Time Division Multiplexing Algorithm for Routing In Time Critical Scenarios

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ABSTRACT

Data density has a linear relation with fixed size of data and non-linear relation with variable size of data. It is challenging to manage variable size data with variable arrival rate. Given a node capacity where arrival rate is not in control then this problem becomes further challenging and requires an algorithmic solution. This research undertakes variable size data and variable rate of arrival at a node capacity and proposes an arbitration algorithm with management of node dispatch capacity algorithm to solve this problem, which will be tested against Knapsack Problem. This work has numerous industrial and social applications. Traffic management for emergency vehicle is one such challenge.

Keywords - Deadlock, Density Management & Processing, Multiplexing, Intelligent Transport System.

I INTRODUCTION

In recent past, data volume and their formats have undergone unpredictable development to support technically advanced applications. Apart from other domain, it has also affected Intelligent Transportation System (ITS) significantly, which has a major role in smart urban planning. Because of random and dynamic behavior of transport system, a flexible and comprehensive architecture is required to control the real-time traffic [1]. Modern communication and information technology is responsible for hazard free transmission and secure handling of these data through different nodes with the help of channels connecting them.

The properties of the connecting links which carry the data, determine the density level at an intermediately node. This density needs efficient management otherwise deadlock may arise bringing down the throughput of the system. Also, some data sets are important for the system under consideration, which require immediate processing. So, the capacity of available channel should be filled with data having higher priorities for optimum utilization.

In this paper, a new strategy is proposed for assigning the data sets with unknown arrival pattern, to an outgoing link of fixed capacity for a certain time slots, which is dynamically calculated. Here. The concept of Knapsack Problem is used by considering the bandwidth of the connecting links as weights or capacity and the data sets to be carried, as items. The idea is to analyze the links as sacks which should be assigned those items for further transmission that provide maximum benefit.

The research contribution of the paper can be summarized as:

(i) In order to optimize the data flow in a system, knapsack approach is proposed to reduce the waiting time of emergency packets i.e the time critical scenario are serviced first.

(ii) The overall density is distributed evenly over the network to increase its throughput and to avoid the condition of deadlock.

One of the applications of this work is in the field of intelligent transport system (ITS) but is applicable to various domains as well (eg. Wireless Sensor Network). An overview of related work in the field of routing and managing related data is given in the following section.

II LITERATURE SURVEY

The reason to approach Knapsack Problem to facilitate routing methodology is that it is very popular since centuries and several techniques are available to solve this type of problem (eg. dynamic programming, branch and bound). Silvano et al. has given an overview of basic technologies and recent advancement proposed for them along with the comparative study of their efficiency for randomly generated data instances [1].

The routing algorithms are expected to manage and control the traffic congestion or density by evenly distributing the data. The traffic network may be carrying data in the form of packets, voice or vehicles. Soh et al. has modeled the single intersection point using M/M/1 queue model. Their purpose is to minimize the queue length which automatically minimizes the delay time and increases the network throughput [2].

It is well observed that success of a routing algorithm implemented on a system depends on the accuracy of traffic congestion estimates. There are several works proposed for detection and management of traffic congestion in different fields using different technologies, algorithms and set-ups. In vehicular traffic network, one possible way is to use RFID and GSM equipped probe vehicle, which calculates vehicular speed and the average waiting time of vehicles over a stretch of road [3]. Roy et al. have used manageable, reliable and cost-effective technology RFID to detect traffic density and accordingly traffic signals are managed using GSM [4]. Also, image processing techniques [5] and video analysis of chaotic unlaned traffic [6] can be used to estimate traffic congestion. With the advancement in smart-phones, app based activities are used to identify certain signaling patterns in cellular core network for different roads. These signals may be processed to extract congestion related information [7][8][9].

Some proposed works provide route guidance for specific elementary entities, which are critical to the application and are delay-sensitive. For e.g. an ambulance trip creates time- critical scenarios and it needs to reach the destination in minimum possible time. Rashmi et al. have used RFID to instruct the traffic signals of a lane for making a clear passage for the ambulance, when it is approaching the signal [10]. To handle such time critical situation, classification of available vehicle cluster and identifying some particular vehicle is an important function, the ITS is expected to perform. Ozkurt et al. Have presented a Neural Network model for classifying the vehicles on a stretch of road using video frames and estimating the density [11]. Recently Rajeshwari et al. Have presented a system to identify specific vehicles like Ambulance and stolen vehicle [12].

Success of any routing algorithms requires no presence of blocked points, which may cause zero-movement in the system [13][14]. Sun et al. has focused on utilizing the existing infrastructure of vehicular wireless network for providing route-guidance and avoid deadlock type of situations. They have formulated two algorithms: one guides in centralized manner while others approach is distributed [15].

This paper proposes a methodology to ensure delivery of time-critical entities in minimum possible time and to distribute the density evenly on the basis of priority of moving elements for smooth flow of traffic. The model proposed in this article can be applied to different network infrastructures deployed to serve different purposes.

III PROPOSED MODEL

The routing process forwards the network traffic from their source toward their ultimate destination through intermediate nodes by selecting best paths in the network. Here is presented a typical scenario for an intermediate node where incoming and outgoing links are available for four different directions [Figure 1].

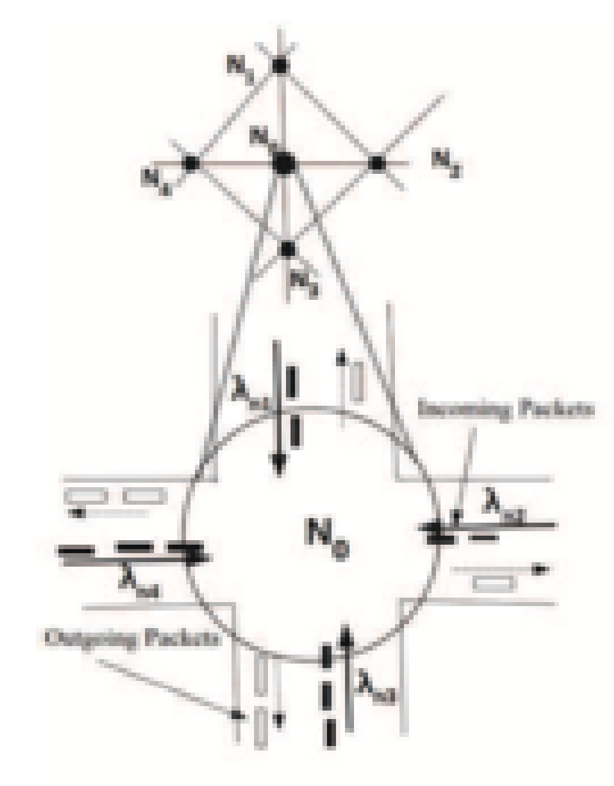

Fig. 1. Forwarding at an intermediatory node

The packets arrival rate for each incoming flow is different and independent of each other, λn1 , λn2 , λn3 and λn4. This paper considers the bandwidth of all the outgoing links, (N0, Ni) as sack, where 1 ≤ i ≤ 4 are assigned to the higher prioritize data sets by sub-dividing the transmission time.

The time slot for different priority-wise categories of data should be determined by their priority. The purpose of the model is to satisfy the following objective:

where, $\lambda n0 = \lambda n1 + \lambda n2 + \lambda n3 + \lambda n4$, and Prob(n0, ni) is Probability of assigning a packet to (n0, ni). Estimation of the Probi is explained further in next subsection.

(a) System Description

Let the system is defined as S = {s, e, X, Y, DD, NDD, fp, fc, fme, fs, Memsh, ... | φ } for programmer's perspective. Above terms will be described shortly in the flow of explanation.

Let, s be the known distinct start state which contributes in the initialization of functions and hence the constructor of the class which will be derived in the UML of system **S**. Let e be the known distinct end state going into which may result into desired outcomes. Let, Y $\in$ **S** be the set of outcomes of **S** and X $\in$ **S** be the input set of **S**. The function fme is the implementation of the proposed algorithm resulting into outcome Y. Let, DD the deterministic behavior of function and data which helps in identifying the load/store functions or assignment functions which contribute in the space complexity resulting into tables and NDD be the non-deterministic computing functions of the system S which is to be solved by computing functions which contribute in time complexity of the algorithm.

Let N $\in$ X be set of the nodes in the system **S** such that:

N = {ni | i = 0, 1, 2, ... z} working as source/destination/routing points and Tz be the time slots divided for any (ni, nj) connections, which holds following relation with capacity C and density δ of the considered path (i, j):

(i) The first slot of time-subdivision should be used to fill the best (N0, Ni) for a packet with urgent

$$Tz(i,j) \propto \delta(i,j) / C(i,j) \quad (2)$$

priority (conventionally tagged with 0) to ensure their delivery to the destination in shortest possible time.

(ii) Remaining slots should fill the available sacks as per the flow balance equation to distribute the density evenly in the network for better utilization:

$$\lambda(N0, Ni) = \lambda n0 . Prob(n0, ni) \quad (1)$$

Let the elementary entities are represented with set P $\in$ X, where P = {pi | i = 0, 1, 2 .... ∞}. The number of p arrived in the system can not be controlled. fp assigns deterministically defined priority levels Prj to flowing packets Pi such that

$$fp : \forall_P Pi \in P, \exists_{Pr} Prj, \text{ where } 0 \le j \le 8.$$

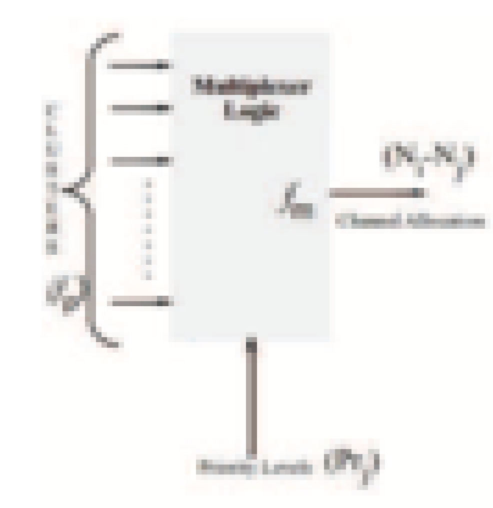

Fig. 2. Multiplexing logic

The output of fp is list of grouped packets having j number of elements. Let nr is a routing node having k links, then $\forall_P$(r, t) link, where $0 \le t \le k$, fp(r,t) can be defined as:

$$L[j] \leftarrow fp(r,t) \ (P(r,t) [n], Pr[j]) \quad (3)$$

where n is the number of packets in (r, t) links.

Each clusters of packets obtained as elements of Lj should be mapped to the next node respectively on the basis of priority in every slot. This task is done by a multiplexer fm [Figure 2], which selects best candidate from the list returned by fp.

The output of fm for a given Pi is serialized by fme to generate Yi $\in$ Y such that Y $\subset$ N. The efficiency of N. The efficiency of fme depends on different parameters of X $\in$ S:

a. Best Case: $[L0(i,j) / (n_i,n_j)] \leq T0(i,j) \sqcap CC(i,j)$, for agiven (n_i, n_j). $t{=}0\ t$

In this case, the time critical cluster L0 will cross the n_r without any delay in first sub-division of time band T0. In the remaining slots, the clusters $L1 - Lj$ having priority $(1 - j)$ in one to one correspondence are distributed using flow balance equation as P given in equation (1). This depends on the inflow rate (Σ^k λ) and the probability $Prob_i \in p_i$ to be assigned to next link (n_j, n_k),

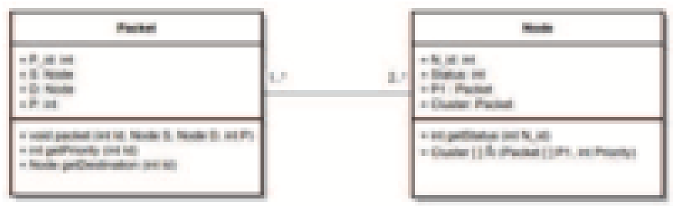

Fig. 3. Class Diagram

which is a part of the best route for p_i. The probability, $Prob_i$ has linear relation with Priority Pr_i of p_i .

For any two clusters L_k and L'_k having priority pr and pr' respectively, where pr > pr'. fmc assigns L_k to (n_r, n_t) and L'_k to (n_r , n'_t) such that $(n_r, n_t) < (n_r, n'_t)$, both n_t and n'_t have reachability to specified destination.

b. Worst Case: $[L0(i,j) / (n_i,n_j)] \leq T0(i,j) * CC(i,j)$, for agiven (n_i, n_j).

In this case, higher prioritize clusters will have to wait for next T0 slots at node n_r which will be available after k clock cycles, where k is the number of links connected from r. This results in worst case for delay sensitive entities.

The static view of the proposed system is represented as a class diagram given in figure 3. It displays two classes named as Packet and Node and associated data member and their behavior.

(b)Experimental Setup

In order to test the performance of the proposed routing method, vehicular traffic system is considered. Here the traveling entities act as packets having poison arrival rate and traffic signals or junction symbolizes the intermediately nodes n_i. The link capacity depends on the connecting paths between two junctions. The priority level depends on the criticality of the class of vehicles. The algorithm alters the signaling pattern of a traffic signal by sub-diving the available time slot to fill the outgoing links with high prioritized vehicles.

To construct the large road network and generate vehicle traffic, a realistic open source traffic generator, Simulation of Urban Mobile (SUMO) [17] is used. In the simulation, random routing request is generated, which are measure input to the proposed algorithm. For topologies of roads, the road network is constructed by extracting the data from open Street Map [18] and converting it to sumo compatible map using Net convert [19].

IV CONCLUSION

Various applications have some data sets that are not delay- tolerant, so their delivery to the specified destination is a time critical event. This paper proposes a routing methodology based on Knapsack problem algorithm applicable in such scenarios of various domains such as traffic algorithm, wireless network, etc. Knapsack Problem is successfully tested based on the proposed algorithm.

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