Enhanced Forward Explicit Congestion Notification for Data Center Ethernet Networks

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IEEE 802.1au Interim Meeting, Geneva, May 29, 2007

These slides are also available at:

http://www.cse.wustl.edu/~jain/ieee/fecn705.htm



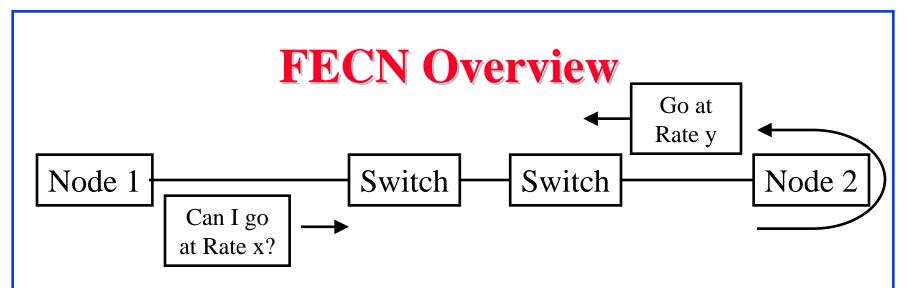
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Enhanced FECN

- Congestion Control and Avoidance
- **□** Rate Probe Reflection and Generation
- Preliminary simulation results



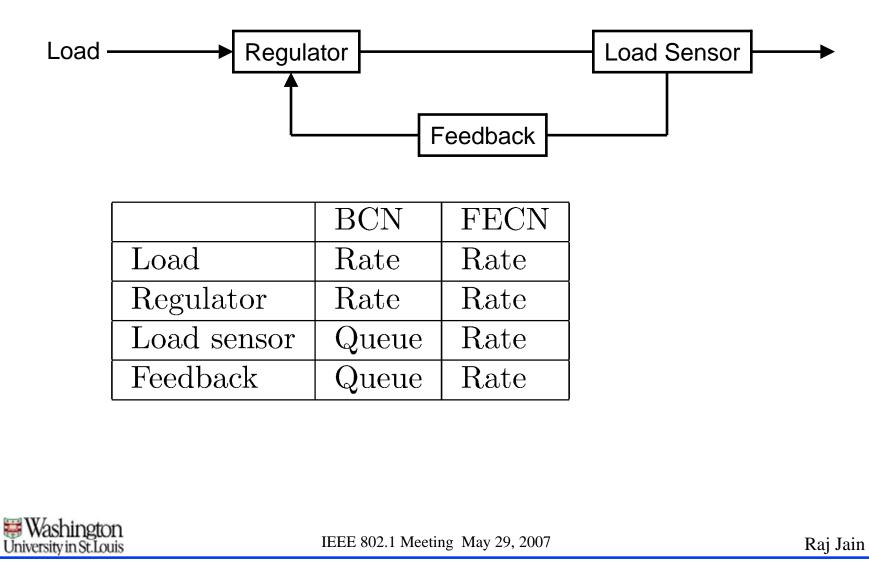


- Periodically, the sources probe the network for best available rate using "Rate Discovery packet"
- □ The probe contain only rate, Rate limiting Q ID
- □ The sender initializes the probes with rate=-1 ($\Rightarrow \infty$)
- □ Each switch computes an "advertised rate" based on its load
- □ The switches adjust the rate in probe packets down if necessary
- □ The receiver reflects the RD packets back to the source
- □ Source send at the rate received

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Essential Components of Control



Strengths of FECN

- 1. Explicit feedback vs implicit (drift up)
- 2. Rate based feedback vs queue feedback *Queue feedback from very different link rates are not comparable.*
- 3. Rate based load sensor vs queue based sensor *Instantaneous queue values are very noisy indicator of load.*
- Simple source algorithm No computation. No drifts. No RTT measurements. Single feedback signal (BCN, BCN0, BCNmax, ...)
- 5. Very low overhead = 1/10th BCN [Cisco's simulations]
- 6. Fast rate increase vs drifting
- 7. Perfect fairness
- 8. Only feedback format needs to be standardized. Internal algorithms should be left to vendors and users.

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Feedback: Desired Changes in FECN

Don't automatically start with a rate regulator \Rightarrow Start high



Enhanced FECN

- 1. Switch from congestion avoidance to congestion control \Rightarrow Allow fast start
- 2. Combine the best of FECN and BCN



Congestion Control vs Avoidance

- □ Control = Reactive vs Avoidance = pro-active
- $\Box \text{ Pro-active} \Rightarrow \text{Slow start}$
- □ Fast start and regulate if congestion experienced
- □ Notes:
 - □ Fast start (with any scheme) lasts only as long as effectively there is a single flow
 - □ With two or more flows passing through a congestion point, there will be congestion



Rate Probe Reflection and Generation GoatRate y Node 1 GoatRate y Switch SwitchSwitch

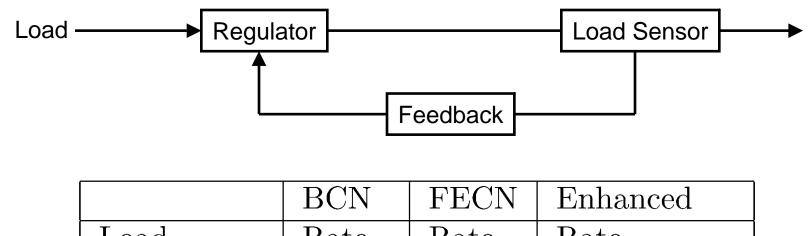
Enhancements:

- □ Probes can be reflected by any switch
- □ Probes can even by generated by the switches
- Rate increase can occur only by destination (or final switch) reflected probes.
- Rate decrease can be caused by any probe regardless of its origin or reflection point



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Essential Components of Control (Cont)



	BCN	FECN	Enhanced
Load	Rate	Rate	Rate
Regulator	Rate	Rate	Rate
Load sensor	Queue	Rate	Rate+Queue
Feedback	Queue	Rate	Rate



FECN Tag Format

- All tags have the same format. Switch generated
 BCN00 is identical to source generated FECN tag
- Switch can only generate backward rate decrease signal to $0 = R_{min}$
- Source behavior is same for reflected or switch generated FECN tags
- □ FECN Tags at Source:

CPID=0 Desired Rate ∞

BCN00 from Switch:

 $\boxed{\text{CPID} \quad \text{Rate} = \text{R}_{\min}}$



Source Action

- □ When to start tagging:
 - *As soon as a flow starts (simple); T=1ms (Congestion avoidance)
 - Only when a flow receives a BCN00 from switch (Congestion Control)



Switch Action

- Switches update rate in the tag if their advertised rate is lower and update CPID.
- □ Under severe congestion: $(q > Q_sc threshold)$
 - □ *Generate BCN00 by sampling if q >Q_sc
 - $\blacksquare \quad \text{Set rate to } \mathbf{R}_{\min} = \mathbf{C}/\mathbf{N}\mathbf{0}$
 - $\hfill \quad When q \leqslant Q_sc \ use \ normal \ FECN$



Control Parameters

- □ Fast Start in all cases
- No pause
- $\Box \quad Frequency of tagging = 1 ms$
- $\Box \quad Qsc = 80 \text{ packets of } 1500 \text{ bytes} = 120 \text{ kB}$
- $\square R_{\min} = 500 \text{ Mbps (To be studied further)}$
- **Control Schemes:**
 - **G** FECN
 - □ BCN
 - □ FECN with BCN00



Simulation Parameters

- Network Configuration
 - □ Configurations: 1 Congestion Point (CP)
 - □ Link Capacity = 10Gbps (Default)
 - □ Congested link 10G
 - \Box Switch port buffer size = 150 KB (100 pkts)
 - $\Box \quad Switch latency (1us) + Prop delay (0.5us)$
- **Traffic Pattern**
 - □ UDP
 - $\Box \quad Workload = CBR \ 10Gbps$
 - □ Frame size: Fixed 1500B

 Simulation duration: 100ms (4 flows start at 5ms and 2flows end at 80ms)

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FECN Parameters

- $\Box \quad T = 1 \text{ms and } 0.05 \text{ms}$
- □ a = 1.1, b=1.002, c = 0.1
- Qeq = 16*1500B (100 packets)
- □ Initial source rate R0=10Gbs \Rightarrow fast start



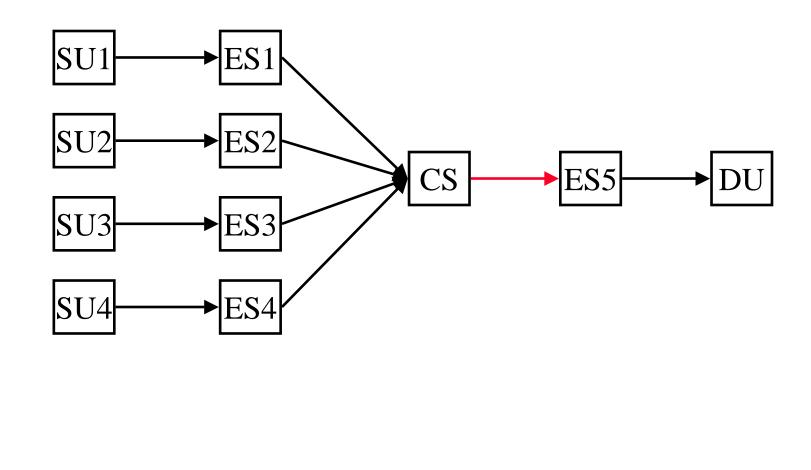
BCN Parameters

- □ Qeq = 16*1500B (100 packets)
 - \Box W=2, Gi = 0.53, Gd = 0.0002667, Ru = 1Mbps.
- $\Box Fixed Sampling = 75000B (2\%)$
 - $\Box \quad \text{Over sampling (10\%) if } Q > Qsc (Qsc=80)$
- **BCN-Max used in lieu of BCN(0,0)**



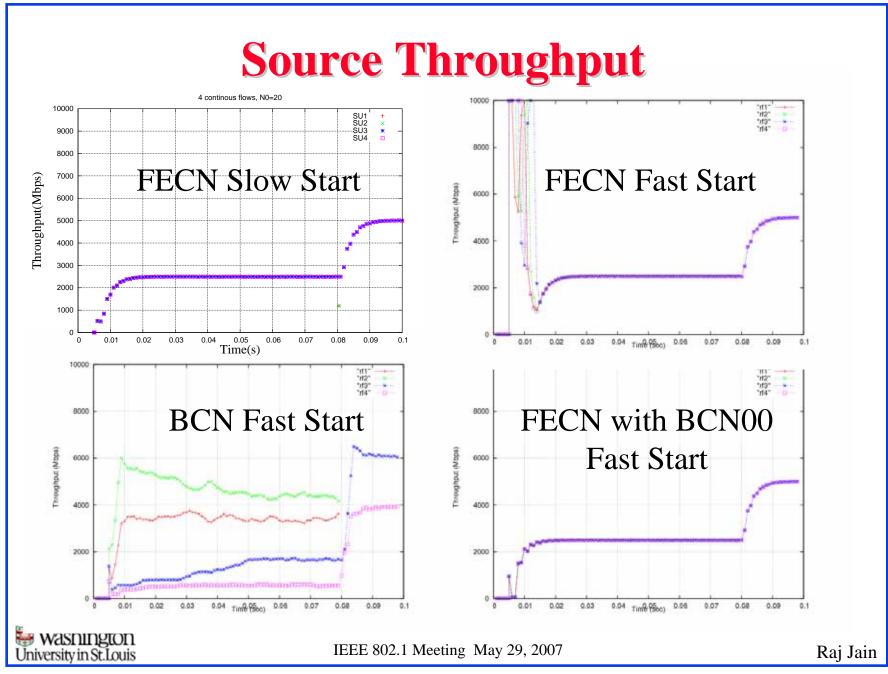
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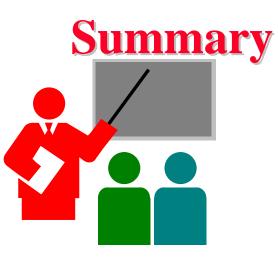






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- 1. Preliminary simulations show that FECN with BCN00 works better than FECN or BCN alone.
- 2. Combines the fast rise, low overhead, and fairness of FECN with fast decrease of BCN00.
- 3. This enhancement allows sources to fast start. Rate regulator can be installed after receiving BCN00.
- 4. Need to do more detailed simulations.
- 5. In particular, the min rate R_{min} needs further investigation.

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