IMPLEMENTATION GRAPH THEORY IN MAKING A TOUR TRIP

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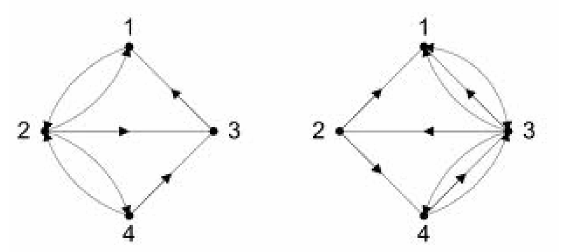
***Abstract*—Every people definitely happy if they going to have a tour trip, so the tour trips must be a perfect, so that the participant will not be disappointed. A perfect trip must make the entire participant enjoy the trip and give them good memories about the trip. A perfect trip can be made with a perfect trip planning, and making a perfect tour planning is not an easy work to do. Now the problem is how to make this trip is easier to be planning. In this paper will be discuss how a graph theory can be used to resolved this problem. Many people didn't know that turning the trip plan into a graph is easier to understanding. The graph will help you in making a decision what kind of trip do you want. The timeline trips also can be represented by a graph, it's will make the timeline is more simple and make the reader easier to know about the information. This graph will also help you in finding the route so you will not get bored when you in the way to the vacation place.**

***Index Terms*—Tour trip, graph, directed graph, coloring graph.**

I. INTRODUCTION

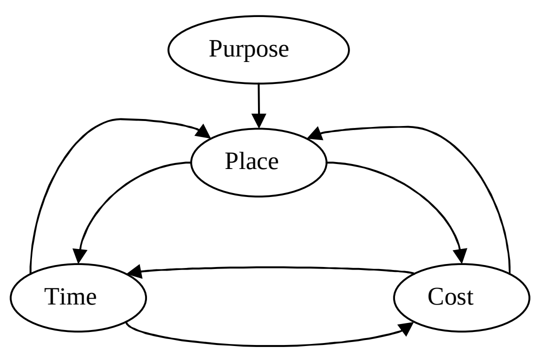
Every people needs some time to relax their mind and body from their daily activities. Many ways that they can do to relax, like do sports, watching a movie, playing video games, playing music, shopping, or just lying around on the bed. But most of all, when they got their vacation, they use it to travel with their friends, family, or just doing it alone. When they want to have a trip, they sure want their trip is going to be a perfect trip. This paper discuss about how the graph theory will help you so you can make a good tour trip plan.

You need some steps to be done, in making the tour tips. You must know what your purpose in doing the trip is, this purpose will affected to where you want to do this trip. For example if you want to have an education trip, you will go to the country that have an great education such as Japan, England, etc, or if you want to have a discovery trip, you will go the historical place like Borobudur temple or angkor wat. How long you will be doing this trip will affect the place of your trip too, for example if you want a trip that only be held in 2 days, your trip better to go to the nearest town (like if you living in Jakarta, then a trip to Bandung maybe will be one of the option). Where the tour trip will be held, how long it's to be held, will affected how much the cost of this trip. All of these steps for making a tour trip can be represented by a graph theory. In graph theory these steps call as a directed graph (Picture 1.1).



Picture 1.1 Example of directed graphs

In this tour planning case, the vertex can represent the type of "the problem that we must know to make a good trips plan", and the arrow or edges shows us the effect of one vertex to another vertex. With making the directed graph (Picture 1.2), we will more easily to set plan to making the dream trip.



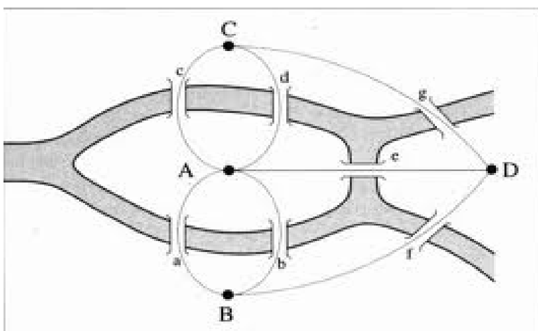
Picture 1.2 Directed graph of trip plan

II. BASIC THEORY

II.1 Graph

In mathematics and computer science, graph theory is the study of *graphs*, mathematical structures used to model pair wise relations between objects from a certain collection. Graph is an abstract representation of a set of objects where some pairs of the objects are connected by links. The interconnected objects are represented by mathematical abstractions called *vertex*, and the links that connect some pairs of vertices are called *edges*. Typically, a graph is depicted in diagrammatic form as a set of dots for the vertices, joined by lines or curves for the edges.

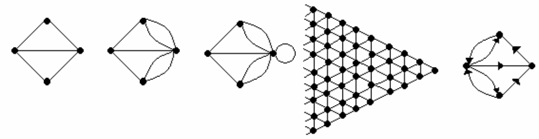
According to history, königsberg bridge problem's (Picture 2.1) is the first problem that uses a graph theory (1736). Swiss mathematician, L.Euler is the first person that can explain the result of this königsberg bridge problem's with a simple verification. He said that it's impossible to go through all the seven bridge (vertex), each bridge once and come back to the first place, if all the degree of vertex is not even. Degree is the number of edges that connect to a vertex, where an edge that connects to the vertex at both ends (a loop) is counted twice.



Picture 2.1 Königsberg bridge problems

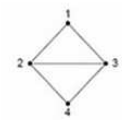
A graph can be represented with no edge, but must have (minimal one) vertex, this kind of graph is called *trivial graph*. Graph also can be grouped into some of categories:

a. *Simple graph*
   A simple graph is an undirected graph that has no loop and no more than one edge between two different vertex (Picture 2.2 a).
b. *Multigraph*
   A graph that have a double edge between two different vertex (Picture 2.2 b).
c. *Pseudograph*
   A graph that have a loop, including having a double edge (Picture 2.2 b, c).
d. *Limited graph*
   A graph that has n vertex, and n is finite (Picture 2.2 a, b, c).
e. *Unlimited graph*
   A graph that has n vertex, and n is infinite (Picture 2.2 d).
f. *Undirected graph*
   A graph in which edges have no orientation at all (Picture 2.2 a, b, c, d).
g. *Directed graph* (*Digraph*)
   A graph that each of the edge has an orientation, the oriented edge called arc (Picture 2.2 e).



Picture 2.2 Graph categories
(from left to right a, b, c, d ,e)

Path of length n, the vertex that listed from v_0 to v_n in a G graph is a sequence that intermittent between the vertex and the edges that make such v_0, e_1, v_1, e_2, v_2, … , v_{n-1}, e_n, v_n so that $e_1 = (v_0,v_1)$, $e_2 = (v_1,v_2)$, … , $e_n = (v_{n-1},v_n)$ is the edges of the G graph. A path that the entire vertex is different and all the edge only can be passed once called *simple path*. A path that start and end on the same vertex called *closed path*, while a path that start and end on the different vertex called *open path*. In picture 2.3, path (1, 2, 4, 3) is a simple and open path, path (1, 2, 4, 3, 1) is a simple and closed path, and path (1, 2, 4, 3, 2) not a simple path, but it's an open path.



Picture 2.3

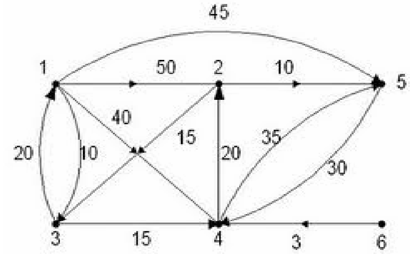
Circuit or *cycle* is a path that starts and ends in the same vertex. Length of the circuit is sum of the edge in that circuit. A Circuit called a *simple circuit* if every edge that be passed is different. Picture 2.3 (1, 2, 3, 1) is a simple circuit, but (1, 2, 4, 3, 2, 1) is not a simple circuit.

II.2 Graph application

These are some of application that related to the path and circuit in the graph theory, *shortest path*, *traveling salesperson problem*, *Chinese postman problem* (also called *route inspection problem*) and *graph coloring*.

1. Shortest path

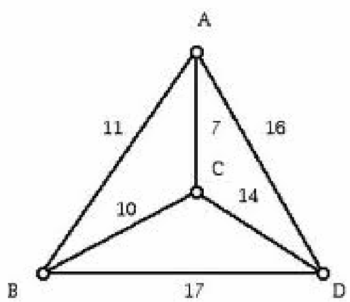
Graph that used for this shortest path problem is a weighted graph (Picture 2.4). The value on the edge determine length between the cities, cost that needed to go to the city, time that needed to travel from a city to another city, etc. Algorithm to find the shortest path to resolve this problem that people most use is *Dijkstra's Algorithm* (conceived by Dutch computer scientist, Edsger Wybe Dijkstra). This algorithm using a greedy principle, that in every step we choose the edge that have the minimum weight and put it in to the solution set.



Picture 2.4 Weighed graph

2. Traveling salesperson problem (TSP)

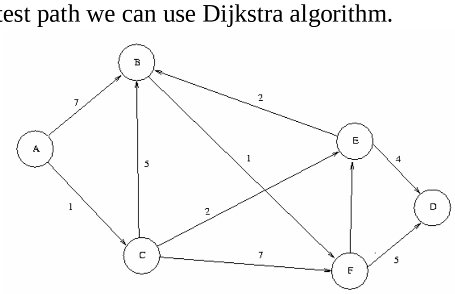
This problem was inspired by the problem of the traveling salesperson. This salesperson must go to visit every city and come back to the first city, of course this salesperson should search the nearest path and visit each city exactly once so this salesperson can do it's job effectively. This TSP can be modeled as an undirected weighted graph (Picture 2.5), usually the model of this problem is a complete graph. *Complete graph* is a graph that the edge connects each pair of the vertex. The city can be represented as vertex of the graph, the path that connected one city to other city can be represented as the edge, and the path's distance can be represented as the edge's value or length. This TSP becomes a Hamiltonian cycle if and only if every edge has the same distance. The most direct solution for this TSP would be to try all permutations and see which one is cheapest (using brute force search).



Picture 2.5 Undirected weighted graph
(Also a complete graph)

3. Chinese postman problem

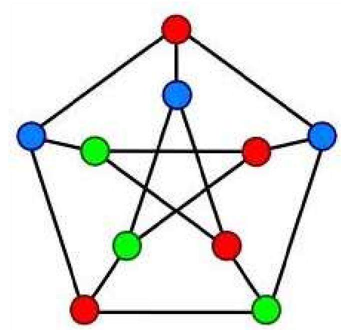
This problem presented for the first time by Chinese mathematician, Mei Gan in 1962. This problem nearly like the Traveling salesperson problem, in Chinese postman problem is to find the shortest closed path or circuit that visits every edge of a (connected) undirected graph. This problem can be modeled by using an undirected weighted graph (Picture 2.6 the solution will be A,B,E,D,F,C,B,F,E,C,A). When this graph has an Eulerian's circuit (a closed walk that covers every edge once), that circuit is an optimal solution. If the graph not an Eulerian's graph, then this problem can be solved with Eulerian's path. Because it can be have more than one Eulerian's path in the graph, so that we must find the shortest Eulerian's path from the last visit vertex back to the first vertex. To find the shortest path we can use Dijkstra algorithm.



Picture 2.6 Undirected weighted graph

4. Graph Coloring

There are three categories in graph coloring; vertex coloring, edge coloring, and region coloring. Vertex coloring, it is a way of coloring the vertex of the graph so that there are no two adjacent vertex that have to share the same color. Since a vertex with a loop could never be properly colored, it is understood that graphs in this context are loop less. A coloring using at most k colors is called a (proper) *k-coloring*. The smallest number of k colors needed to color a graph G is called *chromatic number*, symbolize with $X(G) = k$ (Picture 2.7 $X(G) = 3$). For complete graph K_n have $X(G) = n$, bipartite graph (a graph that can be partitioned into two sets) have $X(G) = 2$, circle graph that have odd n have $X(G) = 3$, and if even n have $X(G) = 2$, and for a tree graph T have $X(T) = 2$, other graph can't be stated in general.



Picture 2.7 Coloring graph

II.3 Trip plan

Making a perfect tour trip, its sound like a piece of cake thing, but actually it's need more effort in making a tour trips. It's very easy if you want to have an own tour trip, just pick the destination where you want to go then just go there, but making the tour trips enjoyable, that is different story. There are many steps to be done and many things you should know. You must know what kind of trip do you like, how many people that will take the trip, how much the cost is needed to go there, how long this trip will be take, where is the best way to go there, etc. The graph theory will help you how to arrange your plan so that you can make a wonderful tour trip.

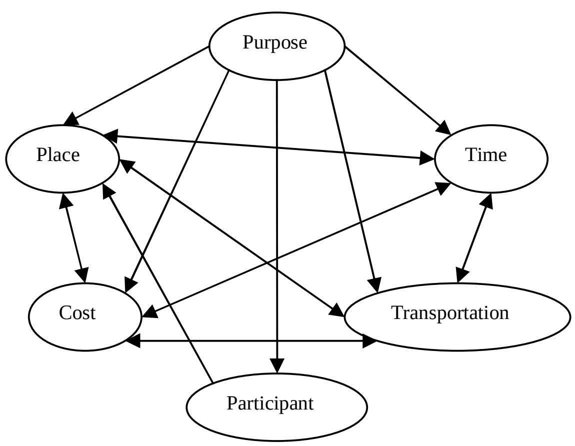
Picture 2.8 Holiday?? Failed

III. Applying The Graph Theory in Making Tour Trip

A. Decide the kind of trip

"Where I want to go on this vacation?" this question usually that people think when they was planning a trip for their vacation, they search for some place that they want to go. Actually the first thing you should know when you want to have a trip, is what is yours purpose doing this trip. True that every people have a trip for their vacation to have fun, but what do you want to do to get the fun, some people maybe want to know the culture of other country, some people maybe just want to have an adventure, some people maybe want to buy other country local production to complete their collection and some people maybe just want to find something new.

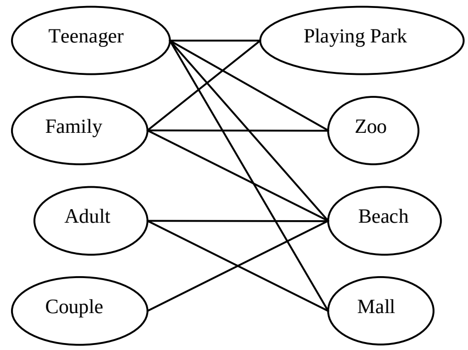
After deciding the purpose, you maybe want to know how long the trip will held if you go there, how much its cost, who will do the trip (teenager, family, couple, old man, etc), where do you want to go, etc. Actually one of this "needed" is linked to other one. How long this trip will be held affected by how much cost you want to spent, where you want to go. If you want this trip held on 3 days, but you can only pay for 2 days trip, or you want to go to New York while you lived in Indonesia (travel from Indonesia to New York need more than 12 hours, so you actually will have only around one day in New York), this entire problem will make you not to enjoy this trip. The alternative to enjoy this trip, maybe you just can find another place that cheaper or just go to the nearest country like Singapore. Making all of this "needed" in to a graph, make us more easily to decide and make the trip, this can be modeled as a directed graph (Picture 3.1).



Picture 3.1 Example tour "needed" graph

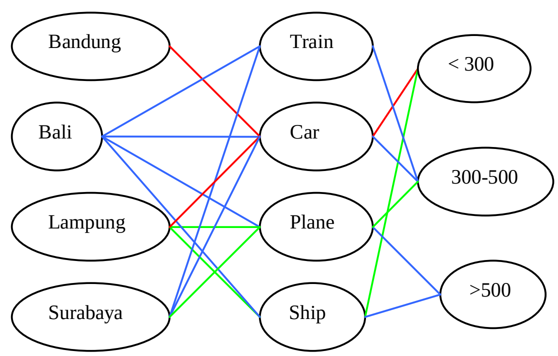
We use directed graph to model this "needed" because there are a "needed" that affect another "needed" but some "needed" is not. From the graph above we can see that the "purpose" of the tour affect all of segment of the needed, so we can say that it's really important to decide what your purpose on the trip is.

We can see that what kind of participant will affect the place the tour will be held. For example that you want to go to Jakarta, if the participant is a teenager or a family maybe Dufan (playing park) or Safari Park (zoo) is a right place, if the participant is teenager or adult maybe a shopping mall can be the place, or if the participant is a couple maybe a romantic trip in Ancol (beach) can be one of the option. This solution can also be modeled by a graph, so you can easier to decide what kind of tour you want to make (Picture 3.2).



Picture 3.2 Graph between participant and place

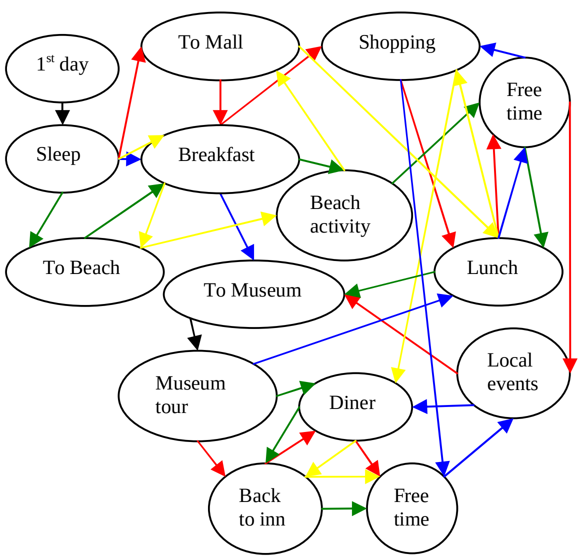
We can also make a combine graph between more than two "needed", for example we can make a graph between place, cost and transportation (Picture 3.3). The graph is showed us how the place and the transportation will affect the cost of the trip, so we can choose the right transportation and the right place.



Picture 3.3 Graph place, transport, and cost

B. Making timeline trip

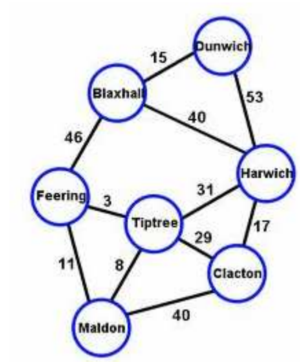
After decide what the trip would be, now we can move to the next step to make the tour trip. In making a tour trip we must know the timeline that the trip. The timeline of the trip is very important in a tour trip, especially if you arrange the tour for other people so they know what time they will be to the location, what activity that they are going to do next, etc. The purpose of making the time line is we can to arrange the best activity so we can more enjoy our trip. To make this timeline of course we must know the entire activity that we want to do, how long the activity will take the time, etc. We can convert all the activity that we want to do into a graph (Picture 3.4), so we can arrange all the activity. This picture shows us how to arrange an activity of one day base on the time. For example in one day we have 24 hours and need around 7 hours to sleep. Let see if we got some activity and the time such as going to mall (go to the mall take time 1 hour), shopping (take time around 5 hours), breakfast (1 hour), lunch (1 hour), dinner (1 hour), to beach (2 hour), beach activity (2 hours), free time (2 hour), to museum (1 hour), touring a museum (2 hour), back to the inn, watching a local events (1 hours). Picture 3.4 will show you some possibility of the timeline, the sum of the activity must be less than 24 hour (make some time to the participant to have their private time or anticipate for some unexpected things). This graph maybe looked bit complex because it's containing four kind of timeline (four kind of timeline possibility can be modeled in one graph), that's why we can say that with this graph much help us in making the timeline.



Picture 3.4 Timeline in a graph

C. Making the route

When you are in a tour trips, you definitely didn't want to through a same way over and over because you will get bored with the view. This is how the graph theory will help you to solve this problem. Not only you can make the route will not be through more than once, but with graph theory you also can know the shortest route so you can traveling more effective. This kind of problem can be modeled by using a weighted undirected graph, with the vertex represented the place, the edge represented the route, and the value represented the time that needed to across the route (Picture 3.5). After we transfer into a graph, than we can choose the right route that we will use, with a problem that we must to visit the entire city (vertex) once with the shortest path (back to the first city is an optional) without through a route (edge) more than once. From Picture 3.5, if we are from Maldon, then the solution would be Maldon – Feering – Tiptree – Clacton – Harwich – Dunwich – Blaxhall.



Picture 3.5 Example of a tour route

IV. Conclusion

Graph is very useful in complete many of the problem in our live, one of them while you are making a tour trip plan. Graph make easier to design the tour trip plan, arranging a timeline activity, and to finding the best route that will use when doing a trip. The type of the graph that we can use to help us are various, it can be a directed graph, undirected graph, weighted undirected graph, etc. Some of the graph theory also used to help us, such as using a Dijkstra's algorithm to solve the shortest path problem, and using an Eulerian circuit to through all the route once and back to the first city.

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