e3	e4	e5	e6
1	1	1	0	1	0	0
2	1	1	1	0	0	0
3	0	0	1	1	1	0
4	0	0	0	0	1	1

Figure 2.7 Incident Matrix

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

3. Adjacency List
For each vertex i inside a graph, there will be a list that contains all vertices that are indicent with vertex i.



Simpul	Simpul Tetangga
1	2, 3
2	1, 3, 4
3	1, 2, 4
4	2, 3

(a)

Simpul	Simpul Tetangga
1	2, 3
2	1, 3
3	1, 2, 4
4	3
5	-

(b)

Simpul	Simpul Terminal
1	2
2	1, 3, 4
3	1
4	2, 3

(c)

Figure 2.8 Adjacency List

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

B. Tree
Tree is a connected, simple, and undirected graph that doesn't contain any circuit.

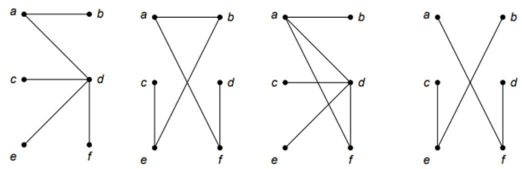


Figure 2.9 Tree

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf

If G = (V,E) is a simple and undirected graph with n vertex, then all of these statements are equivalent :

1. G is a tree
2. All pairs of vertices inside V are connected with a unique path
3. G is connected and has n -1 edges
4. G doesn't have any circuit and has n-1 edges
5. G doesn't have any circuit and addition of an edge in the graph, will form a circuit, and
6. G is connected and all its edges are bridges

Spanning tree of a connected graph is a spanning subgraph of a graph that is a tree. Spanning tree can be obtained by cutting circuit inside a graph, until the graph doesn't contain any circuit, as shown in figure 2.5, where T1 and T2 is a spanning tree of G. Connected graph at least have 1 spanning tree.

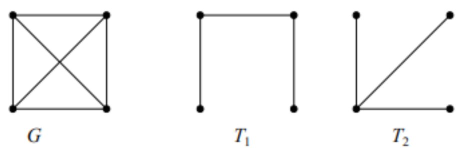


Figure 2.10 (G) Connected Graph (T1) Spanning Tree (T2) Spanning Tree

Source : https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf

A connected and weighted tree can have more than 1 spanning tree. Spanning tree with the lowest weight is called Minimum Spanning Tree. In several cases, there is a possibility where two edges have the same value. Therefore, there can be multiple Minimum Spanning Tree with different edges, but has the same weight.

C. Prim Algorithm
There are several ways that can be conducted to search for Minimum Spanning Tree of a graph. Two of the most common ways are Prim Algorithm and Kruskal Algorithm. The only difference between those 2 algorithms are Prim Algorithm start

from a node, while Kruskal Algorithm start from an edge.

There are 3 steps in Prim Algorithm :

1. Choose an edge from the graph that has the lowest weight, put that edge inside T.
2. Choose edge (u,v) that has the lowest weight and incident with vertex in T, but edge(u,v) doesn't make any circuit exist on T, put edge (u,v) inside T.
3. Repeat those steps until all the vertices in the graph are connected, forming a complete minimum spanning tree.

Important things to note is that there can be multiple edges with the same weighted value and therefore, there can be multiple minimum spanning tree. Example of Prim Algorithm can be seen at figure 2.12, where we used Prim Algorithms to convert a graph (Figure 2.11) into a minimum spanning tree (Figure 2.13).

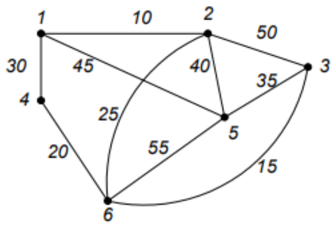
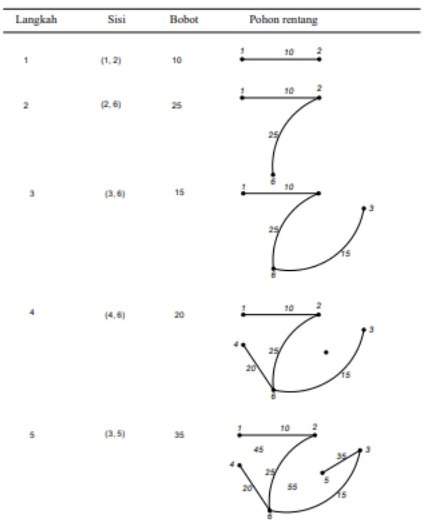


Figure 2.11 Weighted Graph

Source : *https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf*

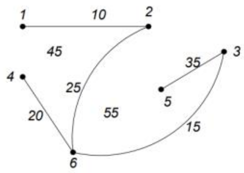


Langkah	Sisi	Bobot	Pohon rentang
1	(1, 2)	10	
2	(2, 6)	25	
3	(3, 6)	15	
4	(4, 6)	20	
5	(3, 5)	35	

Figure 2.12 Prim Algorithm

Source : *https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf*

Pohon merentang minimum yang dihasilkan:



Bobot = 10 + 25 + 15 + 20 + 35 = 105

Figure 2.13 Minimum Spanning Tree

Source : *https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf*

D. Bali

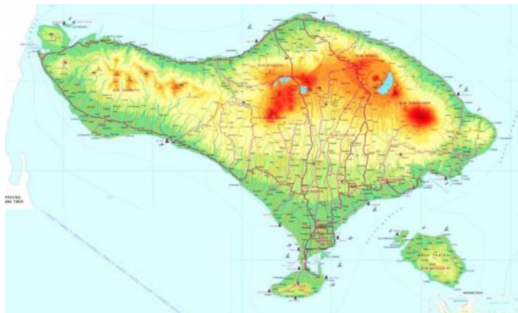


Figure 2.14 Bali's map

Source : https://www.tataruang.id/2022/03/30/peta-provinsi-bali-lengkap-dengan-nama-kabupaten-dan-kota/

Bali, also known as the Island of Gods, is one of 34 provinces in Indonesia . Bali is located between Java Island and Lombok Island and surrounded by Bali Strait, Lombok Strait, Bali Ocean and India Ocean. Due to it's astronomical position, Bali has a tropical climate. Bali is divided into 8 districts (Jembrana, Tabanan, Badung, Gianyat, Klungkung, Bangli, Buleleng, Karangasem) and 1 city (Denpasar).

In general, Bali's topography also varies from lowlands, beaches, highlands, and mountains. Mountains in Bali extends from west to east. These diversity is used by Bali's governance to attract tourists. Bali not only consist of one big island, but it also has several small islands. Several of these small islands are well-known such as Nusa Penida.

E. Tourist Destinations in Bali

Districts/City	**Tourist Destinations**
Denpasar	10
Badung	36
Gianyar	61
Bangli	42
Klungkung	17
Karangasem	15

Buleleng	25
Tabanan	24
Jembrana	15
Total	245

Table 1 Tourist Destinations in Every District in Bali

The data from the table 1 shows there are 245 tourist destinations in Bali in 9 different districts. This paper will only use 15 tourist destinations from different districts. The tourist destinations that will be used are :

1. Kuta Beach
   Kuta Beach is located in districts Badung, Bali. Kuta is one of the most well-known beach in Bali due to it's beautiful beach. The most outstanding part of Kuta is it's long coastline (approximately 2,5 km). This coastline offer a beautiful view of sunset. Moreover, there are many local stores, bars, and restaurants that can be visited.
2. Kelingking Beach
   Kelingking Beach is located in Nusa Penida, island that is separated from the main island of Bali. Kelingking beach can be reached from the main island by taking a 30 – 45 minutes trip with fery boat from Sanur Beach. In Kelingking Beach, tourists can get a nice and expansive view of India Ocean, from the cliff. If tourist want to see the beach in Kelingking Beach, they have to go down from the cliff and the access towards the beach is not fully covered by stair.
3. Broken Beach
   Broken beach is located in Nusa Penida, the same as Kelingking Beach, and can be accessed from the main island with the same way. When tourist arrived in Broken Beach, they will be welcomed with Broken Beach's natural pool that has a diameter of 98 meters. Moreover, there is a massive arch that tourist can walk across. Unfortunately, tourists can't go down to the sea, since there is no access towards the beach. So this breathtaking view can only be enjoyed from the cliff.
4. Diamond Beach
   Diamond beach is located in Nusa Penida, the same as the other two, and can be accessed with the same way. When tourist arrived at Diamond Beach, they will be served by an amazing view of India Ocean that has can be seen from the cliff. In 2018, Bali's governance has made stairs to the beach, so it is accessible for all tourists. Diamond beach has the best access compared to another beach in Nusa Penida
5. Bilabong Beach
   Bilabong beach is located in Nusa Penida, the same as the other three, and can be accessed with the same way. Bilabong beach is well-known for it's beautiful infinity pool that is framed by rock cliffs. Tourists can swim in this infinity pool if the tide is low.
6. Pandawa Beach
   Pandawa Beach is located at Badung, South Kuta, Bali. This beach is surrounded by two cliffs with one of them has the face of Kuti goddess and Pandavas (Mythology from Bali). When tourists arrived at Panda Beach, they will be amazed by the beautiful panorama of high cliff, flanking the road. Moreover, sand in this beach is so white and clean.
7. Tanah Lot Temple
   Tanah Lot, which means Land in the Sea, is located in Tabanan, Bali. The temple sits on a large offshore rock which has been shaped continuously over the years by the ocean tide. Tanah Lot is separated from the coastline by 20 meters far. It is one of the seven sea temples in the coast of Bali. Based on Bali's mythology, this temple is always protected by holy snakes, that can be found until today. Not only beautiful view of temple, tourists can also watch sunset from the coastline in Tanah Lot temple.
8. Mount Batur
   Mount Batur is an active volcano located in Bangli, Bali. It is 1717 meters tall and predicted to be 50.000 years old. Mount batur is one of the most visited places in Bali, specially for watching sunrise. In order to watch sunrise, tourists have to hike approximately 7 km. The hike can be done by almost all people.
9. Uluwatu Temple
   Uluwatu Temple, locally known as Pura Luhur Uluwatu is one of Bali's nine key directional temples and perched on top of a steep cliff approximately 70 meters above sea level. Luhur means "something of divine origin" ,Ulu "land's end" and watu means "rock". Inside this temple, tourists can see a breath-taking architecture of the temple. Another attraction that can be seen in Uluwatu Kecak Dance, traditional dance from Bali.
10. Ubud
    Ubud can be said as Bali's cultural heart and is known as the greenest part of Bali. This area is located in the cool mountains and it is the home of the Balinese royal family and a flourishing arts centre. Most of Bali's museums and galleries are centered in Ubud. Ubud's role as the epicenter of Balinese culture makes it the most perfect place to see traditional Balinese dance and drama. Moreover, there is also Ubud Monkey Forest, a natural forest inhibited by wild monkeys.
11. Tegalalang rice terraces
    Tegallalang rice terraces is situated in a valley that offers extraordinarily scenic lookouts over the terraces and surrounding green landscape. It has been listed in UNESCO world heritage site. Once a tourist arrive at Tegalalang rice terraces, they will be welcomed with a view of rice fields from the top of the elevation. However, it is possible for tourists to climb down and explore the rice fields by themselves.
12. Melasti Beach
    Melasti beach is a beautiful beach located below a high cliff. High cliffs cleaved used as a road with many bends. From top, the road looks beautiful with limestone cliffs. High chasm that separates the paved road to Melasti Beach has also become a favorite of visitors, because of their altitude that reach 100 – 150 meters. Tourists can get a lovely viewpoint from the small hill. From that small hill, tourists can see beautiful beach from above and also the ocean.
13. Sekumpul Waterfall
    Sekumpul waterfall is known as one of Bali's most spectacular cascades, with a collection of 7 tall and misty

waterfals in one area. These 7 waterfalls each have their own uniqueness and characteristic. The height of Sekumpul Waterfall is around 100 meters.

14. Tanjung Benoa
    Tanjung Benoa is one of few beaches in Bali that have white sands and have a really long coastline. Tanjung Benoa has two sides with one side facing west and another one facing east. Since Tanjung Benoa is located on a cape, it's tides are really calm and the average depth only 6 meters. These conditions make Tanjung Benoa really suitable for water sports.
15. Seminyak
    Seminyak is extremely dynamic, vibrant, colorful and energetic. It's a place where foodies, shopaholics, beach lovers, and families mix together to enjoy the atmosphere of a beach town. In Seminyak, there are many top-restaurants in Bali that served both western and local foods of Bali.
16. Canggu
    Canggu is defined by its four main roads. Batu Bolong road is the heart of Changgu and tourists can find the most cafes, restaurants and boutiques. At the end of Batu Bolong road, there is a beach called Batu NBolong Beach. Pantai Berawa road has a more elite air with many fancy boutique, hotels, and private villas. This road leads to Berawa Beach and Finns Beach Club, one of the most famous club in Bali. Padand Linjong street on the other side of Batu Bolong, leads to the surfers's favourite, Echo Beach. The last road, Pererenan road is the furthest away from the main streets. It is the perfect place if tourists are looking for peace and quiet.

III. Implementation

A. Collecting Data

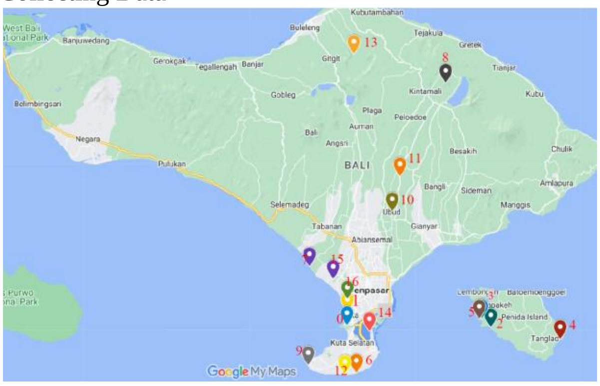


Figure 3.1 Tourist Destinations in Bali

All those tourists destinations that are mentioned above can be converted into several pins in google maps, as shown in fig 3.1. Each number in that map represent tourist destination mentioned in previous chapter. Since almost all tourist destinations are widely spread, sometimes it can be confusing for tourists to create their itinerary. Therefore, to solve this problem, this map will be converted into a weighted graph and will use Prim Algorithms to create the most efficient itinerary.

First step to convert all these locations into graph is converting all points into vertices. Even though there are 16 tourist destinations, this paper will add 3 more vertices into the graph. The first vertex represents International Ngurah Rai Airport, which will be the starting point. The second vertex will represent the Sanur Harbor, since the itinerary include trip to Nusa Penida and Nusa Penida can be accessed only through the harbor. The third vertex represents Banjar Nyuh Harbor, which located in Nusa Penida. All of the vertices can be seen at table 2.

Places	Vertex
Ngurahrai International Airport	0
Kuta Beach	1
Kelingking Beach	2
Broken Beach	3
Diamond Beach	4
Bilabong Beach	5
Pandawa Beach	6
Tanah Lot Temple	7
Mount Batur	8
Uluwatu Temple	9
Ubud	10
Tegalalang Rice Terrace	11
Melasti Beach	12
Sekumpul Waterfall	13
Tanjung Benoa	14
Seminyak	15
Canggu	16
Sanur Harbor	Sanur
Banjar Nyuh Harbor	Nusa Penida

Table 2 Tourist Destinations and it's representation in vertices

After converting all tourist destinations into vertices, the next step will be to connect all adjacent vertices. In this case, vertices *u* and *v* will be considered as a adjacent if *u* and *v* can be connected directly, without passing any vertices. This can be solved by looking at the maps.

The last step is giving all edges a value, based on the time needed to travel from one vertices to another. This paper use travel time, instead of distance, due to the facts that several places in Bali can be accessed faster even though it has more distance. The list of edges can be seen at table 3, while the final graph can be seen at figure 3.3.

Edges	Vertices	Travel Time (minutes)
e_1	(0,1)	14
e_2	(0,6)	32
e_3	(0,9)	39
e_4	(0,12)	33
e_5	(0,14)	28
e_6	(0,Sanur)	27
e_7	(1,16)	10
e_8	(1,Sanur)	35

e_9	(2,3)	28
e_{10}	(2,4)	68
e_{11}	(2,Nusa Penida)	40
e_{12}	(3,5)	4
e_{13}	(3,Nusa Penida)	45
e_{14}	(4, Nusa Penida)	63
e_{15}	(6,12)	18
e_{16}	(6,14)	34
e_{17}	(7,10)	60
e_{18}	(7,13)	126
e_{19}	(7,15)	41
e_{20}	(8,11)	58
e_{21}	(8,13)	125
e_{22}	(9,12)	25
e_{23}	(10,11)	18
e_{24}	(10,13)	119
e_{25}	(10,15)	64
e_{26}	(10,16)	55
e_{27}	(10,Sanur)	46
e_{28}	(11,13)	131
e_{29}	(15,16)	28
e_{30}	(16,Sanur)	49
e_{31}	(Sanur, Nusa Penida)	40

Table 3 List of Edges in Graph

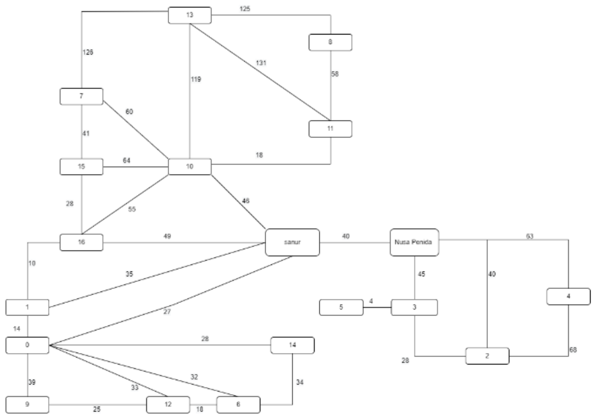


Figure 3.3 Graph of all tourist destinations

B. Search for Minimum Spanning Tree with Prim Algorithm

After done converting the maps into graph, the next step will be searching for Minimum Spanning Tree with Prim Algorithm :

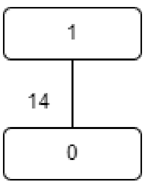
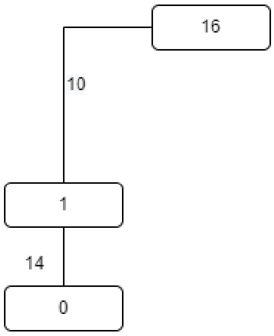
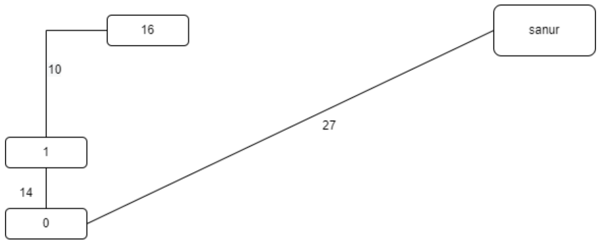


Figure 3.4 Step 1, start from vertex 0 (since it is the airport (arriving point). Choose the lowest edge, e_1



Figures 3.5 Step 2, add e_7 into the tree



Figures 3.6 Step 3, add e_6 into the tree

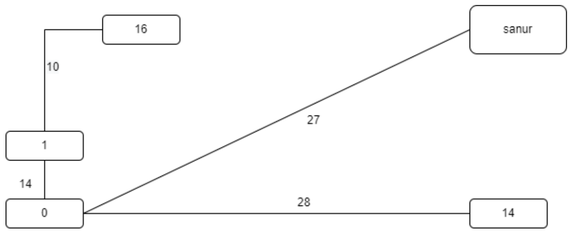


Figure 3.7 Step 4, add e_5 into tree

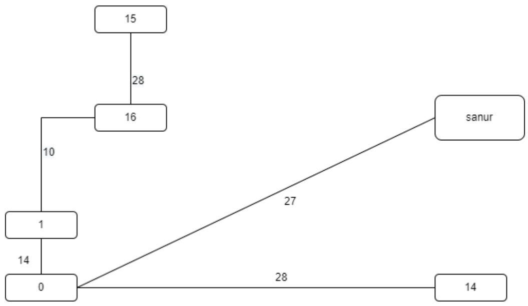


Figure 3.8 Step 5 add e_{29} into tree

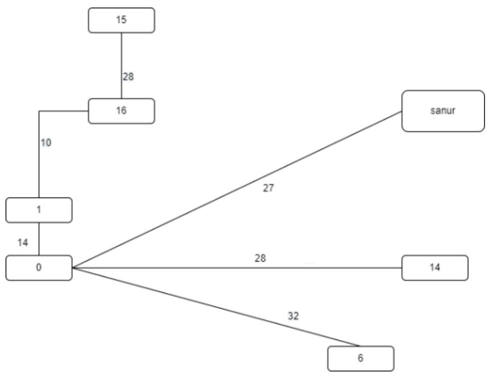


Figure 3.9 Step 6, add e_2 into tree

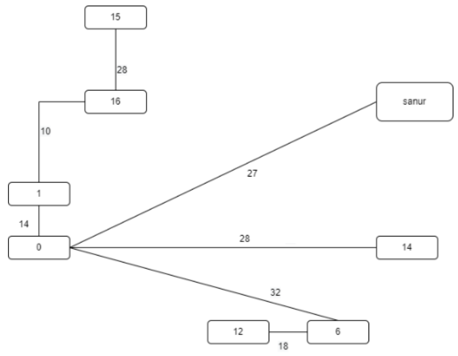


Figure 3.10 Step 7, add e_{15} into tree

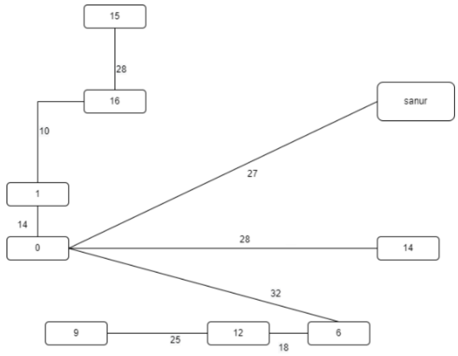


Figure 3.11 Step 8, add e_{22} into tree

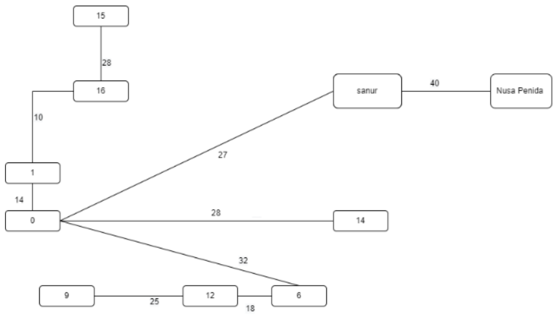


Figure 3.12 Step 9, add e_{31} into tree

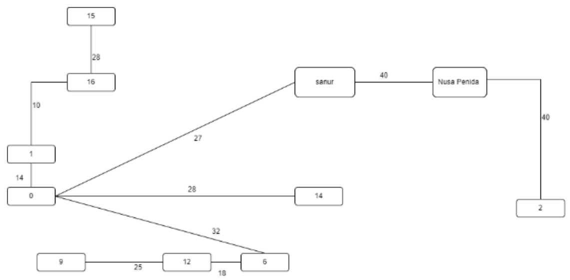


Figure 3.13 Step 10, add e_{11} into tree

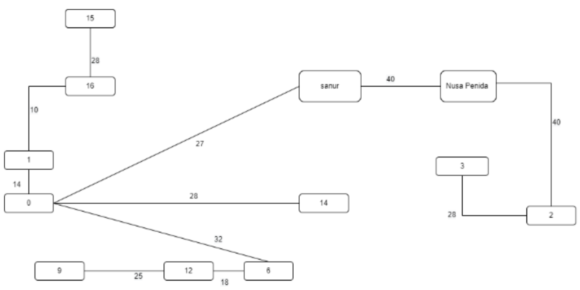


Figure 3.14 Step 11, add e_9 into tree

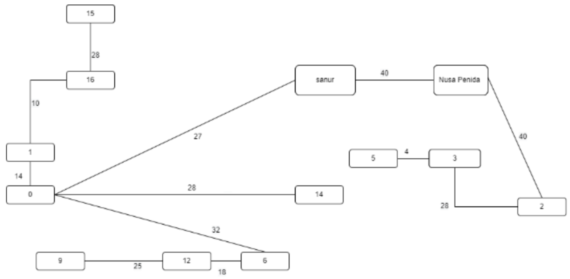


Figure 3.15 Step 12, add e_{12} into tree

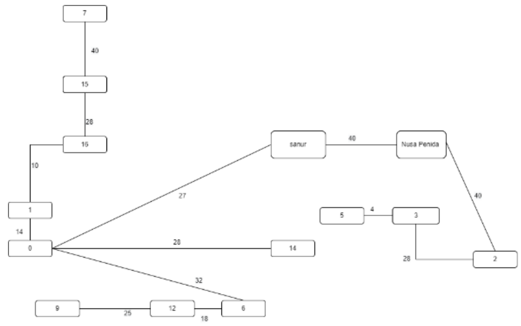


Figure 3.16 Step 13, add e_{19} into tree

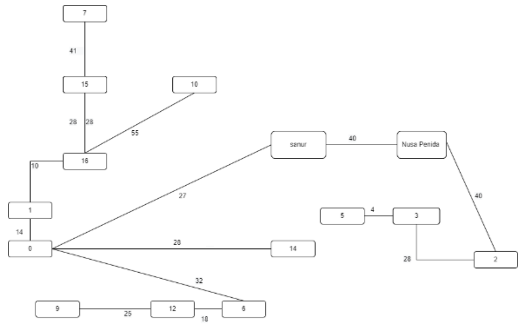


Figure 3.17 Step 14, add e_{26} into tree

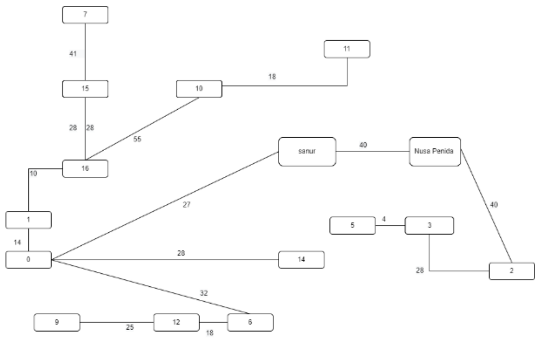


Figure 3.18 Step 15, add e_{23} into tree

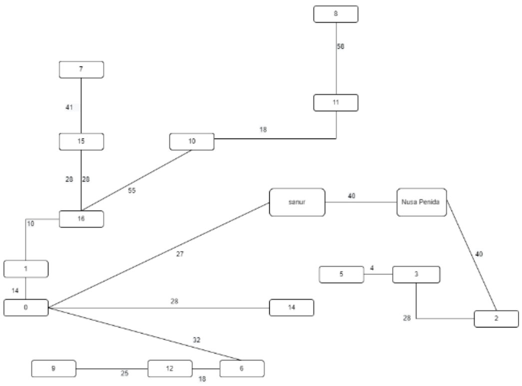


Figure 3.19 Step 16, add e_{20} into tree

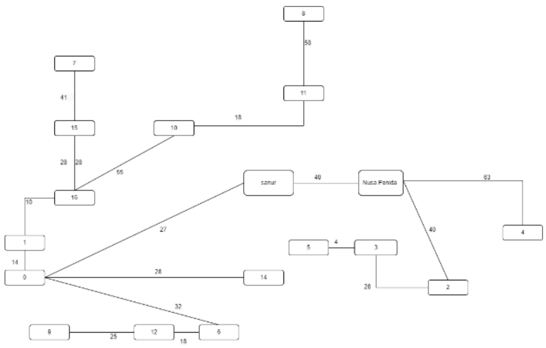


Figure 3.20 Step 17, add e_{14} into tree

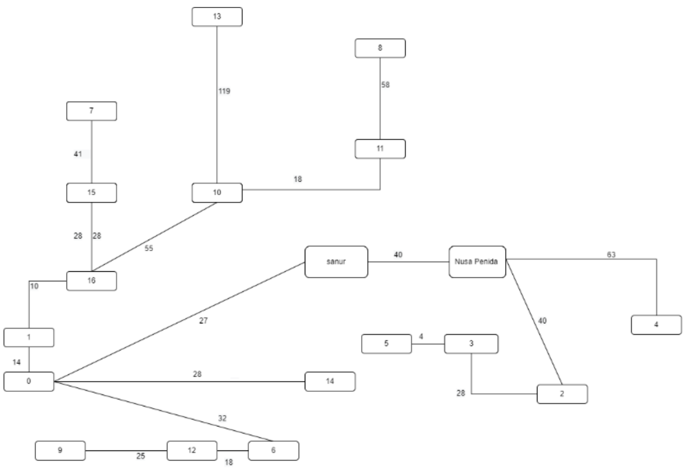


Figure 3.21 Minimum Spanning Tree

The process of creating minimum Spanning Tree stops when all vertex has been connected, as shown in fig 3.21.

IV. ANALYSIS

The minimum spanning tree of tourist destinations can become a guidance for any tourist that want to explore Bali.In order to take full advantage of this tree, a tourist has to visit at least one of the nodes more than once. For example, if a tourist wants to visit all beaches in Nusa Penida Island, then they have to visit Nusa Penida's harbor more than once. However, even with the worst scenario, tourist will spend less time than any other route in the graph. This problem can be minimalized by not visiting all places. Another alternative is to book a hotel at the vertices that needed to be visited more than once. By doing this, there is no time wasted, except for rest.

V. CONCLUSION

In conclusion, prim algorithm has successfully created the most efficient itinerary for few tourist destinations at Bali. Even though several places have to be visited more than once, it is still one of the most efficient itinerary (since there are a lot of possibilities for minimum spanning tree).

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PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

Bandung, 12 Desember 2022

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