Advanced Computer Networks

Congestion Control (2)

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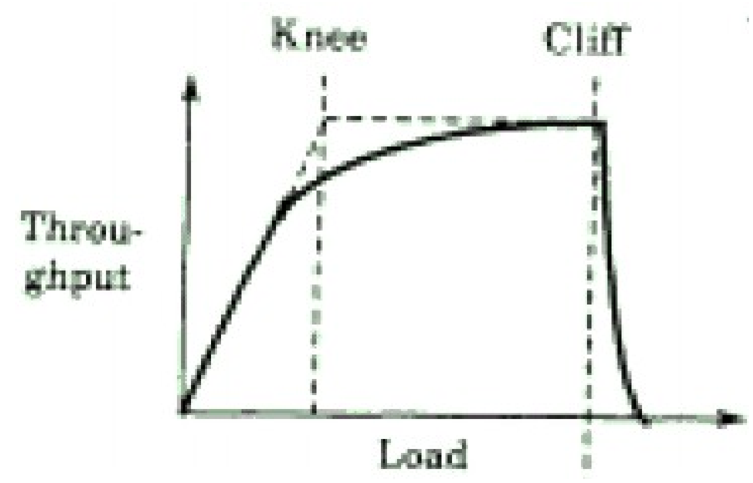
Summer 2007

Feedback on reading & presentation

- Be aware of deadlines
- Ideas, strengths and weaknesses
  - of the paper and related research work!
  - design paper vs performance analysis/improvement paper
- Paper presentation
  - present main ideas: e.g., schemes, analysis approaches
  - interact with the audience
  - adjust the presentation adaptively
- People from the same group
  - lead the discussion!

Review: TCP congestion control

- Design principle
  - packet conservation with ack self-clocking
- Congestion control algorithms
  - slow-start
  - congestion avoidance
  - timeout retransmission
  - fast retransmit
  - fast recovery

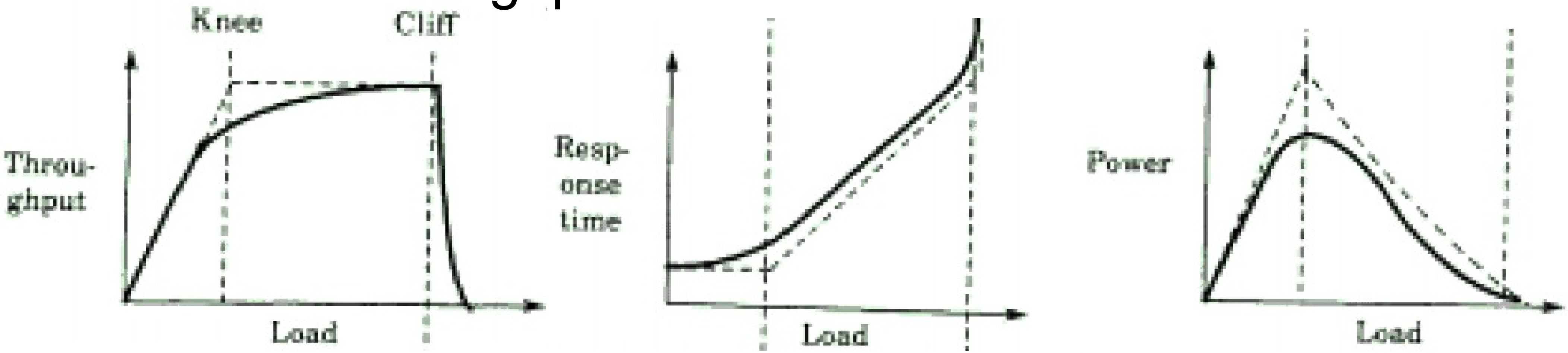


Discussion

- Critics on TCP congestion control

Network congestion

- What can endpoint observe?
  - longer round-trip time
    - extra queuing delay at routers
  - higher packet loss ratio
    - buffer overflow at routers
  - lower throughput



TCP Vegas [BOP94]

- More aggressive retransmission with fine-grained timer
  - Reno: 500 ms coarse-grained timer
    - also usually one timer for a window of packets
- More conservative congestion avoidance
  - Reno: cwnd increased by one MSS every RTT
    - or 0.5 MSS if delayed acknowledgment is used
- Slower than “slow-start”
  - Reno: cwnd doubled every RTT
- Changes only at TCP sender

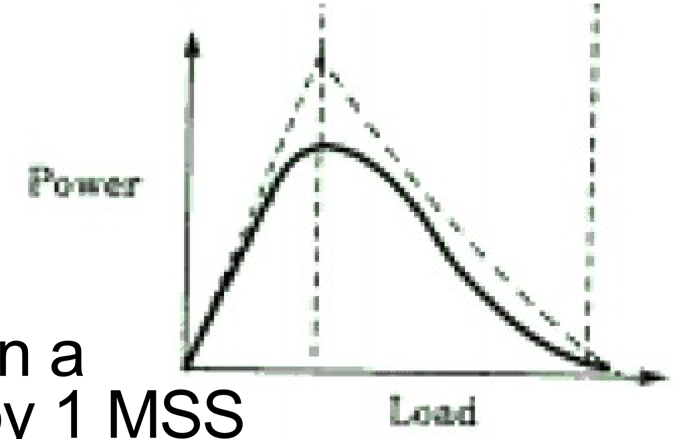
Fine-grained timer

- Fine-grained timer for each packet
  - for a more accurate RTT calculation
  - sender: read and record system clock
    - e.g., utilize TCP timestamps option
- Retransmission triggers
  - check fine-grained timeout when receiving
    - duplicate acknowledgment
    - first or second acknowledgment after retransmission
  - also “fall back” to Reno timeout
- Only reduce cwnd for loss event at current rate

Q: delayed acknowledgment?

Proactive congestion control

- Related work
  - Wang and Crowcroft's DUAL
    - cwnd increases as Reno
    - every 2 RTTs, reduce cwnd by 1/8 if RTT>(RTTmin+RTTmax)/2
  - Jain's CARD
    - every two RTT, if Diff(win)*Diff(rtt) > 0, decease win by 1/8
    - otherwise, increase win by 1 MSS
    - oscillate between WINmin and WINmax
  - Wang and Crowcroft's Tri-S
    - increase 1 MSS every RTT
    - if the throughput improvement is less than a half of the initial segment, reduce cwnd by 1 MSS



Conservative congestion avoidance

- Vegas calculates
  - expected throughput: cwnd / baseRTT
  - actual throughput: cwnd / currentRTT
  - Diff = Expected – Actual > 0
- Window adjustment algorithm
  - two thresholds: a < b
  - if Diff < a, increase cwnd linearly
  - if Diff > b, decrease cwnd linearly
  - goal: a < Diff < b
    - try to probe for extra capacity

Q: how to determine baseRTT?

Q: how to determine a and b?

Slower than “slow-start”

- Vegas in “slow-start”
  - exponential cwnd increase in every other RTT
  - to allow the comparison
    - expected throughput
    - actual throughput
    - Diff = Expected – Actual > 0
  - c: “slow-start” threshold
  - if Diff > c, do congestion avoidance

Q: how to determine c?

Performance evaluation

- Simulation and experimentation
  - one-on-one with Reno
    - Reno is not adversely affected

	Reno/Reno	Reno/Vegas	Vegas/Reno	Vegas/Vegas
Throughput (KB/s)	60/109	61/123	66/119	74/131
Throughput Ratios	1.00/1.00	1.02/1.13	1.10/1.09	1.23/1.20
Retransmissions (KB)	30/22	43/1.8	1.5/18	0.3/0.1
Retransmit Ratios	1.00/1.00	1.43/0.08	0.05/0.82	0.01/0.01

  - with background traffic
    - considerable performance improvement over Reno
- Implementation in x-kernel: extra features
  - e.g., reduction by 1/4, large initial win, burst limit, ...

Further discussion

- Critics on TCP Vegas

This lecture

- Delay-based congestion avoidance
  - TCP Vegas
- Explore further
  - J.S. Ahn, Peter B. Danzig, Z. Liu and L. Yan, "Evaluation of TCP Vegas: Emulation and Experiment." SIGCOMM 95.
  - J. Mo, R. La, V. Anantharam, J. Walrand. "Analysis and Comparison of TCP Reno and Vegas." INFOCOM 99.
  - U. Hengartner, J. Bolliger and Th. Gross, "TCP Vegas Revisited." INFOCOM 2000
  - S. Low, L. Peterson, and L. Wang, "Understanding TCP Vegas: A Duality Model." JACM 2002
  - http://netlab.caltech.edu/FAST/references.html#vegas

Next lectures

- TCP-friendly congestion control
  - [PFTK98] Padhye, J., Firoiu, V., Towsley, D., and Kurose, J., "Modeling TCP Throughput: a Simple Model and its Empirical Validation". In Proceedings of ACM S IGCOMM 1998. [TCPmodel]
- Explicit congestion control
  - [KDR02] Dina Katabi, Mark Handley, and Chalrie Rohrs. Congestion Control for High Bandwidth-Delay Product Networks. In the proceedings on ACM Sigcomm 2002. [XCP]