P2P VoD: Does it Scale?

Samuli Aalto, Pasi Lassila

Aalto University School of
Electrical and Engineering

Email: {firstname.lastname}@tkk.fi

Niklas Raatikainen, Sasu Tarkoma, Petri Savolainen

Helsinki Institute for Information Technology (HIIT)

Email: {firstname.lastname}@hiit.fi

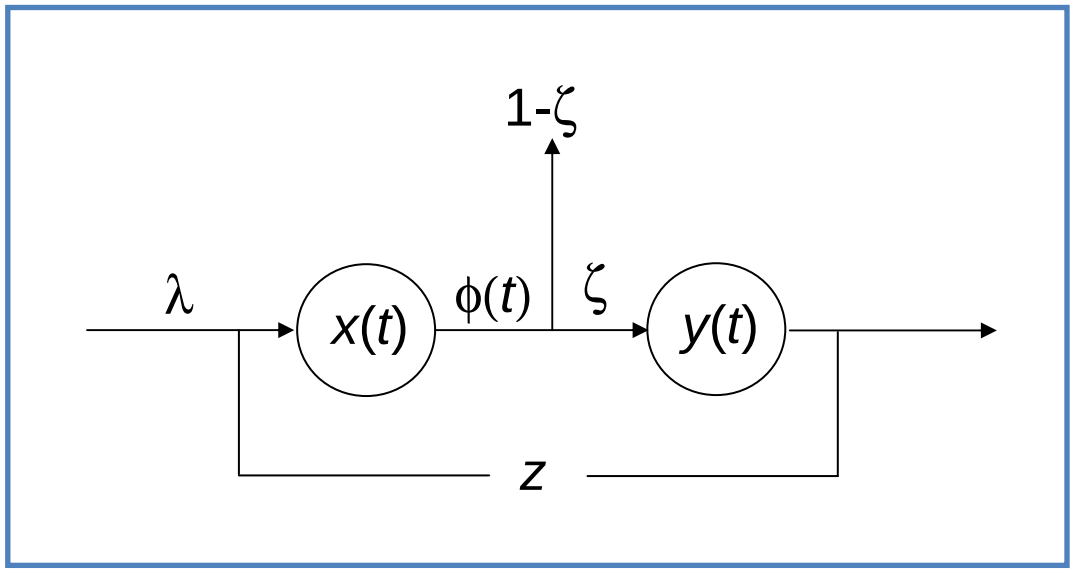
Problem statement

- Fundamental idea in P2P: clients also act as servers
- P2P VoD: combines file sharing (video exists) and realtime streaming (user wants to view file asap)
- Fundamental question: Are P2P VoD systems scalable?
  - (Qiu & Srikant, 2004) : P2P file sharing systems can scale independent of peer arrival rate if peers cooperate “even a little bit”
  - (Parvez et al., 2008): similar conclusions for VoD using simplified playback phase modeling
- We give a fluid model where playback phase is modeled explicitly and characterize conditions for acceptable QoS.

Fluid model (1)

- Assumptions:
  - All users have same upload (μ) and download (*c*) capacities
  - Users leave once the video is over (conservative assumption)
  - *z* = time to watch video (video size / coding rate)
- Other parameters:
  - η = sharing efficiency factor (peer/chunk selection policies)
  - ζ = probability that a leacher will stay as a seed
  - *k* = number permanent seeds (that never leave)
- State variables:
  - $x(t)$ = number of leachers at time t
  - $y(t)$ = number of seeds at time t

Fluid model (2)

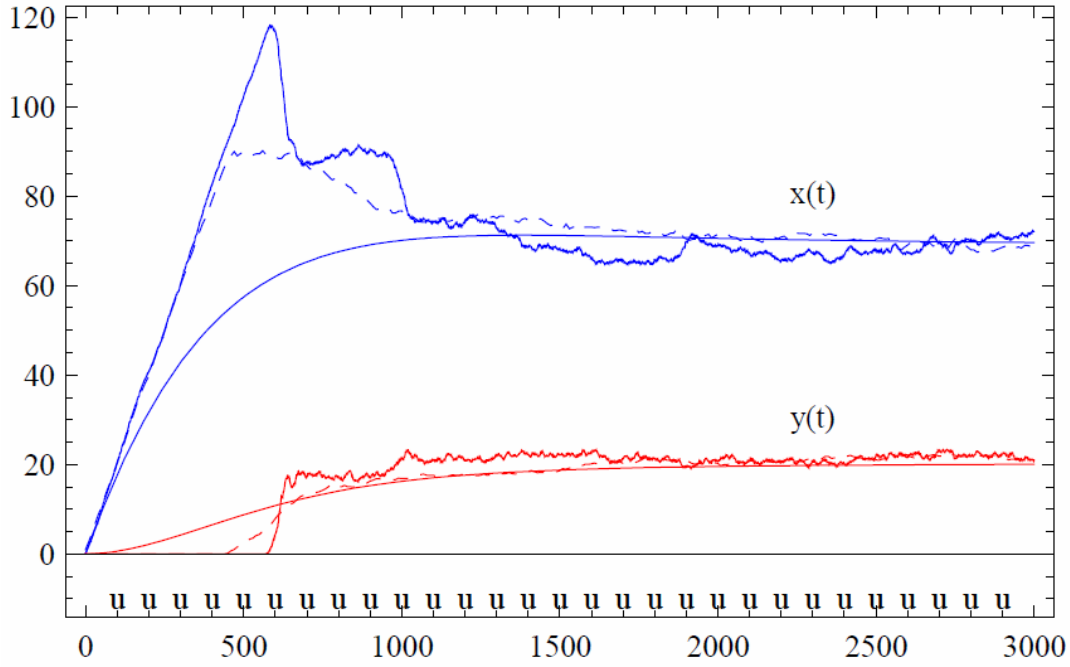


$$\begin{cases} x'(t) = \lambda - \phi(t), \\ y'(t) = \zeta\phi(t) - \frac{y(t)}{z - x(t)/\lambda} \end{cases}$$

$$\phi(t) = \min\{cx(t), \mu(\eta x(t) + y(t) + k)\}$$

Validation

– Compare ($x(t)$, $y(t)$) from fluid model (solid) with stochastic model (dashed) and BitTorrent simulations (jagged)



Steady state is approximated very accurately!

Steady-state analysis

- Solve $x'(t) = y'(t) = 0 \Rightarrow$ explicit steady-state solution $(\bar{x}, \bar{y})$ for upload and download constrained cases

- Positivity, uniqueness, stability of $(\bar{x}, \bar{y})$
  - $\bar{x} \geq 0, \bar{y} \geq 0, \phi(t)$ is satisfied at steady state
  - local stability of differential equations

Steady-state synthesis

– The system has a unique and stable equilibrium and QoS is good (service rate > coding rate) if

$$\eta > \frac{1}{z}(\frac{1}{\mu} - \frac{k}{\lambda})$$

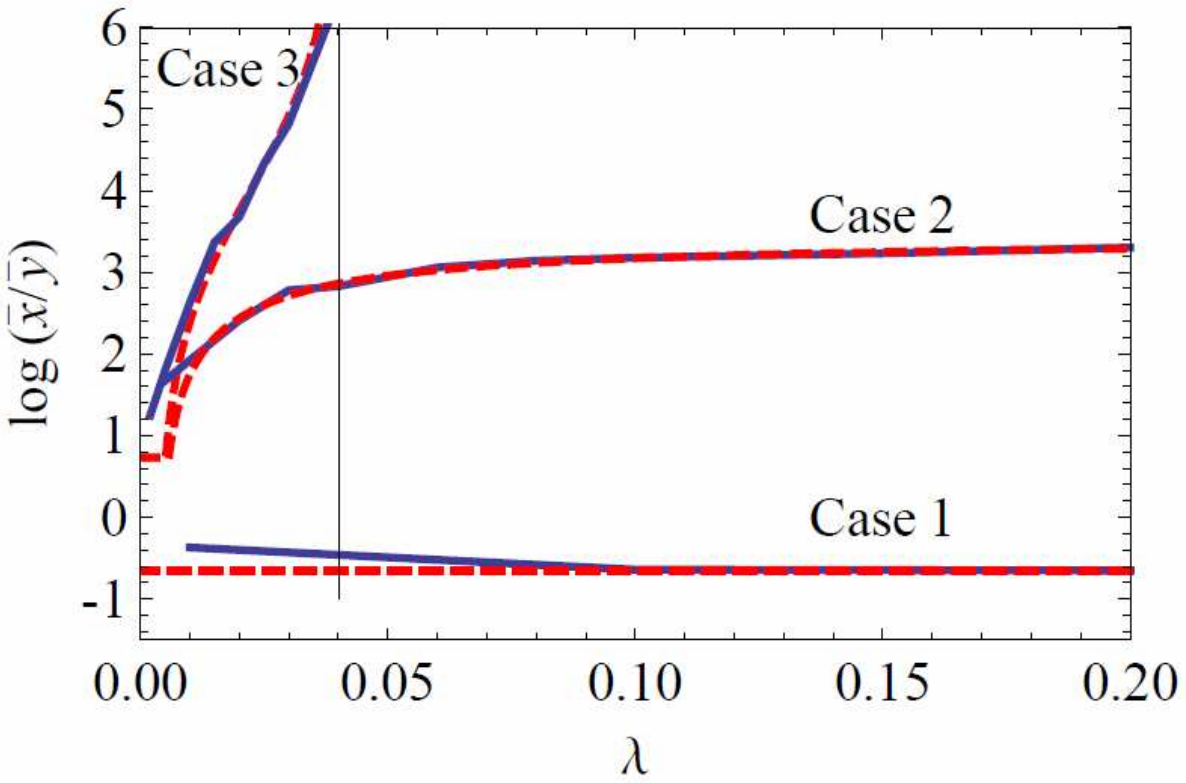
– System is scalable (QoS ok independent of arrival rate λ) if

$$\eta > \frac{1}{z\mu}$$

- Scalability is independent of permanent seeds/altruism

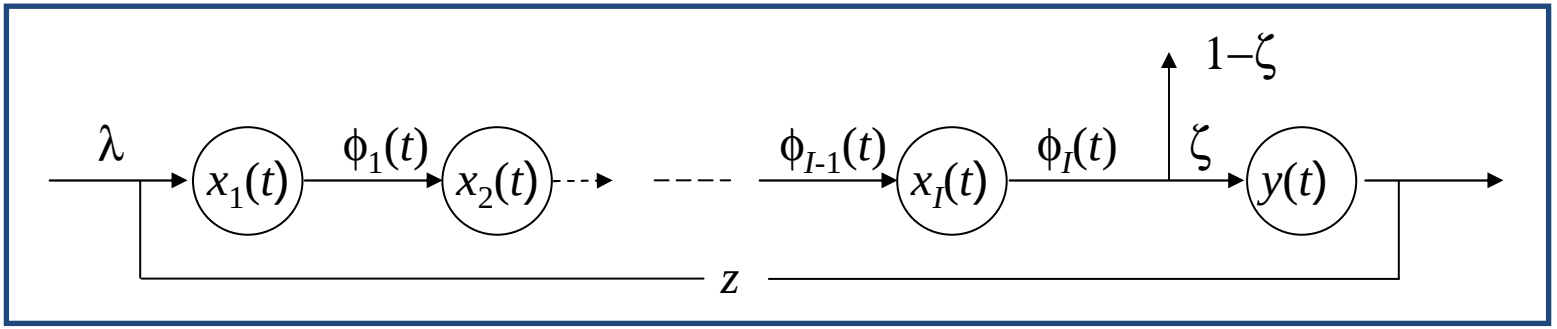
Efficiency η is critical for operation!

Scalability example



Fluid model for segmented system

- Efficiency parameter η not ”very natural”
  - In VoD only older peers can help younger ones
- Segmented system without η parameter



  - Exact analysis not possible…
  - Segmented system is never scalable, but limit can be improved by increasing number of phases (last phase is the bottle neck)

Conclusions

- Fluid models for analyzing P2P VoD
  - Black-box model, with h parameter
  - Segmented model
- Scalability
  - Black-box model: system can scale if efficiency is ”good enough”
  - Segmented model: never scalable, but limit can be improved by splitting in smaller segments
- Open questions:
  - What happens in the limit when nof segments goes to infinity?
  - Impact of peer capacity heterogeneity?

Papers

1. S. Aalto, P. Lassila, N. Raatikainen, P. Savolainen and S. Tarkoma, “P2P Video-on-Demand: Steady State and Scalability”, in *Proceedings of IEEE Globecom*, 2010.

2. S. Aalto, P. Lassila, S. Tarkoma and P. Savolainen, “Segmented P2P Video-on-Demand: Modeling and Performance”, in *Proceedings of 22nd International Teletraffic Congress* (ITC 22), 2010.