

CS 5224

Access Control and End-to-end Performance

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Outline

- Policing using Leaky Bucket
- End-to-end Performance using Leaky Bucket and WFQ
- Reference:
 - Mischa Schwartz, "Broadband Integrated Networks," Chapter 4 and 6.

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Access Control

Goal: limit traffic to not exceed declared parameters

- Monitor and control the traffic sent by user to network
 - Ensure it conforms to the traffic descriptors specified
 - Users found violating their "agreements" will have packets tagged or dropped
 - Also called Usage Parameter Control (UPC), credit management, traffic "policing"
- Traffic may be "shaped" or "smoothed" to reduce any adverse impact on the network
 - Usually, buffer the packets at the "access" routers and then send out packets at a smoothed, more regular rate

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Policing Mechanisms

Three common-used criteria:

- *(Long term) Average Rate:* how many packets/bits can be sent per unit time (in the long run)
 - crucial question: what is the interval length: 100 packets per sec or 6000 packets per min have same average!
- *Peak Rate:* e.g., 6000 pkts per min. (ppm) avg.; 15000 ppm peak rate
- *(Max.) Burst Size:* max. number of pkts/bits sent consecutively (with no intervening idle)

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Example

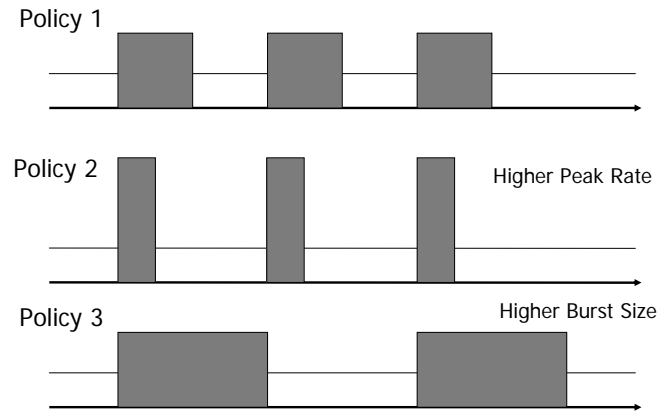
- Policy 1 (assume ATM, constant 53 bytes pkt)
 - Average rate = 1000pps or 424Kbps
 - Peak rate = 2Kpps or 848Kbps
 - Burst Size = 1000 packets or 424Kb
- Policy 2 (assume ATM)
 - Average rate = 1000pps or 424Kbps
 - **Peak rate = 4Kpps or 1696Kbps**
 - Burst Size = 1000 packets or 424Kb
- Policy 3 (assume ATM)
 - Average rate = 1000pps or 424Kbps
 - Peak rate = 2Kpps or 848Kbps
 - **Burst Size = 2000 packets or 828Kb**

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Example (Worst Case)



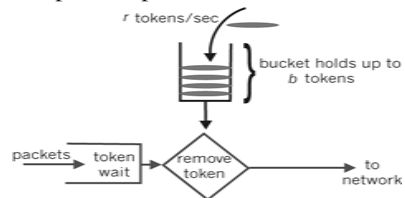
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Policing Mechanisms

Token Bucket: limit input to specified Burst Size and Average Rate.



- bucket can hold σ tokens
- tokens generated at rate ρ token/sec unless bucket full
- over interval of length t : number of packets admitted less than or equal to $(\rho t + \sigma)$.

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Deterministic Bound

- If the amount of traffic sent over any time interval can be bounded, can performance bound be provided?
- Yes, a deterministic bound can be provided:

- Reference:

- R. Cruz, "A Calculus for Network Delay, Part I and Part II," IEEE Trans on Information Theory, Jan 1991.
- Parekh and Gallager, "A Generalized Processor Sharing Approach to Flow Control in Integrated Services Network: The Multiple Node Case." IEEE/ACM Trans. On Networking, Apr 1994.

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Deterministic Bound

- Recall that using leaky bucket policy, over interval of length t , the number of packets admitted less than or equal to $(\rho t + \sigma)$.
 - Assume peak rate is “infinity”
- Let GPS be implemented along the routers and $g(k)$ be the service rate allocated at router k , $r(k)$ be the link rate
 - Let $g(\min)$ be the smallest rate allocated over all k routers
 - The worst case end-to-end delay (D) is bounded by $D \leq \sigma/g(\min)$
- If WFQ is implemented, due to the effect of packet switching
 - $D \leq \sigma/g(\min) + \sum_{k=1}^{N-1} P_{\max}/g(k) + \sum_{k=1}^N P_{\max}/r(k)$

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Example

- Consider a connection with leaky bucket parameters (16KB, 150Kbps). $P_{\max}=8KB$. What is g if end-to-end is to be less than 70ms?
 - $\sum_{i=1}^k P_{\max}/r(i) = 10 * 8192 * 8/45M = 14.56ms$
 - $\sigma/g + (k-1)P_{\max}/g \leq 55.44ms$
 - $g = (16*8*1024 + 9*8192*8)/0.05544 = 13Mbps$
- Note that the required rate is $13Mbps/150Kbps = 86.7$ times the average rate
 - Large packets can cause substantial delay
 - If packet size is reduce to 1.5KB, $g = 3.6Mbps$
 - If packet size is further reduced to 53 bytes, $g = 289 Kbps$

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How Efficient?

- GPS/WFQ provides deterministic (worst case) bounds
 - In reality most packets may not experience close to maximum delay
 - The amount of scheduling resource required is often substantial
- Statistical bounds are much more efficient
 - E.g. $< 0.1\%$ of the packets have delay more than 70ms
 - However, statistical bounds (e.g. using equivalent bandwidth) are much harder to compute in practice

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