ABE: Providing a Low Delay within Best Effort

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Introduction
- Multimedia applications can perform well under a wide-range of loss (repair)
- Delay often the major impediment for interactive MM applications
- Internet is “best-effort” with one QoS of traffic for all
  - DiffServ requires monitoring of classes
- Want to keep it simple, but add support for delay sensitive MM traffic
  → Alternative Best Effort (ABE)

Outline
- Introduction (done)
- The ABE Service (next)
- Implementation
- Simulation Results
- Related Work
- Conclusions

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- Introduction (done)
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  - Definition
  - Green does not hurt blue
  - Router requirements
  - Inter-working and Migration
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Definition
- ABE packets are either green or blue
  - (Neutral colors, green for “go”)
  - Application chooses to make packets green
  - Default is blue
- Green packets get low, bounded delay
- Green does not hurt blue
  - Blue has same or better throughput even if green traffic
- All ABE packets in same best-effort class
  - Traditional congestion control
  - All blue gets more throughput than all green

Possible Packet Coloring Strategy

Assume: utility(rate, delay) = 0 if rate < min
utility(rate, delay) = linear with delay if rate > min
Discussion

- Interactive applications send mix of blue and green
  - “Probe” packets to determine region
- Traditional applications send all blue
  - Care more about throughput
- Note, says nothing about TCP-friendly
  - Still same problem as with best-effort
  - Green makes it no worse since doesn’t hurt blue
- Backbones have low delay, so likely ABE in peripheral routers
- Delay bound offered depends upon hops
  - Assume 2-6 low-speed hops
  - Delay 100-150 msec total, maybe 50 for network
  - Per-hop delay about 5-20 msec

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Green Does Not Hurt Blue

- When there is green traffic in addition to traditional blue traffic, we must have
  - Local transparency to blue
  - Throughput transparency to blue

Local Transparency to Blue

- Consider a traditional router that treated all packets equal (no ABE)
- Should have same delay as traditional router
- If blue not dropped with traditional router, then not dropped with ABE router
- If TCP friendly:
  \[ \theta = \frac{g}{R \sqrt{\frac{g}{2} + 3m \sqrt{\frac{g}{2} + 1 + 32j^2}}} \]
- What might happen to throughput for green?
  \[ \rightarrow \] Need throughput transparency

Throughput Transparency to Blue

- If green flow is TCP friendly, should get less or equal throughput as blue flows
- Hard to implement exactly since hard to measure
  - Hard to measure TCP friendly, even!
  - Consider it to be a loose requirement
- Implement by making sure green has higher loss ratio

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Router Requirements

- Provide low, bounded delay to green
- Provide local transparency to blue
- Provide throughput transparency to blue
- Preserve packet sequence within blue and green
  - May be out of order across colors
- Keep green packet loss as low as possible
  - Make green attractive as possible

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Interworking and Migration

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  - Duplicate Scheduling with Deadlines
  - Properties of (DSD)
- Simulation Results
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Implementation

- Could try modified FCFS:
  - For blue, enqueue normally
  - For green, drop if delay > max
  - (What is a problem with this?)
- Instead, use separate queues
  - But still work conserving
- Deadlines associated with each packet
  - Dequeue color that has earlier deadline
  - If both, use a control function for fairness
  → Duplicate Scheduling with Deadlines (DSD)

DSD Overview
**DSD Example**

At time t=0:

- Buffer = 7
- Max d = 3

Deadlines: 6 4 3 2 0

Blue Queue: B, B, B, B, B, B, B

Green Queue: G, G

Serve: G1, B2, B3, B4
Drop: G2 (deadline missed), B6 (buffer full)

**Duplicate Scheduling with Deadlines**

At time t=5:

- Buffer = 7
- Max d = 3

Blue Queue: B, B, B, B, B

Green Queue: G, G, G

Serve: G3, B5, B7, B8 and B9

**DSD Modifications**

- Only enqueue green packet if length of green queue + blue packets with deadline less than d < d
  - So, would not have enqueued G2
- If either can be served, if [0,1] < g then pick green else blue
  - g=1, favor green, g=0 favor blue
  - (g=1 in example)
- Can also use active queue management (AQM) for congestion monitoring

**Properties of DSD**

- Buffer always less than Buff because of virtual queue
- All blue packets served by deadlines, so same as or earlier than best-effort
- All green packets served before d, else dropped

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**Simulation**

- Done in NS-2
- Show green does not hurt blue
- Show green benefits from low delay
- Show loss rates for both types
- Compare to reference condition, flat best-effort FCFS (droptail) router
Simulation Setup

- blue are TCP-Reno, green are TCP-Friendly [BB00]
- Some simulations have one additional green source that is unresponsive CBR
- packet size 1000 bytes
- delay max = 0.04 seconds
- simulations run for 300 seconds

Throughput - Equal

- 10 blue, 10 green
- all TCP-friendly

Queuing Delay - Equal

- Loss: (ABE, BE) green: (4.97%, 3.3%) blue: (3.2%, 2.5%)

Throughput - Unequal

- 10 blue, 6 green
- all TCP-friendly

Throughput – CBR

- 10 blue, 1 green
- CBR

Throughput – CBR + Friendly

- 10 blue, 10 green
- TCP-friendly, 1 green CBR
Throughput – Mixed Green + Blue

- 10 blue, 10 green
- TCP-friendly, 1 green CBR
- Green does 80% green and 20% blue

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Related Work
• IntServ
  – admission control plus reservation
  – Per-flow accounting and charging
  – Doesn’t scale
  – May perform on edge only
• DiffServ
  – Aggregates (classes) of flows
  – Scales better

Related Work
• Low delay service
  – Crowcroft et al (also gets more throughput)
  – EF provides low delay and low loss
  – SIMA has level for how ‘real-time’ traffic is
• Low delay class
  – Dovrolis et al
  – AF – Assured Forwarding
• All require changes to existing price structures. Incremental deployment difficult.

Conclusion
• ABE
  – Supports low delay
  – No reservation or signaling required
• Choice of green or blue up to application
• One ABE implementation presented (DSD)
• Simulation and implementation suggest:
  – Green benefits from lower delay
  – Blue not harmed
  – Under a variety of conditions

Future Work?
Future Work

• Applications that use green
  -- Adaptively
• PQ benefits of ABE to MM
• Implementation overhead of ABE
• More colors for more MM applications:
  -- dark green, light green, neon green …
• More colors for more blue applications
  -- Web, Email, Telnet, File Transfer