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Flow-Aware Networking extension for IP over WDM environments

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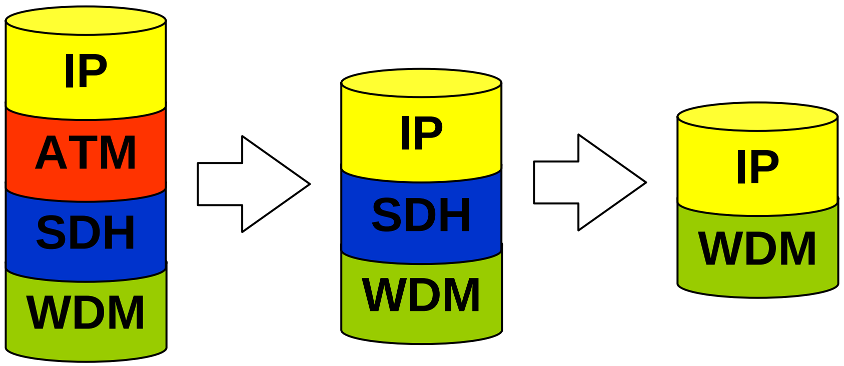
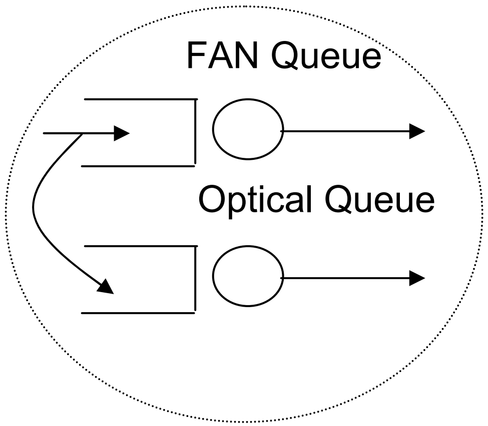
Multilayer Flow Aware Networking

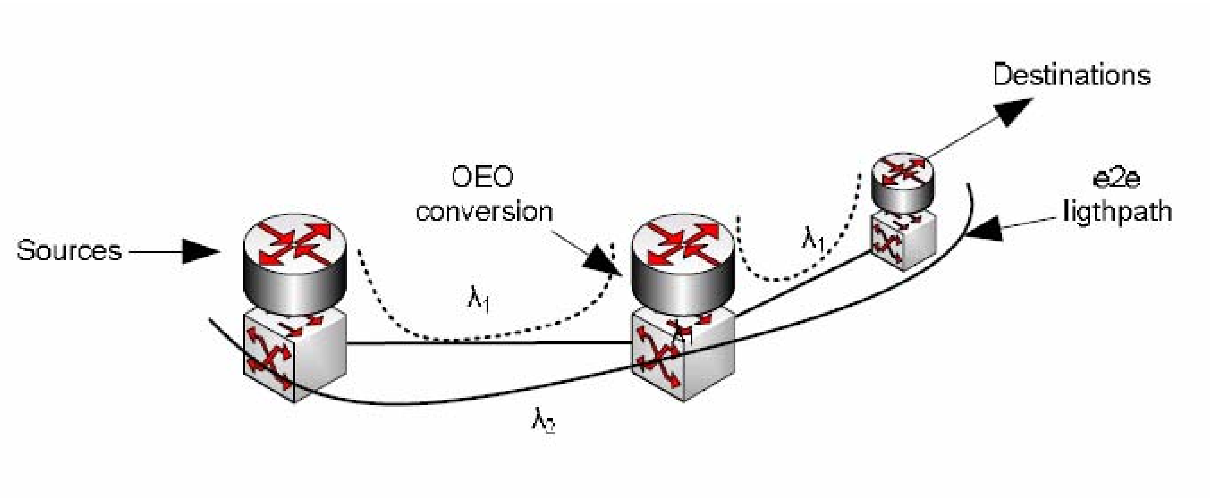
- Motivation:
  - Flow Aware Networking is a promising technology for IP QoS.
  - Core network is migrating to an IP over WDM architecture.





Multilayer Flow-Aware Networking

- Objectives:
  - Enhance FAN to work in a multilayer scenario.
  - Search policies to route flows into the optical domain in an efficient way.



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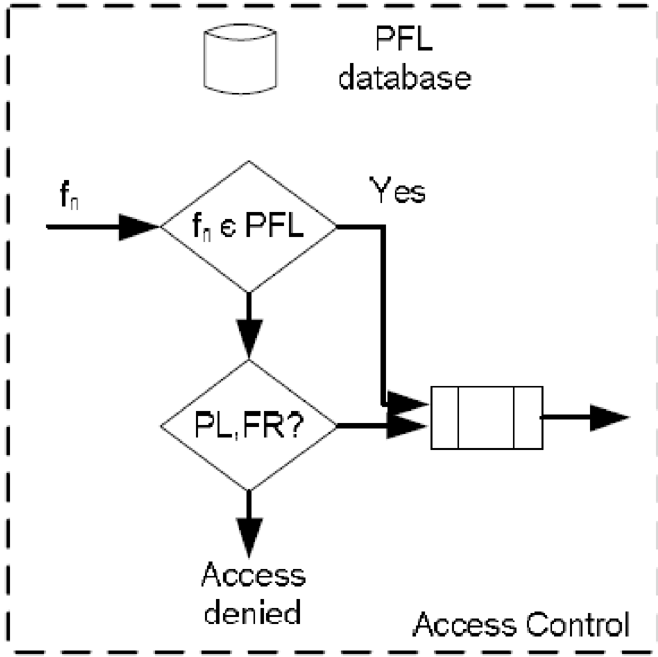
FAN Introduction

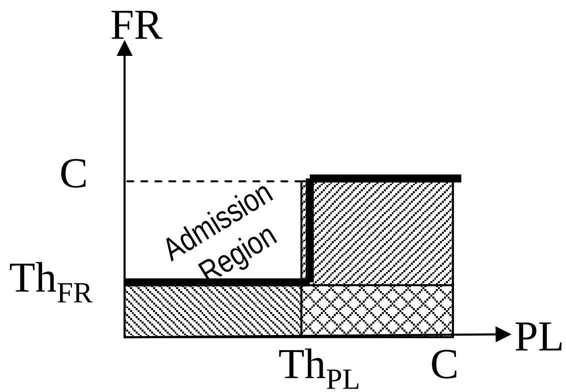
Flow-Aware Networking

- FAN objectives:
  - Minimize streaming flows delay.
  - Assure a minimum rate to elastic flows.
- Characteristics:
  - Decisions: flow level
    - Although it works at packet level
  - If a flow is accepted, it is protected.
- Monitoring parameters
  - Fair Rate (FR) estimation of the available bandwidth.
  - Priority Load (PL) estimation of the load of the priority packets.

Flow-Aware Networking

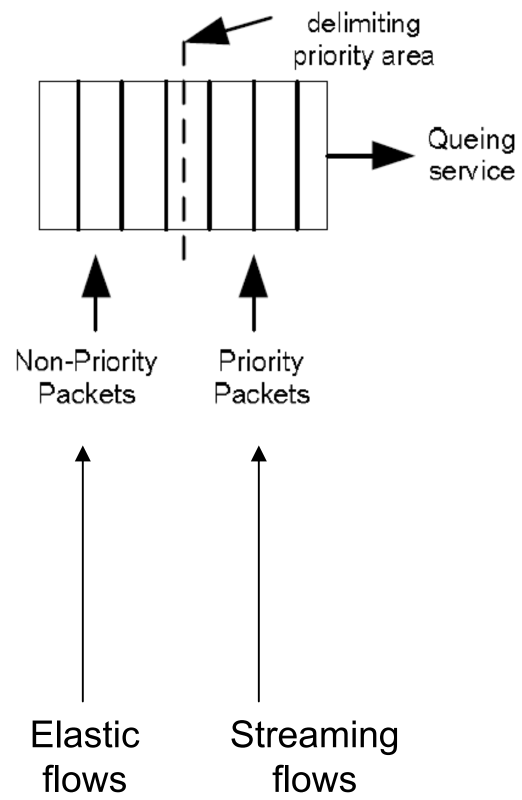
- Implicit classification:
  - Streaming flows: rate less than Th_{FR}.
  - Elastic flows: others.
- Admission control:
  - Check if the incoming packet flow is in the PFL.
    - Yes: it is served.
    - No: Check if $PL < Th_{PL}$ and $FR > Th_{FR}$.





Flow-Aware Networking Queue

- There are two proposed FAN queues:
  - Priority Fair Queue (PFQ)
    - PFQ is used in my simulations.
  - Priority Deficit Round Robin (PDRR)
- Both has the same performance, although PDRR computational time is lower.



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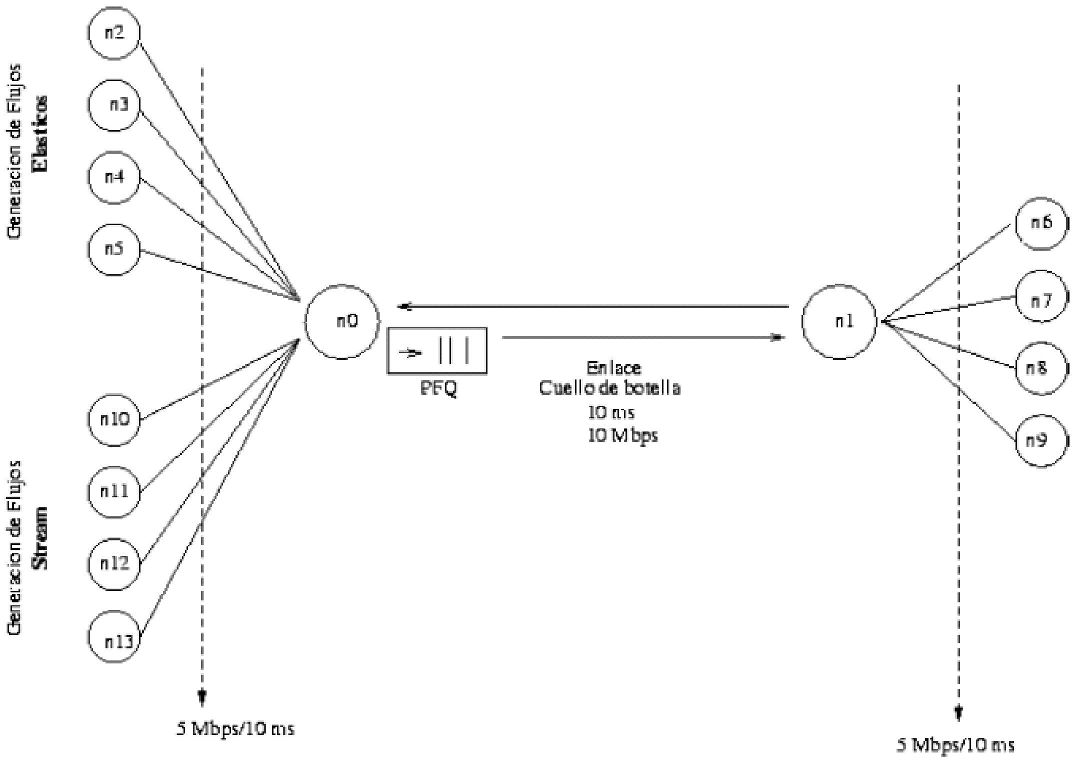
FAN Scenario Examples

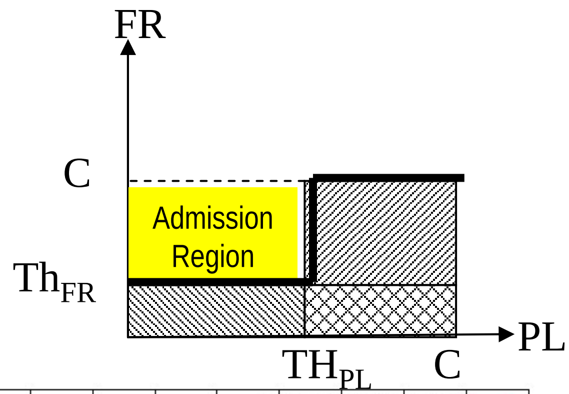
Scenario Topology

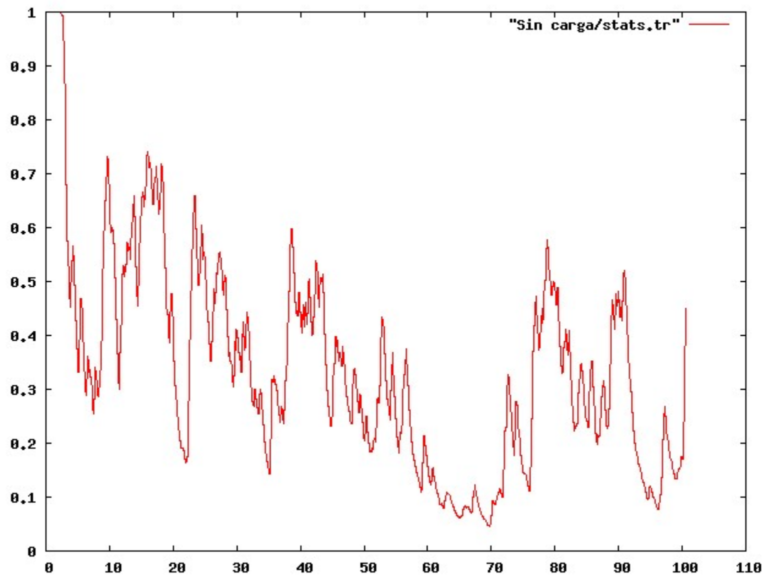
- FR=5% link capacity.
- PL=80% link capacity.



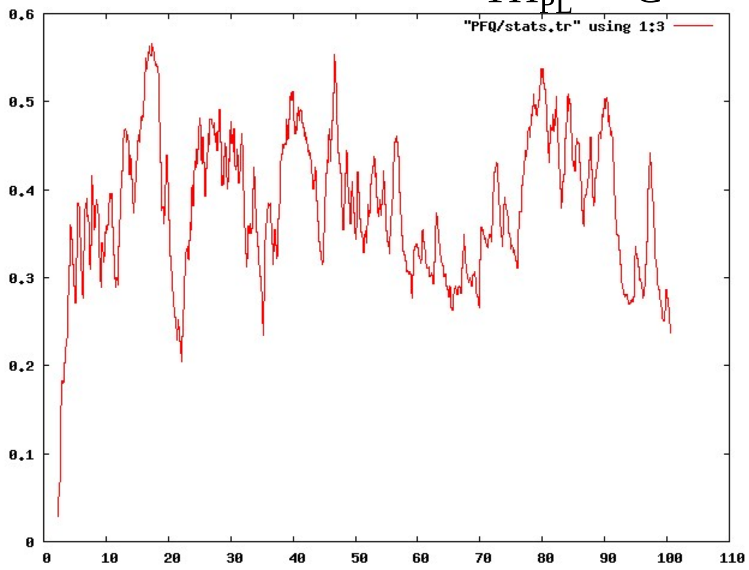
Underloaded Scenario

- In this situation:
  - FR and PL are inside their range.





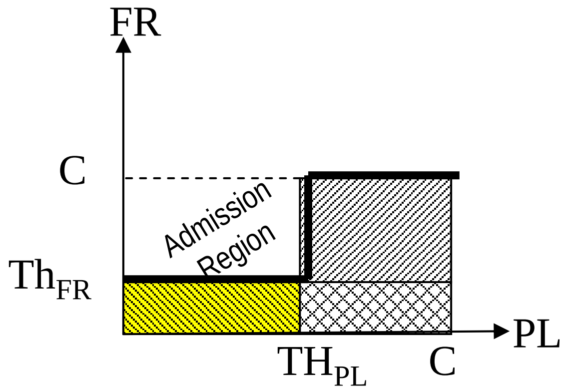
Fair Rate

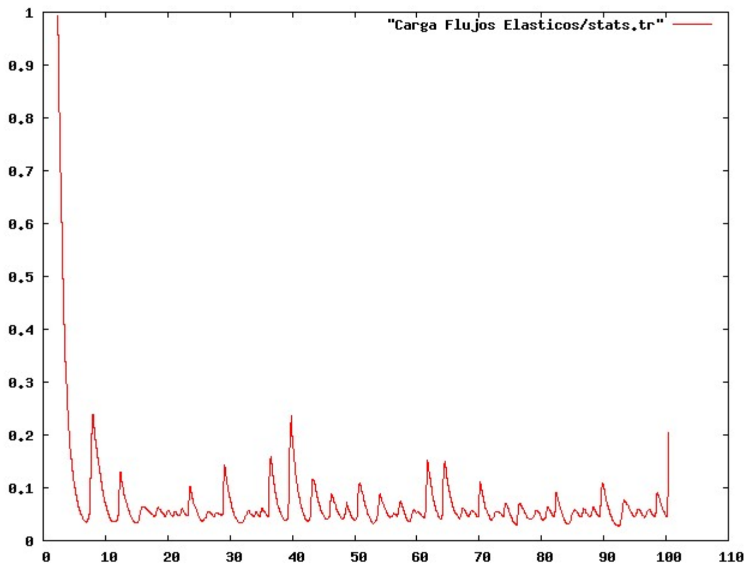


Priority Load

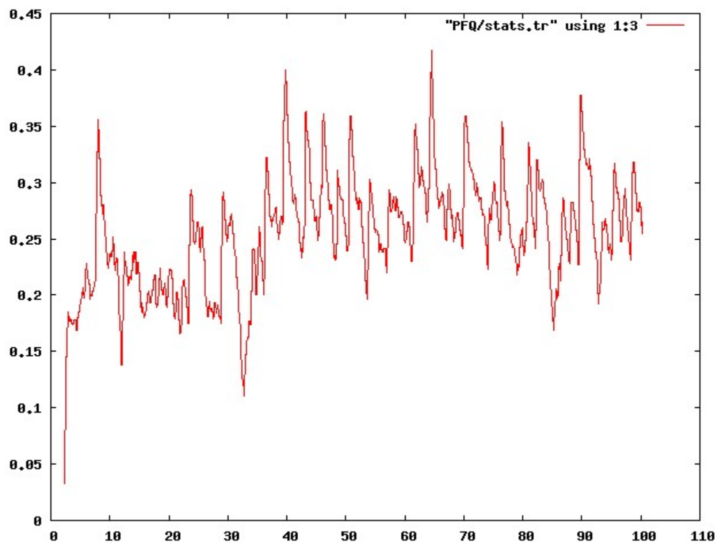
Elastic Loaded Scenario

- In this situation:
  - FR is out of range.
  - PL is inside its range.





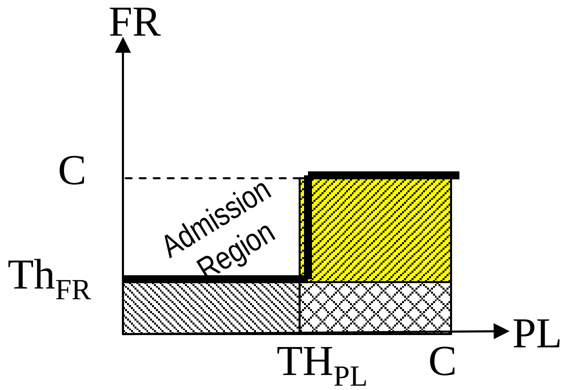
Fair Rate

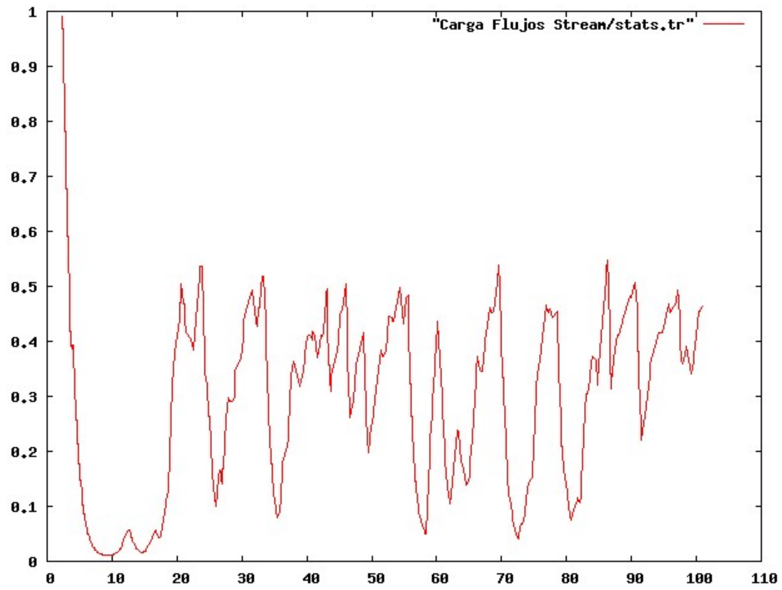


Priority Load

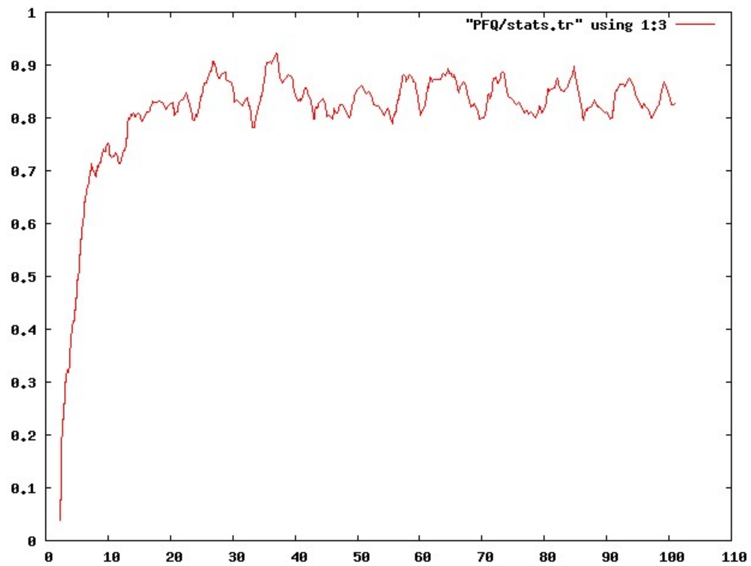
Streaming Loaded Scenario

- In this situation:
  - PL is out of range.
  - FR is inside its range.





Fair Rate

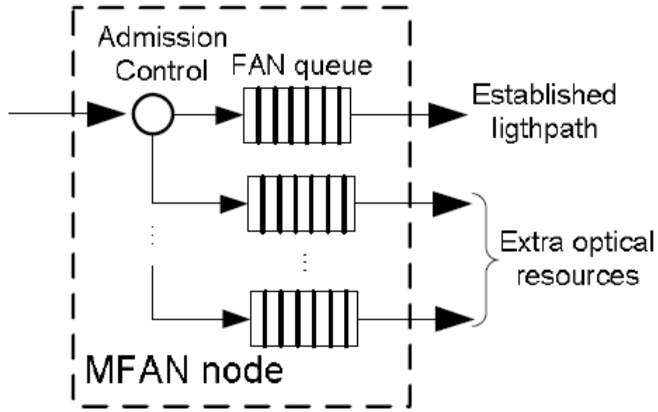


Priority Load

FAN Extension

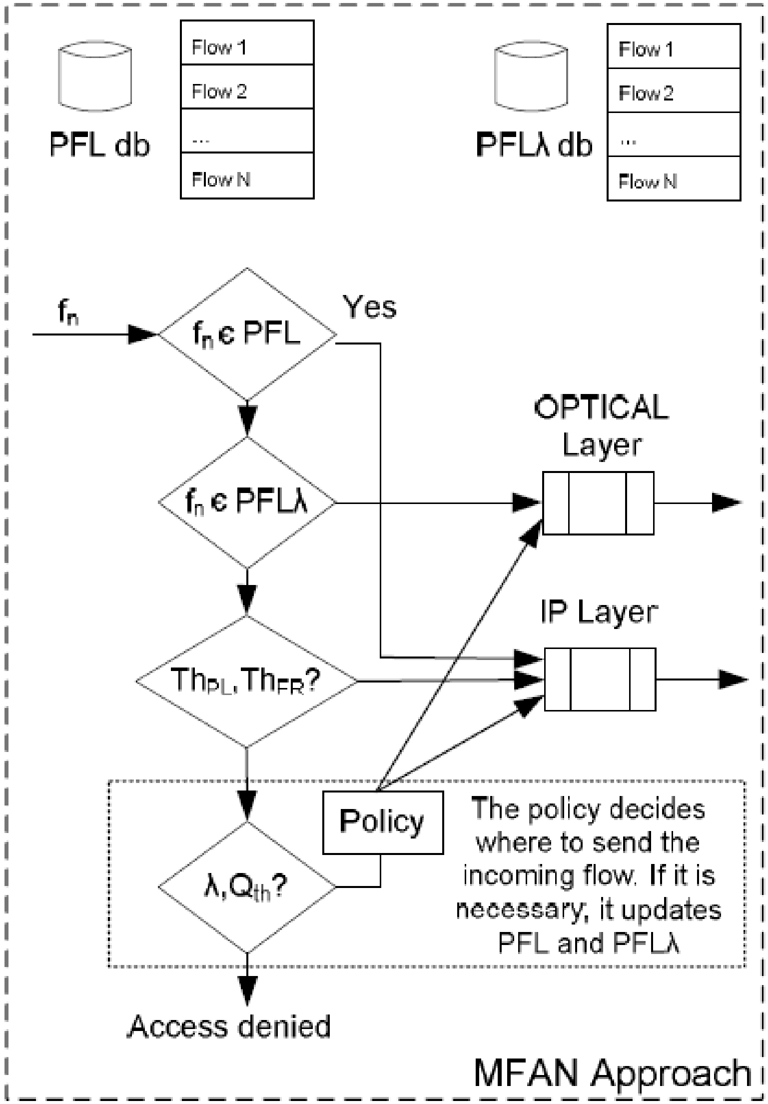
Multilayer FAN Node

- MFAN node is able to ask for extra optical resources.
- MFAN provides QoS at IP level using FAN.
- Assumptions:
  - If FAN queue can process the traffic it will be used.
    - FAN QoS is good enough.
  - Optical extra resources provides a best effort interface to the network without any extra QoS assurance.



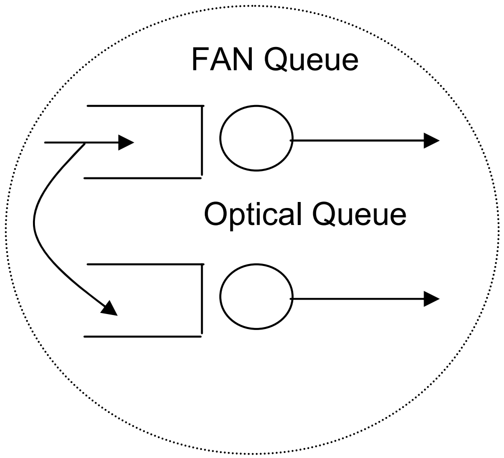
Admission control in MFAN

- Add a monitor module to for optical queue performance.
- If the queue is under one threshold the flow is accepted.
- Which flow should be sent over the optical queue?
  - Policies.

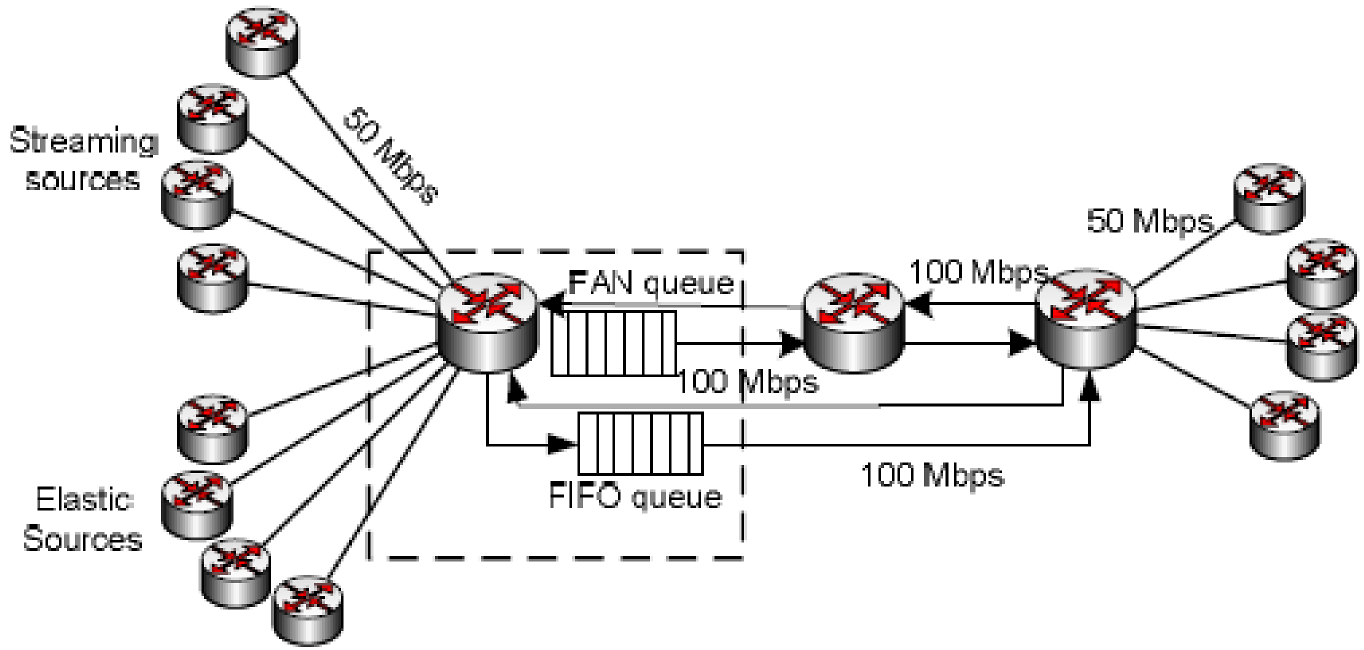


Policies for MFAN

- Policies:
  - Newest-flow policy:
    - The incoming new flow is sent over the optical queue.
  - Most-Active-flow policy:
    - When a packet has to be discarded, FAN discards the packets from the flow with a greatest backlog.
    - Send the most active flow over the optical queue.
    - Streaming flows are excluded.
  - Oldest-flow policy:
    - Send the oldest active flow in the system.
    - Streaming flows are excluded.



Scenario topology



Scenario definition

- Traffic input: [Kor05]
  - Flows arrivals (elastic and streaming) Poisson processes.
    - Streaming (phone connections)
    - Elastic (Frank Kelly “Stochastic Networks”)
  - Streaming flows:
    - UDP
    - Exponentially distributed on- and off-periods (μ=500 ms) with an emission rate of 64 Kbps.
    - Rate: 32 Kbps (packets length 190 bytes)
    - Flows length 1 minute on average.
  - Elastic flows
    - TCP Reno
    - Packets of 1 KB
    - Flow size truncated Pareto distribution
      - Shape 1.5, μ=25 packets, minimum 8 and maximum 1000 packets.
      - From 8 Kb to 1 Mb.
  - Elastic flows count for 80% of overall traffic. [Kor05]
  - Link buffer: Q=RTTxC

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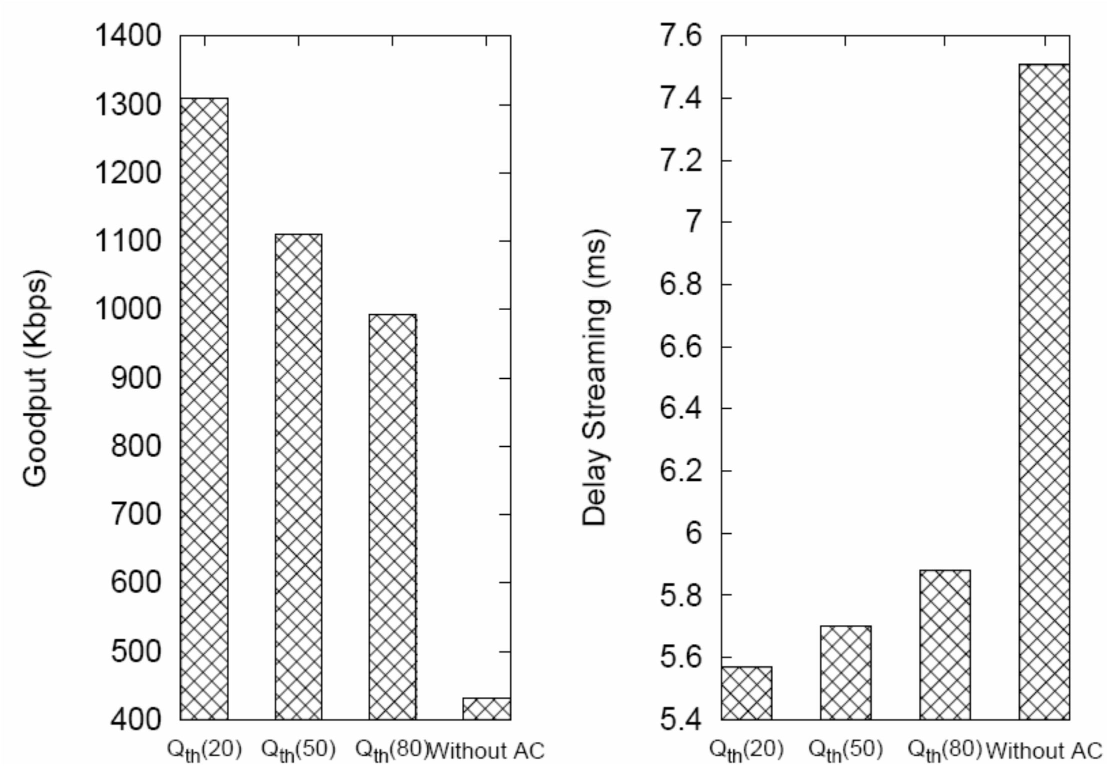
Results

Metrics

- The metrics are related with the optical queue.
- FAN queue performance is equivalent with all policies.
- Metrics:
  - Rejection ratio.
    - Rejected flows/Incoming flows
  - Delay of streaming packets.
    - Delay in the optical queue.
  - Goodput for elastic flows.
    - Useful rate in bits per second.

Admission control

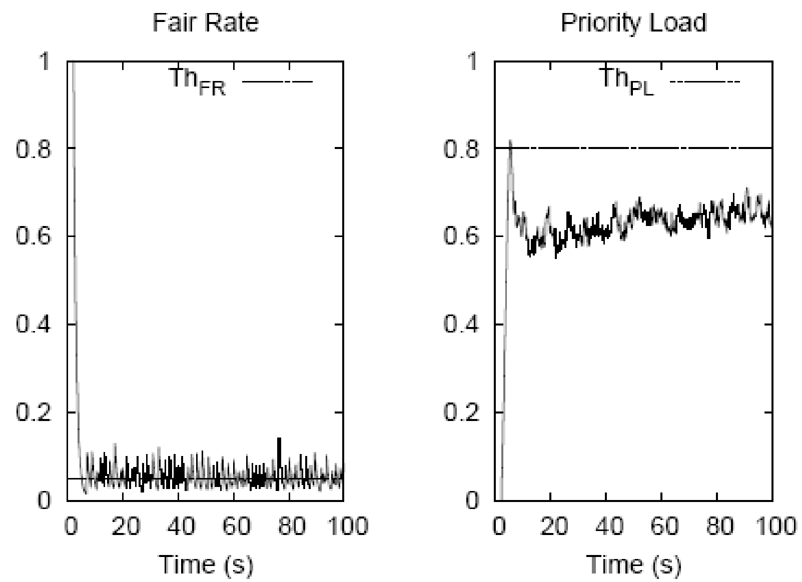
- The admission control is an useful method to control the service degradation.



Newest-flow Policy

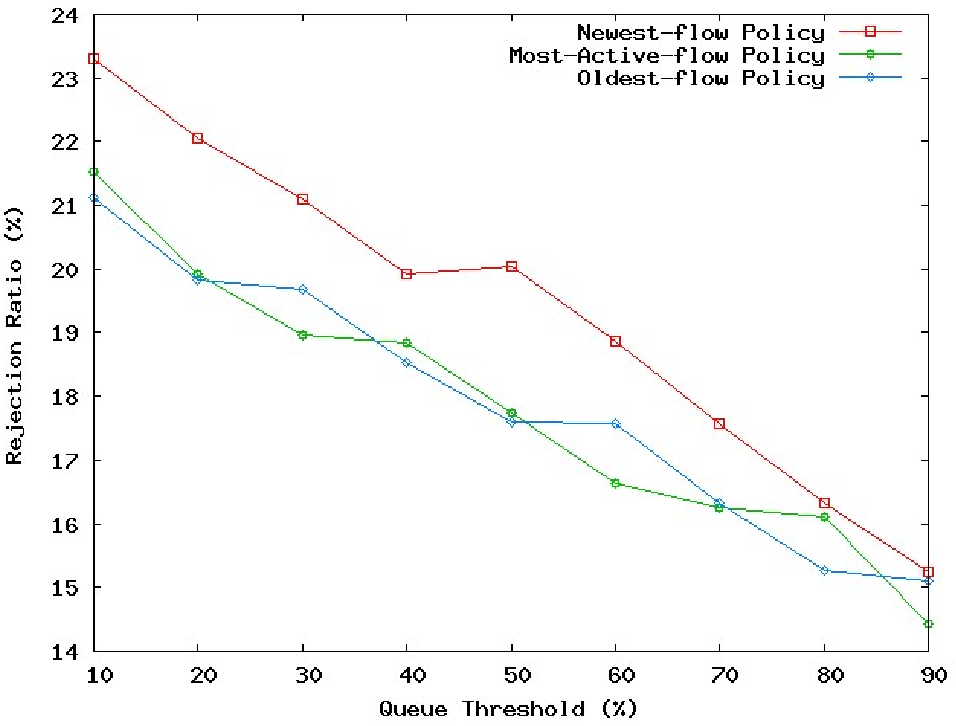
Implicit classification

- In Most-Active flow and Oldest flow policy, streaming flows are excluded.
- The reason is that in our scenario the system is congested due to elastic flows.
  - It is reasonable not to extract flows that are not congesting FAN queue.



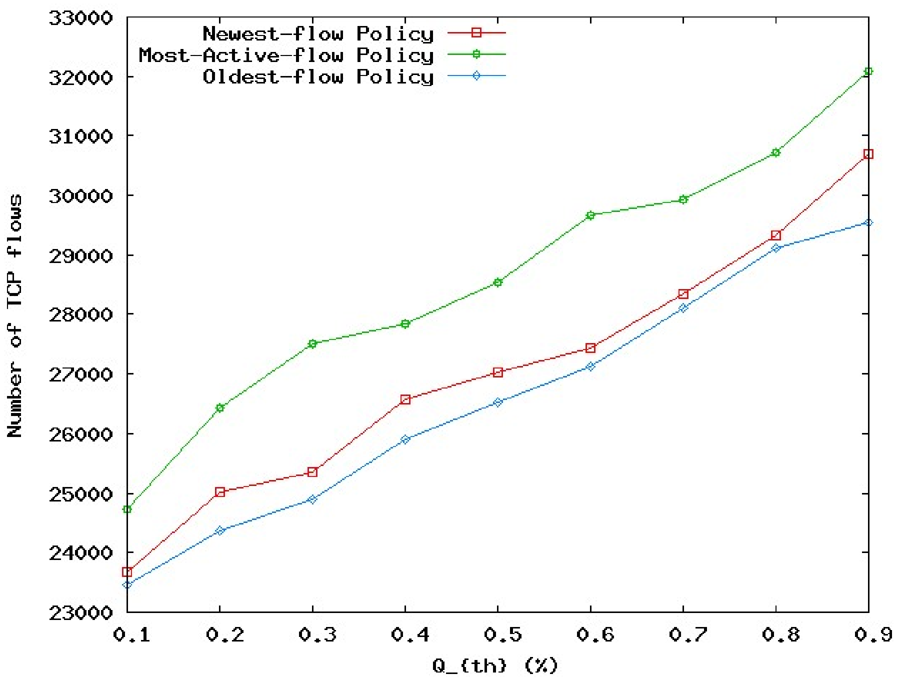
Rejection ratio

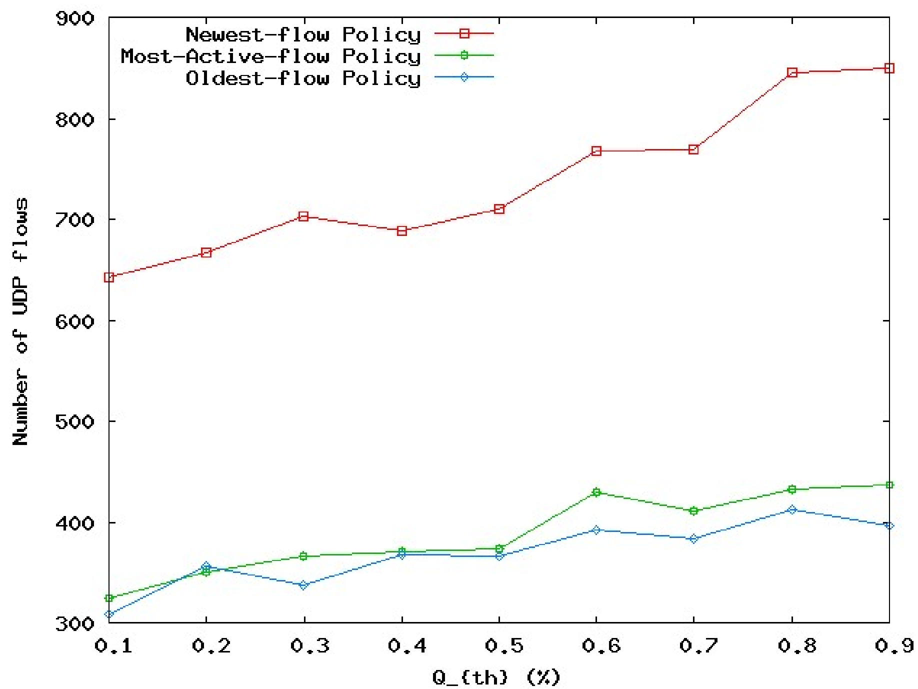
- Newest policy rejects more flows than the others.
  - It does not use any information about the flows.



Flow proportion in the optical queue

- Depending on the policy the number of TCP and UDP flows in the optical queue is different:
  - Newest-flow policy → greatest number of UDP flows
  - Most-Active-flow policy → greatest number of TCP flows

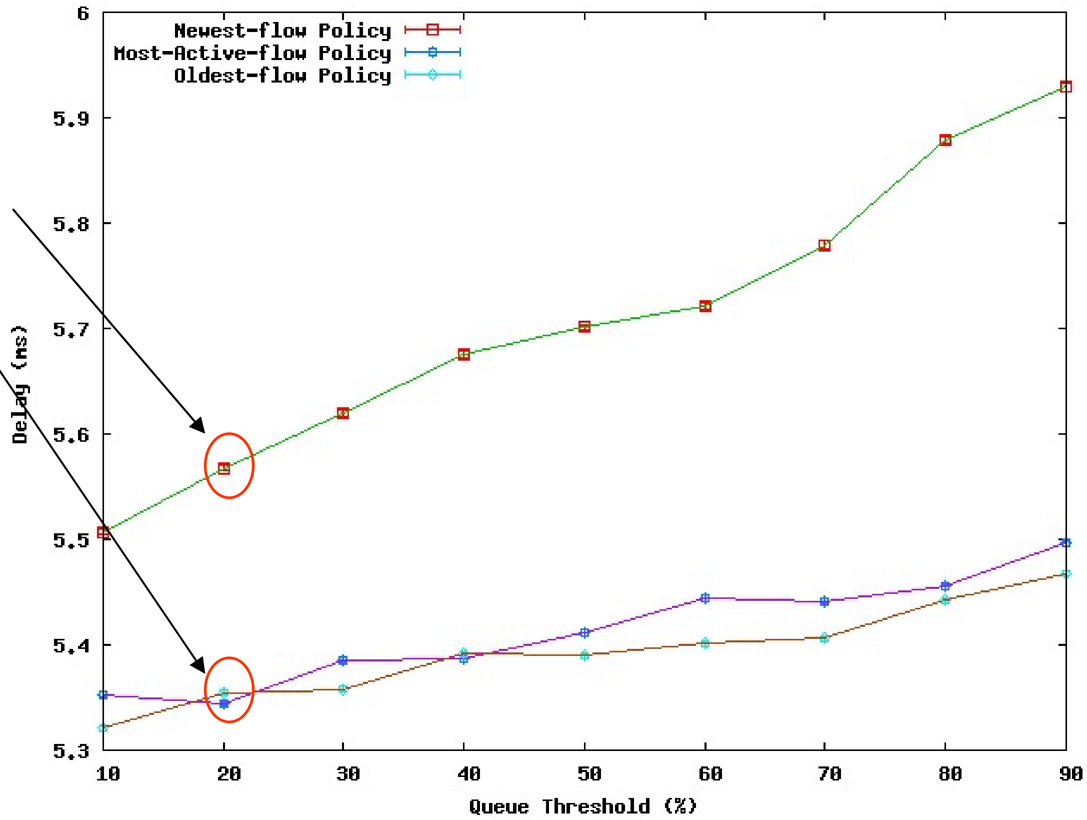




Streaming packets delay in Optical Queue

- Rejection ratio and number of UDP flows explain the policies performance.
  - The less UDP flows the smaller is the delay.

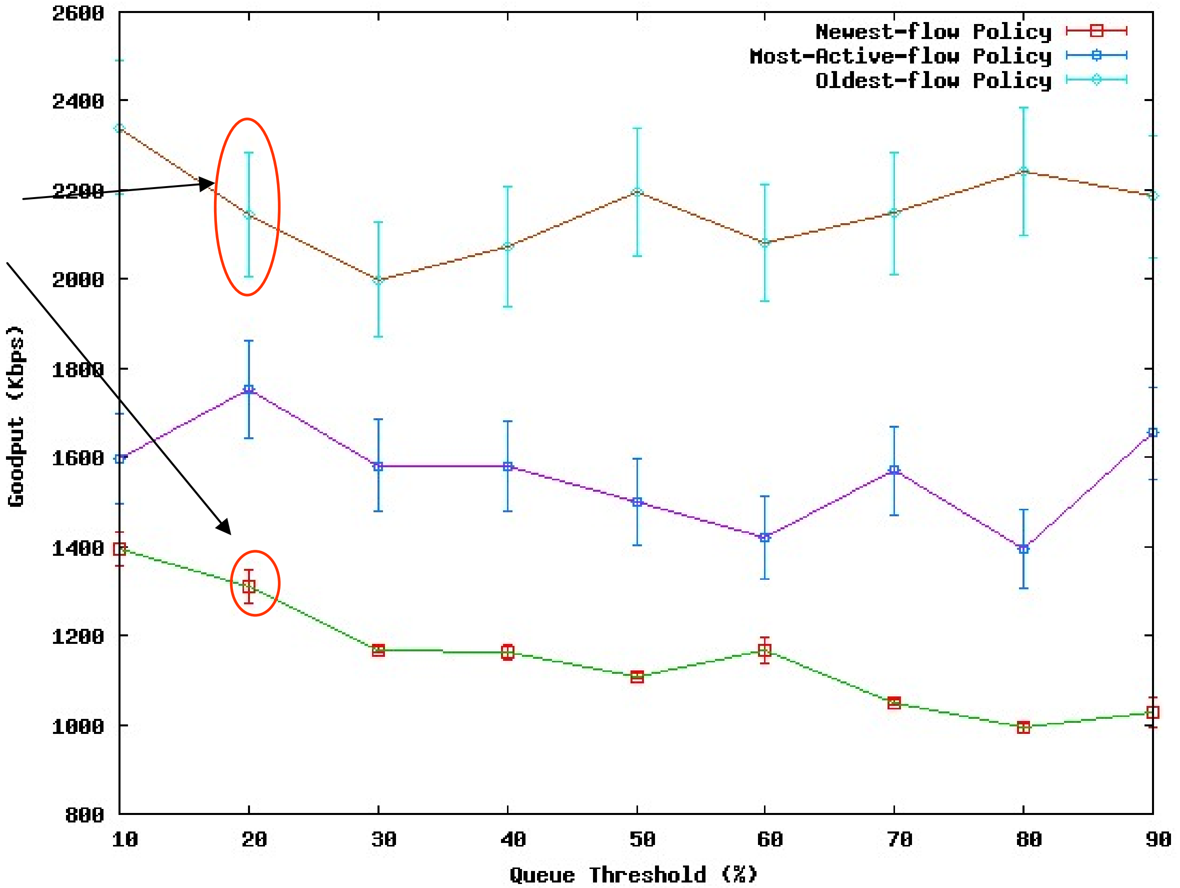
Confidence intervals 95%



Elastic flows Goodput Optical Queue

- Similar conclusions than previously can be achieved.
  - Most-active-flow policy sends more TCP flows to the optical layer, so the goodput is lower than Oldest-flow policy.

Confidence intervals 95%



Contributions

- The main contribution of this work is the enhancement of the FAN architecture in a multilayer scenario.
  - Keep FAN's Simplicity.
  - FAN monitoring parameters are used.
  - Admission control is maintained.
- Three policies proposes and evaluated:
  - The Oldest policy has shown a better performance.