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A Cluster Based Feasible Time Interval for Tracking Lost or Stolen Vehicle

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***Abstract*— The system for tracking and monitoring lost or stolen vehicle is challenging. This device is widely used to assess the vehicle's location using GPS technology. It can be used to track a vehicle or vehicle fleet and to obtain information about the vehicle's current location. There are various challenges for tracking and monitoring vehicles and finding lost vehicles due to the lack of proper real-time vehicle location and hence it is difficult to take necessary action in the immediate proper time after the vehicle has lost or stolen. In this paper a Cluster Based Feasible Time Interval for Vehicle Tracking (CFTVT) algorithm for measuring the minimum time interval for taking action after the vehicle has lost or stolen is proposed. This proposed model helps to imply any appropriate vehicle tracking algorithm in the exact proper time after the vehicle has been lost or stolen.**

***Index Terms*— Lost Vehicle Tracking; Stolen Vehicle Tracking; Cluster Based Feasible Time**

I. INTRODUCTION

The system proposed in this article is to measure the minimum time interval for taking an action to find the lost or stolen vehicle. There are several systems or algorithms are available in the literature for tracking lost or stolen vehicles. But any of these systems will not be effective if it is not possible to implement in the proper time. Here, we develop a Cluster Based Feasible Time Interval for Vehicle Tracking (CFTVT) algorithm to measure the minimum time interval to implement any of the existing vehicle tracking algorithms to track the lost or stolen vehicle.

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The major advantages of clustering a large-scale network, where the management and the information accumulation would be attained very easily within the network clusters [1]. In order to provide an easily accessible network, clustering is done on the basis of specific application requirements. Nodes are constructed in clusters using certain parameters, such as nodes that will join the clusters, exit nodes used to leave the network. However, the clustering technique is principally handled for data distribution and routing in the network [2, 3]. Therefore, the clustering method helps to divide the whole network into several smaller sub-networks. There are many techniques found in the literature for clustering the network [4-7]. Khakpour et. al. [8] describes the main causes to use clustering in the network such as (i) aggregated network scalability by generating network fragments [9]; (ii) decreasing the quantity of communications being transferred within the network [10]; (iii) declining crowding in network communications [9,11]; (iv) serving optimum quality of service (QoS) and appropriate routing of communications [12]; (v) capturing with variable network connectivity [13]; and, (vi) shrinking argument and hidden fatal problems [14].

Several techniques for vehicle observing, vehicle alerting systems, and vehicle tracking systems have been anticipated by many researchers. Benjamin et al. [15] presented a real-time computer vision structure to trace vehicles and ensure traffic reconnaissance based on a audiovisual figure processing technique. Akande [16] offers automatic vehicle location as an innovative process to trace and scrutinize any vehicle endowed with a software unit receiving and transmitting signals over the GPS satellite. Rauf and Kamal [17] anticipated a clever GPS navigation system. In this system, a neural network is accompanied to manage impaired raw signals taken by the GPS receiver. Jianping et al. [18] developed GPS based real-time vehicle alarm monitoring and alerting system that occupied GPRS and CSD on the implanted system. Venkatakrishnan and Seethalakshmi [19] presented Public transport ticketing and monitoring system contains GPS, GSM, RFID, and Zigbee for the consumers. The usage of GSM and GPS technologies allows the system to trace vehicles and presents rationalized data about current tours. Patinge and Kolhare [20], Khan and Mishra [21], Hannan et al. [22], Pham et al. [23], Maruthi and Jayakumari [24], and many researchers developed the vehicle tracking and monitoring system for lost or stolen vehicles.

All the above-discussed systems will not be efficient if the action has not been taken at the appropriate time. In this paper, we develop such a system so that it is possible to measure the minimum time interval to take immediate necessary actions after the vehicle has been lost or stolen. The rest of the paper is divided into four sections. Section 2 described the Cluster Based Feasible Time Interval for Vehicle Tracking (CFTVT) algorithm, section 3 includes the pseudocode of the CFTVT algorithm, section 4 illustrates a numerical example implemented by the CFTVT algorithm and section 5 concludes this paper.

II. ALGORITHM FOR VEHICLE TRACKING SYSTEM

A. Cluster Based Feasible Time Interval for Vehicle Tracking (CFTVT) Algorithm

First, we consider a network of a city and divide this network into a number of clusters. Each of the clusters contains arcs and nodes. Some nodes connect the clusters call connecting or shared nodes and some nodes are exit nodes located on the boundary of the network.

Step-1: Identify the vehicle's last position, a node of a cluster, before the vehicle has lost or stolen;

Step-2: Find the shortest travel times from the node of the vehicle's last position to each of the exit nodes of the network.

Step-3: Find the minimum shortest travel time (say T_{min}^{E}) from Step-2.

Step-4: Find the minimum shortest travel time from the vehicle's last position to any exit node through the clusters. To obtain this travel time follow the following procedure:

Find the minimum shortest travel time (say t_1) from the vehicle's last position to among the connecting nodes of its associated clusters. Block the other associated clusters which have travel greater than t_1. Also, block the cluster where the vehicle has been lost or stolen. Again, identify the minimum shortest travel time (say t_2) from the last connecting node to among the connecting nodes of its associated clusters. Block the other associated clusters which have travel greater than t_2.

Continue this process until no unblock cluster is available.

Step-5: Find the minimum shortest travel time (say t_l) from the last connecting nodes found from Step-4(b) to the exit node of that cluster.

Step-6: Add all the travel time obtained from Step-4 and Step-5; say T_{min}^{C}.

Step-7: The feasible minimum time interval: $[T_{min}^{E}, T_{min}^{C}]$ where $T_{min}^{E} \leq T_{min}^{C}$; Stop.

III. PSEUDOCODE FOR CFTVT ALGORITHM

We consider a city where the vehicle has been lost or stolen. Let $\mathrm{G} = (\mathrm{N}, \mathrm{L})$ be the graph of the city network, where N be the set of nodes or vertices, and L be the set of links or arcs of the pairs of nodes belonging to N. We divide this city into a finite number of $k\ (\geq 2)$ cluster network zones. Let $C_i = (N_i, L_i) \subset G; i = 1, 2, \dots, k;$ be the i^{th} cluster of the network G. Every two adjacent clusters have the connecting or shared node(s). Let $a_j^{(p,q)}$ be the connecting or shared node of any two adjacent clusters C_p and C_q and let $S = \left\{a_j^{(p,q)} \mid j \geq 1\right\}$ be the set of all these connecting or shared nodes. Let e_i^k be any exit node of the k^{th} cluster and let $X = \left\{e_i^k \mid i = 1, 2, \dots, m\right\}$ be the set of all the exit nodes. Only the clusters on the boundary of the network G have the exit nodes. Let $n_i^k\ (i \geq 1)$ be any node in the graph G located on the k^{th} cluster other than the connecting and the exit node. Let $(i, j) \in L$ be the arc or link of any two directly connected nodes and let t_{ij}^k be the travel time from i^{th} node to j^{th} node of the k^{th} cluster.

Here we assume that the vehicle has lost or stolen on any of the nodes of any cluster. Let v_r^s of the r^{th} node located on the s^{th} cluster be the last location before the vehicle has lost or stolen. Now we apply the shortest path algorithm to find all the shortest paths from v_r^s to each of the exit nodes $e_i^k (i = 1, 2, \dots, m)$. Let $t_i^e (i = 1, 2, \dots, m)$ be the travel times of these shortest paths. Let $E_t = \{t_i^e \mid i = 1, 2, \dots, m\}$ be the set of the travel times of all the shortest paths from v_r^s to each of the exit nodes e_i^k. Let $T_{min}^{E} = \min\{t_i^e \mid t_i^e \in E_t\}$ be the minimum travel time among all the obtained shortest travel times.

Now we find the shortest path from the v_r^s node to the exit node of any boundary cluster through the associated cluster(s) of the s^{th} cluster C_s. Let t_1 be the minimum travel time among the shortest path(s) from the v_r^s node of s^{th} cluster to the connecting node(s) $a_j^{(s,p)}; p = 1, 2, \dots, p, \dots q;$ of its associate cluster(s). Let C_p be the nearest associated cluster among all other associated clusters of the s^{th} cluster C_s. Block the other (if exists) associated cluster(s) of C_s which has the greater travel time than t_1. Again, find the shortest paths from the connecting or shared node $a_j^{(s,p)}$ to the connecting node(s) of the associated cluster(s) of C_p and let t_2 be the minimum travel time among these shortest paths. Similarly, block the other (if exists) associated cluster(s) of C_p which has the greater travel time than t_2. Continue this process until there is no unblocked associated cluster. Now find the shortest travel time, say t_l, from the connecting node of the last reached boundary cluster to the exit node of this cluster. Let $T_{min}^{C} (= \sum_{i=1}^{l} t_i)$ be the total travel time of v_r^s node to the exit node through the associated clusters.

Therefore the time interval $[T_{min}^{E}, T_{min}^{C}]$ where $T_{min}^{E} \leq T_{min}^{C}$ is the feasible minimum time period for taking action to find the vehicle after lost or stolen. A formal algorithm for obtaining feasible time interval for tracking lost or stolen vehicle is given below:

Let, initially S' be the subset of S that contains the connecting or shared nodes of the associated cluster(s) of v_r^s node of the s^{th} cluster C_s.

A. ALGORITHM CFTVT

BEGIN

Identify the vehicle's last position v_r^s node before the vehicle has lost or stolen;

Find the shortest travel times t_i^e from v_r^s node to each of the exit nodes $e_i^k (i = 1, 2, \dots, m)$;

SET $T_{min}^E \leftarrow \min\{t_i^e | t_i^e \in E\}$;

SET $p_w^j \leftarrow v_r^s$;

SET $S' \leftarrow$

$$\left\{ \begin{matrix} b_p^{(j,q)} | connecting\ node(s) of\ the\ cluster(s) \\ q\ associated\ with\ j^{th}\ cluster \end{matrix} \right\} \subset S$$

SET $T \leftarrow NULL$;

WHILE no unblocked cluster have found DO

Find the minimum travel time t_i among the shortest path(s) from p_w^j node of j^{th} cluster to all the connecting node(s) of the set S',the associated cluster(s) of p_w^j node;

$T \leftarrow T + t_i$;

$p_w^j \leftarrow b_p^q$ is the connecting node of the travel time t_i;

$$S' \leftarrow \left\{ \begin{matrix} set\ of\ the\ connecting\ nodes\ associated\ to \\ p_w^j\ node\ of\ j^{th}\ cluster \end{matrix} \right\};$$

Block the clusters which have the greater travel time than t_i;

ENDWHILE;

Find the shortest travel time t_l, from the connecting node to the exit node of the last reached boundary cluster;

$T \leftarrow T + t_l$;

SET $T_{min}^C \leftarrow T$;

Feasible minimum time interval: $[T_{min}^E, T_{min}^C]$ where $T_{min}^E \leq T_{min}^C$;

END;

IV. NUMERICAL ILLUSTRATION

Consider a city with the following network graph.

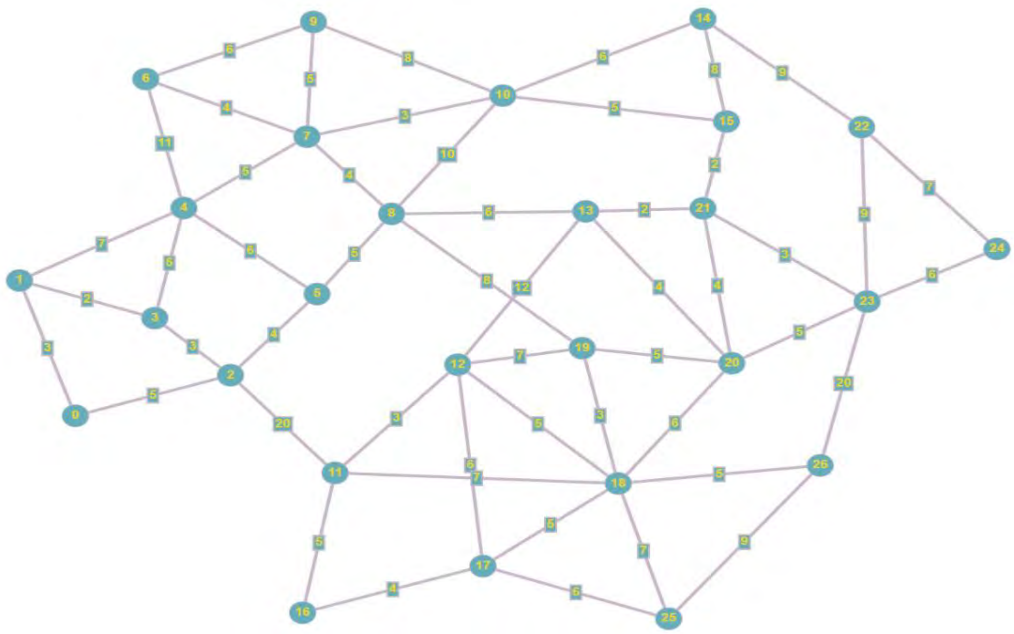

Fig 1. Graph of the Network of the City

The city is divided into five clusters say, A, B, C, D, and E. There is a total of 27 nodes are named as $\{0,1,2,3,4 \dots \dots \dots \dots \dots .26\}$. Clusters are contained all the nodes are given in below:

$A = \{0,1,2,3,4,5\}$,

$B = \{4,5,6,7,8,9,10\}$,

$C = \{8,12,13,18,19,20\}$,

$D = \{11,12,16,17,18,25,26\}$,

$E = \{10,14,15,20,21,22,23,24\}$

The city has some Exit nodes such as $X = \{0,9,16,24\}$ which are used to get out of this city into another city. The set of connecting or shared nodes is given by $S = \{4,5,8,10,12,18,20\}$. It is required to find the time interval for taking an action after any vehicle has lost or stolen in any of the nodes in this city. Let us consider the last position or node where the vehicle has lost or stolen is, $v_r^s = 19$ in the cluster C. Here we using the Dijkstra algorithm to find the shortest path from node 19 to all of the exit nodes and shown in Table 1.

Therefore, the minimum Shortest Travel Time among all of the shortest paths is, $T_{min}^E = 12$ along with the Shortest Path from node 19 of cluster C to node 16: $19 \rightarrow 18 \rightarrow 17 \rightarrow 16$.

TABLE 1.
THE SHORTEST PATHS FROM THE NODE OF THE VEHICLE HAVE LOST OR STOLEN TO THE EXIT NODES

The shortest paths from the node of the vehicle have lost or stolen (v_r^s) to the exit nodes			
Starting Node (v_r^s)	Exit Nodes (X)	Shortest Path (Applying Dijkstra algorithm)	Shortest Travel Time
19	0	$19 \rightarrow 8 \rightarrow 5 \rightarrow 2 \rightarrow 0$	22
	9	$19 \rightarrow 8 \rightarrow 7 \rightarrow 9$	17
	16	$19 \rightarrow 18 \rightarrow 17 \rightarrow 16$	12
	24	$19 \rightarrow 20 \rightarrow 23 \rightarrow 24$	16
Minimum shortest path and time:		$19 \rightarrow 18 \rightarrow 17 \rightarrow 16$	$T_{min}^E = 12$

Now we find the shortest path from node $v_r^s = 19$ of cluster C to the nearest exit node through the clusters. The adjacent clusters of cluster C are B, D, and E. The set of connecting nodes between cluster C and its adjacent clusters is, say, $S_1 = \{8, 12, 18, 20\}$. Table 2 calculates the shortest paths from node 19 to the nodes of the set S_1.

TABLE 2.
THE SHORTEST PATHS FROM THE NODE v_r^s TO THE CONNECTING NODES OF THE SET S_1

The shortest paths from the node $\boldsymbol{v_r^s}$ to the connecting nodes of the set $\boldsymbol{S_1}$			
Starting Node ($\boldsymbol{v_r^s}$)	Connecting Nodes ($\boldsymbol{S_1}$)	Shortest Path (Applying Dijkstra algorithm)	Shortest Travel Time
19	8	19 → 8	8
	12	19 → 12	7
	18	19 → 18	3
	20	19 → 20	5
Minimum shortest path and time:		**19 → 18**	$\boldsymbol{t_1 = 3}$

Therefore, the nearest cluster of C is cluster D. and the minimum Shortest Travel Time from node 19 of cluster C to node 18 of cluster D is, $t_1 = 3$. Hence block the clusters: B, C, E.

Here, A is only the unblock adjacent cluster of the cluster D. The set of connecting nodes between cluster D and its adjacent cluster A is, say, $S_2 = \{2\}$. Now Table 3 demonstrate the shortest paths from node 18 of the cluster D to the nodes of the set S_2.

TABLE 3.
THE SHORTEST PATHS FROM NODE 18 OF THE CLUSTER D TO THE CONNECTING NODES OF THE SET S_2

The shortest paths from node 18 of the cluster D to the connecting nodes of the set $\boldsymbol{S_2}$			
Starting Node	Connecting Nodes ($\boldsymbol{S_2}$)	Shortest Path (Applying Dijkstra algorithm)	Shortest Travel Time
18	2	18 → 19 → 8 → 5 → 2	20
Minimum shortest path and time:		**18 → 19 → 8 → 5 → 2**	$\boldsymbol{t_2 = 20}$

Thus, the nearest cluster of the cluster D is A. and the minimum Shortest Travel Time from node 18 of cluster D to node 2 of cluster A is, $t_2 = 20$. There is no unblocked adjacent cluster left for cluster A and the exit node of cluster A is 0.

TABLE 4.
THE SHORTEST PATHS FROM NODE 2 OF CLUSTER A TO THE EXIT NODE 0

The shortest paths from node 18 of the cluster D to the connecting nodes of the set $\boldsymbol{S_2}$			
Starting Node	Exit Nodes (X)	Shortest Path (Applying Dijkstra algorithm)	Shortest Travel Time
2	0	2 → 0	5
Minimum shortest path and time:		**2 → 0**	$\boldsymbol{t_3 = 5}$

Here, Table 4 shows the shortest path from node 2 to the exit node 0 of this cluster A is $t_3 = 5$. Hence block cluster A. Thus, the minimum Shortest Travel Time from the node of the vehicle has lost or stolen $v_r^s = 19$ to the nearest exit node through the clusters is,

$$\boldsymbol{T_{min}^C} = t_1 + t_2 + t_3 = 3 + 20 + 5 = 28.$$

Therefore, the expected minimum travel time interval for taking action after the vehicle has stolen is $\left[\boldsymbol{T_{min}^E}, \boldsymbol{T_{min}^C}\right] = [\boldsymbol{12}, \boldsymbol{28}]$.

V. CONCLUSION

In this paper, we developed an algorithm to measure the minimum time interval to take necessary action after any vehicle has been lost or stolen. Many algorithms and systems have been found in the literature for tracking lost or stolen vehicles, but these algorithms cannot possibly imply if the action has not been taken at the appropriate time. Our developed model is easy to implement and is adaptable to any existing vehicle tracking algorithm. Further research can be conducted to integrate the CFTVT algorithm along with the existing vehicle tracking algorithm.

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