Rate Based Congestion Control for the Internet

(work in progress)

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Outline

• Problem Statement
• The Model
• Rate Control Protocol (RCP)
• Future Work
Internet Congestion Control

Goals of a congestion control scheme:

– Limit flow rates to avoid "congestion"
– Use the network resources efficiently to minimize flow durations
– Ensure fairness in resource allocation among flows
Problem Statement

• Finding congestion control scheme for high bandwidth Internet
  – Link capacities will continue to increase
  – Conjecture: Flow sizes remain relatively constant
  – An increasing number of flows could finish within a round-trip time (RTT)

• Current congestion schemes:
  – Feedback based
  – Force flows to last multiple RTTs

• Short flows: flow size/link capacity << RTT
Example: A Short Flow

TCP Congestion Control

But the flow could finish within one RTT!

We want something like this!
Characteristics of the New Scheme

• **Open loop based:**
  – No feedback
  – Flow rate determined at start by interaction between routers and end-host

• **Flow/user centric** instead of packet centric

• Low flow response times

• Fair amongst flows
Assumptions

• Flows arrive according to a Poisson Process
• Flow sizes are independent and identically distributed
• Network consists of short flows only*

*Will be removed later
Optimal Solution

• Single bottleneck link
• Average flow delay minimized when:
  – Flows arrive as single entities
  – Shortest Remaining Processing Time (SRPT)
• Problems
  – Scheduler at output queue
  – Knowledge of flow sizes and per flow state
  – Large buffer
System Model

$M/G/1$ input process to a single server queue
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Observations and Intuition

• With an infinite buffer and $\rho < 1$
  – If flows come at maximum rate, they will be served
  – But maximum buffer occupancy may be large

• If flow rates are small
  – Load is smoother
  – Buffer requirement is lower
An Example

R = C

Load
Buffer Occupancy

R = C/2

Load
Buffer Occupancy
Rate Control Protocol (RCP)

Connection setup: 3-way handshake

Data packets sent at granted rate

Sender

Syn+Request Rate

Syn+Ack

+Granted Rate

Ack+Data

Receiver

Request rate granted or decreased by routers

Sender notified of granted rate
Rate Control Protocol: Router

• Router determines “n”
• Router grants rate $C/n$ to each flow
• This provides fairness amongst flows
• Choosing $n$ involves considerations of
  – Buffer requirement
  – And flow response time
RCP in Action

Request Rate
= 100Mb/s

Request Rate
= 20Mb/s

Request Rate
= 20Mb/s
M/G/1 Input Process

- Arrival process (flow start times) and departure process (flow finish times) are both Poisson($\lambda$)
- Number of active flows $N(t)$ is $\text{Poisson}(\lambda \mathbb{E} \tau) = \text{Poisson}(n\rho)$
- $\Pr\{\text{load}(t) > 1\} = 1 - \text{PoissonCDF}(n)$
- Given $\Pr\{\text{load}(t) > 1\}$, $n$ only depends on $\rho$!
How to Choose “n”

\[ \text{Prob}\{\text{load}>1\} = 1 - \text{Poisscdf}(n, n_\rho) \]
Simulation Comparison of TCP and RCP

Single bottleneck link of 100Mb/s; RTT=200ms; $\rho=0.8$; $n=8$; flow size~Uniform[50, 150]kB

*Pr{load(t)>1} from simulation matches theoretical values
Future Work

• Derive buffer distribution with different “G”
• Investigate effects of buffer size on RCP
• Intuitively, RCP should also work for long flows
  – Performance of RCP with long-tailed traffic, etc.
• User models: Interaction of load and network
• Find optimal $n$ which minimizes average delay