Control Architecture for Tuning First-Order and Second-Order Statistics of Traffic

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Outline

- Discussion on limitations of one-dimensional queue management
- Brief description of our proposed new congestion control architecture
- Simulation results

General Method of Congestion Control

- A model is chosen (such as a rate-based model or an average-queue-length model) to characterize queueing status.
- Based on the output of the model, routers determine the congestion degree, and act accordingly by either dropping or marking packets.
- End-systems respond to these droppings or markings by adapting output traffic.

Limitations of One-Dimensional Queueing Characterization Models

- Both *rate-based model* and *average-queue-length model* are referred to as ***one-dimensional*** models.
- Rate-based model is only the first-order approximation of arrival traffic. It can not determine the queueing behavior by its own.
- Average-queue-length model characterizes the average queueing status of a queueing system, but there is no clear or simple mapping between the model and traffic characteristics.

Two-Dimensional Queueing Characterization Model

- Two metrics — utilization factor ρ and burstiness factor η, are used in this model.
- ρ and η are independent
- ρ is determined by first-order statistics of traffic.
- η is determined by second-order statistics of traffic.

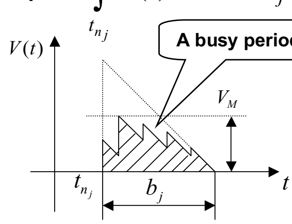
Calculation of ρ and η

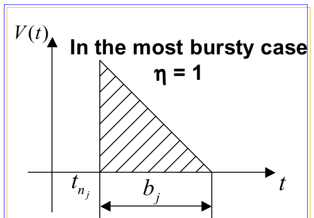
ρ is defined as

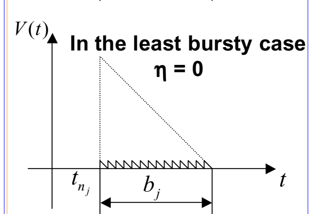
ρ = *arrival_rate/link_speed*

η is defined as

$$\eta = \int_{t_{n_j}}^{t_{n_j}+b_j} V(t)dt / 0.5b_j^2$$



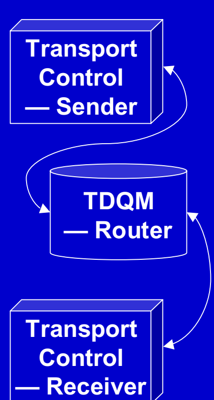




Property of η

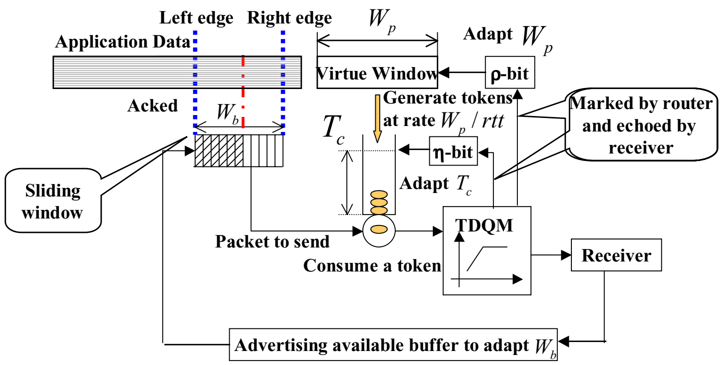
- η is dimensionless and monotonically related to Hurst Parameter *H*
- Both η and *H* take values in the same range as [0,1]
- In extreme cases, such as very bursty cases ($\eta \rightarrow 1$) and very smooth cases ($\eta \rightarrow 0$), calculated η is very close to *H*

Architecture Components



- **New architecture consists of *Two-Dimensional Queue Management (TDQM)* and *Transport Control*.**
- ***TDQM* marks packets with either *ρ-bits* or *η-bits* or both based on measured queue's *utilization factor* and *burstiness factor*.**
- ***Receiver* echo back all marked bits in ACK packets, and *sender* adapts the characteristics of output traffic according to these echoed bits.**

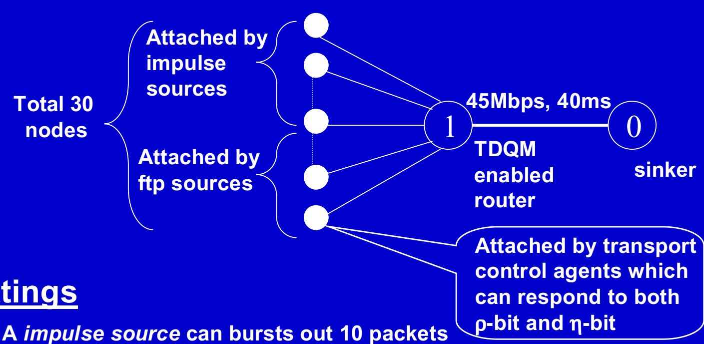
Operation



General Algorithm of TDQM

for each packet arrival
    calculate the average utilization factor ρ
        if min_ ρ_th < ρ < max_ ρ_th
            calculate probability P_ρ
            with probability P_ρ:
                mark the arriving packet with a ρ-bit
        else if max_ ρ_th < ρ
            mark the arriving packet with a ρ-bit
    calculate the average burstiness factor η
        if min_ η_th < η < max_ η_th
            calculate probability P_η
            with probability P_η
                mark the arriving packet with a η-bit
        else if max_ η_th < η
            mark the arriving packet with a η-bit

Case Study—A Simulated Network

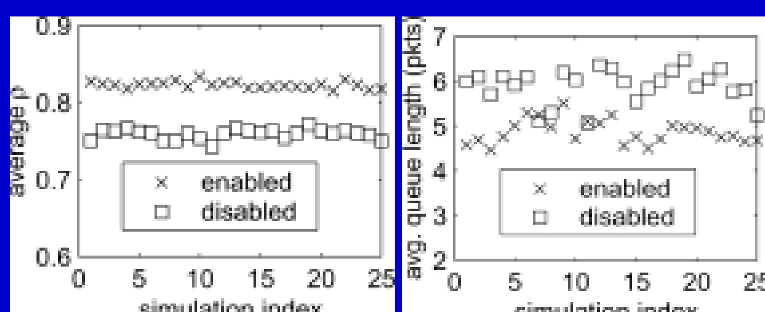


Settings

A *impulse source* can bursts out 10 packets per 40ms with packet size 1k byte/packet

[min_ ρ_th, max_ρ_th] = [0.9, 1.0]   [min_ η_th, max_η_th] = [0.1, 0.2]

Throughput and Queue Length



Comparisons between two group of simulations — in the group, when both ρ-loop and η-loop are enabled, the system can achieve higher throughput but maintain shorter average queue length than in the other group when only ρ-loop is enabled and η-loop is disabled.

Properties

- By conducting TDQM, this architecture can de-couple first-order and second-order traffic control.
- Due to the de-coupling, this architecture can achieve a throughput close to a pre-configure range, and at the same time tune the queueing behavior into a desired manor specified by the burstiness factor.
- It can serve both stream-like traffic and impulse traffic well.

Future Work

- More simulation study is needed to justify the benefit of conducting second-order traffic control.
- Explore reasonable system configuration parameters and optimal algorithms for calculating real-time smoothed ρ and η.
- We are considering a prototype implementation.

Let's make things better. Qiong Li 3/12/01 PHILIPS