

Multiprocessor Stochastic Model for Elastic Traffic with Different Service Capacity

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ABSTRACT

Mobile ad hoc network (MANET) is a self-organized mobile nodes group that is connected fairly with low wireless bandwidth links. This manuscript proposes an innovative efficient queuing architecture, which supports for both elastic and inelastic traffic arises real time world. Packets or jobs of inelastic flows are always preferred for service comparing to those of the elastic flows. If any link is significantly weighted down by the inelastic traffic, it causes in great delays. To sort the problem the virtual queue algorithm gives the veteran delay compare to virtual queues that are served at a fraction of the actual service rate and by using the virtual queue-length values in utility function.

Keywords - Ad hoc networks, multiprocessor queuing model, dynamic waiting room, mobile networks.

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I. INTRODUCTION

Mobile ad hoc network (MANET) is a group of self-organized mobile nodes that are associated with comparatively low bandwidth wireless links. Each node has its own area of control, which is called a cell, only within which others can receive its transmissions. In MANET, there is no fixed infrastructure [1, 2]. Consequently, when nodes are free to ramble, the network topology may change rapidly and randomly over time, and nodes automatically make their own accommodating infrastructures [3]. There is a range of applications of MANET like video conferencing, rescue operations, military applications, disaster management, etc.

Many popular machine-learning algorithms have also been adopted for use in analyzing association studies. Notable examples are decision trees (both bagged, i.e. random forests, [4] and boosted support vector machines (SVM), Bayesian networks], and neural networks [5]. In particular, tree-based methods such as random forests and boosted decision trees have been found to perform well in a variety of association study analyses. Machine learning approaches are appealing because they assume very little a priori about the relationship between genotype and phenotype, with most methods being flexible enough to model complex relationships accurately. Both types of tree based methods (bagged and boosted) can provide measures of relative variable importance, but these indicators lack measures of uncertainty, so they are unable to determine how likely a variable's relative importance score is to occur by chance without resorting to permutation testing.

Queuing in mobile ad hoc network Queuing resolves the discipline for ordering entities in a queue [6-9]. It describes the way in which resources are divided as packets and the order in which they are served. Queuing mechanisms control the transmission process by indicating which packets must be transmitted and which packets must be dropped. It affects the packets latency qualified by

finding the waiting time of the packet. Some examples of queuing are first in, first out (FIFO); last in, first out (LIFO); priority queuing (PQ); the shortest is served first; service in random order; round robin, random exponential marking (REM); etc.

II. ADVANTAGES AND ISSUES OF QUEUING IN MANET

There are some advantages of queuing in MANET since it resolves the discipline for ordering entities in a queue and traffic distribution; packet scheduling affects the performance of multipath routing in mobile ad hoc networks. Therefore, queuing can reduce the re-sequencing delay. The packet scheduling intends to assign packets in a proper order to minimize the re-sequencing delay. It can also evade the transmission delay and packet loss in the network. Nodes should delay the assembly of new route passing through them when their load level is high. By proper scheduling, as the channel is shared fairly, the throughput is high even at moderate mobility [10]. Scheduling can provide strict bandwidth allocation assurance since no transmission conflicts exist.

There are some issues of queuing in MANET. The queuing techniques play the most important factor in service differentiation. Implementation of conventional priority queuing strategy in MANET [10] is considerably complex. Taking an example, firstly, [11, 12] a simple priority queue makes sure that high-priority packets are given unqualified preference over low-priority packets as proposed in the flexible quality of service (QoS) model for MANETs [13, 16]. Secondly, they are regarded as a FIFO queue, which they improve with a mechanism called random early discard with in/out buffer management. In the same way, service differentiation in stateless wireless ad hoc networks [14, 15] also theoretically employs a priority queue but confines the amount of real-time traffic for protecting the lower-priority traffic from starvation [17].

III. ELASTIC AND INELASTIC TRAFFIC

Inelastic traffic does not easily adapt to changes in delay and throughput. Real-time multimedia (audio streaming, video, VoIP) is an example of inelastic traffic. Inelastic traffic needs special treatment, while elastic traffic could perceptibly also benefit from such treatment. In general, the quality of wireless links would be affected by many factors like collisions, fading or the noise of environment.

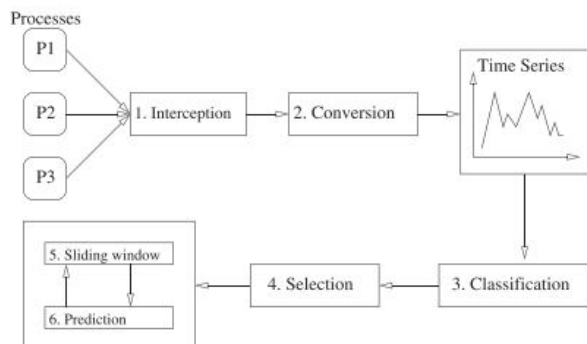


Fig 1. Schematic diagram for predictive approach

A token-based resource allocation technique is proposed for multiservice flows in MANET. In that technique, it is assumed that the nodes cycle has three states such as noncritical section (NCS), entry section (ES) and critical section (CS). During deployment, the node is in NCS state, and after receiving the unique tokens, it enters into CS state [18]. The scheduler sends the resource request message in different queues using fuzzy-based flow prioritization technique. If the available resource exceeds the required resource, the scheduler allocates the inelastic service similar to the available resource until the inelastic queue gets empty. Then the token is passed to the queue that contains elastic service flows. Based on simulation results, the proposed approach allocates the resources efficiently.

As an extension, this work proposes an effective queuing architecture that can handle both elastic and inelastic traffic flows and assign different dropping precedence for different priority of traffic. The solutions of this work prove that the proposed architecture offers better fairness and delivery ratio with reduced delay and drop [19].

IV. EXISTING AND RELATED WORK

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Packet scheduling discussed that connected to traffic assignment and packet in MANET. This work proposes a packet scheduling framework to study the effect of scheduling strategy on the re-sequencing delay. Two packet-scheduling schemes uniform round scheduling (URS) and non-uniform round scheduling (NURS) based on the optimal traffic distribution were studied in this work, and it was analyzed that URS scheme outperforms the NURS one. Furthermore, by increasing the round length, the URS scheme supplementary decreases the re-sequencing delay. The authors modeled every path as a multiple-node M/M/1 tandem network. They assume that the end-to-end path delay follows the normal distribution. The performance metric like end-to-end path delay and re-sequencing delay is discussed in this paper. When average arrival rate λ is increased, the time in every queue is increased by which re-sequencing delay is also increased. Saritha et al. [8] proposed a cross-layer mechanism for scheduling. Cross-layer mechanism is able to overcome many challenges for QOS due to excessive channel sharing. By adopting cross-layer approach to determine the order of the nodes, the packets will be scheduled to give a very high throughput. In this mechanism, when packet loss and retransmission is essential, still the nodes get sufficient time to serve those nodes. Because of time loss, all the other nodes are finished. These techniques significantly reduce latency and losses. The mechanism needs to improve this technique by adopting a suitable bandwidth estimation mechanism as one of the parameters for scheduling.

A research problem related to efficiency and fairness of ad hoc networks is discussed in the paper [13]. This work proposes a novel and efficient contention-based back off mechanism for wireless ad hoc networks, which is adaptive efficiency-fairness tradeoff (AEFT) back off algorithm. The authors increase the contention window at the time when channel is busy, then use an adaptive window to reduce the back off time when the channel is idle by fair scheduling. The fair scheduling principally adopts maximum successive transmission and collision limit to terminate the fairness. This algorithm provides a larger fairness index and a tradeoff between efficiency and fairness.

The proposed model can improve total throughput. Performance metrics like back off time, threshold and efficiency have been discussed in this paper. The proposed algorithm needs to address the continuous maximum successive transmission and the deferring or collision limit problem.

Mamatha et al. [20] discussed about the problem on feedback and blocking system in the smart antenna system in wireless ad hoc networks. The authors propose a novel

directional network allocation vector-based packets scheduling (DBPS) algorithm in this paper. The proposed DBPS algorithm uses the DNAV information and chooses the fittest packet in the smart antenna system. It makes greatest of the communication status of the neighbor nodes and is further adaptive to the network topology.

Hence, nodes can efficiently extend the spatial reuse and address the HOL blocking problem [21]. The proposed algorithm improves the throughput greatly and decreases the interference. It needs to study the performance of the DBPS algorithm in the more complex network topology and to extend to some multihop scenarios.

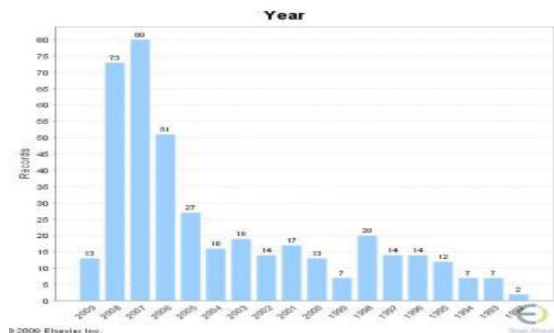


Fig 2. FPGA Multiprocessor systems publication records

A novel model is proposed distributed scheduling and active queue management mechanism for wireless ad hoc networks. This approach is based on a random access scheduler where the transmission-attempt probabilities depend on the local backlog. This mechanism is simple and able to be implemented in a distributed fashion. The proposed scheduling mechanism needs only a redefinition of the transmission probabilities at personage nodes. The proposed algorithm shows high throughput and fair bandwidth allocation. This algorithm suffers from the exposed terminal problem. Approaches to avoid this problem by improving the channel feedback need to be investigated.

Jaramillo and Srikant converse the predicament of congestion control and scheduling in ad hoc wireless networks that must support a combination of best-effort and real-time traffic. This work proposes an optimization framework for the problem of congestion control and scheduling of elastic and inelastic traffic in ad hoc wireless networks. Authors presented a decomposition of the problem into an online algorithm that can make best possible decisions at the same time as keeping the network stable and satisfying the inelastic flow's QoS constraints.

Example of Trace File

pid	inode	amt	time	op
p41	f0	313	24	r
p89	f3	94	171	w
p10	f9	92	81	w
p32	f0	826	132	w
p69	-	-	76	d
p1	f5	292	70	w

The scheduling problem for elastic and inelastic flows in a common framework by using deficit counters. Performance metrics like throughput are discussed in this paper. The channel state is considered constant during the entire frame in this work; study of this framework in the unknown channel state case is still needed. Traffic model for inelastic packets assumes that packets arrive at the beginning of the frame and all have the same delay, but it is not possible that all frames have the same delay, so it should be discussed in this framework with regards the difference in frame delay.

V. THE PROPOSED MARKOV MODEL

The systems that are of interest are modeled by two-dimensional Markov processes on semi-infinite lattice strips. The state of the system at time t is denoted by two integer valued random variables, $I(t)$, $J(t)$; $I(t)$ taking a finite set of values and $J(t)$, an infinite set of values. Without loss of generality, we can assume the minimum value of $I(t)$ is 0 and the maximum is N . The minimum value of the random variable $J(t)$ is 0 and it can take values from 0 to ∞ . The Markov process is denoted by $X = \{I(t); J(t) ; t \geq 0\}$. We assume this is irreducible with a state space $\{0, 1, \dots, N\} \times \{0, 1, 2, \dots\}$. For the convenient depiction, it is assumed that $I(t)$ varies in the lateral or horizontal direction and $J(t)$ is represented in the vertical direction of the semi-infinite rectangular lattice strip. The possible transitions that underlie this Markov process are given by:

- A_j – purely lateral transitions – from state (i, j) to state (k, j) , $(0 \leq i, k \leq N ; i \neq k ; j = 0, 1, 2, \dots)$;
- B_j – one-step upward transitions – from state (i, j) to state $(k, j + 1)$, $(0 \leq i, k \leq N ; i \neq k ; j = 0, 1, 2, \dots)$;
- C_j – one-step downward transitions – from state (i, j) to state $(k, j - 1)$, $(0 \leq i, k \leq N ; i \neq k ; j = 1, 2, \dots)$;

As it is seen above, the possible change in J in any transition is either +1 or -1 or 0. Later in this chapter, we shall also consider the Markov process Y for finite state space and Z in which multi-step jumps in J are possible. A_j , B_j and C_j are the transition rate matrices, square matrices each of size $(N + 1) * (N + 1)$, associated with (a), (b) and (c) respectively. Thus, $A_j(i, k)$, $(i \neq k)$ is the transition rate from state (i, j) to state (k, j) , and $A_j(i, i) = 0$. $B_j(i, k)$ is the transition rate from (i, j) to $(k, j + 1)$. $C_j(i, k)$ is the transition rate from (i, j) to $(k, j - 1)$, initially $C_0 = 0$, by definition. We assume the process has a threshold, an integer M , $(M \geq 1)$ such that the instantaneous transition rates of (a), (b) and (c) do not depend on j when $j \geq M$ in the case of (a), $j \geq M - 1$ in the case of (b), and when $j \geq M$ for (c). In the following chapters, it can be seen that such a threshold does exist in a large variety of real world problems occurring in computing and communication systems. Hence from this, we have

$$A_j = A, j \geq M ; B_j = B, j \geq M - 1, C_j = C; j \geq M + 1 \quad (1)$$

When the process is irreducible and the corresponding balance equations of the state probabilities have a unique normalized solution, we say the process is ergodic and in this case there exists a steady state for this process. The

objective of this analysis is to determine the steady state probability $p_{i,j}$ of the state (i, j) in terms of the known parameters of the system. $P_{i,j}$ is defined as:

$$P_{i,j} = \lim_{t \rightarrow \infty} P\{I(t) = i, J(t) = j\}; \quad i = 0, 1, 2, \dots \quad (2)$$

Let D_j^A, D_j^B and D_j^C be the diagonal matrices, of size $(N+1) \times (N+1)$ each, defined by their i^{th} diagonal element as,

$$D_j^A(i,i) = \sum_{k=0}^N A_j(i,k), \quad D_j^B(i,i) = \sum_{k=0}^N B_j(i,k), \quad D_j^C(i,i) = \sum_{k=0}^N C_j(i,k) \quad (3)$$

In other words, the i^{th} diagonal element of each of these diagonal matrices is the i^{th} row sum of the corresponding transition rate matrix. Then we also get similar diagonal matrices D^A, D^B and D^C for A, B and C respectively.

$$D^A(i,i) = \sum_{k=0}^N A(i,k), \quad D^B(i,i) = \sum_{k=0}^N B(i,k), \quad D^C(i,i) = \sum_{k=0}^N C(i,k) \quad (4)$$

VI. STOCHASTIC MEASURES

All the states in a row of the lattice Markov process have the same value j for the unbounded random variable J(t). Similarly, any column consists of states with same i. Here, it is mathematically convenient to define the row vectors V_j as,

$$V_j = [P_{0,j}, P_{1,j}, \dots, P_{N,j}]; \quad j = 0, 1, 2, \dots \quad (5)$$

Thus, the elements of V_j are the probabilities of all states in a row, where $J = j$. In order to solve for the probability distribution $\{P_{i,j}\}$, it is necessary to solve the balance equations. It is mathematically more elegant to work with vectors V_j compared to $P_{i,j}$. The steady state balance equations satisfied by the vectors V_j are:

$$V_j[D_j^A + D_j^B + D_j^C] = V_{j-1}B_{j-1} + V_jA_j + V_{j+1}C_{j+1}; \quad j = 0, 1, \dots, M-1 \quad (6)$$

$V_{-1} = 0$ by definition. And, the balance equation for $j \geq M$:

$$V_j[D^A + D^B + D^C] = V_{j-1}B + V_jA + V_{j+1}C; \quad j \geq M-1 \quad (7)$$

The equations represented in (2.7) are infinite in number for infinite queue. In addition to them, we have another equation resulting from the fact that all the probabilities $P_{i,j}$ sum to 1.0:

$$\sum_{j=0}^{\infty} V_j e = 1.0 \quad (8)$$

Where e is the column vector having $N+1$ elements and that are equal to 1. This definition of e , column vector is valid throughout this thesis.

$$V_j Q_0 + V_{j+1} Q_1 + V_{j+2} Q_2 = 0; \quad j = M-1, M, \dots \quad (9)$$

where $Q_0 = B$, $Q_1 = A - D^A - D^B$ and $Q_2 = C$. This is a homogeneous vector difference equation of order 2, with constant coefficients. $Q(\lambda)$ is the characteristic matrix polynomial associated with this difference equation.

$$Q(\lambda) = Q_0 + Q_1 \lambda + Q_2 \lambda^2 \quad (10)$$

We also refer to $Q(\lambda)$ as the characteristic matrix polynomial of the Markov process X. The solution of (2.9) is closely related to the eigen values and the left-

eigenvectors of $Q(\lambda)$. Let (λ, ϕ) be an eigen value-eigen vector pair of $Q(\lambda)$, thus satisfying the equation:

$$V_j = \sum_{k=0}^{d-1} a_k \phi_k \lambda_k^{j-M+1}; \quad j = M-1, M, \dots \quad (11)$$

In the state-probability form:

$$P_{i,j} = \sum_{k=0}^{d-1} a_k \phi_k(i) \lambda_k^{j-M+1}; \quad j = M-1, M, \dots \quad (2.13)$$

where a_k ($k = 0, 1, \dots, d-1$) are arbitrary constants, some of them may be complex.

In order to get the relevant solution from the general solution, let us consider some of the known steady state properties of the probability distribution. We know the sum of the probabilities of all states in any column is less than 1 though these states are infinitely many. Now consider the probability sum,

$$\sum_{j=M-1}^{\infty} P_{i,j} = \sum_{j=M-1}^{\infty} \sum_{k=0}^{d-1} a_k \phi_k(i) \lambda_k^{j-M+1}$$

The above is the sum of probabilities of all states in the i^{th} column that are above $j \geq M-1$.

VII. VIRTUAL QUEUE ALGORITHM

The packets from the inelastic flows have strict priority over their elastic counterparts because the inelastic applications are delay sensitive. Hence, the inelastic flows are not able to see the elastic flows in the queues in which they traverse. However, in some situations, the link might be critically loaded by the inelastic traffic itself resulting in huge delays. The elastic traffic also has some slight delay constraints. By applying virtual queues, which serves at the fraction of the actual service rate, and using the virtual queue-length values in utility function, the experienced delay can be reduced.

VIII. CONCLUSION

In this paper we projected queue based architecture for elastic as well as inelastic traffic for service. If a link is critically loaded by the inelastic traffic, then it causes a large delay. Consequently elastic traffic also has delay constraints. For this virtual queue algorithm is used to reduce the delay using virtual queues and virtual queue-length values. The optimization framework is used where scheduling algorithm allocates the resource fairly in the network. Based on priority, the packets are classified as low-, medium- and high-priority data packet for drop preference. Schematic results are proved for the proposed architecture for better fairness and delivery ratio that reduces delay and drop.

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