

# ConEx Crediting & Auditing

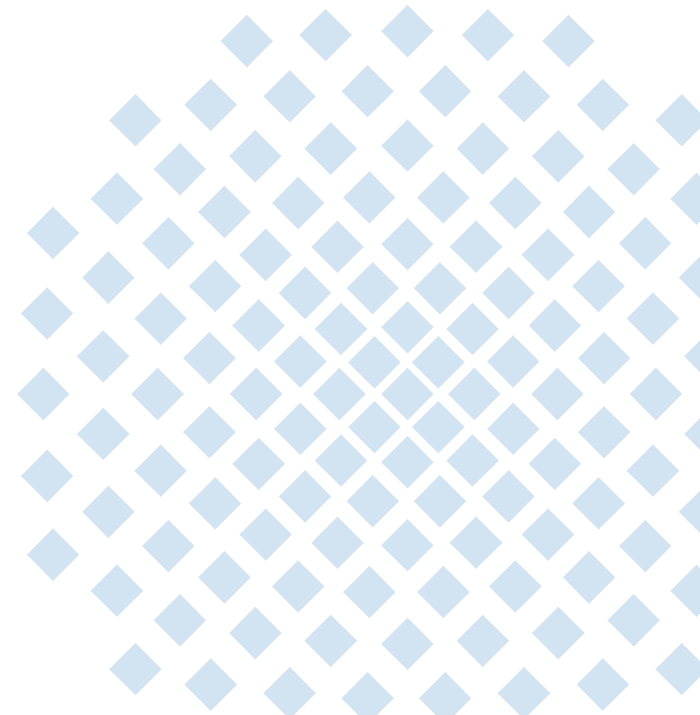
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ConEx – 87. IETF Berlin – July 29, 2013

draft-wagner-conex-credit-00

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# Motivation

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- Need auditing to provide incentives for declaring congestion honestly
- Need credit to avoid per flow RTT estimation in audit
  - as ConEx signal is delayed by one RTT
- Credit needs to be well defined to coordinate audit and sender behavior correctly
  - draft conex-tcp-modifications depends on definition

## *Definitions*

### Congestion occurrence

The occurrence of a congestion signal, today a packet loss or ECN-CE mark

### Congestion event

One or more congestion occurrences within one RTT. Therefore perceived as one congestion event by today's congestion control algorithms.

# Open Issues

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## No incentives to conceal congestion by sending credits

Allowing credit to replace ConEx congestion (L or E) signals may ruin incentives to send congestion signals

ConEx information need to be sent accurately and timely

## Handling Loss of ConEx-marked Packets

ConEx-marks shouldn't be retransmitted (due to time-dependency)

Sender could send replacing credit or audit could estimate loss of ConEx-marked packets

## Independence from Audit State

Flows may be re-routed or audit devices may be (re-)started

## Assumption on Distance between Congestion Events

Audit shouldn't rely on distinguishable congestion events

- Today's congestion control typically results in several RTTs between congestion events
- Doesn't hold for very small RTTs/RED scenarios and future fine-grained congestion notification

# Basic Audit Implementation

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- 5 Counters (Re-Echo-Loss, Re-Echo-ECN, Loss, ECN-CE, credit)
    - $\text{Loss-balance} = \text{Re-Echo-Loss} - \text{Loss}$
    - $\text{ECN-balance} = \text{Re-Echo-ECN} - \text{ECN-CE}$
    - Balance negative after congestion event
    - Will get balanced again after one RTT
      - if reported honestly & ConEx marks are not lost
  - Audit penalizes flow by dropping packets if misbehavior / cheating is detected
- **How can misbehavior be detected?**
- **Which definition of credit allows reliable audit functioning?**
- Credit to cover negative balance during unknown RTT
  - Credit meaning needs to be well defined for audit and ConEx sender

# Credit Definition

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... as Congestion Substitute

→ Credit as equal substitute for L- or E-marks

... as Congestion Surcharge

→ Credit as fixed surcharge for the lateness of the real ConEx signal

... as BDP-scaled Surcharge

→ Credit as surcharge equivalent to the lateness of the real ConEx signal

... as Short-Lived Congestion Risk Compensation

→ Credit is a fixed surcharge for the lateness of the real ConEx signal with limited lifetime

# Credit Definition

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*... as Congestion Substitute*

## Audit Implementation

- For each loss or ECN-CE decrease respective balance
- Penalty criterion: **Loss-Balance + ECN-Balance + Credit < 0**

## Sender's perspective

Pays for loss and ECN-echos by L- / E-marks or credit

## Characteristics

Credit as equal substitute for L- or E-marks

- Real congestion level can be concealed by not sending L/E marks at all
- Loss of ConEx marks can be detected and balanced by sending credit
- No incentive to send any ConEx marks at the end of a connection
- No credit sent during long periods → high impact of loss of audit state expected

# Credit Definition

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*... as Congestion Surcharge*

## Audit Implementation

- For each loss or ECN-CE decrease respective balance and credit counter
- Penalty criterion: **Credit** < 0

## Sender's perspective

Pays twice for congestion: in advance in credits and afterwards in ConEx L- or E-marks

## Characteristics

Credit as fixed surcharge for the lateness of the real ConEx signal

- Congestion can be concealed
- Credit frequently sent → lower impact of loss of audit state

# Credit Definition

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*... as BDP-Scaled Surcharge*

## Audit Implementation

- For each loss or ECN-CE decrease respective balance and credit counter
- While one balance is negative, decrease credit for any packet seen
- Penalty criterion: **Credit** < 0

## Sender's perspective

Sends credits on a congestion event until there was one RTT without congestion

## Characteristics

Credit as surcharge equivalent to the lateness of the real ConEx signal

- Congestion can be concealed
- Sender has to send more credit for longer RTTs (although out of his control)
- Needed credit depends on distance of congestion occurrences within one congestion event



# Credit Definition

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*... as Short-Lived Congestion Risk Compensation*

## Audit Implementation

- For each loss or ECN-CE decrease respective balance and credit
- For each incoming credit set an expiration timer decreasing credit counter  
Expiration time must be fixed and known to all parties, e.g. 300 seconds  
*Note: can be implemented using aggregation bins for credit expiry, e.g. for 10 seconds*
- Penalty criterion: **Credit** < 0

## Sender's perspective

Pays twice for congestion in credit and ConEx-E/-L marks plus replaces expiring credit

## Characteristics

Credit is a fixed surcharge for the lateness of the real ConEx signal with limited lifetime

- Senders are forced to send ConEx credit marks until end of connection
- Credit frequently sent → lower impact of loss of audit state

# Potential Extension

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*for all surcharge-based approaches*

- Goal: Credits should be no replacement for ConEx marks
  - ConEx marks must be received after RTT
    - remember loss and ECN-CE counter state of previous (max) RTT
  - May use worst-case RTT
    - worst-case RTT may be a fixed long time
    - no per-flow-estimate
- Additional penalty criterion
$$\text{Re-Echo-Loss}_{\text{now}} - \text{Loss}_{\text{now} - \text{maxRTT}} + \text{Re-Echo-ECN}_{\text{now}} - \text{ECN-CE}_{\text{now} - \text{maxRTT}} \geq 0$$

## Characteristics

- Detection of congestion concealing for longer flows
- No means against congestion concealing of short flows

# Discussion

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## *General*

### Congestion Concealment

As in all penalty criteria *credit* appears, credit still may be used to conceal congestion

### Loss of ConEx marks

- Detected best by the sender, but requires credit as substitute
- Audit can estimate loss for longer flows by comparing average total loss rate to loss rate of E- and L-marks
  - Since ConEx marks are sent one RTT after a congestion event, loss of ConEx marks should be less than overall average loss
$$(\text{Lost\_Packets} - \text{Re-Echo-Loss}) / \text{Lost\_Packets} \leq \text{Lost\_Packets} / \text{All\_Packets}$$
$$(\text{ECN-CE} - \text{Re-Echo-ECN}) / \text{ECN-C} \leq \text{Lost\_Packets} / \text{All\_Packets}$$

### Independence from audit state

- Surcharge approaches expected to be more robust
  - since senders are frequently replacing consumed credit anyway
- Requires more research

	Substitute	Surcharge	BDP-Scaled Surcharge	Short-lived Congestion Risk Compensation
Complexity	+	+	+	0
Handling loss of ConEx marks	+	at audit	at audit	at audit
Independence from audit state	-	+?	+?	+?
Incentive to send ConEx marks to end of connection	-	+	+	+
Detect congestion concealing for longer flows	-	with crit. 2	with crit. 2	with crit. 2
Detect congestion concealing for short flows	-	-	-	-
Specific advantages	credit substitutes ConEx signals			
Specific disadvantages	credit substitutes ConEx signals		credit cost out of control of sender	more complex implementation

# Summarizing Thoughts

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- Substitute approach does not allow to detect congestion concealing at all
- BDP-Scaled Surcharge brings cons but no pros
- Surcharge approaches can be improve by worst-case RTT criterion  
Do we want that? Can we define a global worst case RTT?
- Expiring credits improve audit functioning only if worst-case RTT criterion is not used

# Backup

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## Substitute Approach

- + Handling loss of ConEx marks
- + Simple implementation
- High impact of loss of audit state expected
- No means against congestion concealing at all
- No incentive to send any ConEx marks to the end of a connection

## Surcharge Approach

- + Simple implementation
- + Detection of congestion concealing for longer flows
  - o Handling loss of ConEx marks at the audit
- No incentive to send any ConEx marks to the end of a connection
- No means against congestion concealing of short flows

## BDP-scaled Surcharge Approach

- + Simple implementation
- o Handling loss of ConEx marks at the audit
- Sender has to pay more for longer RTTs although out of his control
- Distribution of congestion occurrences within one event effects credit cost heavily
- No incentive to send any ConEx marks to the end of a connection
- No means against congestion concealing of short flows

## Short-Lived Congestion Risk Compensation Approach

- + Acceptable implementation (see note slide 9)
- + For longer flows provides means to detect congestion concealing (see note slide 7)
- o Handling loss of ConEx marks at the audit
- No means against congestion concealing of short flows