

# Re-ECN: Adding Accountability for Causing Congestion to TCP/IP

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IETF-65 tsvwg Mar 2006



# problem statement (§1)

- previous draft-00 focused on how to do policing
  - problem solved is actually how to allow *some* networks to do policing

## conservative networks

- might want to throttle if unresponsive to congestion (VoIP, video, DDoS)

## middle ground

- might want to cap congestion caused per user (e.g. 24x7 heavy sources)

## liberal networks

- open access, no restrictions
- evolution of hi-speed/different congestion control,... new worms

- many believe Internet is broken
  - not IETF role to pre-judge which is right answer to these socio-economic issues
  - Internet needs all these answers – balance to be determined by natural selection
  - ‘do-nothing’ doesn’t maintain liberal status quo, we just get more walls
- re-ECN goals
  - just enough support for conservative policies without breaking ‘net neutrality’
  - manage evolution of new congestion control, even for liberal → conservative flows
  - nets that allow their users to cause congestion in other nets, can be held accountable

# doc roadmap

Re-ECN: Adding Accountability for Causing Congestion to TCP/IP

[draft-briscoe-tsvwg-re-ecn-tcp-01](#)

*intent*

§3: overview in TCP/IP

§4: in TCP & others

§5: in IP

§6: accountability apps

*stds*

*inform'l*

Emulating Border Flow Policing

using Re-ECN on Bulk Data

[draft-briscoe-tsvwg-re-ecn-border-cheat-00](#)

*intent: informational*

RSVP Extensions for Admission Control over Diffserv using Pre-congestion Notification

[draft-lefaucheur-rsvp-ecn-00](#)

adds congestion f/b to RSVP

*intent*

*stds*

dynamic

sluggish

accountability/control/policing

(e2e QoS, DDoS damping, cong'n ctrl policing)

border policing for admission control

...  
netwk cc

hi speed cc

TCP

DCCP

UDP

QoS signalling (RSVP/NSLP)

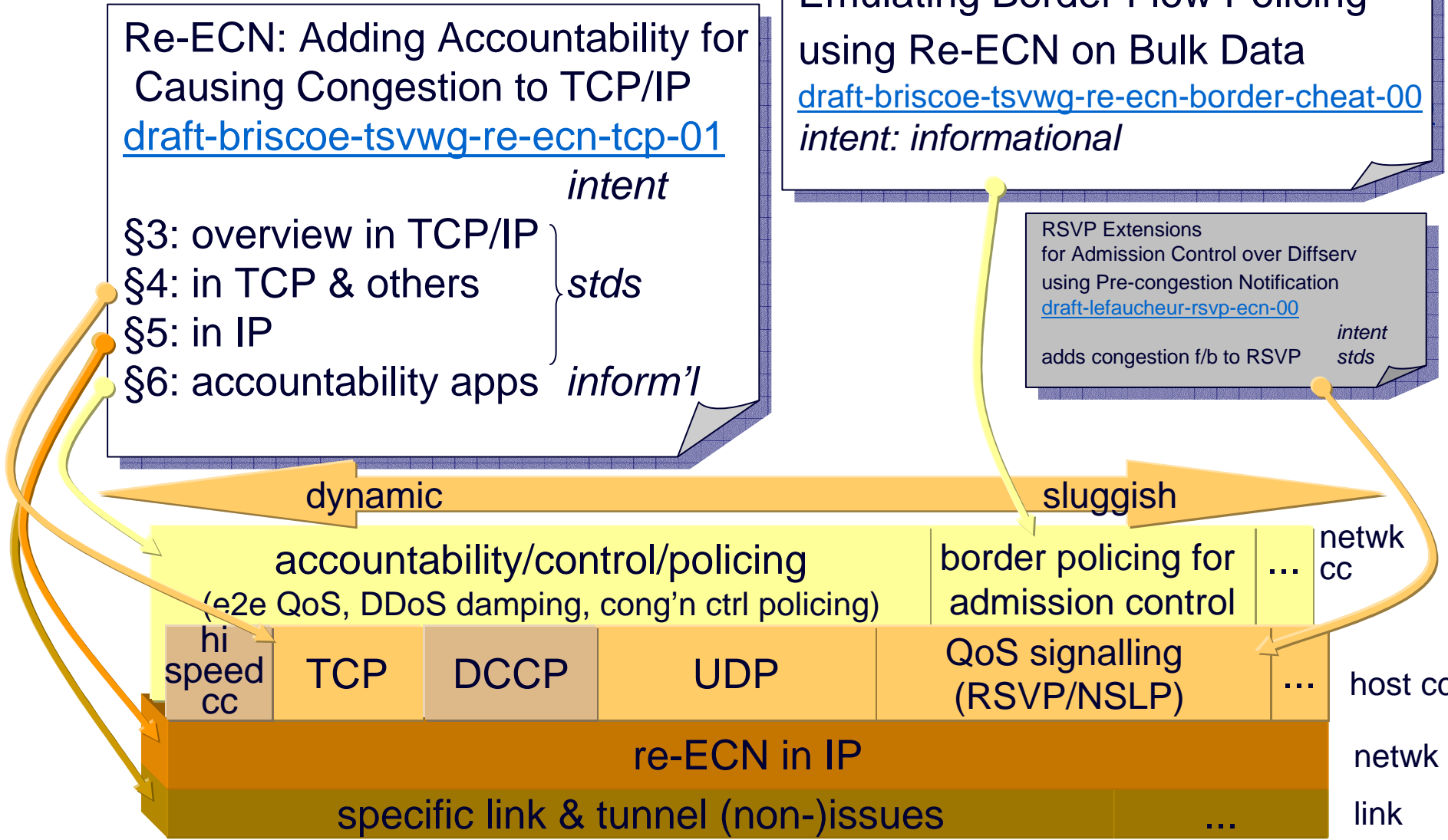
...  
host cc

re-ECN in IP

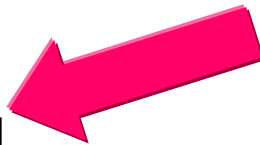
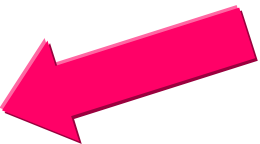
netwk

specific link & tunnel (non-)issues

...  
link

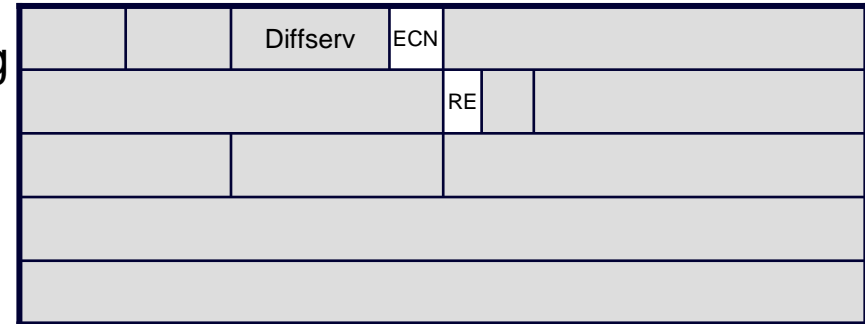


# completely updated draft-01

- Re-ECN: Adding Accountability for Causing Congestion to TCP/IP
- IETF-64 Vancouver Nov 05
  - **initial draft, intent then:**
    - hold ECN nonce ([RFC3540](#)) at experimental 
    - get you excited enough to read it, and break it
  - thanks to reviewers (on and off-list); you broke it (co-author noticed flaw too)
- now
  - **updated draft:** [draft-briscoe-tsvwg-re-ecn-tcp-01.txt](#)
  - **ultimate intent:** standards track
  - **immediate intent:** re-ECN worth using last reserved bit in IP v4? 

## changed re-ECN wire protocol in IPv4 (§3)

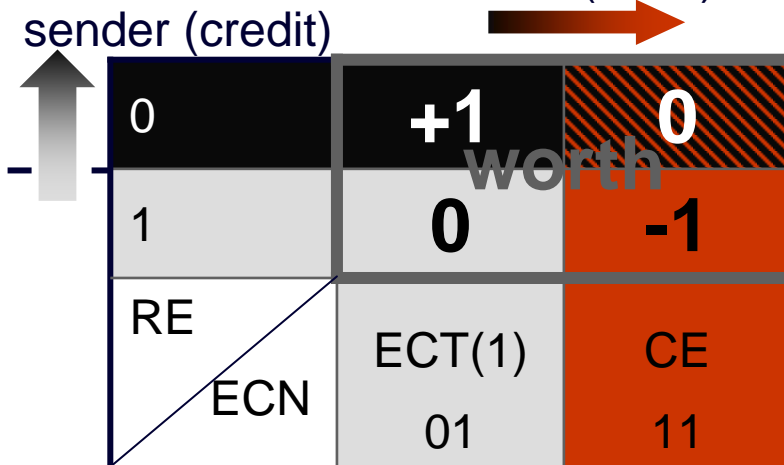
- propose Re-ECN Extension (RE) flag
  - for IPv4: propose to use bit 48 (was reserved)
  - set by sender, unchanged e2e



- once flow established
- sender re-inserts ECN feedback into forward data ("re-ECN") as follows
  - re-ECN sender always sets ECT(1)
  - on every **congestion event** from transport (e.g. TCP)

sender   blanks   RE  
 else   sets   RE

- conceptually, 'worth' of packet depends on 3 bit 'codepoint'
- aim for zero balance of worth in flow



# flow bootstrap

- feedback not established (**FNE**) codepoint; RE=1, ECN=00
    - sent when don't know which way to set RE flag, due to lack of feedback
    - 'worth' +1, so builds up credit when sent at flow start
  - after idle >1sec next packet MUST be **FNE**
    - enables deterministic flow state mgmt (policers, droppers, firewalls, servers)
- FNE** packets are ECN-capable
- routers MAY ECN mark, rather than drop
  - strong condition on deployment (see draft)

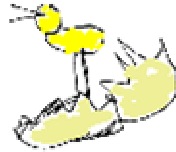
- **FNE** also serves as state setup bit [Clark, Handley & Greenhalgh]
  - protocol-independent identification of flow state set-up
  - for servers, firewalls, tag switching, etc
  - don't create state if not set
  - may drop packet if not set but matching state not found
  - firewalls can permit protocol evolution without knowing semantics
  - some validation of encrypted traffic, independent of transport
  - can limit outgoing rate of state setup
- considering I-D [Handley & Greenhalgh]
  - state-setup codepoint independent of, but compatible with, re-ECN
- **FNE** is 'soft-state set-up codepoint' (idempotent), to be precise

# extended ECN codepoints: summary

- extra semantics backward compatible with previous ECN codepoint semantics

ECN code-point	ECN <a href="#">[RFC3168]</a> codepoint	RE flag	Extended ECN codepoint	re-ECN meaning	'worth'
00	not-ECT	0	Not-RECT	Not re-ECN capable transport	
		1	FNE	Feedback not established	+1
01	ECT(1)	0	Re-Echo	Re-echo congestion event	+1
		1	RECT	Re-ECN capable transport	0
10	ECT(0)	0	---	'Legacy' ECN use	
		1	--CU--	Currently unused	
11	CE	0	CE(0)	Congestion experienced with Re-Echo	0
		1	CE(-1)	Congestion experienced	-1

## other changes in draft (27pp → 65pp)



- easter egg added : )
- re-ECN in TCP fully spec'd (§4), including ECN-capable SYN
- network layer (§5)
  - OPTIONAL router forwarding changes added
    - preferential drop: improves robustness against DDoS
    - ECN marking not drop of **FNE**
  - control and management section added
- accountability/policing applications described (§6)
  - incentive framework fully described
    - example ingress policers & egress dropper described
    - pseudo-code TBA
  - DDoS mitigation explained
  - why it enables simpler ways to do e2e QoS, traffic engineering, inter-domain SLAs (still ref'd out)
- incremental deployment added (§7) → next slide
- architectural rationale added (§8)
- security considerations added (§10) → next slide but one



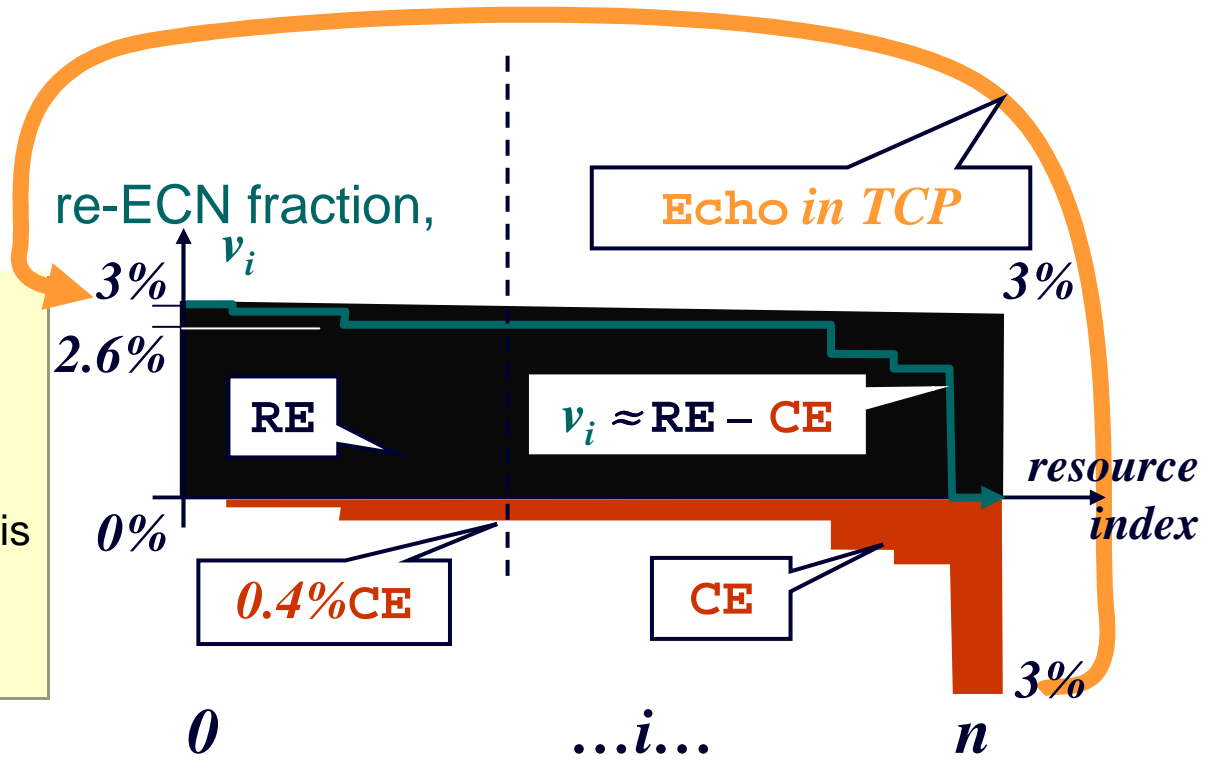
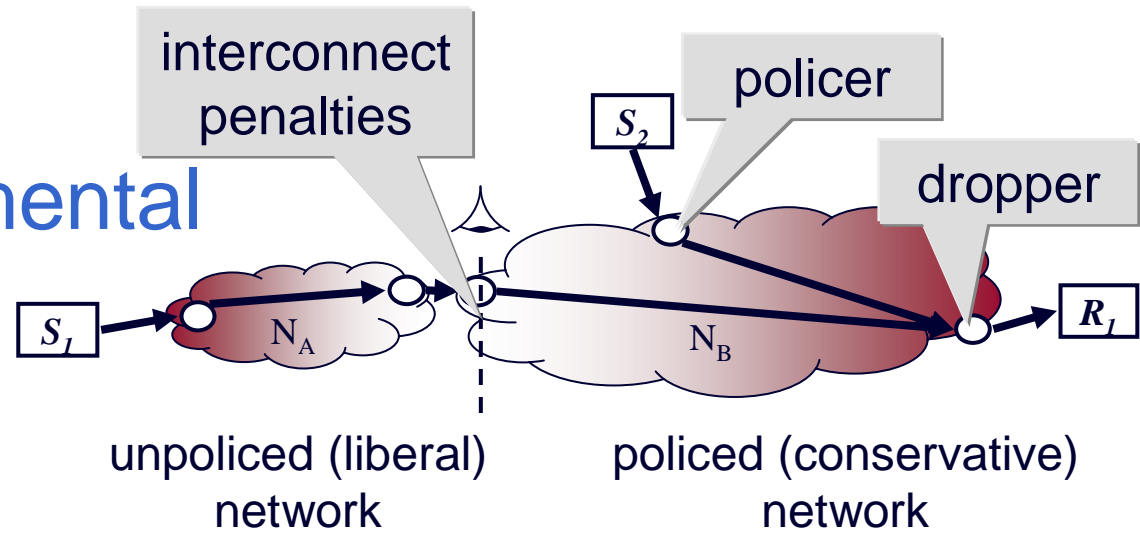
## added incremental deployment (§7: 5½pp)

- brings together reasoning for wire protocol choices
- added deployment scenarios & incentives
  - everyone who needs to act, must have strong incentive to act
  - and incentives must arise in the order of required deployment
- main new messages
  - **first step** to break ECN deployment deadlock
    - edge-edge PCN for end-to-end controlled load (CL) QoS
  - **next step:** greed and fear motivators
    - help TCP (naively friendly) against greedy (streaming) apps
    - probably vertically integrated (conservative) operators first
    - 3GPP devices leak deployment to other networks by roaming
  - unilateral deployment per network ...

# re-ECN incremental deployment

0	+1	0
1	0	-1
RE	ECT(1)	CE
ECN	01	11

- on every congestion event from TCP, sender blanks RE, else sets RE
- at any point on path, diff betw fractions of RE & CE is downstream congestion
- routers unchanged



## added re-ECN security considerations (§10)

- egress dropper
  - robust against attack that plays-off against ingress policing
  - robust against state exhaustion attacks (by design of **FNE**)
  - write-up of state aggregation implementation TBA
  - believe new protocol allows dropper to be robust against dynamic attacks
- working on preventing collateral damage where malicious source spoofs negative traffic like someone else's flow
- see also
  - limitations text added (§6.3) – presented in Vancouver
  - tsvwg posting “traffic ticketing considered ineffective or harmful” (26 Jan '06)
- security of re-ECN deliberately designed not to rely on crypto
- provoking you to break re-ECN

## summary

- enables ‘net neutral’ policing of causes of congestion
  - liberal networks can choose not to police, but still accountable
- simple architectural fix
  - generic accountability hook per datagram
  - requires one bit in IP header
- ECN nonce of limited scope in comparison
- fixed vulnerabilities so far by making it simpler
  - working on robustness to new attacks
- detailed incremental deployment story

## plans in IETF

- split draft into two and fill some 'TBAs':
  - protocol spec
  - accountability/policing applications
- implementation/simulation next
- re-TTL draft planned (Appendix E gives exec summary)
- independent flow state setup draft (possibly)
- spec detail more than sufficient for intensive review
  - ~20 controversial points highlighted
  - strongly encourage review on the tsvwg list
- changing IPv4 header isn't a task we've taken on lightly

# Re-ECN: Adding Accountability for Causing Congestion to TCP/IP

[draft-briscoe-tsvwg-re-ecn-tcp-01.txt](#)

## Q&A



# Emulating Border Flow Policing using Re-ECN on Bulk Data

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IETF-65 tsvwg Mar 2006



# simple solution to a hard problem?

- Emulating Border Flow Policing using Re-ECN on Bulk Data
  - **initial draft:** [draft-briscoe-tsvwg-re-ecn-border-cheat-00](#)
  - **ultimate intent:** informational
  - **exec summary:** claim we can now scale flow reservations to any size internetwork *and* prevent cheating





# doc roadmap

Re-ECN: Adding Accountability for Causing Congestion to TCP/IP  
[draft-briscoe-tsvwg-re-ecn-tcp-01](#)

*intent*

- §3: overview in TCP/IP
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*stds*

*inform'l*

Emulating Border Flow Policing using Re-ECN on Bulk Data  
[draft-briscoe-tsvwg-re-ecn-border-cheat-00](#)  
*intent: informational*

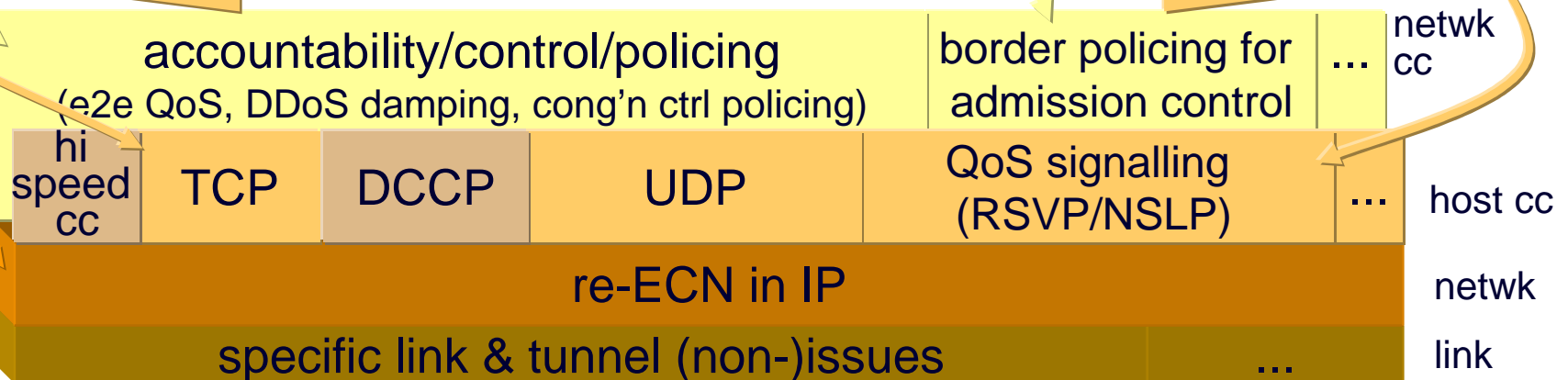
RSVP Extensions for Admission Control over Diffserv using Pre-congestion Notification  
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*intent stds*

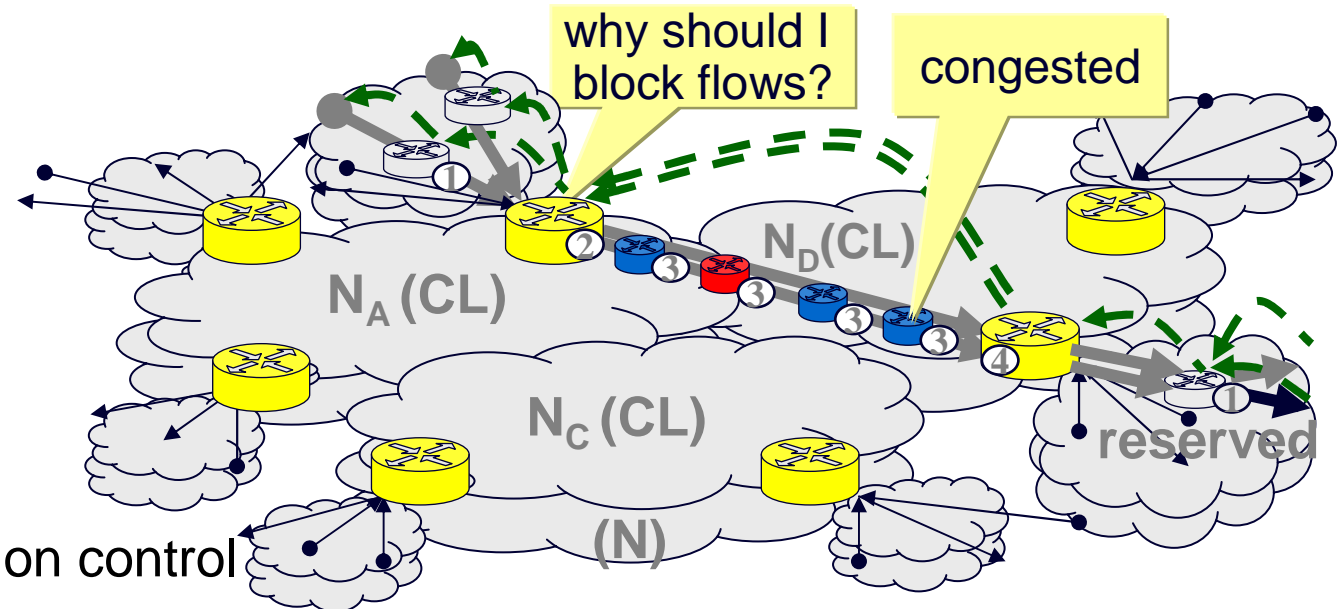
adds congestion f/b to RSVP

dynamic

sluggish



## problem statement

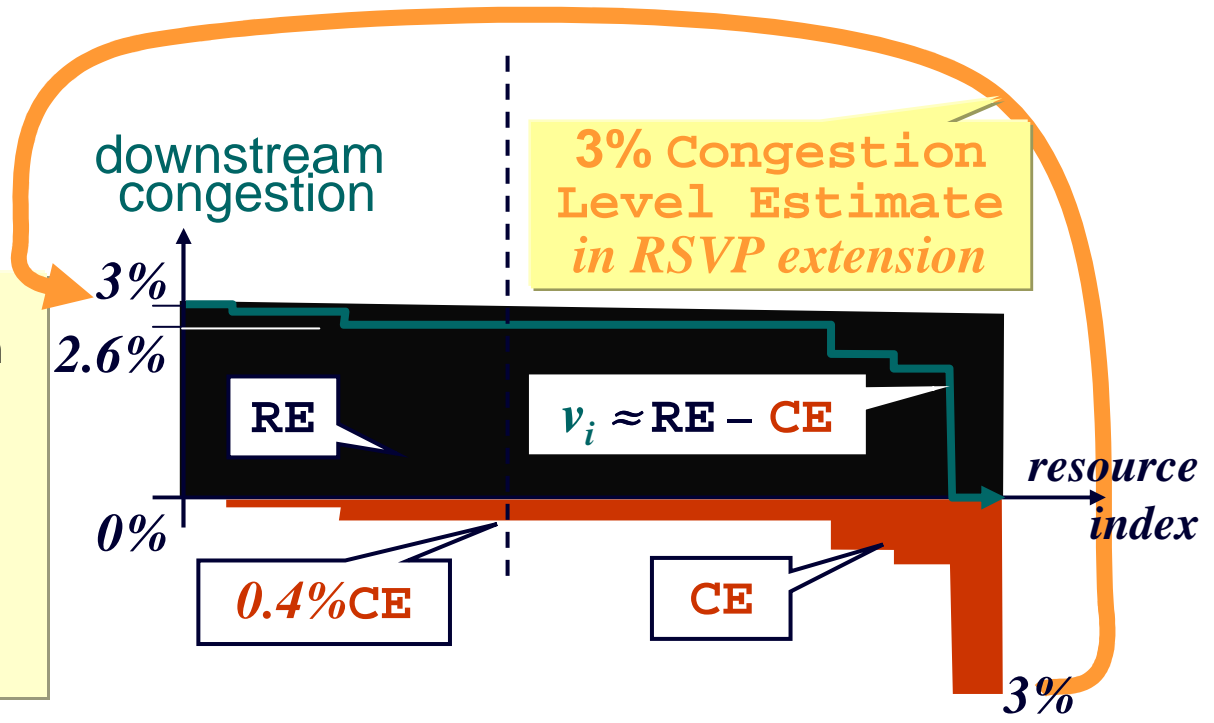
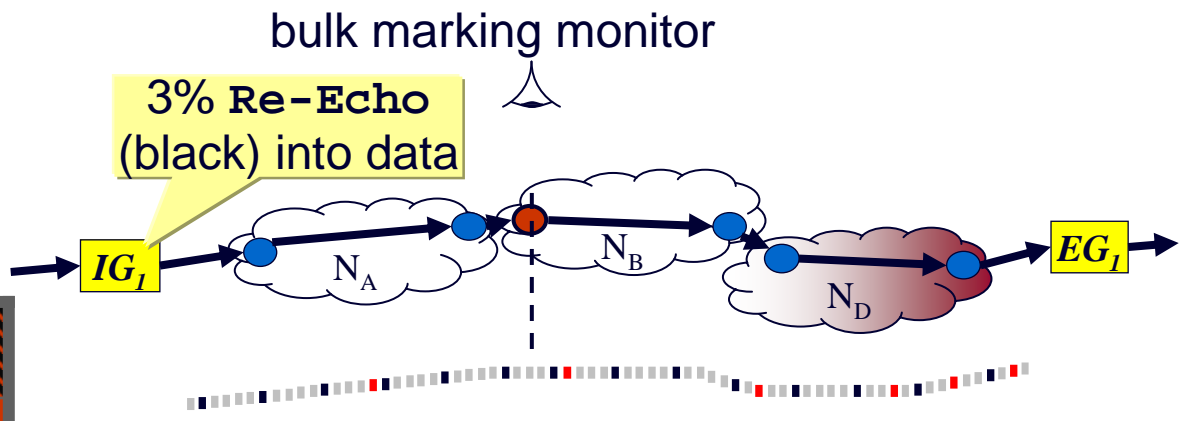


- flow admission control
  - a network cannot trust its neighbours not to act selfishly
  - if it asks them to deny admission to a flow
    - it has to check the neighbour actually has blocked the data
  - if it accepts a reservation
    - it has to check for itself that the data fits within the reservation
- traditional solution
  - flow rate policing at borders
- can pre-congestion-based admission control span the Internet?
  - without per-flow processing at borders?

# solution: use re-ECN

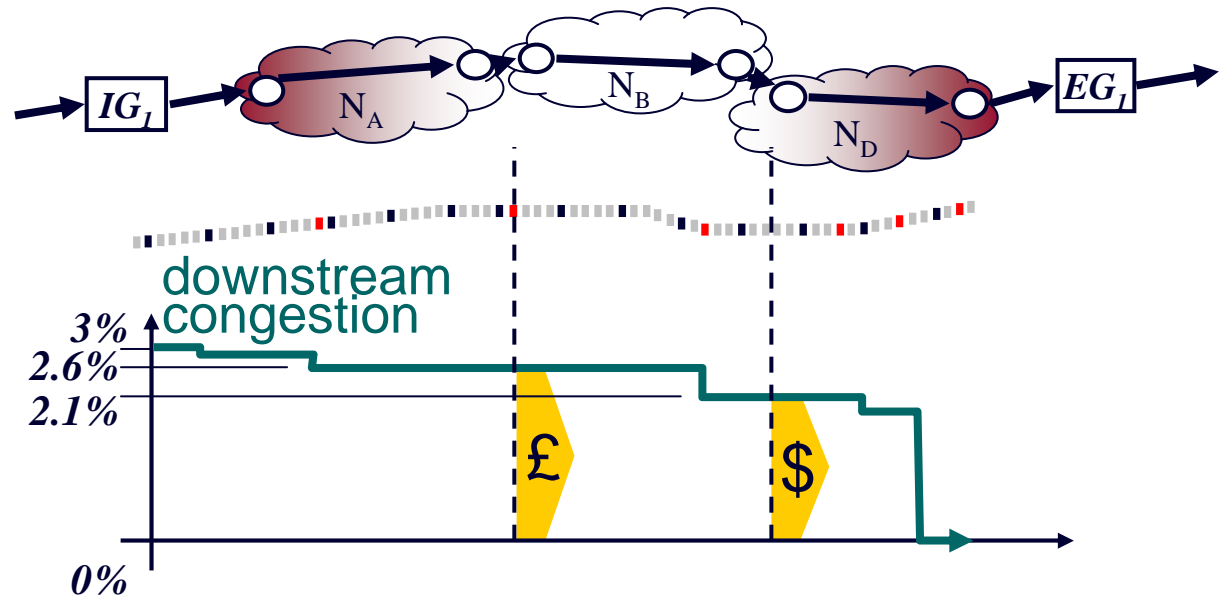
0	+1	0
1	0	-1
RE	ECT(1)	CE
ECN	01	11

- ingress gateway blanks RE, in same proportion as fraction of CE arriving at egress
- at any point on path, bulk diff betw fractions of RE & CE is downstream congestion
- routers unchanged



## inter-domain accountability for congestion

- metric for inter-domain SLAs or usage charges
  - $N_B$  applies penalty to  $N_A$  in proportion to bulk volume of **RE** less bulk volume of **CE** over, say, a month
  - could be tiered penalties, directly proportionate usage charge, etc.
  - flows and f'back de-aggregate precisely to responsible networks
- see draft for fail-safes against misconfigs etc.

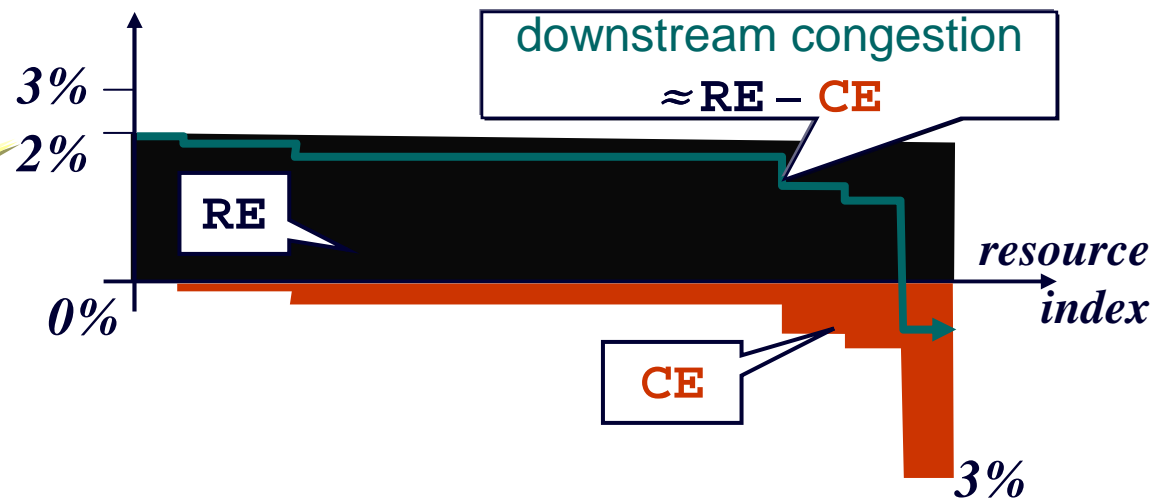
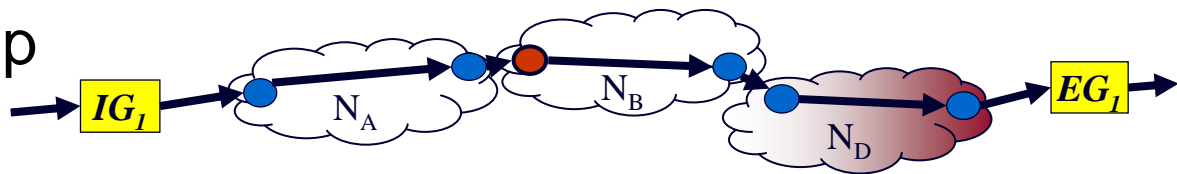


## note well: not standardising contracts

- want to avoid protocols that depend on particular business models
  - only standardise the protocol
  - then networks can choose to use the metric in various ways
- the contractual arrangement was an example to prove a solution exists
  - networks can choose other, broadly similar arrangements
  - or choose not to use it, and to do per-flow processing instead
- only concerns interconnection within Diffserv region

# why should ingress re-echo honestly?

- if  $N_D$  detects persistent imbalance between **RE** and **CE**, triggers sanctions
- probably not drop
  - raise mgmt alarm
  - sanction out of band



## summary

- claim we can now scale flow reservations to any size internetwork *and* prevent cheating
  - without per-flow processing in Internet-wide Diffserv region
  - just bulk passive counting of packet marking over, say, a month
- see draft for
  - why this is a sufficient emulation of per-flow policing
  - results of security analysis, considering collusions etc.
  - protocol details (aggregate & flow bootstrap, etc)
  - border metering algorithms, etc
- comments solicited, now or on list

# Emulating Border Flow Policing using Re-ECN on Bulk Data

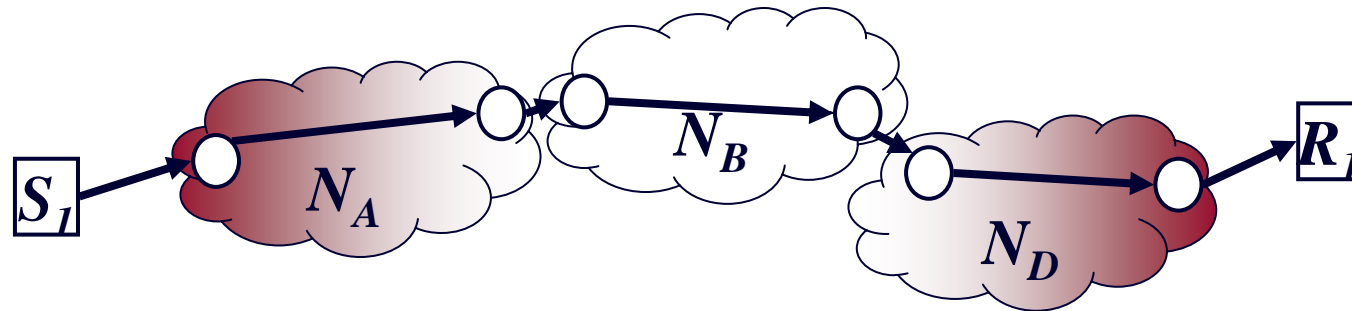
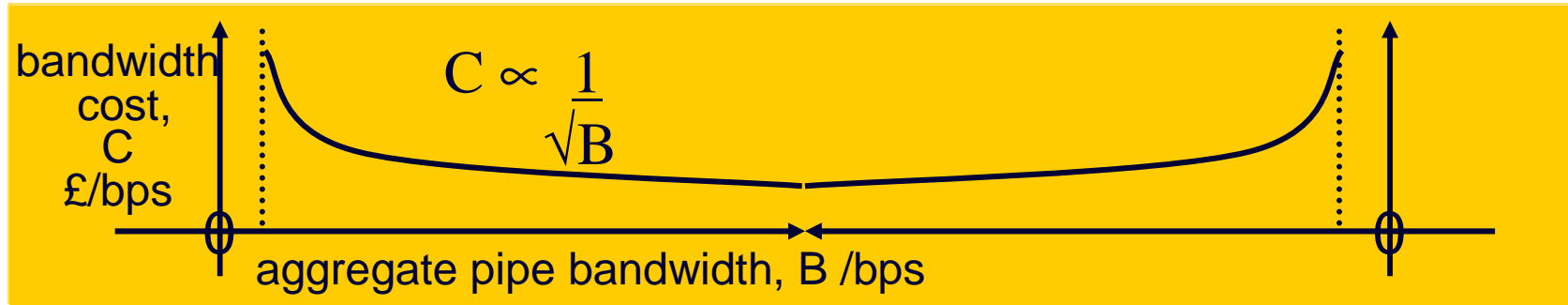
[draft-briscoe-tsvwg-re-ecn-border-cheating-00.txt](#)

## Q&A





# path congestion typically at both edges



- congestion risk highest in access nets
  - cost economics of fan-out
- but small risk in cores/backbones
  - failures, anomalous demand

## you MUST do this

## you may not do this

- logically consistent statements
- build-time compliance
  - usual standards compliance language (§2)
- run-time compliance
  - incentives, penalties (§6 throttling, dropping, charging)
- hook in datagram service for incentive mechanisms
  - they can make run-time compliance advantageous to all

## previous re-ECN protocol (IP layer)

ECN code-point	standard designation
00	not-ECT
10	ECT(0)
01	ECT(1)
11	CE

- sender re-inserts congestion feedback into forward data: “re-feedback”

on every **Echo-CE** from transport (e.g. TCP)

sender sets **ECT(0)**

else sets **ECT(1)**

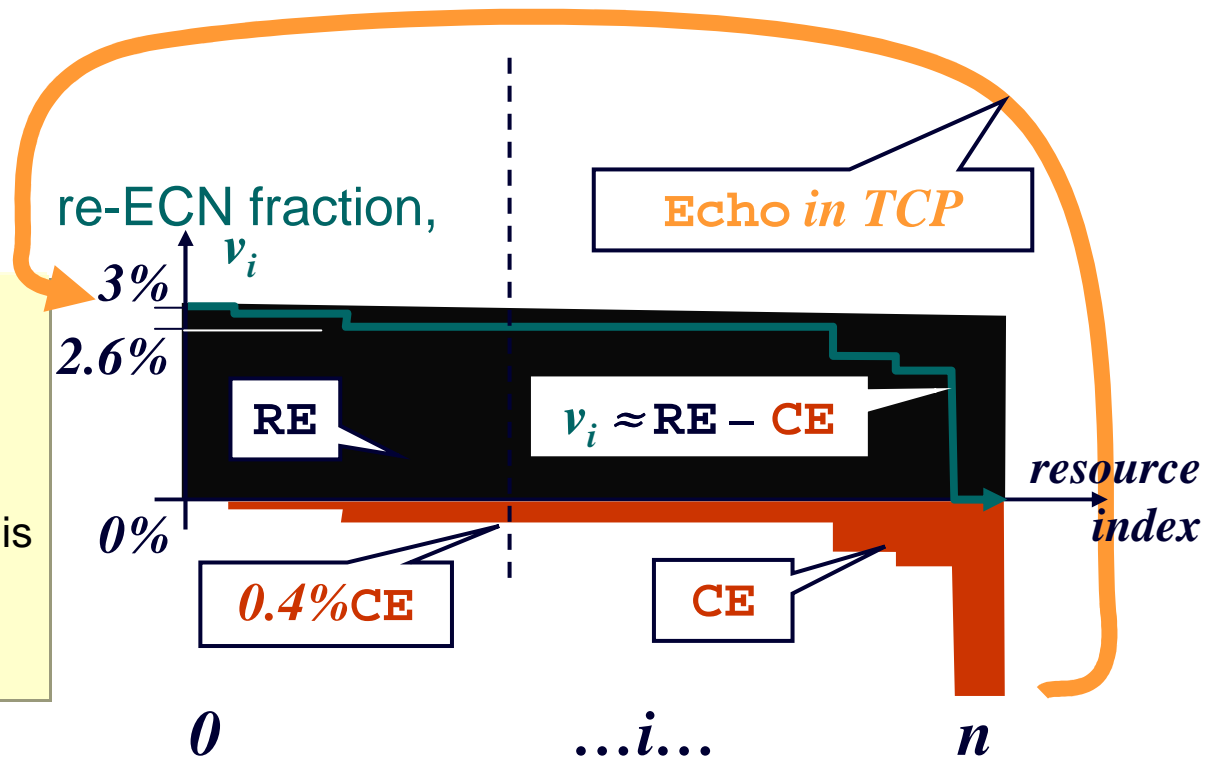
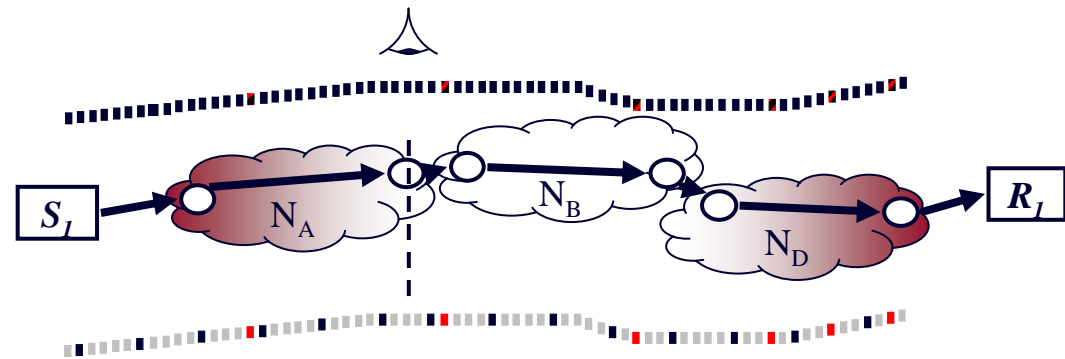
- Feedback-Established (FE) flag

IPv4 control flags		
FE	DF	MF

# re-ECN (sketch)

0	+1	0
1	0	-1
RE	ECT(1)	CE
ECN	01	11

- on every **congestion event** from TCP, sender blanks **RE**, else sets **RE**
- at any point on path, diff betw fractions of **RE** & **CE** is downstream congestion
- routers unchanged



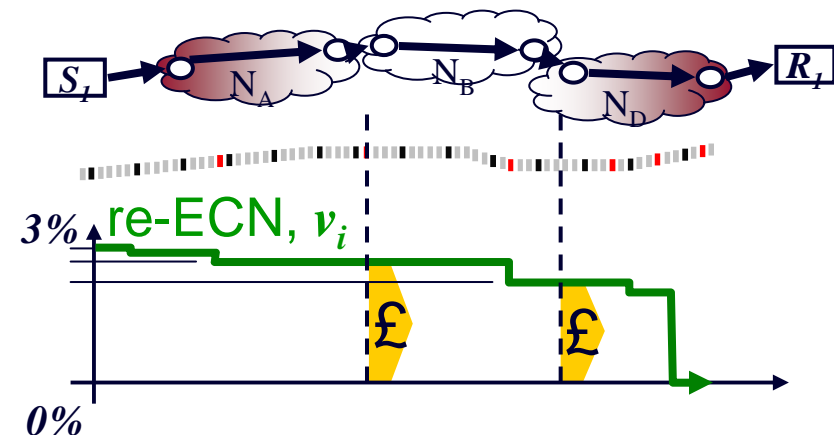
## re-ECN in TCP (§4) updated

- flow start now fully spec' d (incl. example session)
- goal: all packets can be ECN capable
  - can now allow ECN capable SYN (and SYN ACK)
    - with a strong deployment condition (see draft)
  - pure ACKs, re-transmissions, window probes: still **Not-ECT**
- re-ECN hosts don't need ECN nonce [[RFC3540](#)] support

## accountability for congestion

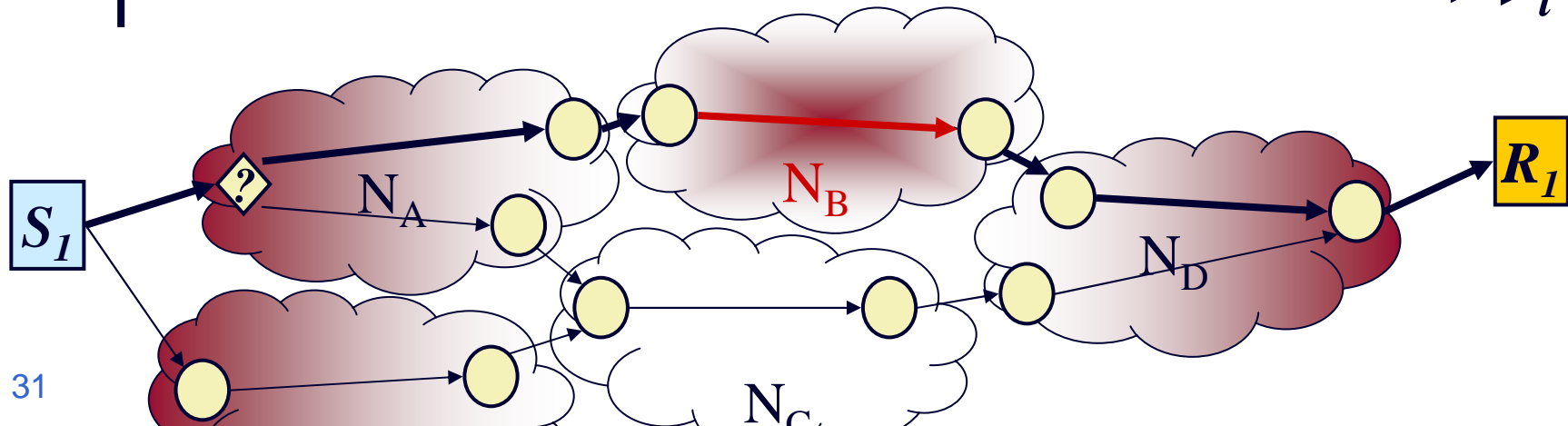
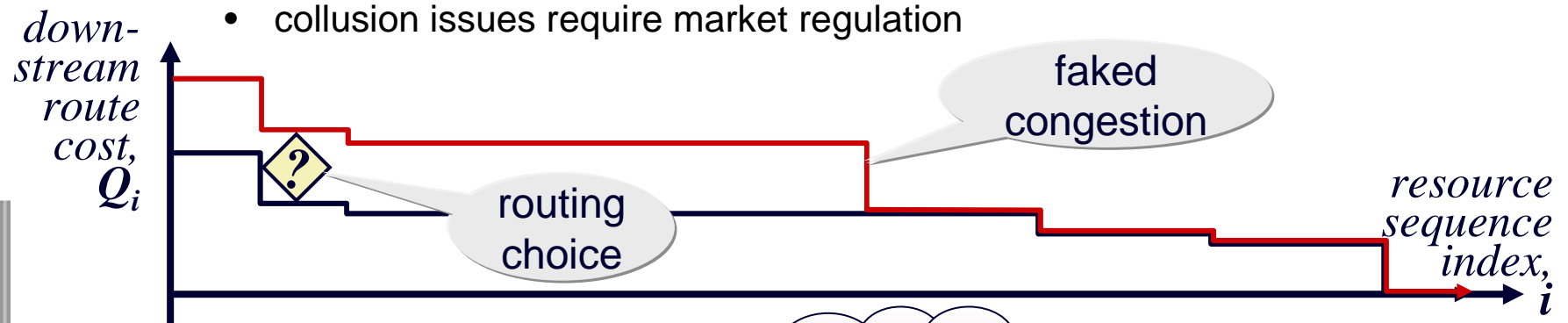
# other applications

- congestion-history-based policer (congestion cap)
  - throttles causes of past heavy congestion (zombies, 24x7 p2p)
- DDoS mitigation
- QoS & DCCP profile flexibility
  - ingress can unilaterally allow different rate responses to congestion
- load sharing, traffic engineering
  - multipath routers can compare downstream congestion
- bulk metric for inter-domain SLAs or charges
  - bulk volume of **ECT(0)** less bulk volume of **CE**
  - upstream networks that do nothing about policing, DoS, zombies etc will break SLA or get charged more

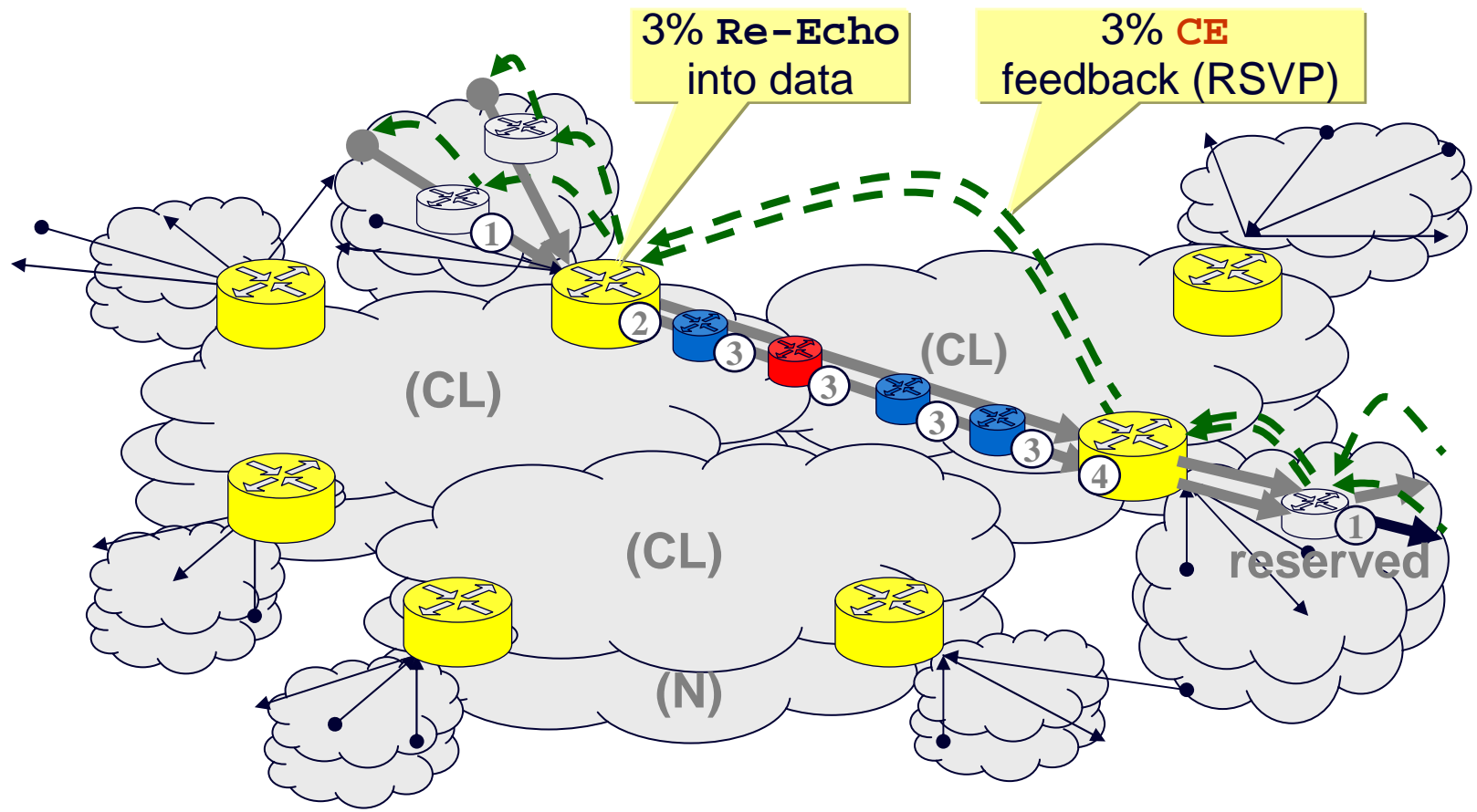


## congestion competition – inter-domain routing

- if congestion  $\rightarrow$  profit for a network, why not fake it?
  - upstream networks will route round more highly congested paths
  - $N_A$  can see relative costs of paths to  $R_1$  thru  $N_B$  &  $N_C$
- the issue of monopoly paths
  - incentivise new provision
  - collusion issues require market regulation



# border anti-cheating solution





## BT IPR related to [draft-briscoe-tsvwg-re-ecn-tcp-00.txt](#)

- See IPR declaration at [https://datatracker.ietf.org/public/ipr\\_detail\\_show.cgi?&ipr\\_id=651](https://datatracker.ietf.org/public/ipr_detail_show.cgi?&ipr_id=651) which overrides this slide if there is any conflict
- 1) WO 2005/096566                      30 Mar 2004                      published
- 2) WO 2005/096567                      30 Mar 2004                      published
- 3) PCT/GB 2005/001737                      07 May 2004
- 4) GB 0501945.0 (EP 05355137.1) 31 Jan 2005
- 5) GB 0502483.1 (EP 05255164.5) 07 Feb 2005
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