Cell-level Simulation with ATM Traffic Monitoring Tool

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I. Introduction

Internet traffic is growing rapidly world-wide, and the proliferation of new applications is causing its characteristics to change. In such new telecommunication environments, capturing traffic characteristics is an important issue for economical development and evaluation of new technologies. Here, we propose an approach that is based on traffic monitoring with a measuring equipment.

II. Traffic monitoring with CapTie

Traffic modeling in the ATM layer requires traffic data with fine granularity. However, it is often difficult because the priority of traffic measurement supported by the network nodes is not very high. In order to solve such diffuculty, we use CapTie [4], which is a traffic measuring tool developed based on the header trace mode of OC3MON [1]. It is software that works on a PC with network interface cards (NICs). The PC equipped with CapTie is tapped at a pair of OC3 links by using optical splitters (Figure 1). CapTie can offer the the sequence of cell/packet arrivals with timestamp.

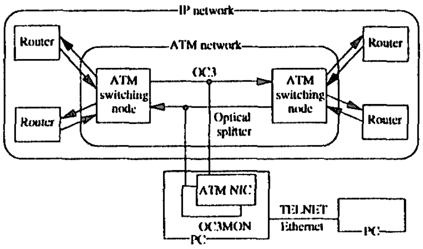

Fig. 1: Traffic monitoring by OC3MON

III. Real-Time Simulation

A. Estimation of an arrival sequence

From the measured cell/packet arrival sequence data, we first need to reproduce the cell/packet arrival sequence at the network node. Since CapTie is tapped at an output link (Figure 1), what we can observe is not the cell/packet arrival sequence but the cell/packet transmission sequence. Therefore, our simulation tool incorporates an algorithm for estimating the arrival sequence from the transmission sequence.

Here, we adopt a simple algorithm for estimating an arrival sequence from a transmission sequence. (For another algorithm and comparison between them, see [4].) Actually, we can observe the time instance when the first cell of each packet passes a certain point of a link and then observe how many cells belong to the same packet and will pass the point. With this information, the simple cell arrival sequence estimation (S-CASE) algorithm estimates the arrival instance of each cell at the arrival observation point.

Let $t(i)$ be the observed timestamp of the first cell of the i-th packet, and let $n(i)$ be the number of cells belonging to the i-th packet. Let H be the input link capacity where we assume for simplicity that each input link has the same link capacity. Let L be the length of a cell. The following estimated arrival epoch of the j-th cell belonging to the i-th packet, $t(i,j)$, is provided by the S-CASE algorithm, as

$$t(i,j) = t(i) + (j-1) * L/H. \qquad (1)$$

The S-CASE algorithm assumes implicitly that the first cell does not wait for any time in the transmission queue and that the remaining cells arrive at the input link speed without interruption (see Figure 2).

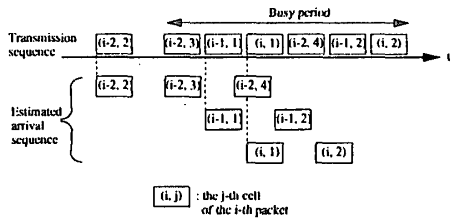

Fig. 2: Example of the event sequence

B. Queue deacy parameter method

The arrival sequence algorithm in the previous section can (approximately) reproduce the cell arrival sequence at the multiplexing point (the transmission queue) of a switching node. With that sequence, the simulator in the post-processing PC can simulate an output link with different bandwidths in order to solve dimensioning problem.

Here, we describe a simple and heuristic bandwidth dimensioning method based on the buffer occupancy measurement. We call this method the queue decay parameter method. Consider a single server queueing model as a model of the transmission queue in an ATM switching node. From the result of the large deviation principle and related works (e.g., see [3]), the asymptotic behavior of the queue length Q is expressed as

$$p(k) \equiv P\{Q \geq k\} \simeq a \exp(-bn(k)), \qquad (2)$$

where a and b are constants and $n(k)$ is a function of k. Figure 3 shows the distribution $p(k)$ through the simulation with 44 samples. From the figure, we can observe that the decay parameter a is nearly equal to 1. Moreover, the decay of the queue length seems exponential. Therefore,

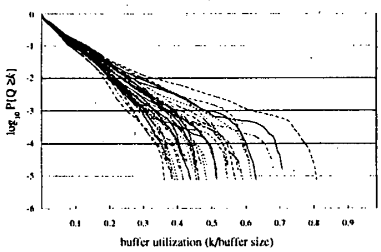

Fig. 3: Queue length distribution

$n(k) = k$ and the traffic is considered to have short-term dependence. As a result, we have a simple approximation formula

$$p(k) \simeq \exp(-bk). \qquad (3)$$

Equation (3) is similar to the M/M/1 queueing model with different values of b. In the M/M/1 case, $b = -\log(r)$ where r denotes the utilization. In Figure 3, each sample gives the ratio of $-\log(r)$ to b between 6 to 11, which is greater than the M/M/1 case (because of the burstiness of the input traffic). With the same samples, we tested the values of $-\log(r)/b$ for different VP bandwidths, varying from 15 to 40 Mbps, in Figure 4. For each sequence of data, the values of $-\log(r)/b$ were almost constant, where the bandwidth takes a value in the range of 15-30 Mbps. From those observations, we finally obtained a simple bandwidth control method as follows.

1. Measure the utilization r_m and queue length distribution $p(k)$ for a certain k.
2. Estimate the decay rate b_m by $b_m = -\log(p(k))/k$ (see (3)).
3. With objective cell loss ratio CLR_o and buffer size K, estimate the desirable decay rate b^* that satisfies $p(K) = CLR_o$, by $b^* = -\log(CLR_o)/K$.
4. Assume that $-\log(r)/b$ is constant, and calculate the utilization r^* when $p(K) = CLR_o$ by solving the formula
$$-\log(r^*)/b^* = -\log(r_m)/b_m. \qquad (4)$$
5. Dimension the bandwidth so that the utilization becomes r^*.

When the ratio $-\log(r_m)/b_m$ in (4) changes in some range, conservative management is possible with the greatest value, because a larger value will lead to lower utilization r^*.

IV. Numerical example of real-time simulation

The developed system was applied to a bi-directional link in SINET (the Science Information Network) [2], which is a nationwide large IP network for research organizations in Japan, whose core network is implemented on an ATM network. The monitored link was between the University of Tokyo and the NACSIS (National Center for Science and Information Systems) network office. As mentioned in the previous section, the bandwidth of each link was dimensioned using the queue decay parameter method based on data measured in the week before this trial by an ATM switching node accommodating the link. The CLR objective was 10^{-6}.

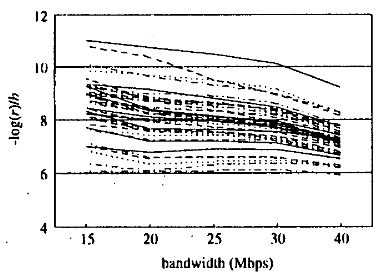

Fig. 4: $-\log(r)/b$ vs. bandwidth

Figure 5 plots the CLR of each link simulated by the real-time simulator for one hour during a busy hour. The CLR obtained by the simulator almost agreed with the objective. (In our experience, the CLR is a very difficult parameter to manage, so the agreement was actually far better than we expected.)

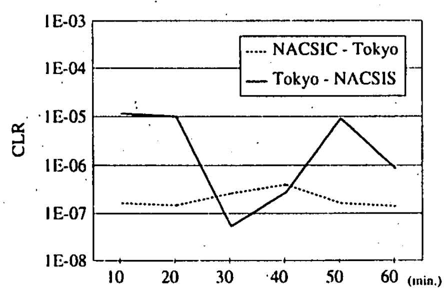

Fig. 5: The CLR during a busy hour

V. Conclusion

We have developed traffic monitoring equipment called CapTie and a real-time simulator using data from CapTie. The cell arrival sequence estimation methods used in it were evaluated. Using these two systems, the proposed dimensioning method was evaluated for real IP traffic data on an ATM network and shown to be accurate. The developed system enables us to implement a new approach for network engineering. We will apply the system to the self-sizing network in the near future.

Acknowledgments

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