A brief introduction to Flow-Aware Networking

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UNIVERSITY OF CAMBRIDGE

Introduction

- Overview related to work I have done during my PhD
- Flow-Aware Networking is a concept proposed by James Roberts, my advisor
- **Motivation**: inefficiency and complexity of standardized QoS architectures...
- ... because traffic is hard to characterize (e.g. failure of token bucket)
- **Objective**: define a simple and robust architecture to provide QoS (initially in the backbone)

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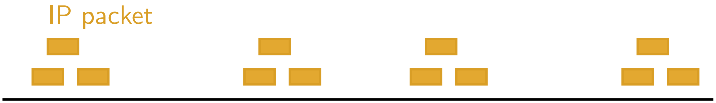

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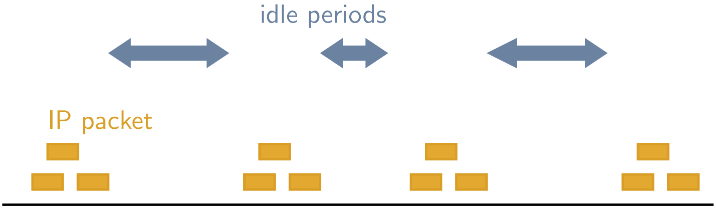

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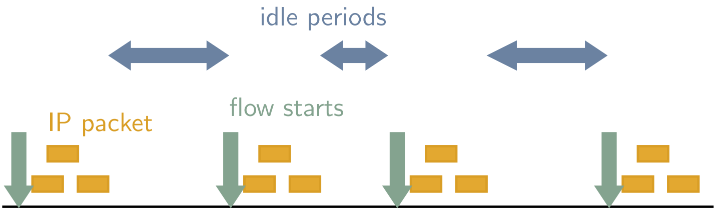

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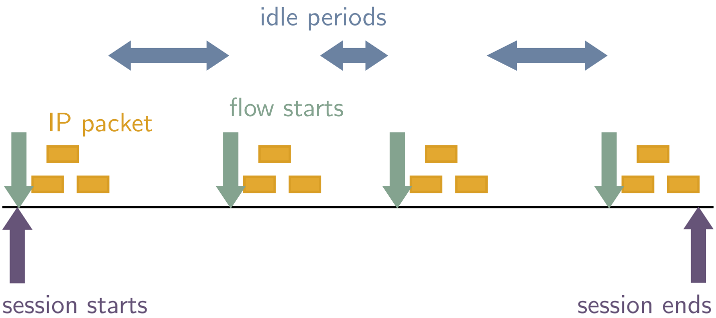

Flow structure of traffic

- Example of flow in IPv4:
  (src/dst IPs, src/dst ports, protocol) + timeout
- Finite size flow arrivals, according to a stochastic process,
- #flows varies: significant characteristic = average link load
- The flow peak rate defines :
  - **bottlenecked flows**: peak rate limited flows: the link only "sees" a packet from time to time
  - **non-bottlenecked flows**: usually high exogeneous rate, share bandwidth thanks to protocols like TCP
- The vast majority of flows are *bottlenecked*...

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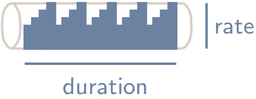
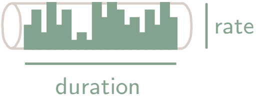
Characterization of traffic: flows as boxes

Elastic flows



Streaming flows



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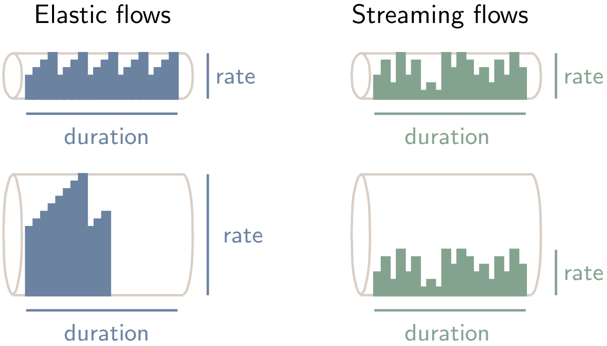

Elastic flows

rate

duration

rate

duration

Streaming flows

rate

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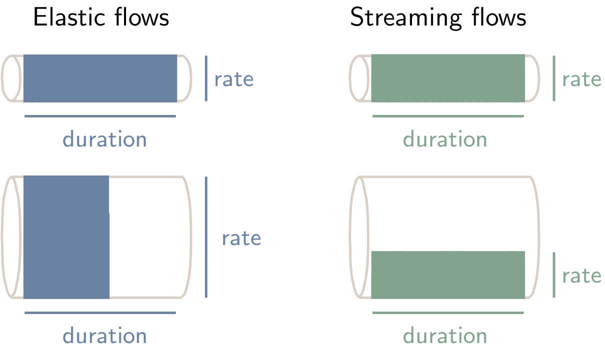

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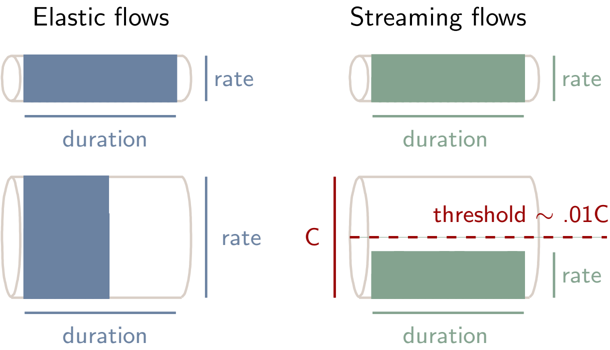
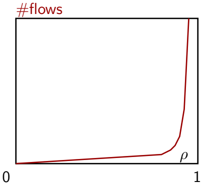
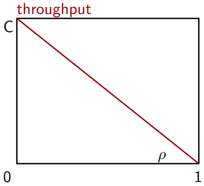


Elastic (Statistical Bandwidth Sharing)

- Processor Sharing (PS) models : M/M/1/PS queue
- Good approximation of TCP performance
- Insensitivity to flow distributions
  - only depends on the load (ρ = arrival rate x size / C)
  - E[flows in progress] $= \frac{\rho}{1-\rho}$
  - E[throughput] $= C \cdot (1 - \rho)$





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- ... in practice $\rho < 0.5$ and E[flows in progress] $= O(10^4)$
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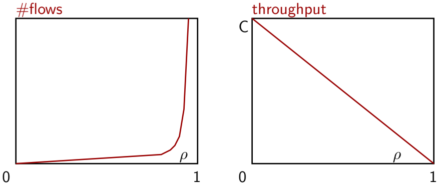

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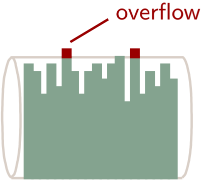

- Controlled performance $\equiv P[\text{input rate} < C] \leq \epsilon$
- Ensure transparent regime for streaming flows
- Performance is insensitive to detailed traffic characteristics
- Locally Poisson arrivals : M/M/1 good approx.
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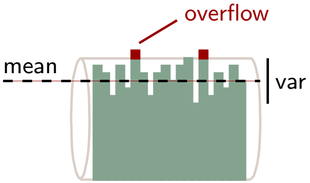

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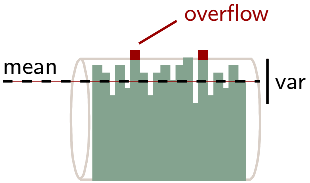

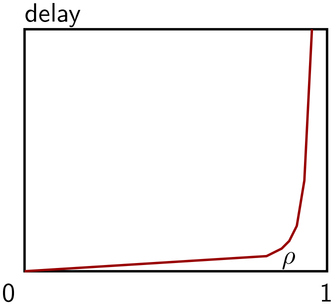

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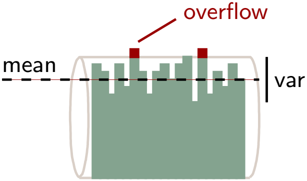

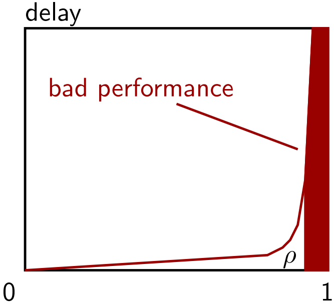

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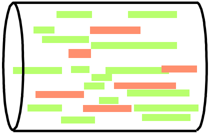

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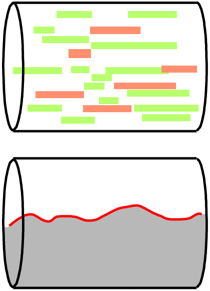
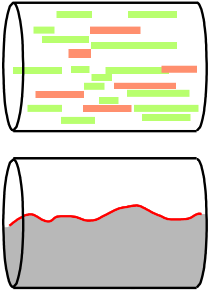


Link utilization regimes

”transparent”



negligible loss
and delay

FIFO sufficient

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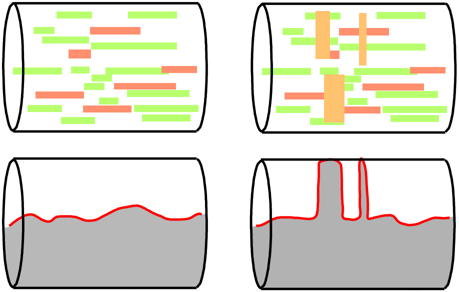

”transparent”

negligible loss

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FIFO sufficient

”elastic”

excellent for elastic,

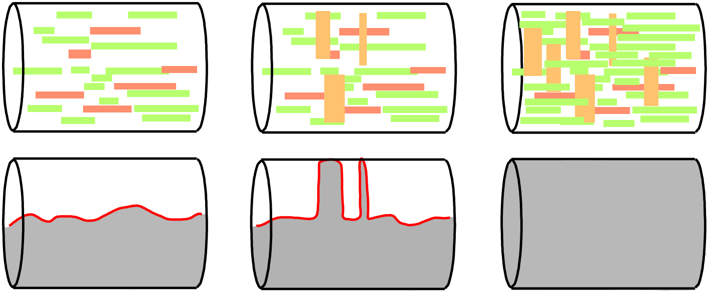
some streaming loss

needs

differenciation

Link utilization regimes

"transparent" "elastic" "congested"



negligible loss and delay

FIFO sufficient

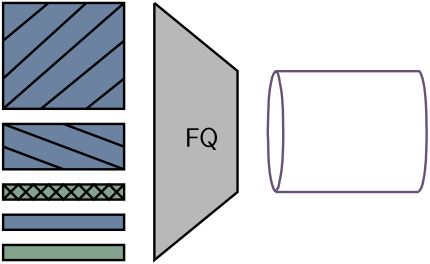
excellent for elastic, some streaming loss

needs differenciation

low throughput, significant loss

needs overload control

Priority Fair Queueing



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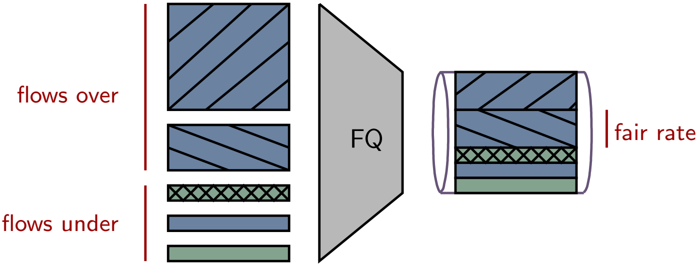

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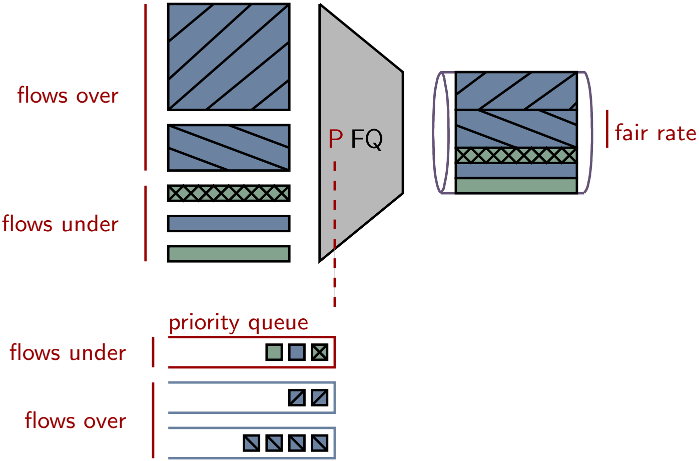

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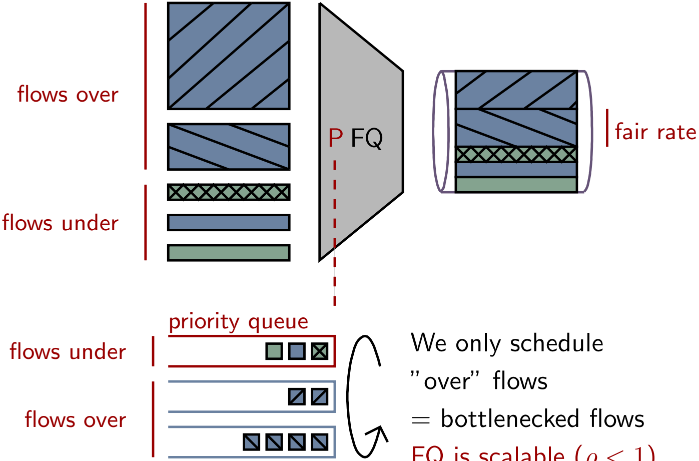

We only schedule "over" flows
= bottlenecked flows

FQ is scalable ($\rho < 1$)

Coupling PFQ with Flow Level Admission Control

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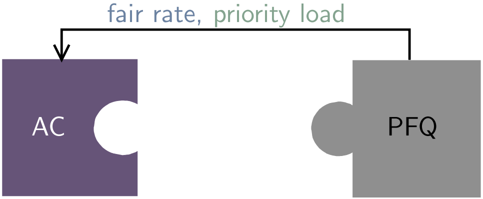

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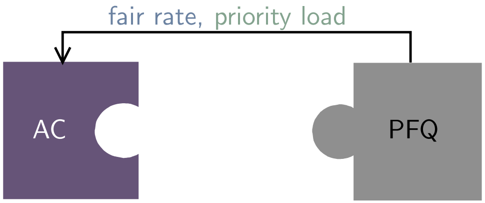

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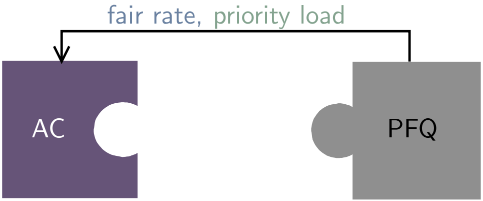

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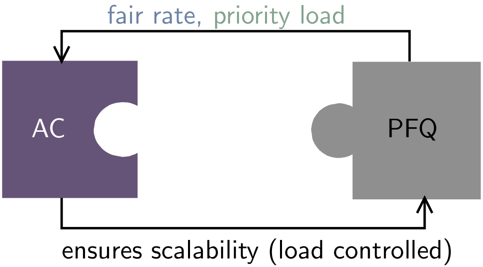

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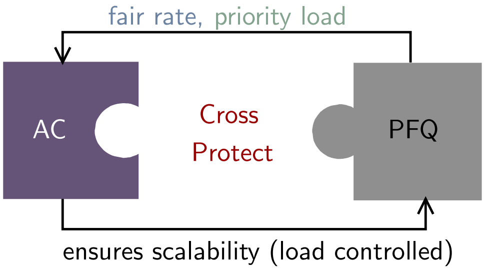

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Some work in the FAN context (PhD)

- Simulation (NS-2) and GNU/Linux testbed (XP as a kernel module)
- Some results on a real traffic trace (France Telecom backbone)
- Investigations on the buffer sizing issue for IP routers
- Fair Queueing and TCP performance
- Proposition of a more efficient admission control algorithm for streaming flows
- Thoughts on adapting Cross-Protect for optical networks
- Proposition to introduce Flow-Aware Networking in the access network (Self-Protect) + testbed

Conclusion

- Need to account for the real nature of traffic
- Flow level modelling is efficient
- Important characteristics : load, flow peak rate
- Cross-Protect = Admission Control + Fair Queueing