A Case for TCP-Friendly Admission Control

Adrian S-W. Tam, Dah-Ming Chiu, John C. S. Lui, Y. C. Tay

June 21, 2006

The Problem

- Given a network serving both elastic (TCP) and inelastic (UDP) flows
- Elastic flows perform congestion control and
  inelastic flows perform admission control but *not* congestion control

The Problem

- Given a network serving both elastic (TCP) and inelastic (UDP) flows
- Elastic flows perform congestion control and
  inelastic flows perform admission control but *not* congestion control
  - Yes, we know the *orthodox* way is TCP-friendly congestion control, but we assume they are performing admission control in this study

The Problem

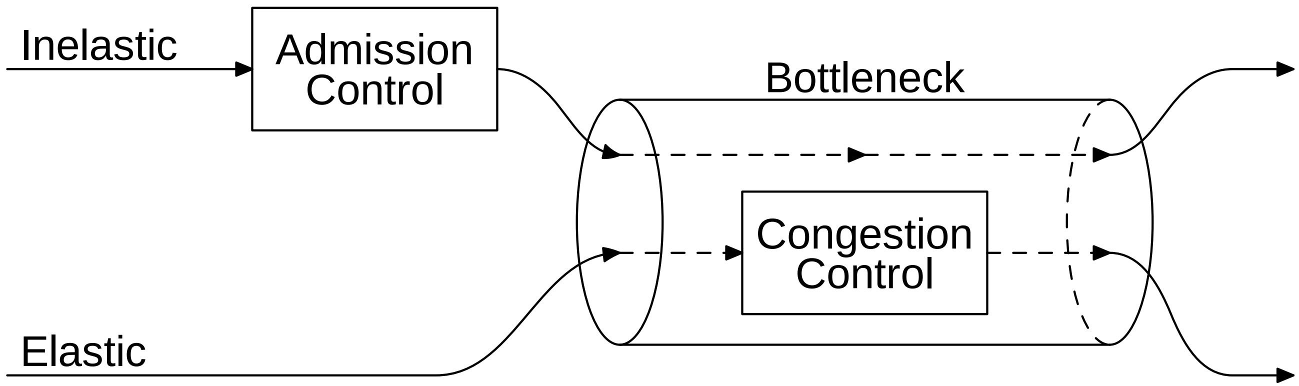
- Given a network serving both elastic (TCP) and inelastic (UDP) flows
- Elastic flows perform congestion control and
  inelastic flows perform admission control but *not* congestion control
  - Yes, we know the *orthodox* way is TCP-friendly congestion control, but we assume they are performing admission control in this study
- How would admission control performed by inelastic flows affect the network?
  - Is it effective in avoiding congestion?
  - Would it be friendly to elastic (TCP) flows?

Admission Control

- Admission control is to decide whether a flow can use the network or not
- Generally, admission control is a function of
  - The nature of the flows (duration, data rate, etc.)
  - The nature of the network (bottleneck capacity, number of elastic flows, number of inelastic flows, etc.)

Modelling

- Assume the single-bottleneck network has two kinds of flows:
  - Elastic flows: FTP flows, using TCP congestion control
  - Inelastic flows: Video streaming, no congestion control but have a desired data rate α
- Network's bottleneck bandwidth is normalized to 1
- Elastic flows will share the available bandwidth equally
- Inelastic flows will consume bandwidth α unconditionally
  - Have priority to use the bandwidth
  - But they have to do admission control first



Abstract Algorithm

We model both congrestion control and admission control as fluid and with no feedback delay

An *idealized* algorithm of admission control for inelastic flows:

1. Parameters given: α, ϵ
2. Probe and check if $n\epsilon + (m+1)\alpha > 1$
   - Where n is the number of elastic flows and m the number of inelastic flows using the network
   - If the inequality is true, refuse to use the network
   - Otherwise, join the network and send data constantly at rate α

Parameter α depends on the content of the stream

Parameter ϵ is knob for adjusting the aggressiveness of admission control

Dynamics

- Poisson arrival for both elastic and inelastic flows
  - Elastic flows' arrival rate: λ_{e}
  - Inelastic flows' arrival rate: λ_{i}
- All flows are finite, and in certain distribution
  - Mean file size of elastic flows: μ_{e}
  - Mean holding time of inelastic flows: μ_{i}
- Define: $\rho_{\mathrm{e}} = \lambda_{\mathrm{e}}/\mu_{\mathrm{e}}$ and $\rho_{\mathrm{i}} = \lambda_{\mathrm{i}}/\mu_{\mathrm{i}}$

The stability of network depends on elastic flows only ($\rho_{\mathrm{e}} < 1$).

- Independent of inelastic flows because they have admission control
- When the network is severely congested, the elastic flows will accumulate, which prohibits new admission of inelastic flows.
- Eventually, the network has only elastic flows, thus the stability depends only on them
- Details are in Section III.B

See also Peter Key et al, “Fair internet traffic integration: Network flow models and analysis”, Annales des Telecommunications, 2004. (A different model but similar conclusion)

Aggressiveness

(in section IV.B)

- τ: The remaining work in the network
- N_{e}: Poisson counter with rate λ_{e}
- N_{i}: Poisson counter with rate λ_{i}
- $\mathbf{1}(\cdot)$: Indicator function
- $I(n,m)$: Admission control

$$d\tau = -\mathbf{1}(\tau > 0)dt + S_{\mathrm{e}} dN_{\mathrm{e}} + I(n,m) S_{\mathrm{i}} dN_{\mathrm{i}}$$

(in section IV.B)

- τ: The remaining work in the network
- N_{e}: Poisson counter with rate λ_{e}
- N_{i}: Poisson counter with rate λ_{i}
- $\mathbf{1}(\cdot)$: Indicator function
- $I(n, m)$: Admission control

$$d\tau = -\mathbf{1}(\tau > 0)dt + S_{\mathrm{e}}dN_{\mathrm{e}} + I(n, m)S_{\mathrm{i}}dN_{\mathrm{i}}$$

(a Poisson-counter driven stochastic differential equation — PCDSDE)

Take expectation:

$$dE[\tau] = -E[\mathbf{1}(\tau > 0)]dt + E[S_\mathrm{e}]E[dN_\mathrm{e}] + E[I(n,m)]E[S_\mathrm{i}]E[dN_\mathrm{i}]$$
$$= -\Pr[\tau > 0]dt + \frac{1}{\mu_\mathrm{e}} \cdot \lambda_\mathrm{e} dt + \Pr[I(n,m) = 1] \cdot \frac{\alpha}{\mu_\mathrm{i}} \cdot \lambda_\mathrm{i} dt$$
$$\frac{dE[\tau]}{dt} = -\Pr[\tau > 0] + \rho_\mathrm{e} + \Pr[I(n,m) = 1]\alpha\rho_\mathrm{i} = 0$$
$$R = \Pr[I(n,m) = 1]$$
$$= \frac{\Pr[\tau > 0] - \rho_\mathrm{e}}{\alpha\rho_\mathrm{i}}$$
$$R = \frac{\rho' - \rho_\mathrm{e}}{\alpha\rho_\mathrm{i}}$$

where $\rho' \approx min(\rho, 1)$ and $\rho = \rho_\mathrm{e} + \alpha\rho_\mathrm{i}$

Significance of ϵ

Admission probability R is independent of aggressiveness ϵ

Therefore,

- For inelastic flows,
  - Inelastic flows are either admitted or rejected
  - The performance measure depends on the probability of admission only in other words, it is independent of ϵ

Admission probability R is independent of aggressiveness ϵ

Therefore,

- For inelastic flows,
  - Inelastic flows are either admitted or rejected
  - The performance measure depends on the probability of admission only in other words, it is independent of ϵ
- For elastic flows, the performance does depend on ϵ
  - If we set $\epsilon = \alpha$, we guarantee elastic flows receive bandwidth no less than that of inelastic flows
  - If $\epsilon < \alpha$, then elastic flows will be worse off

Admission probability R is independent of aggressiveness ϵ

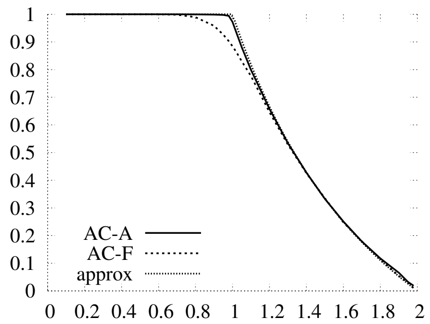
Therefore,

- For inelastic flows,
  - Inelastic flows are either admitted or rejected
  - The performance measure depends on the probability of admission only in other words, it is independent of ϵ
- For elastic flows, the performance does depend on ϵ
  - If we set $\epsilon = \alpha$, we guarantee elastic flows receive bandwidth no less than that of inelastic flows
  - If $\epsilon < \alpha$, then elastic flows will be worse off
- Therefore, it does not hurt for inelastic flows to perform “TCP-friendly admission control” (i.e. $\epsilon = \alpha$)

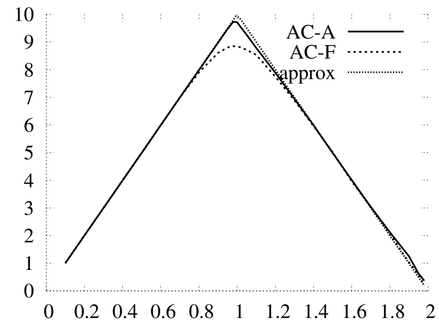
Verification by Simulation

- We verified our result by using a simulation of the *fluid* network
- Simulation result agrees asymptotically

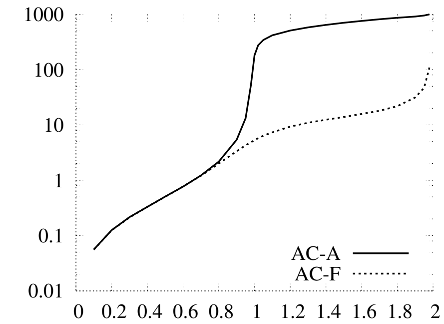
R vs. ρ



m vs. ρ



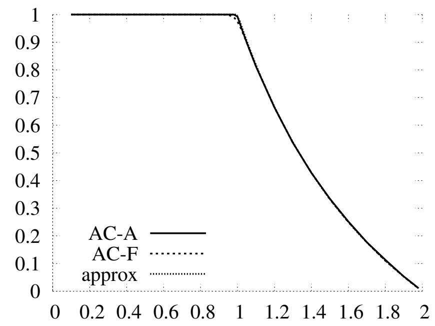
n vs. ρ



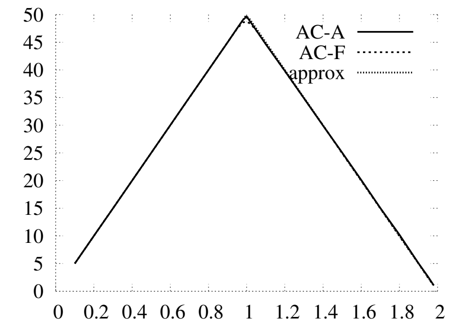
Verification by Simulation

When scaled up:

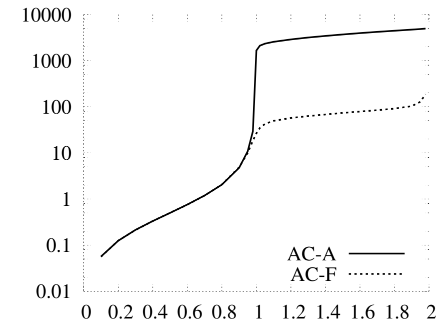
R vs. ρ



m vs. ρ



n vs. ρ



Conclusion and Future works

- This work is based on the assumption that we can effectively probe
  - We provided a skeletal algorithm in section VI
- But we did not addressed:
  - How to implement probing?
  - How to minimize the cost of probing?
- We showed that admission control is reasonable for inelastic flows
  - It does not affect stability
  - It can be TCP-friendly

The End