



Overview of known issues for IEEE 802.1CB FRER ... and next steps

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SRF &
Refinements

Should anyone present know
of any reason that this
couple should not be joined,
speak now or forever hold
your peace.

this presentation

Goal of this presentation

- Presentation of known issues with the Sequence Recovery Function (SRF) in IEEE Std. 802.1CB
- **Goal is to agree:**
Which issues we do care about & want to get „engaged“ with?

us

This slide is not to be taken seriously!

Identified Issues since 2019

Nominal Behaviour / No Failure	Management Reset
	Member Stream Path Jitter (e.g., inference or wireless)
	Talker Pause
	Network Function Virtualization
Failure	Failure before Duplication (or: Failure on all links)
	Failure on one link
Other	Vector Recovery Algorithm with short HistoryLength
	Match Recovery Algorithm w/o intermittent streams

Many issues occur even
under normal operation!



Resulting Effects

Wrong
Counter
Values

Forwarding
of Replicates

Increased
Rate of
Merged
Stream

Elimination
of Valid
Packets

Disclaimer

- Many solutions have been proposed
- **But we will not present the solutions here**
- Let us first agree, if the problems are relevant
- Solutions will be discussed in a separate presentation

References used

[1] Balázs Varga, János Farkas, July 2019

<https://www.ieee802.org/1/files/public/docs2019/new-varga-FRER-improvements-0719-v01.pdf>

[2] Balázs, Farkas, March 2020

<https://www.ieee802.org/1/files/public/docs2020/new-varga-FRER-seamless-reset-0320-v02.pdf>

[3] Maintenance 257, March 2020

<https://www.ieee802.org/1/files/public/docs2020/maint-varga-257-FRER-recovery-window-0320-v01.pdf>

<https://www.802-1.org/items/370>

[4] Balázs, Farkas, March 2020

<https://www.ieee802.org/1/files/public/docs2020/maint-varga-FRER-sequence-recovery-reset-0320-v02.pdf>

[5] Maintenance 265, April 2020

<https://www.802-1.org/items/379>

[6] Balázs, Farkas, Sept 2020

<https://www.ieee802.org/1/files/public/docs2020/new-varga-FRER-RTag-0920-v02.pdf>

[7] Balázs, Farkas, Fejes, Hoefftberger et al., May 2023

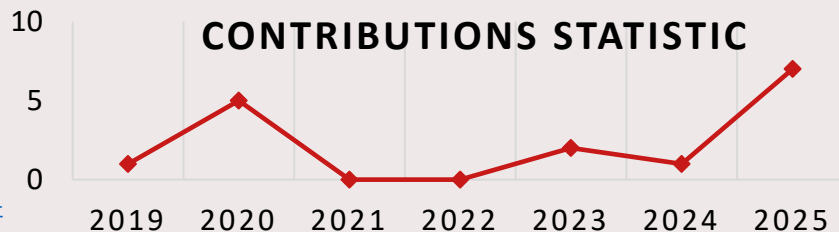
<https://www.ieee802.org/1/files/public/docs2023/new-varga-FRER-extensions-to-support-cloudification-0523-v01.pdf>

[8] Maile et al., Jun 2023

<https://www.ieee802.org/1/files/public/docs2023/new-maile-ensuring-reliable-and-predictable-behavior-of-FRER-0623-v02.pdf>

[9] Maile, June 2024

<https://www.ieee802.org/1/files/public/docs2024/new-maile-FRER-sequence-recovery-configuration-0624-v01.pdf>



[10] IEEE Std. P802.1CBec, Feb 2025 - now

<https://www.ieee802.org/1/files/private/ec-drafts/d0/802-1CBec-d0-2.pdf>

[11] Maintenance 378, March 2025

<https://www.ieee802.org/1/files/public/docs2025/maint-arunarthi-CB-2017-item-378-0310-v02.pdf>

[12] Balázs, Farkas, May 2025

<https://www.ieee802.org/1/files/public/docs2025/maint-varga-CB-2017-item-378-FRER-segrecreset-0525-v00.pdf>

[13] McCall May 2025

<https://www.ieee802.org/1/files/public/docs2025/maint-mccall-cb-2017-item-378-seq-recovery-options-v01.pdf>

[14] Balázs, Farkas, July 2025

<https://www.ieee802.org/1/files/public/docs2025/maint-varga-CB-2017-item-378-FRER-reset-analysis-0725-v01.pdf>

[15] Steindl, Proell, July 2025

<https://www.ieee802.org/1/files/public/docs2025/60802-Steindl-Proell-IA-Controller-ConfDomain-Cloud-0725-v01.pdf>

[16] Balázs, Farkas, September 2025

<https://www.ieee802.org/1/files/public/docs2025/ec-varga-FRER-improvements-0925-v00.pdf>

[17] Extending PAR&CSD for P802.1CBec, Nov 2025

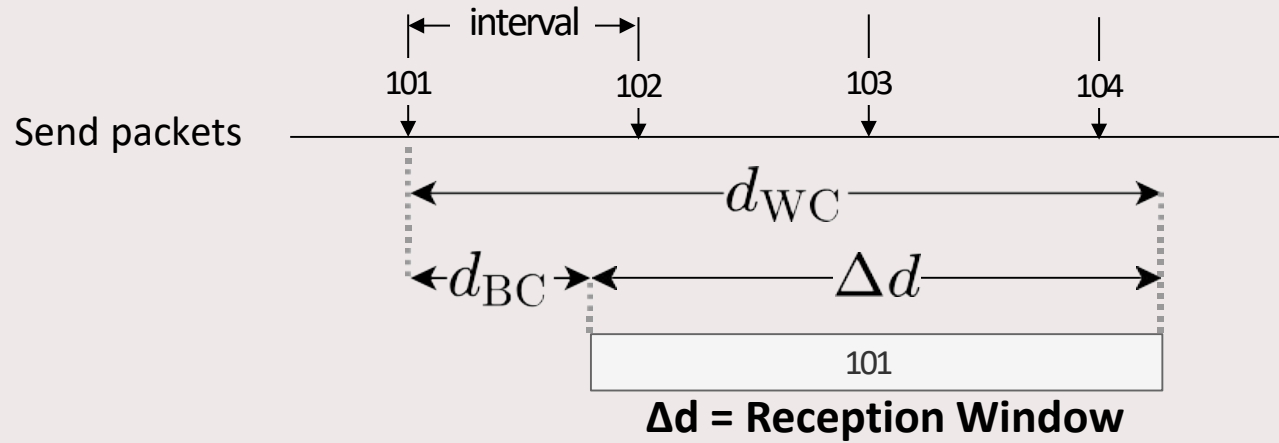
<https://www.ieee802.org/1/files/public/docs2025/ec-draft-PAR-modification-0925-v01.pdf>
<https://www.ieee802.org/1/files/public/docs2025/ec-draft-CSD-modification-0925-v01.pdf>

... let me know if something is missing!

Notation

d_{BC} = Minimum time from the sending of a packet to its earliest possible arrival at the SRF, considering any Member Stream

d_{WC} = Maximum time from the sending of a packet to its latest possible arrival at the SRF, considering any Member Stream



Assumption on the next slides: SRF with Vector Recovery Algorithm

Vector Recovery Algorithm

Seq. Window, with HistoryLength = 5

Seq. History

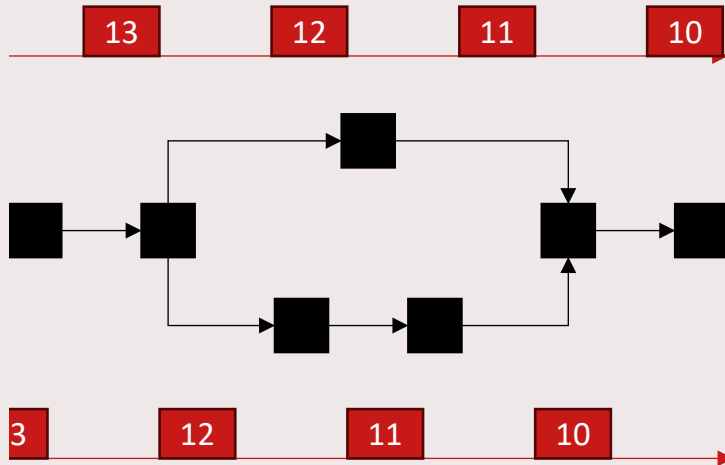
Sequence Window		Next Packet Seq. Nr	Explanation	Passed	Discarded	Replicate	Rogue	Out of Order
		n+...	Outside of Acceptance Interval		✓		✓	
		n+5	Within Acceptance Interval, shift RecovSeqNum	✓				✓
		n+4		✓				✓
		n+3		✓				✓
		n+2		✓				✓
		n+1						
1	RecovSeqNum	n	In Seq. History and Received		✓	✓		
1		n-1			✓	✓		
0		n-2	In Sequence History and not Received	✓				✓
0		n-3		✓				✓
1		n-4	In Seq. History and Received		✓	✓		
		n-5	Outside of Acceptance Interval		✓		✓	
		n-...			✓		✓	

SequenceRecoveryReset

- Resets SRF if no packet is accepted and forwarded for the duration of frerSeqRcvyResetMSec (timeout)
- All entries in Seq. History set to 0
- TakeAny = True, which means that RecovSeqNum will take the value of the next packet received

Ideal Operation

Network Behavior



Under ideal operation (i.e., periodic, no/low jitter)

- RecoverSeqNum = highest received SeqNum (e.g., 0x09 at the beginning, 0x13 at the end of the figure)
- All SeqNums within Sequence Window
- Replicates → eliminated
- Valid packets → forwarded

Output



Grey boxes mean “no issue”

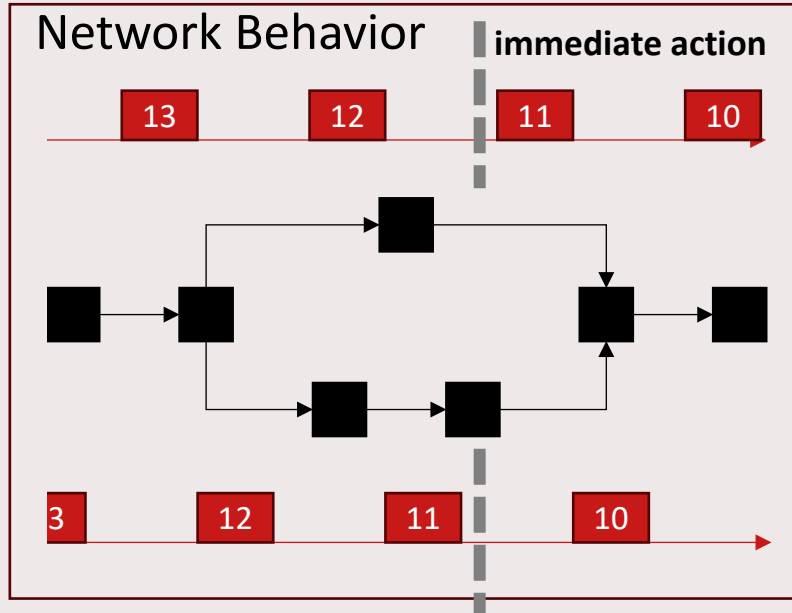
Wrong
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Nominal Behavior: Management Reset



Two Types of Management Resets

1. BEGIN event related reset

- For initial startup of node, resets all functions
- Expected behavior (= no history)

2. frerSeqRcvyReset = True

- Manually triggers SequenceRecoveryReset for stream
 - All entries in SequenceHistory set to 0
 - TakeAny (RecoverSeqNum = next rcv. packet, e.g., 0x10)
- Previously rcv. packet (e.g., 0x11) forwarded → **Replicate**
- **#HistoryLength packets counted as lost** (e.g., 0x08 and 0x09 for HistoryLength = 2)
- **Increased rate** due to Replicates

Output

No. of Replicates depends on Δd



Red boxes mean "issue"

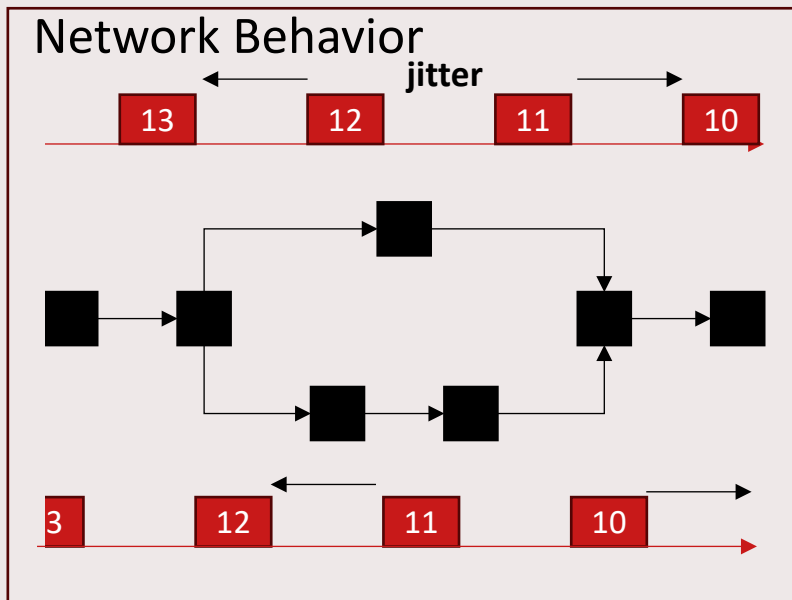
Wrong
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Nominal Behavior: Member Stream Jitter



Jitter on Path
(e.g., due to interference or wireless transmission)

Output

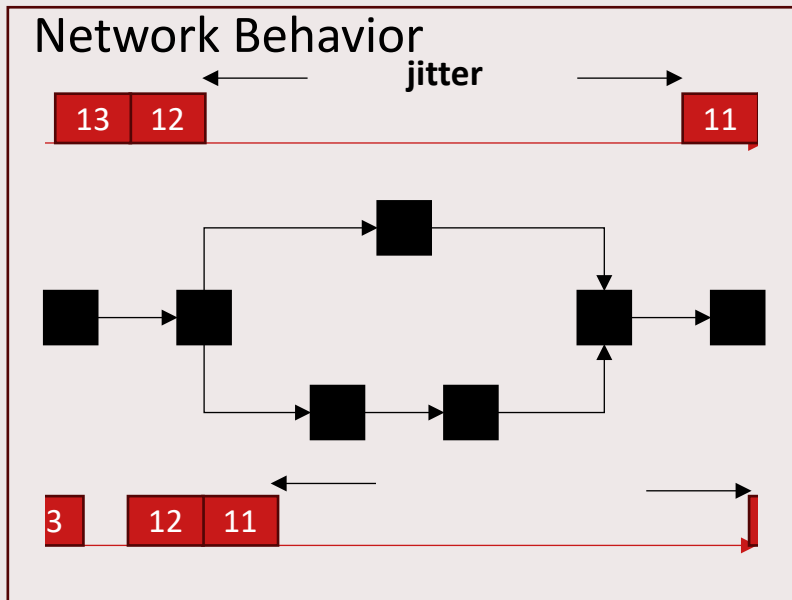
Wrong
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Nominal Behavior: Member Stream Jitter



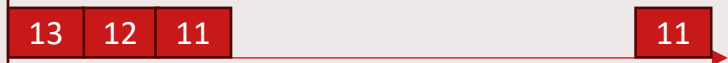
Jitter on Path

(e.g., due to interference or wireless transmission)

- Jitter can lead to long idle time
- Can trigger SequenceRecoveryReset
- Same effects as before
(Replicates, increased rate, loss counter)
- There is nothing that protects a user from this error

Output

No. of Replicates depends on Δd



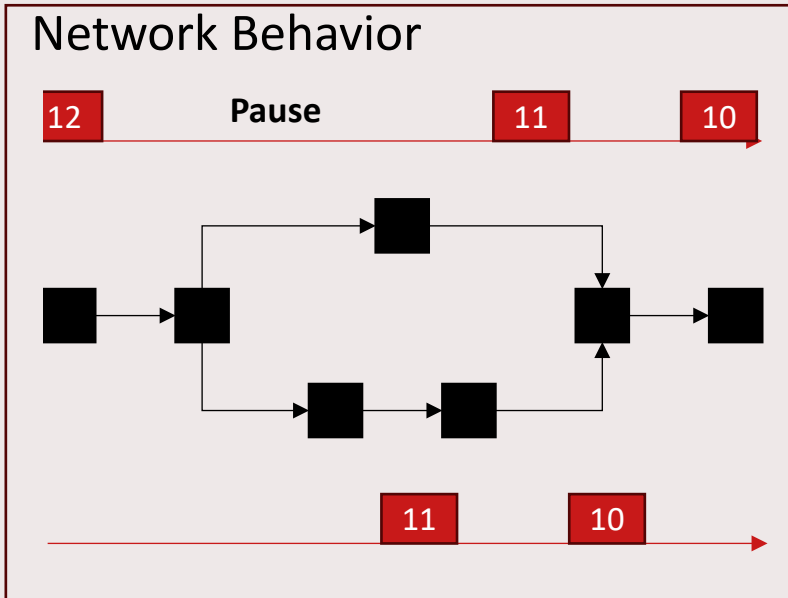
Wrong
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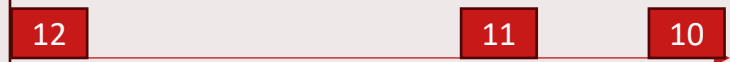
Nominal Behavior: Talker Pause



Talkers are allowed to pause or send less

- Pauses can be arbitrarily long and **arbitrarily often**
- Will trigger SequenceRecoveryReset
- Each time **loss counter increases by #HistoryLength**

Output



Wrong
Counter
Values

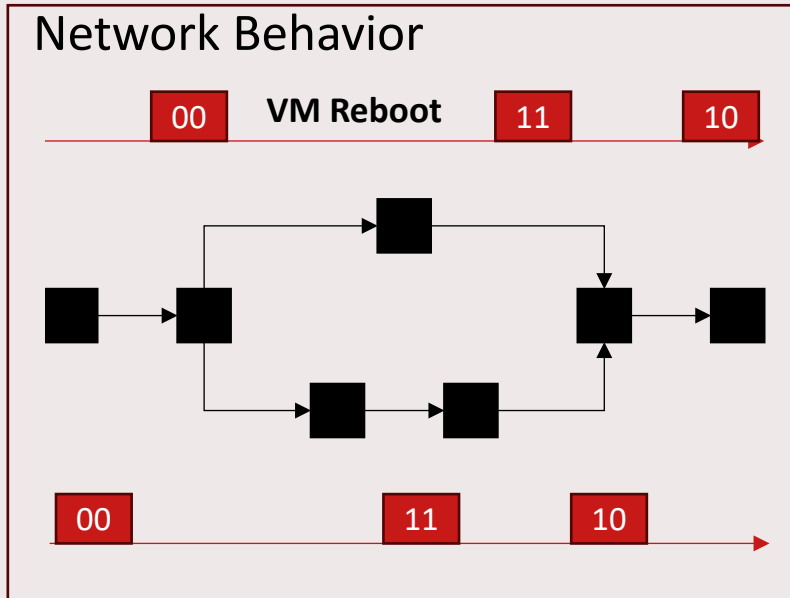
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Nominal Behavior:

Network Function Virtualization (NFV)



Virtualization (e.g., containers, virtual machines)

- FRER functionality might be part of the cloud
- Virtual instances can restart fast (e.g., replication function)
- Next SeqNum is the first value of the SeqNumSpace (i.e., 0x00)
- No timeout → Seq. Window not reset
- **Valid packets discarded** (e.g., 0x00 and following) → outside current Seq. Window
- Will trigger SequenceRecoveryReset after timeout, then same issues as for **Talker Pause** (loss counter)

Output

0x00 11 10
and following packets lost



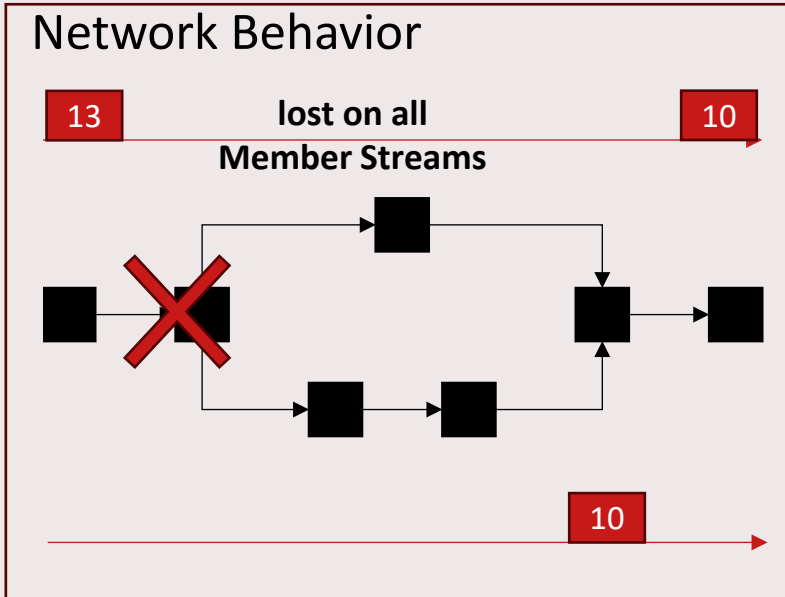
Wrong
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Failure Behavior: Failure before Duplication



All Replicates are lost

(e.g., due to failure before duplication if FRER is in relay node or failure on all links)

- Time of failure can be arbitrary
- Next Sequence Number can be arbitrarily higher (e.g., 0x13 or any higher number)
- **Valid packets discarded** (e.g., 0x13 and following)
→ outside current Seq. Window
- Will trigger SequenceRecoveryReset after timeout, then same issues as for **Talker Pause** (**loss counter**)
- Can be covered as trade-off between the Reset Timeout value and History Length, but careful config. required.

Output

0x13

10

and following packets lost



Wrong
Counter
Values

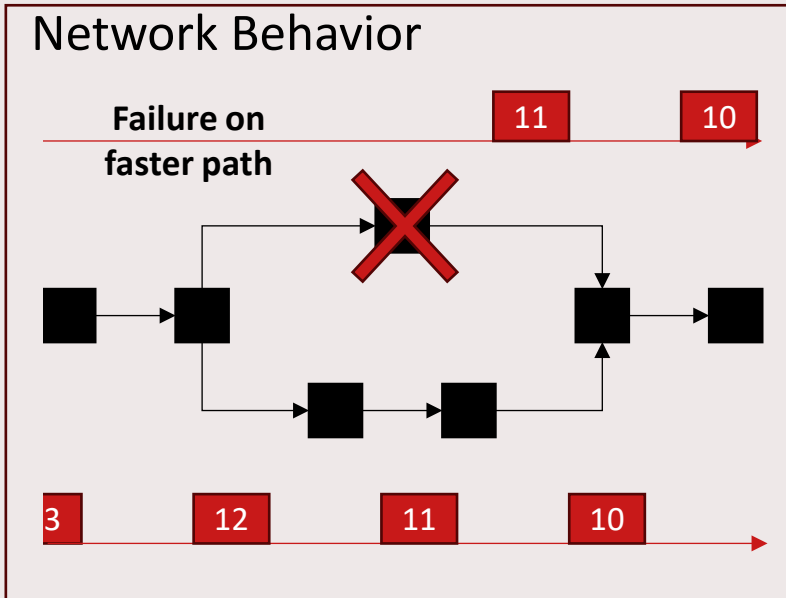
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Failure Behavior:

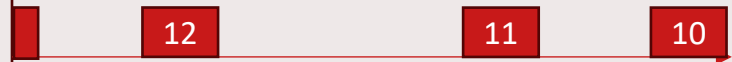
Failure on one Link



Faster Link Failure & Recovery

- Main Use Case of FRER
- Invisible to the application
- Exhibits three phases:
 - 1) Small delay
 - 2) Reception by slower path

Output



Wrong
Counter
Values

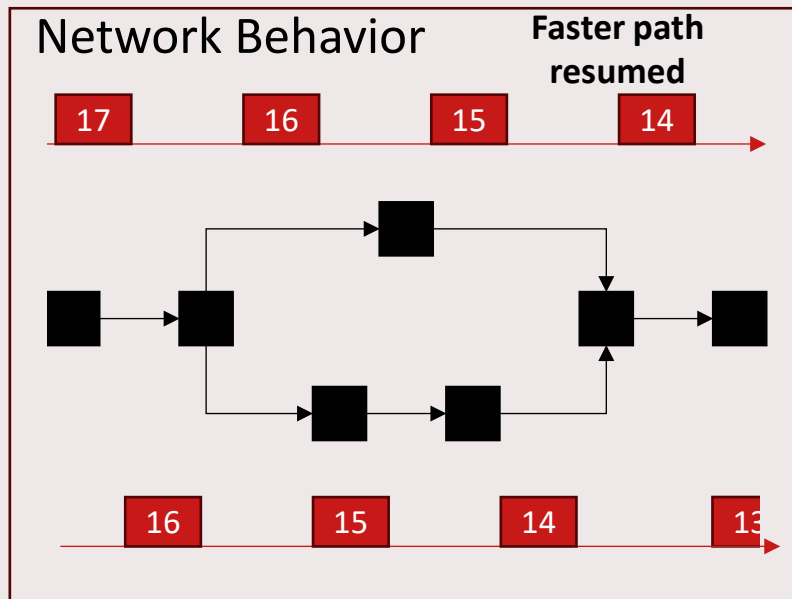
Forwarding
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Failure Behavior:

Failure on one link



Faster Link Failure & Recovery

- Main Use Case of FRER
- Invisible to the application
- Exhibits three phases:
 - 1) Small delay
 - 2) Reception by slower path
 - 3) After recovery, doubled rate of streams

Better illustration on the next slide



Wrong
Counter
Values

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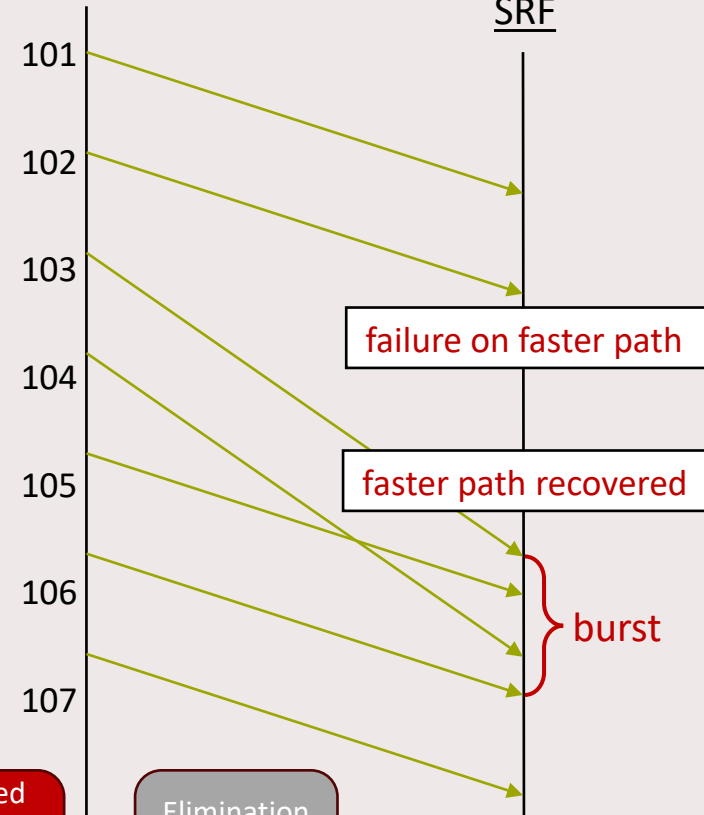
Failure Behavior:

Failure on one link

- Failure transparent to SRF (no timeout, no loss counter, ...)
- SRF might be relay node → Burst of packets forwarded (**doubled the reserved rate**)*
- SRF does not re-shape the flow, neither does Strict Priority (SP) and Credit-Based Shaper (CBS)
→ **has to be considered in subsequent nodes**
- **Careful!**
 - **Changes the latency** in succeeding hops for SP & CBS
 - **Changes the latency** at SRF for all schedulers (i.e., also Asynchronous Traffic Shaper)
 - **Changes parameters** for Per Stream Filtering and Policing (**nowhere considered yet**)

Duplication

SRF



Wrong
Counter
Values

Forwarding
of
Replicates

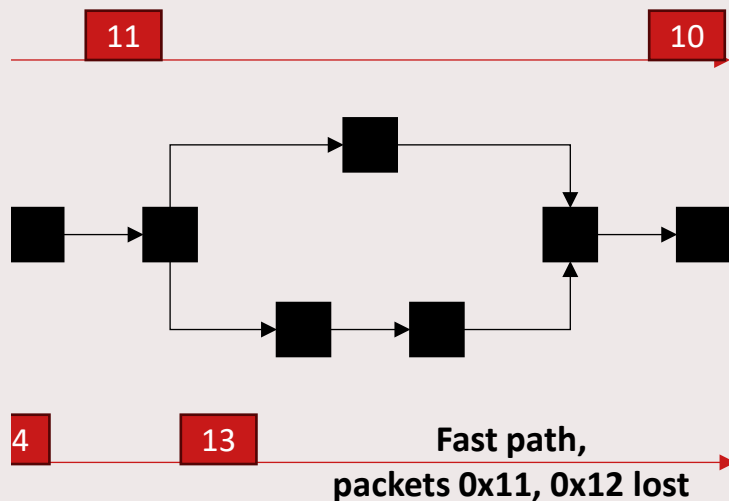
Increased
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Elimination
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* does not increase further, if #pat

Additional Note on VRA

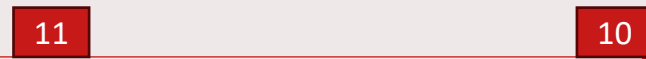
Network Behavior



VRA and HistoryLength

- VRA requires parameter HistoryLength
- Large path delay differences (Δd)
→ relevant in, e.g., in ring topologies
- Too short HistoryLength → **valid packets discarded**
Example: RecovSeqNum = 0x10, HistoryLength = 2
→ packet 0x13 lost (counted as Rouge)
- Problem arises if packets on one link are lost
- Packets from faster path (e.g., 0x13) are dropped
- No guarantee they arrive via slower path
→ risk of complete loss (especially when considering wireless)

Output



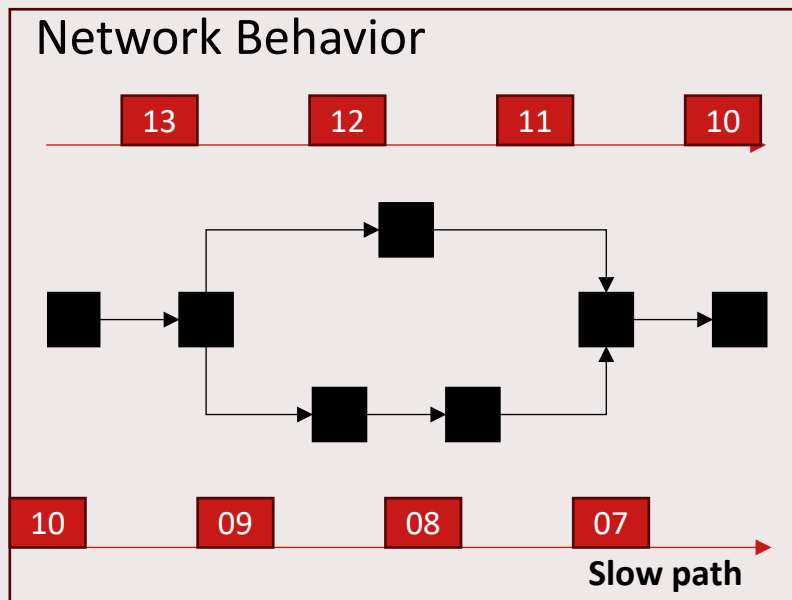
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Additional Note on VRA (continued)



The issue on the previous slide can also happen the other way around

- Slow paths might transmit so slow that packets are out of the Seq. Window (ring topologies!)
- Should be counted as Duplicates, but will be counted as Rouge
- Can be constant, or only occasional, if jitter is high

Output



Wrong
Counter
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Assumption on the next slide: SRF with Match Recovery Algorithm

Match Recovery Algorithm (MRA)

- stores only highest sequence number received
 - only eliminates Replicates with this (one!) sequence number
 - **requires** intermittent streams
- no guidance on how intermittent streams are guaranteed, if wrong:
→ **(constant) forwarding of Replicates**

Wrong
Counter
Values

Forwarding
of
Replicates

Increased
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Elimination
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Discussion

Wrong
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Forwarding
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Nominal Behaviour / No Failure	Management Reset				
	Member Stream Path Jitter (e.g., inference or wireless)				
	Talker Pause				
	Network Function Virtualization				
Failure	Failure before Duplication (or: Failure on all links)				
	Failure on one link				
Other	Vector Recovery Algorithm with short HistoryLength		Nominal Behavior	Failure on one link	
	Match Recovery Algorithm w/o intermittent streams				

Thank you