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An Application Designed To Obtain Maximum Flow during Homogenous Congested Traffic

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Abstract: We all are aware about the situation that the traffic system is facing at the present time. There is a huge congestion in the flow of traffic management which is one of the major problems for all the individual and environment. Generally we all are facing this problem from very beginning but we are not able to handle it in a better way or say we are not able to minimize this problem in a perfect way. We all knew that day by day the life style of human being is automated and the needs are at a high level. Just to optimize the high standard life style, more and more vehicles are bought and used. Because of which only there is a huge homogeneous congestion in the traffic. So to reduce the congestion in traffic by optimizing maximum flow of the vehicles at a time is a main objective of this paper. To optimize this problem we are applying an algorithm called 'Ford-Fulkerson algorithm' which provides the key parameters that can help to reduce traffic congestion in homogeneous traffic. Thus the main purpose of this paper also intends to implement methodology and simulate the traffic scenario and observes its impact on traffic congestion.

Keywords Graph, traffic Signals, Ford-Fulkerson algorithm, multithreading.

I. INTRODUCTION

Traffic congestion is one of the big issues at the present time because in this fast moving world and high standard life ever one wants to moves as fast as possible but because of proper management of traffic it seems quite difficult so to maximize the flow of traffic is the big deal of the management. During traveling a huge mass face this problem in the traffic by spending a lot of time during traffic lights signal. So it is one of the major problems which need to handle in an effective manner so that the maximum flow of traffic can be done during congestion. Various tools and techniques are applied to this implementation.

II. LITERATURE REVIEW

Traffic congestion related issues have been tackled mostly in a most crowded place in a disorganized fashion in the past as well as present too. It is regarded as a huge problem in the context of various scenarios. So to handle this problem various computations and study has been done based on different demographic information and availability. Though various computations had been applied or done, this problem has never seen as a potential graph theory problem, because of which graph theory ideas and solutions have never been applied to gain a practical remedy to achieve the traffic congestion issues [3].

Generally to minimize the maximum congested path we generally apply graph theory so that it can be handle in a proper way but it is not the problem to handle or minimize the solution, its main purpose is to maximize the flow of congested traffic. So we had applied the Ford-Fulkerson's algorithm [1] to gain maximum flow in a congested traffic. The main idea behind applying this algorithm is that it computes the maximum flow in a flow network presented in Srijan Biswas et al. [5]. It is one of the simple algorithms for the flow network. The start and end path is managed by the available capacity within the path and we send the flow along one of these path, then we find another path and so on. Thus the path with maximum available capacity is taken and flow is proceed
Chintan Jain et al. [7] presents an Edmonds-Karp algorithm which uses BFS procedure instead of DFS to find an augmenting path. Modified Edmonds-Karp algorithm is planned to resolve the maximum flow problem in efficient manner. Euclides Pinto et al. [6] proposes a Ford-Fulkerson algorithm to maximize the flow (bandwidth usage) of computer network. It alleviates congestion problems and increases network utilization. And also, presents the analysis of different network scenarios.

I. Fitigau et al. [8] inspect the network performance when using three routing protocols. They are RIP, OSPF and EIGRP. Application such as Video, HTTP and Voice where configured for network transfer. They also observe the behavior when using recovery controller/link failure between network nodes.

A.R. Mahlous et al. [9] present a max flow multipath routing algorithm that is intended to reduce latency, balance traffic load and provide high throughput. Max flow multipath algorithm is based on a Ford-Fulkerson algorithm. It contains determining a set of disjoint paths that are loop free with maximum flow, then splitting network traffic among those paths on a round robin fashion. Mircea Parpalea et al. [11] have proposed an algorithm for minimum flow problem in a para-metric network with linear lower bound functions. It calculates a parametric maximum flow from the destination node to the source node. Algorithm does not work straight in the original parametric network but in the parametric residual network defined as for the parametric maximum flow problem.

Steven H. Low et al. [12] suggested an optimization method to flow control whose aim is to exploit the aggregate source utility over their transmission rates. In this paper, sources select transmission rates that maximize their own welfares, utility minus bandwidth cost, and network links adjust bandwidth prices to organize the sources' decisions. Dorit S. Hochbaum et al. [13] have proposed pseudo flow algorithm for maximize the flow of a network. It employs only pseudo flows and does not generate flows openly. Pseudo flow algorithm solves directly a problem=minimum-cut problem--the maximum blocking-cut problem.

D. Spasov et al. [14] develop a new idea by enhancing RIP in order to decrease its deficiencies. Cloud environment is used to improve and screen the enhanced RIP's packets. Packets were monitored and remote networks were discovered by using them. A. Dwivedi et al. [15] proposes a maximum-flow-based complex network approach for the analysis of the vulnerability of power systems. For assessing the network, Maximum flow from the source (generator) nodes to the sink (load) nodes is considered. Max-Flow Min-Cut Theorem, also known as Ford-Fulkerson Theorem, is used for assessing the capacity of links.

R. Wojcik et al. [16] describes Flow Aware Multi Topology Adaptive Routing (FAMTAR) which is used to route packets in Internet Protocol networks. It syndicates adaptive routing mechanism and flow-aware traffic management. It is used to discovery the best path between two nodes in a network. FAMTAR automatically make extra paths when such request happens.

III. FORD-FULKERSON'S ALGORITHM

It is one of the simple algorithm which helps to gain maximum flow within the flow network [2]. The main aim of this algorithm is to optimize maximum flow in a network. The idea applied behind this algorithm is quite simple. As long as there is a path form the source to the sink i.e. form start node to the end node, based on available capacity on all the edges within the path, we direct the flow along one of these paths, later we find the another path and so on. The path with available capacity is called augmenting path [10].

Let G (V, E) be a graph and for each edge from u to v, let c (u, v) be the capacity and f (u, v) be the flow. We want to find the maximum flow from source to sink where source is denoted by s and sink by t.

1) *Capacity constraints:* $\forall$ (u, v) ∊ E f (u, v) ≤ c (u, v)
(The flow along an edge cannot exceed its capacity.)
2) *Skew symmetry*: $\forall$ (u, v) ∊ E f (u, v) = - f (u, v)
(The net flow from u to v must be opposite of the net flow from u to v.)
3) *Flow conservation*: $\forall$ u ∊ V: u ≠ s and u ≠ t => $\sum$f (u, w) = 0

That is, useless u is s or t. the net flow to the node is zero, except from the source which "produces" flow and the sink which "consumes" flow. Which means that Network flow is a legal flow after each round in the algorithm. We defined the residual network Gf (V, Ef) to be the network with capacity Cf (u, v) =C (u, v) - f (u, v) and no flow . It can occur that a flow from u to v is allowable in remaining network, however disallowed in the original network. If f(u, v)>0and c(u, v)=0 then cf (v, u)=c(v, u)-f(v, u)=f(u, v)>0.

Algorithm
Input graph G with a flow capacity cf, a source node s and a sink node t.
Output A flow from s to t which is a maximum

1) F(u, v)← 0 for all d edges (u, v)
2) While there is a path P from s to t in G , such that cf (u, v)>0 for all the edges (u, v) ∊ p:
   a. Find cf (p)= min{ cf (u, v): (u, v) ∊ p}

b. For each edge (u, v) ∊ p

1) f (u, v)← f(u, v)+cf (p) [send flow along the path]

f(u, v) ← f(u, v)- cf (p) [the flow might returned later

Thus the ford – Fulkerson's algorithm is defined in the graph and maximum flow context.

IV. PROBLEM DEFINITION

The huge congested traffic is one of the major problem and makes the flow of the traffic is extremely slow because of which we are facing a lot of problem during travelling. While traveling from congested area we are always needed to suffer by the traffic signals because of huge congested traffic as a result a different problem are faced like extra traveling time, busy with traffic signals, concentration towards the traffic signals, etc. So it is one of the major problems for the each and every individual life because unless we are aware of this entire problem we are not able to minimize the congested traffic. So the main issue is traffic management. Though we had a traffic lights in all the major area, we had to suffer with all these congested problem because until the signal is green we are not able to move forward and because of which a large traffic gets merged within no time and get congested which is one of the big issues of today's traffic management. So to minimize this problem we are applying Fork-Fulkerson's algorithm to allow maximum flow within the congested traffic.

V. SOLUTION METHODOLOGY

The main objective of this paper is to map problem of maximum flow of congested traffic in a network using Ford-Fulkerson's algorithm. So it can be mapped to the problem of maximizing a flow of network by using nodes as a traffic signals and edges as the roads joining these traffic signals. In this particular scenario capacity of edges can be mapped as a capacity of roads, which in turn can be defined as maximum number of vehicles that can simultaneously use the road without being stopped due to congestion. So by all these mapping we are able to apply Ford-Fulkerson's algorithm to determine optimized signal-timings, maximum speed of the vehicle, and distance between the two vehicles. In all these we can make a use of traffic rules in a better way which results in a maximum flow and less traffic congestions. This derives the main values of these parameters and it clearly shows that by using these parameters traffic congestion can be reduced to some extent. Thus we have implemented the algorithm with these parameters and develop a simulation scenario where traffic signals can be seen clearly and impact of change of parameters can be visually observed within the implementation.

VI. CONCEPT OF MODEL

As we have map the traffic congestion scenario in a network during problem definition, we can develop a kind of model. During this model the particular area is taken where we want to solve traffic congestion using Fork-Fulkerson's algorithm as a capacitated network A. Various traffic junction may be present within this particular area which will act as a vertices of capacitated network and is denoted by J and various roads are joined to these traffic junctions which is denoted by R. Now we had a capacitated network A= (J, R) where each road has a capacity associated with it, let's denote this capacity as C= (J [x], J[y]), where J[x] and J[y] are any two junctions and C represents the capacity of the road of these two junctions. The capacity is dependent on three factors and is combination of all these factors. They are:

1. Length of the road, if a road R1 is a long enough then road R2, than given other two parameters are same, because of which the capacity of R1 will be higher than the capacity of R2, and as a result R1 can hold more number of vehicles without being over-crowed.
2. Green Signal Time, if a road R1 has greater green signal timing than road R2, capacity of R1 will be greater than capacity of R2, as a result R1 can flow more numbers of cars without being over-crowded as time of green signal is more.
3. Maximum Velocity, if a road R1 has more maximum allowed velocity than road R2, then road R1 will have more capacity than R2as a result more number of cars can pass through in very less time.

Thus a combination of all these three parameters defines a maximum possible capacity of any provided road R, and as a solution, flow on this road F (J[x], J[y]) will always be less than or equal to its capacity i.e.

0 <= F (J[x], J[y]) <= C (J[x], J[y]).

One more option can be applied i.e. by modifying Green Signal and Maximum Velocity , keeping length of road in mind , we can modify the flow of the particular road, as a result this flow will always be less than or equal to capacity of the road. Finally the total flow of the area as a summation of flow of all the roads can be defined as:

F(A)=F(J[x1], J[y1])+ F(J[x2], J[y2])+……………..+ F(J[xn], J[yn])

Where F (A) represents the total flow of the area and F (J[x1], J[y1]) represents flow of the road joining x1 and

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x2 junctions. Thus the objective of Ford-Fulkerson algorithm is to maximize flow F (A) by using various flows on the roads. The flows in individual roads can be modified by changing two dynamics parameters (Green Signal Time and Maximum Velocity) along with static parameter (Length of road).

VII. EXPERIMENTATION, ANALYZING AND MODELING

We have made a theoretical framework for traffic congestion problem by mapping to a maximum flow problem, and then applied Ford-Fulkerson's algorithm to solve it for maximum flow using various parameters and experimentation in a simulation environment [4]. Simulation environment is developed using Java, and the results obtained by algorithm is been applied to simulation environment in order to verify that optimized parameters obtained using Ford-Fulkerson's algorithm indeed gives a good results.
This java based simulation is based on the theoretical model which we had discussed above. In this simulation environment various java principles are used such as: Java applet is used to draw the basic road layout, Java multithreading is used to simulate the traffic etc. In order to conduct experiments in controlled environment, various controlling icons are developed. Using these icons various variables in the experiment can be controlled by the users and observes results for them. The controlling icons developed are as followed:

1. Traffic Light: Users can click on RED, YELLOW, and GREEN light in order to change the traffic signals timing. Here right click will increase the value whereas left click will reduce the value.
2. Traffic speed: The user can change the maximum car speed using this icon. Right click will increase the speed whereas left click will decrease the speed.
3. Ford-Fulkerson's Algorithm: On clicking this icon, the algorithm will be used to come up with optimal traffic speed and optimal traffic signals timings which results in maximum traffic flow.
4. Time: It is one of key factor during the whole experiment and is taken as soon as simulation is started.
5. Start: Simulation gets started using this icon.
6. Stop: Simulation get stopped using this icon.
7. Reset: This is the icon which reset the simulation, and as a result traffic lights points to default traffic timings and traffic speed point to default traffic speed.
8. Total flow: It indicates the total number of vehicles reached to the sink nodes i.e. to the destination, which defies the total flow of the traffic network.

Thus Ford-Fulkerson's algorithm aims to get optimal traffic signals timing and traffic speed on order to have maximum traffic flow.

VIII. RESULTS

In this way using Graph theory and Ford-Fulkerson's algorithm congested traffic can be managed by optimizing the maximum flow of vehicles and is reflected as an ideal solution for the problem. As a result the mentioned optimized parameters such as vehicle's maximum velocity, safety distance, and traffic light duration can easily be applied in real life to reduce the traffic congestion.

CONCLUSION

In this paper firstly theoretical model has been developed using graph theory to reduce traffic scenario as a capacitated network and later this concept defines nodes, edges and network flow in terms of roads, traffic Junction and traffic flow. It has been tested practically by implementing a java based simulation. In the simulation environment various different parameters can be applied which impact is clearly observed in traffic flow. Thus using Ford-Fulkerson's algorithm we can compute optimal value for these parameters and can experimentally confirm that these optimal values results in maximum traffic flow during congested traffic. Using this algorithm various traffic scenario such as traffic light timings and traffic speed is observed and computed the optional solution of maximize traffic flow in congested traffic as well as reduce traffic congestion.

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