ABE: Providing a Low Delay within Best Effort

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IEEE Network Magazine
May/June 2001

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)**
- The ABE Service
  - Definition **(next)**
  - Green does not hurt blue
  - Router requirements
  - Inter-working and Migration
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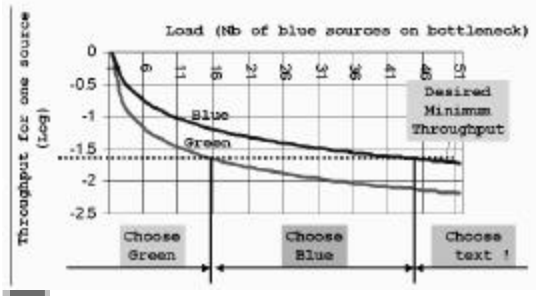
Definition

- 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:

$$\theta = \frac{s}{R\sqrt{\frac{2p}{3}} + 3t_1\sqrt{\frac{3p}{8}}p(1+32p^2)}$$

- What might happen to throughput for green?
  - → 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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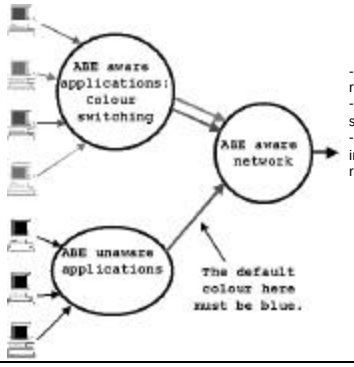
Interworking and Migration



- Can add one router at a time
- Let customers switch to gradually
- Should not impact other routers

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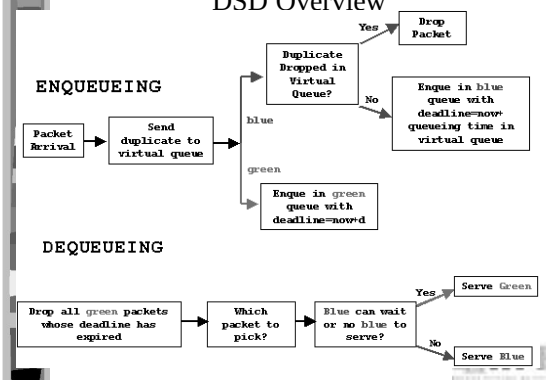
Implementation

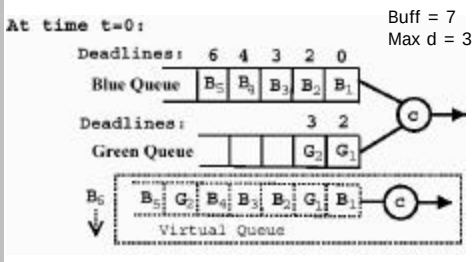
- Could try modified FCFS:
  - For blue, enqueue normally
  - For green, drop if delay > max
  - (What is a problem with this?)
- Instead, use separate queues
  - But still *work conserving*
- Deadlines associated with each packet
  - Dequeue color that has earlier deadline
  - If both, use a control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

→ Duplicate Scheduling with Deadlines (DSD)

DSD Overview

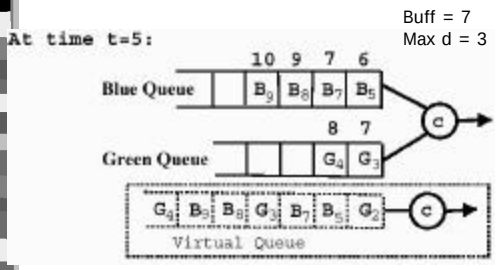


DSD Example



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

Duplicate Scheduling with Deadlines



Serve: G3, B5, B7, 4g, 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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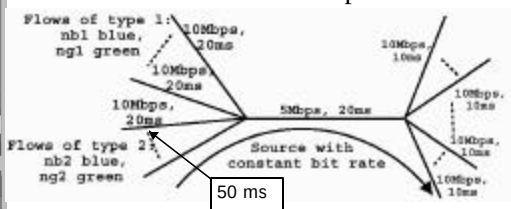
Simulation

- 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

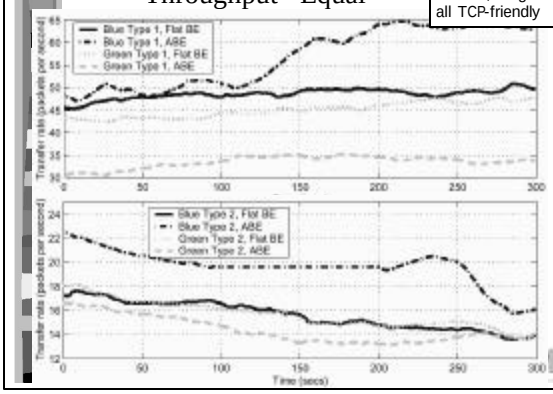
Simulation Setup



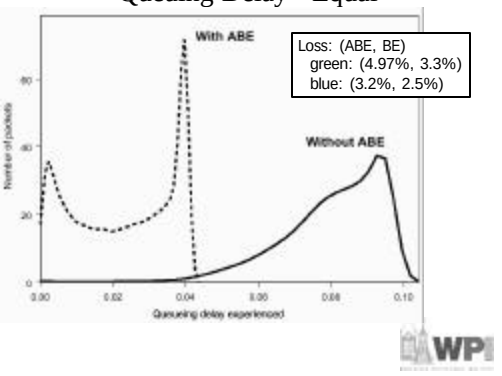
- blue are TCP-Reno, green are TCP-Friendly [BB00]
- Some simulations have one additional green source that is unresponsive CBR
- packet size 1000 bytes
- delay max = 0.04 seconds
- simulations run for 300 seconds

Throughput - Equal

10 blue, 10 green all TCP-friendly

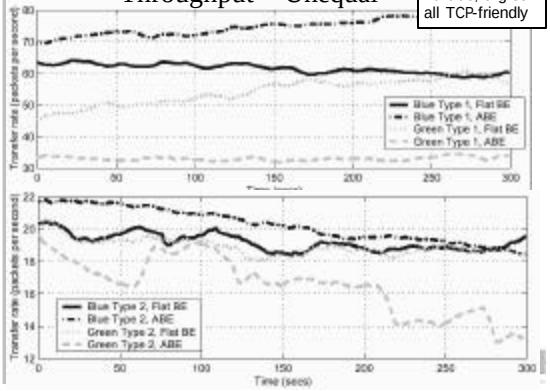


Queuing Delay - Equal



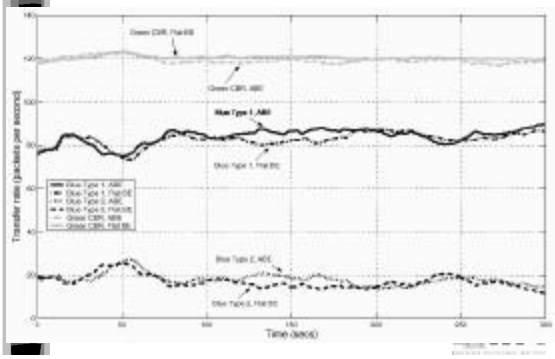
Throughput - Unequal

10 blue, 6 green all TCP-friendly



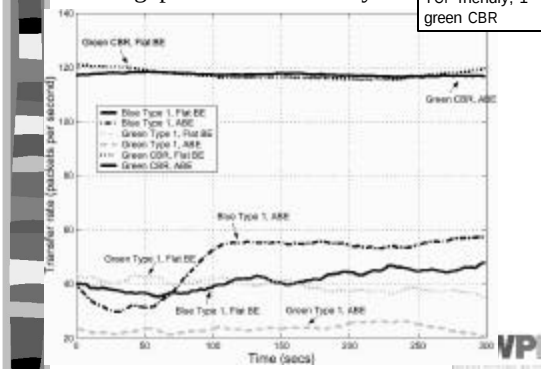
Throughput – CBR

10 blue, 1 green CBR



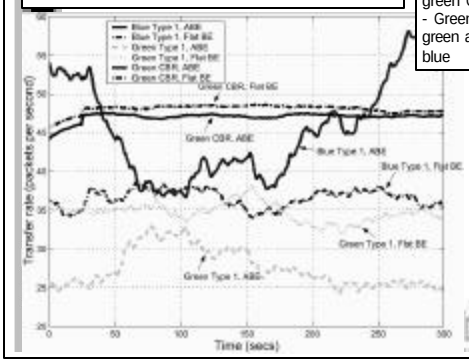
Throughput – CBR + Friendly

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

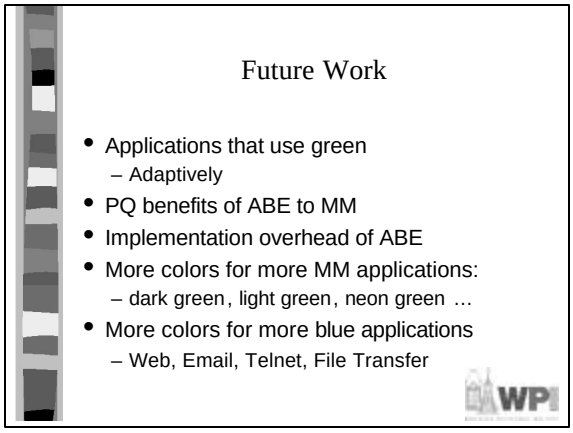
Related Work

- 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
WPI