Dynamic-CBT and ChIPS - Router Support for Improved Multimedia Performance on the Internet

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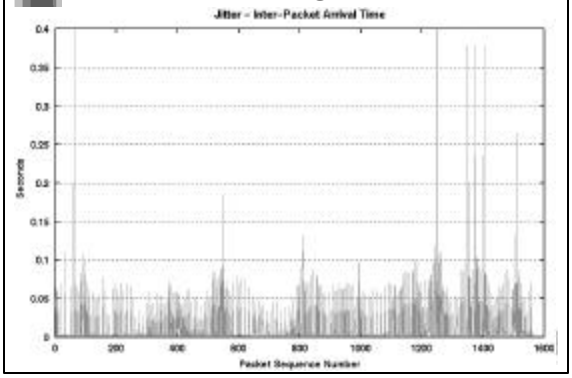
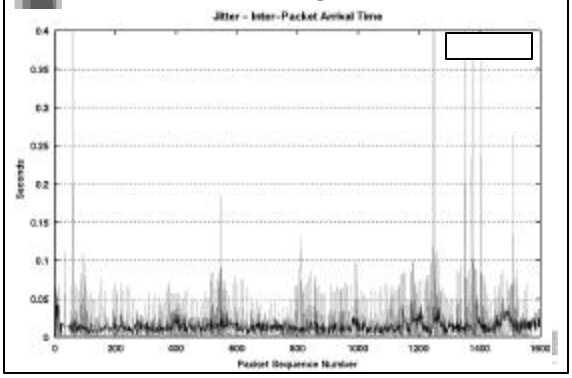
The Internet and Multimedia

- Internet routers are best effort
  - No timing constraints
  - Packet loss, which indicates congestion
- TCP
  - Completely reliable delivery through retransmission
  - Respond to loss as congestion
- But … TCP often unsuitable for interactive multimedia
  - Full reliability not needed
  - Window-based rate fluctuations

Multimedia Using TCP



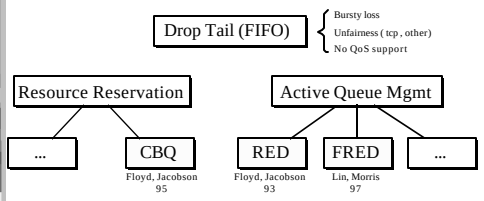
Multimedia Using UDP



Multimedia on the Internet

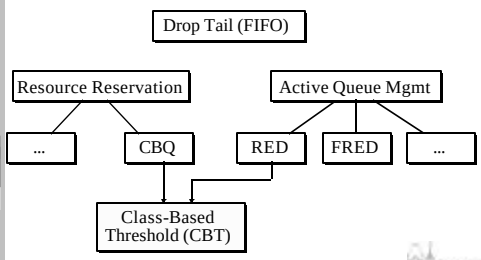
- Multimedia often uses UDP
  - Avoid delay and jitter from retransmission
  - Rate-based
  - Unresponsive!
- Router queue management goals
  - Congestion Control
  - Fairness
  - Reduce Jitter

Current Router Queue Management



Class-Based Threshold (CBT)

AQM Support for Multimedia - Jeffay, 99

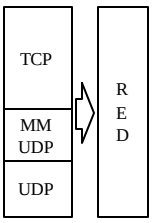


Outline

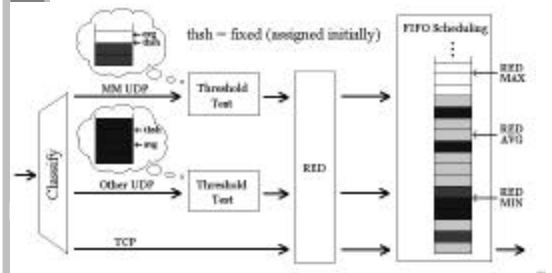
- Introduction ✓
- CBT and D-CBT ⬅
  - Design
  - Evaluation
- ChIPS
  - Design
  - Evaluation
- Conclusion

CBT Concepts

- CBQ + RED: Class-based isolation on RED
- Use Class *Thresholds* and *Avg. # of enqueued packets* on a single FIFO Queue
- Three classes: TCP, MM UDP (flow controlled) and Unresponsive UDP



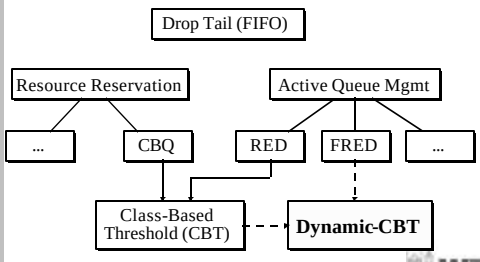
CBT Design



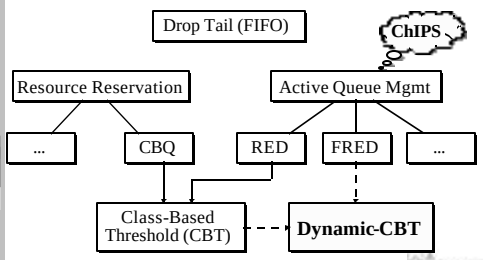
CBT - Pros and Cons

- **Pros:** RED + Class-Based Isolation
  - Early Congestion Notification
  - Protect TCP, and protect (distinguish) MM UDP
  - Different flows coexist with predefined fairness.
  - Dividing bandwidth assigned is up to the class.
- **Cons:** CBQ function w/o admission control
  - Might not work well for certain traffic mixes
  - Arguable that it's not fair (as in the case of CBQ)

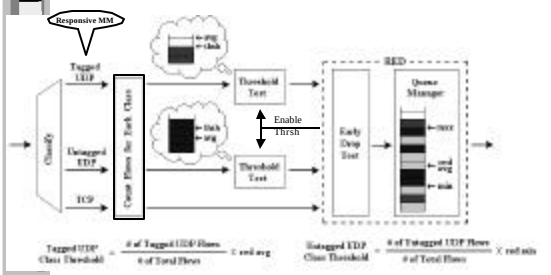
Dynamic-CBT



Dynamic-CBT and ChIPS



D-CBT Design



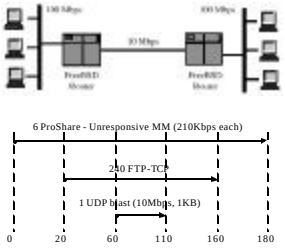
Flow Counting in D-CBT

- For every incoming packet, insert or update <dest-addr, flow-id, local-time> info and update count
  - Sorted Linked List - O(n)
  - Hash Table - O(1)
- Every Δ *ms*, delete old info and update count
  - Sorted Linked List - O(n)
  - Hash Table - O(n)
- (How are flows counted in FRED?)

Evaluation in NS

- Developed responsive multimedia application (for tagged UDP class)
  - AIMD Media Scaling (5 discrete rates)
  - "MPEG-1 like" transmission rates
  - [CC00a], MM-Flow
- Implemented and validated CBT
- Implemented D-CBT and measured congestion time fairness
  - RED vs. CBT vs. D-CBT

Validation of CBT on NS



- RED Settings:

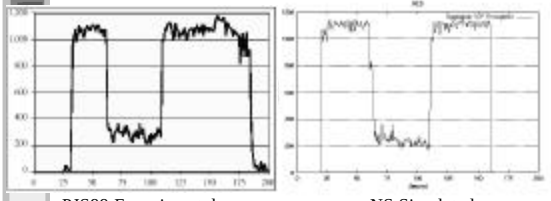
```
qsize   = 60 pkts
max-th  = 30 pkts
min-th  = 15 pkts
qweight = 0.002
max-pro = 0.1
```

- CBT Settings:

```
mm-th   = 10 pkts
udp-th  = 2  pkts
```

Aggregate TCP Throughput under RED

X axis: Seconds, Y axis: Kbyte/Sec



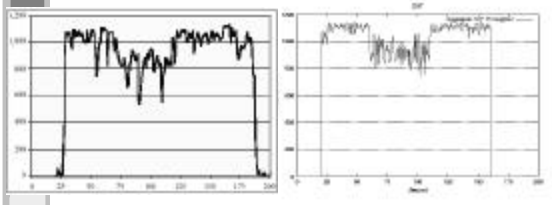
PJS99 Experimental Results

NS Simulated Results

(Our setup is ok, so now can check our CBT test)

Aggregate TCP Throughput under CBT

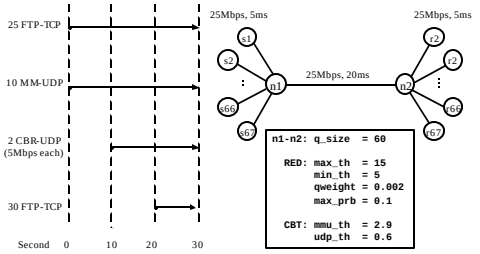
X axis: Seconds, Y axis: Kbyte/Sec



PJS99 Experimental Results

NS Simulated Results

Simulation (RED, CBT, D-CBT)



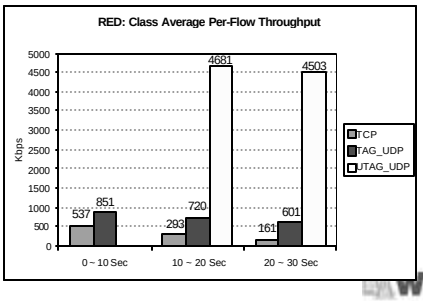
Jain's Fairness Index (f) - Jain, 91

$0 \le f \le 1$ (Greatest Fairness)

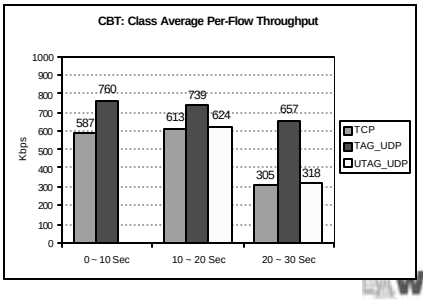
$$f(x_0, x_1, x_2, \ldots, x_n) = \frac{(\sum_{i=0}^{n} x_i)^2}{n\sum_{i=0}^{n} x_i^2}$$

- Examples:
  - 1 flow
  - 2 flows, 5 Kbps each
  - 2 flows, 9 Kbps and 1Kbps

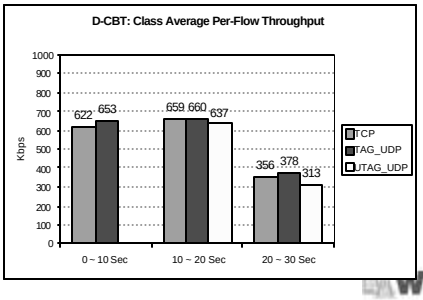
Fairness: RED



Fairness: CBT



Fairness: D-CBT



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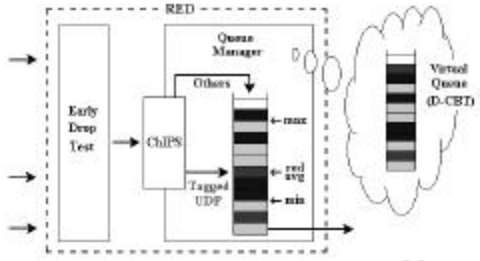
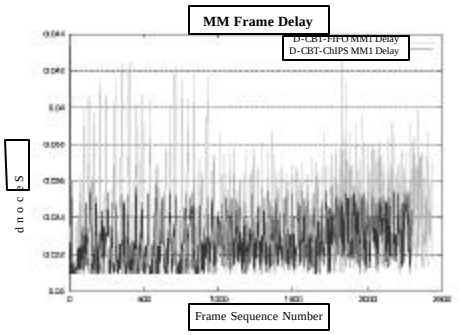
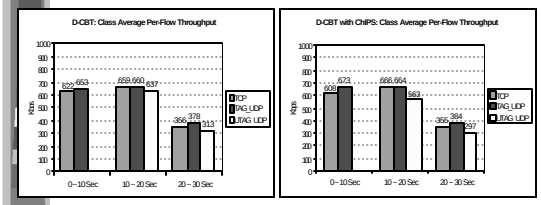
Cut-In Packet Scheduling (ChIPS) Design



ChIPS Evaluation - Jitter



ChIPS Evaluation - Fairness



	TCP Packets Delivered	TCP Packet Drop Rate	TCP Throughput
D-CBT	66,648 pkts	4.46 %	17,773 Kbps
D-CBT w/ ChIPS	66,386 pkts	4.44 %	17,703 Kbps

Conclusion

	Fair to TCP	Fair to Mixed (Fixed)	Fair to Mixed (Variable)	Improve MM Jitter
RED	X			
CBT	X	X		
D-CBT FIFO	X	X	X	
D-CBT ChIPS	X	X	X	X

Future Work

- Active Flow Counting (Overhead)
  - For every incoming packet, update flow info
    - + Hash Table - O(1)
  - Every Δms, delete old flows
    - + Hash Table - O(n)
- Measure Overhead
  - Processing Time and Memory Usage

Future Work

- How many different classes are needed?
  - Example
    - 1 class is RED
    - 1 class per flow is FRED
  - Overhead per class
- Effects of D-CBT and ChIPS on Perceptual Quality

Evaluation of Science?

- Category of Paper
- Science Evaluation (1-10)?
- Space devoted to Experiments?