Class A
Latency Issues

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Latency Calculations

- The latency calculations in this presentation are last bit in – last bit out

- The MAC delays are not taken into account

- The switching delays are not taken into account

- The mentioned number of bytes are incl. preamble and IFG

- The numbers in the graphics are µs

- @FE 7.2µs (90 bytes), 123.36µs (1542 bytes), 86.4µs (1080 bytes)

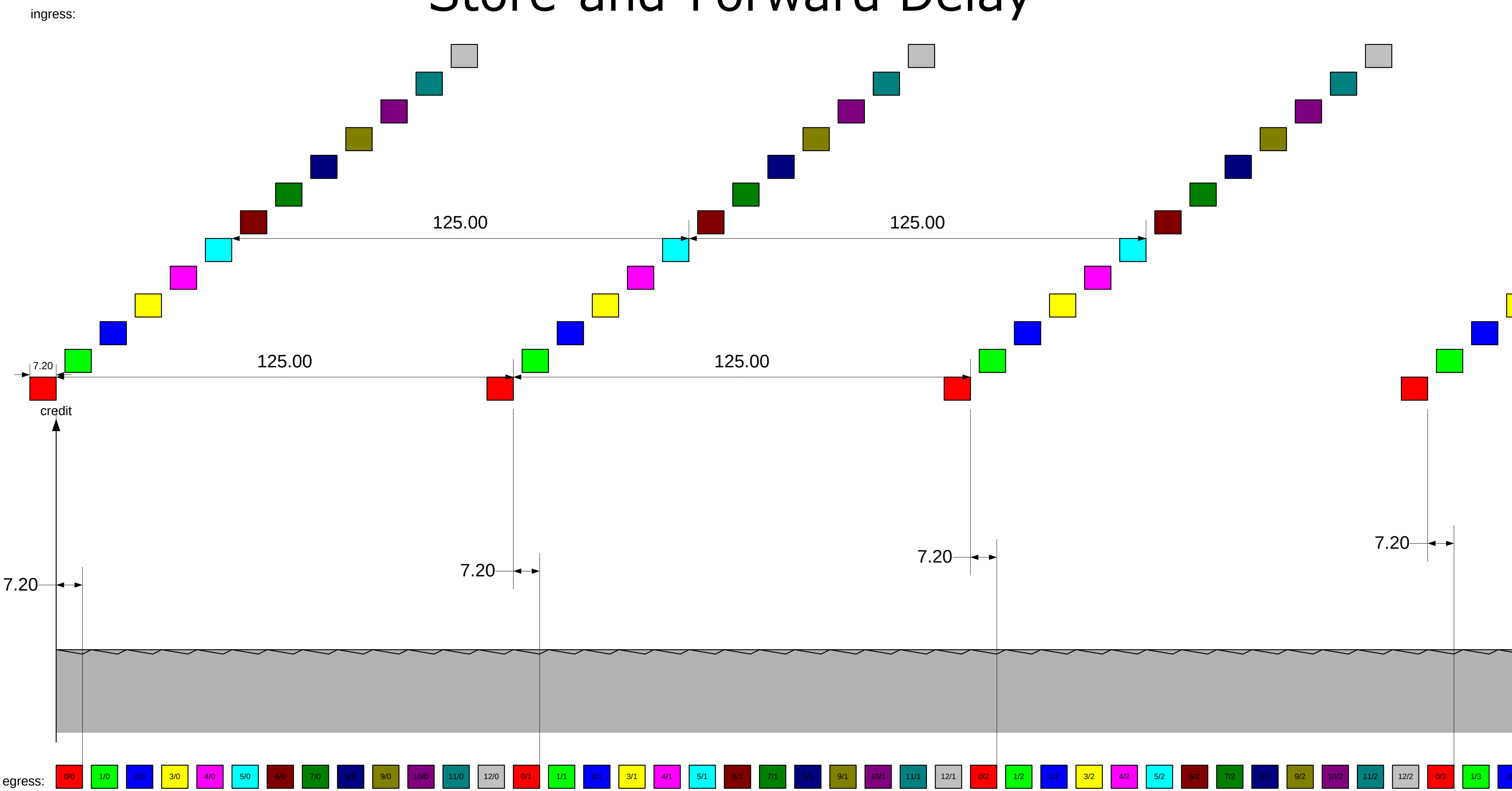
- @GE 7.2µs (900 bytes), 12.36µs (1542 bytes)

Fast Ethernet
Class A Latency

Primary Effects

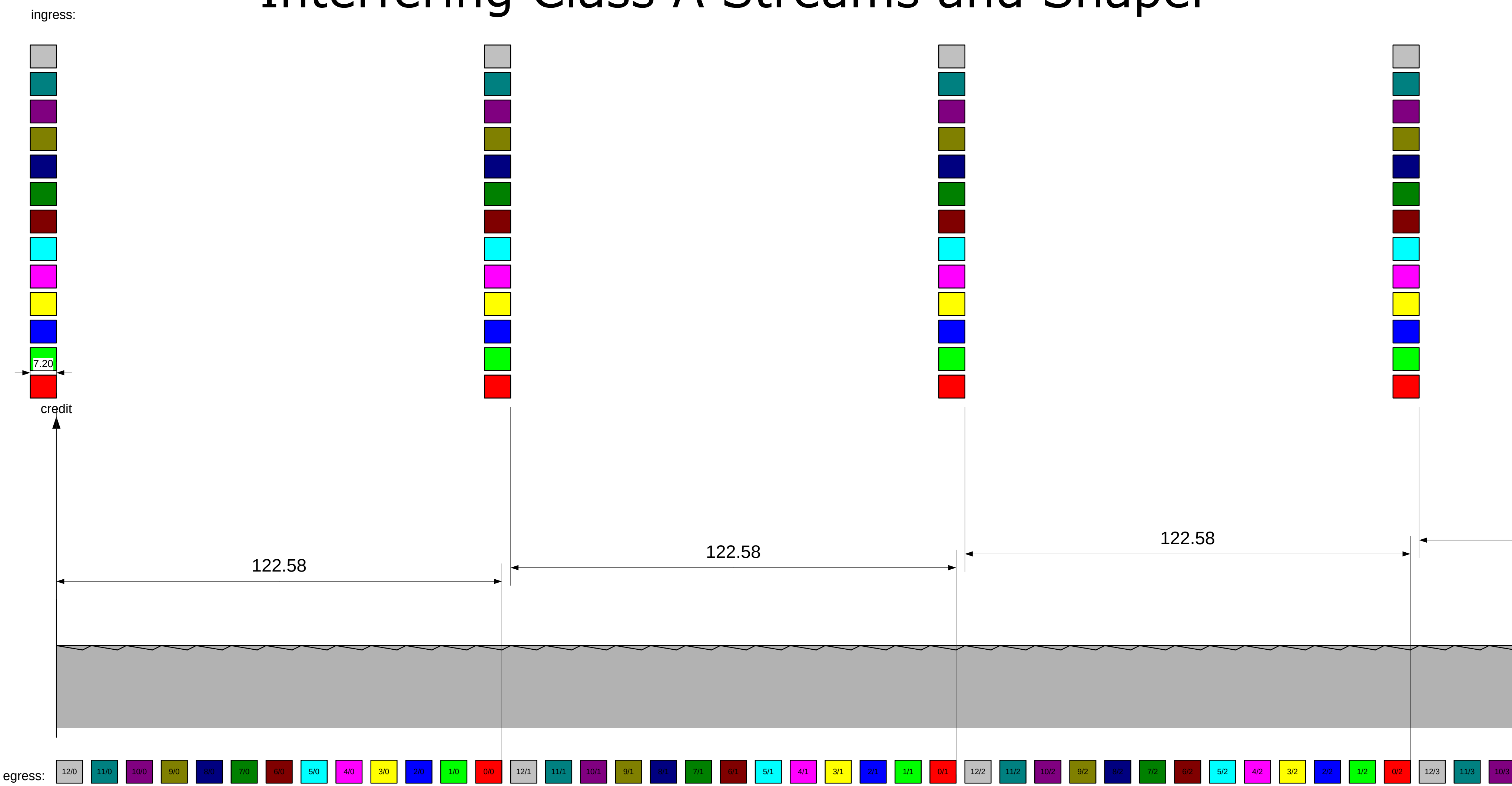
Primary Effect 1: Store-and-Forward Delay

Store-and-Forward Delay



Primary Effect 2: Interfering Class A Streams and Shaper

Interfering Class A Streams and Shaper



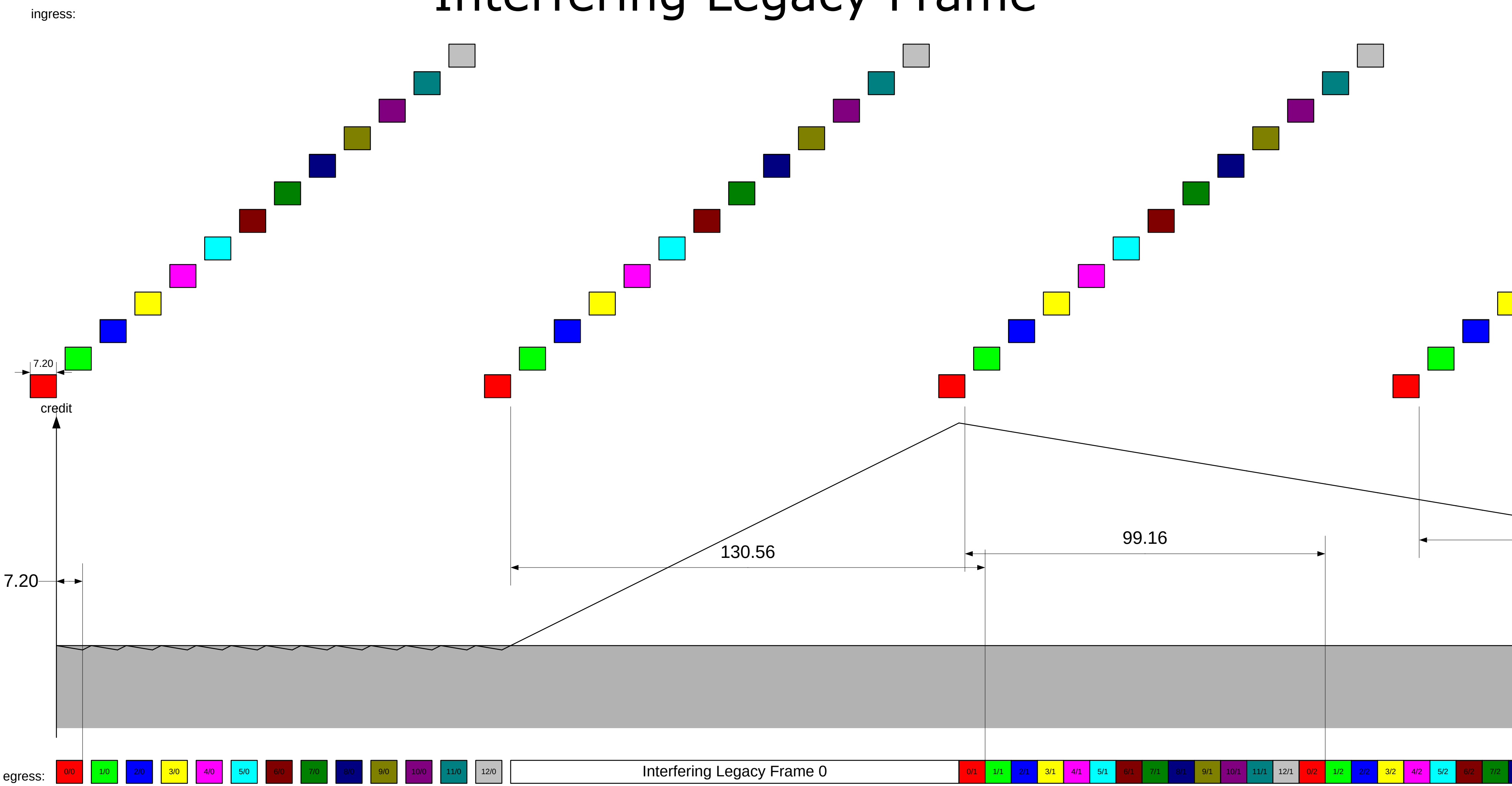
Possible Solutions

- Interfering Class A Streams:
  - Time slots
  - Limit max. used Class A bandwidth (<75%)
- Shaper:
  - Time slots
  - Changes to CBS (allow burst)

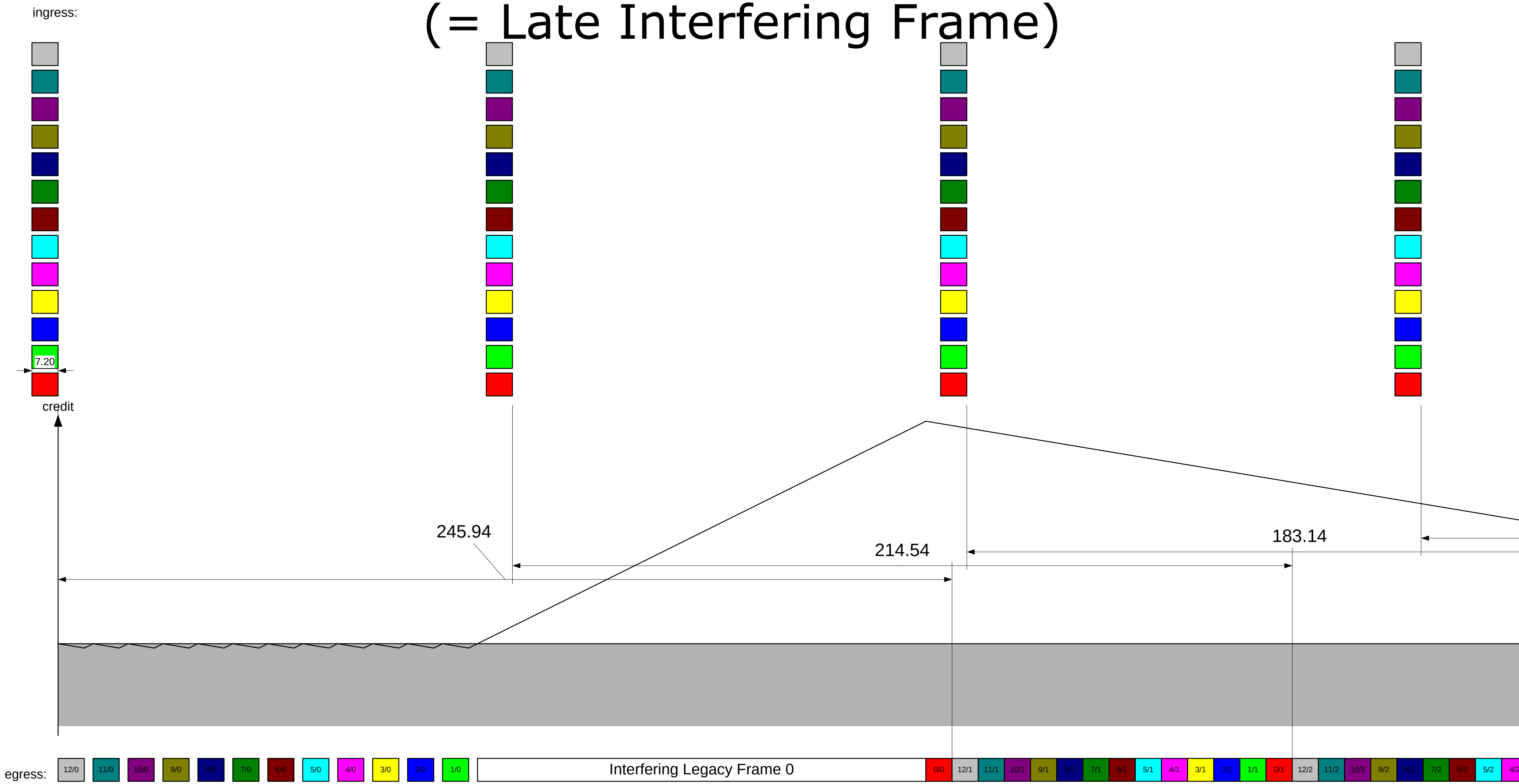
see Franz Goetz “AVB + Extensions for Industrial Communication”, Kauai 2011

Primary Effect 3: Interfering Legacy Frame

Interfering Legacy Frame



Interfering Legacy Frame + Interfering Class A Streams (= Late Interfering Frame)



Possible Solutions

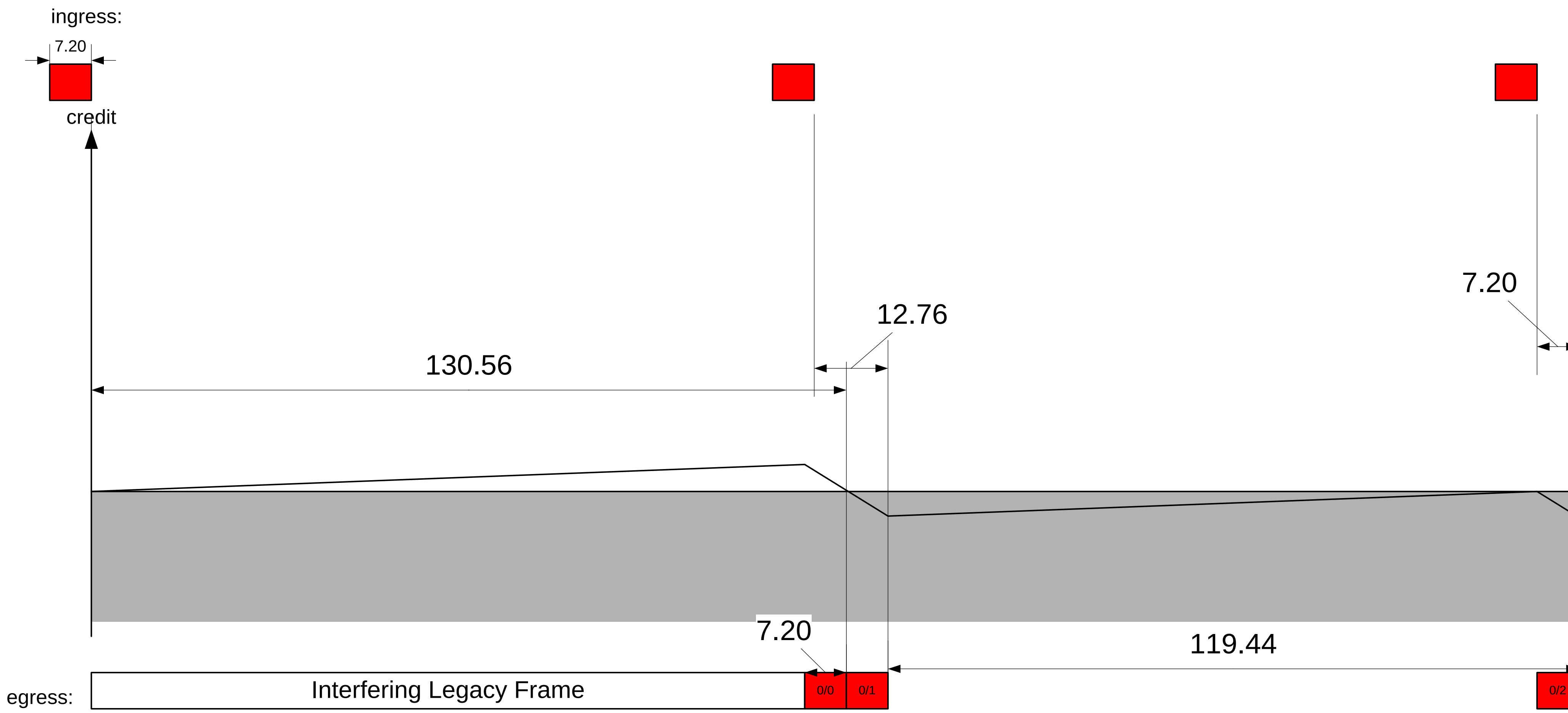
- Fragmentize interfering non class A traffic
- Reduce MTU
- Time slots (separate slots for streams and legacy traffic)

see Franz Goetz "AVB + Extensions for Industrial Communication", Kauai 2011

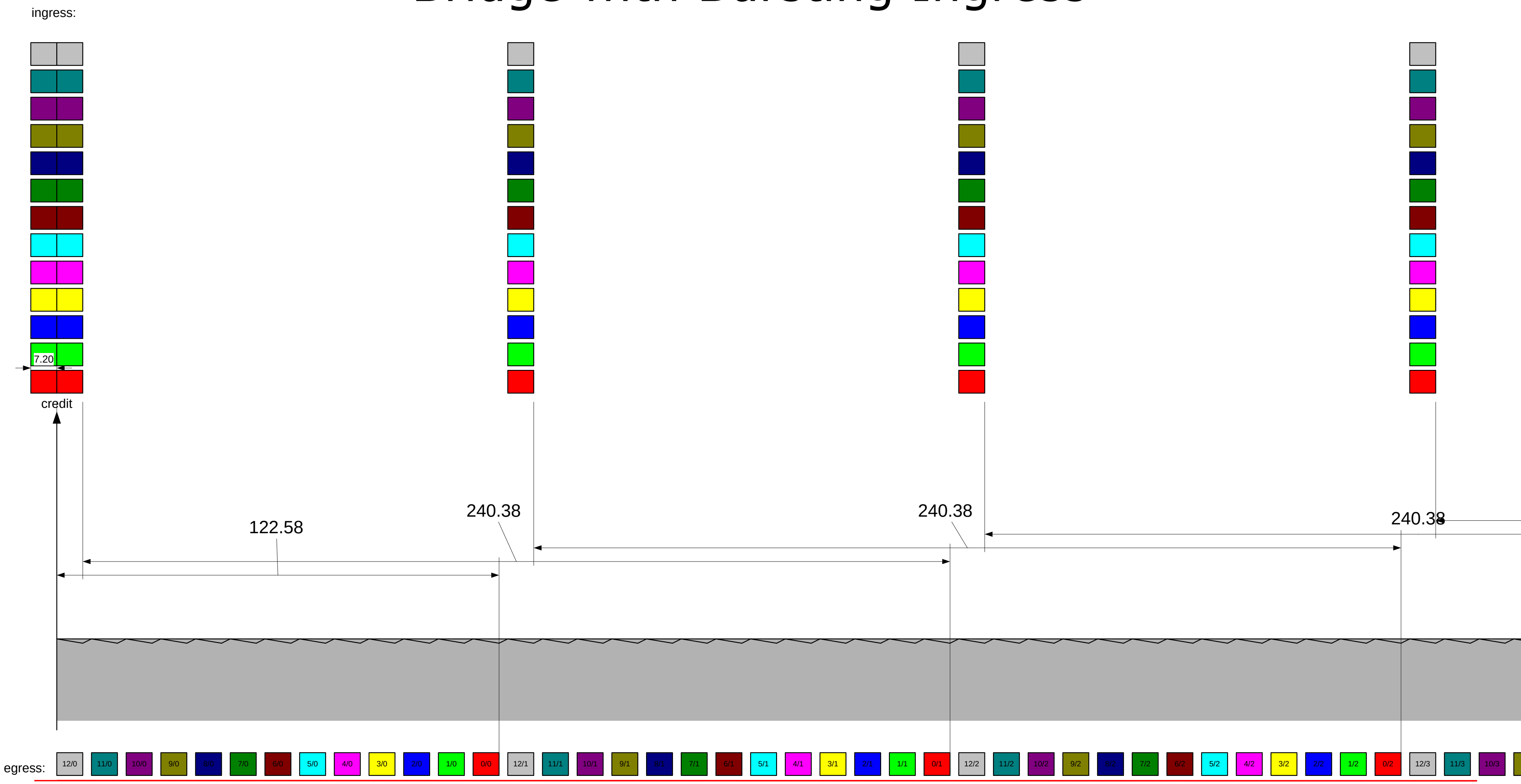
Secondary Effects

Secondary Effect 1: Burst

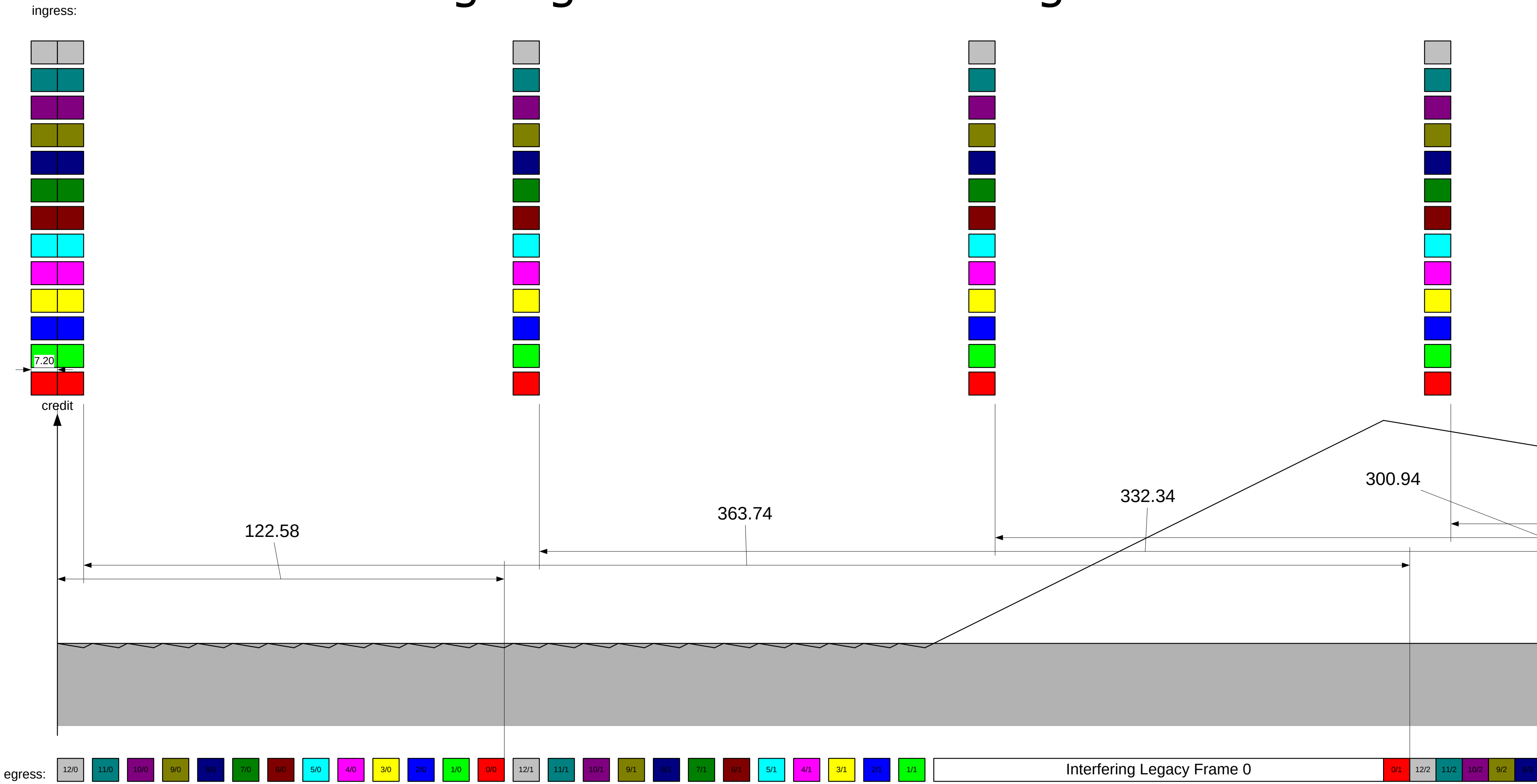
Bursting Talker



Bridge with Bursting Ingress

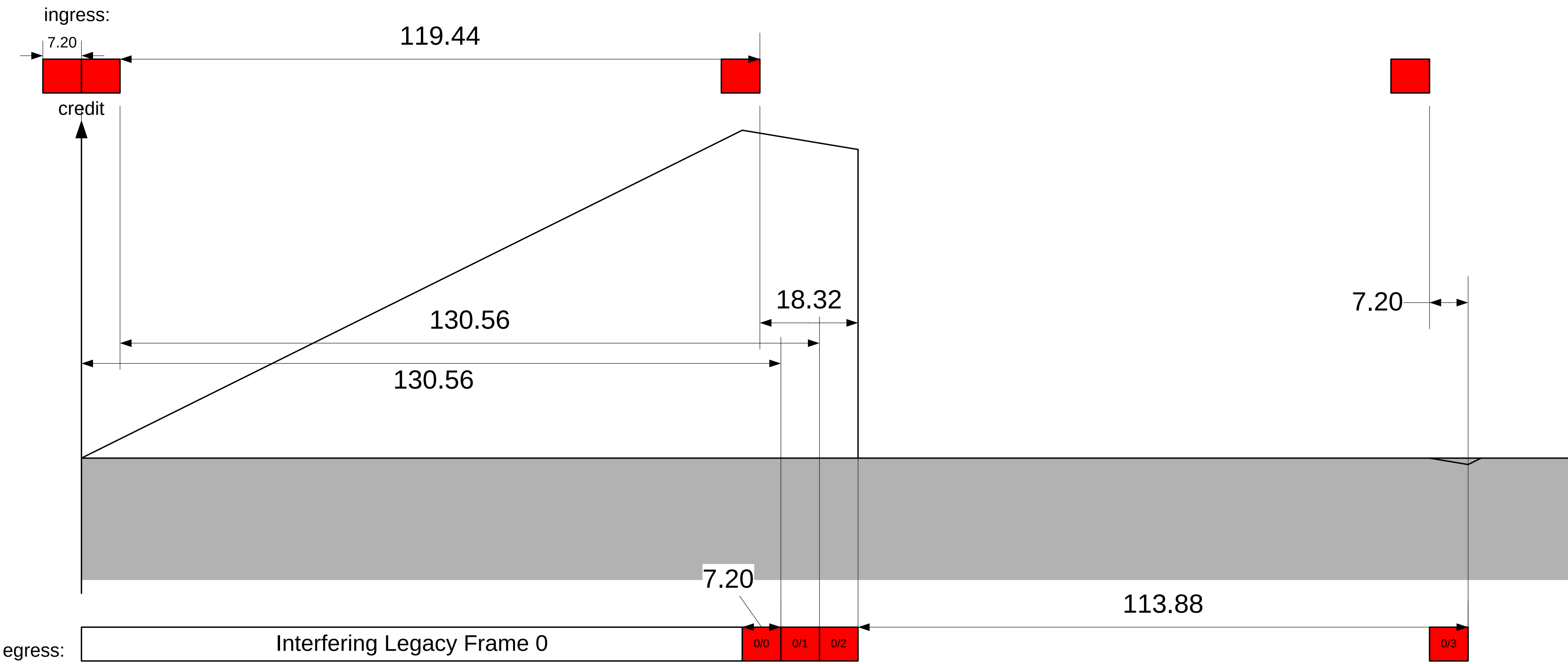


Bursting Ingress with Interfering Frame



Secondary Effect 2: Growing Burst

Example 1: Interfering Frame + More Bandwidth Allocated than Used (1)



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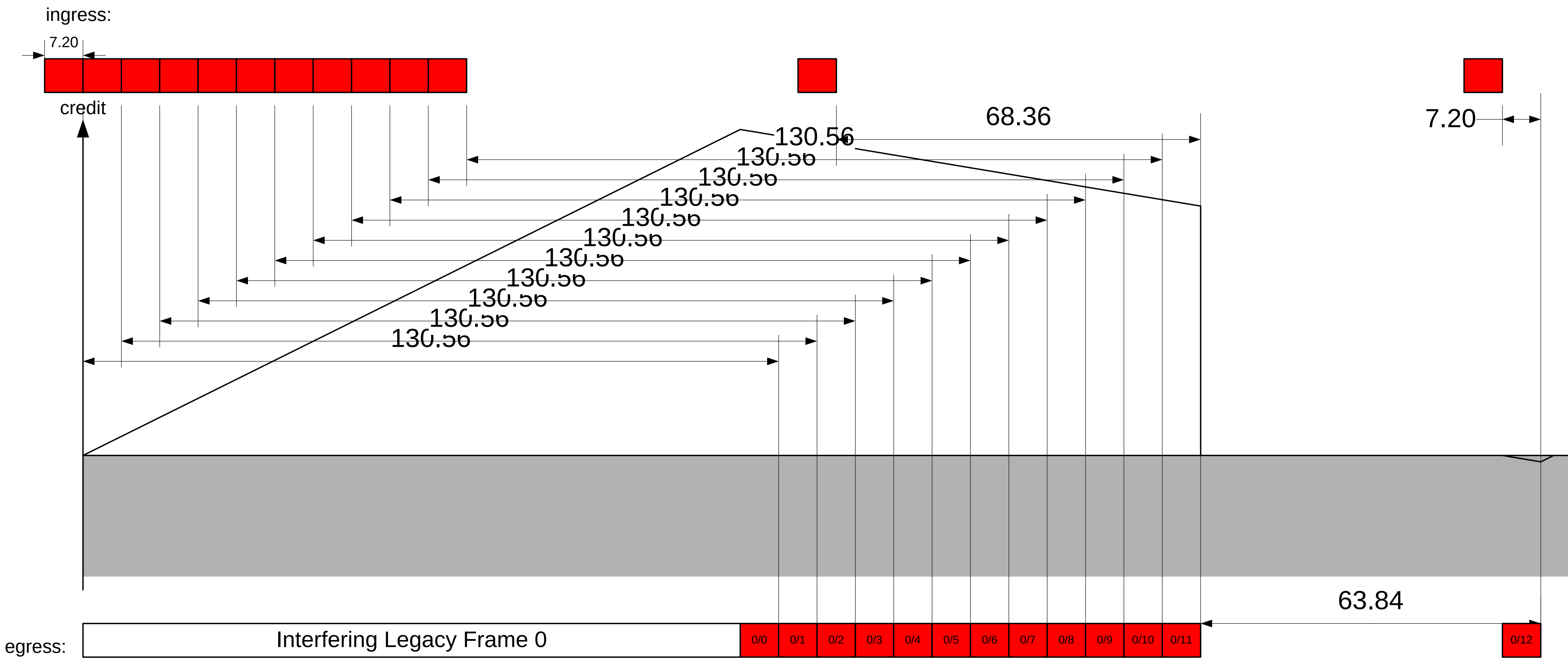
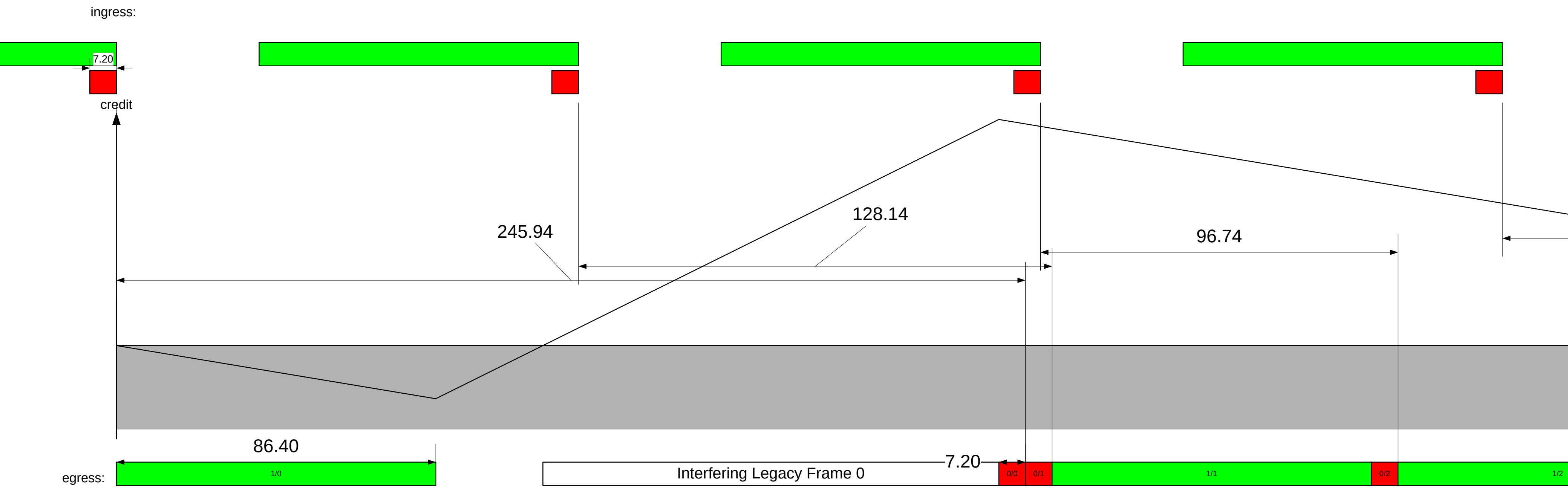
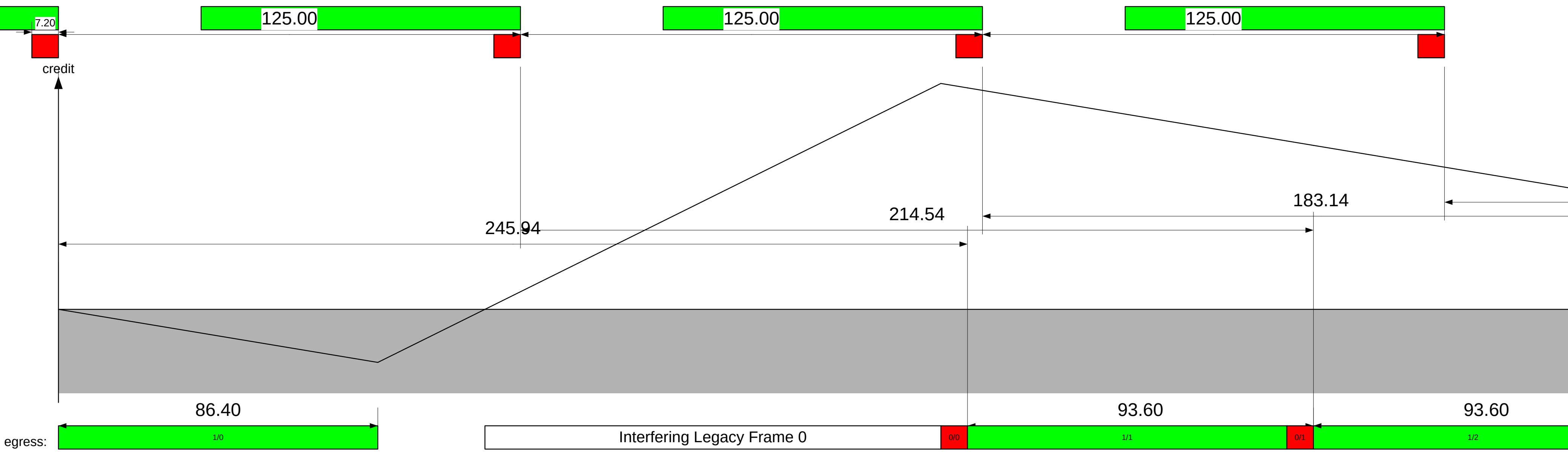
Example 1: Interfering Frame + More Bandwidth Allocated than Used (2)



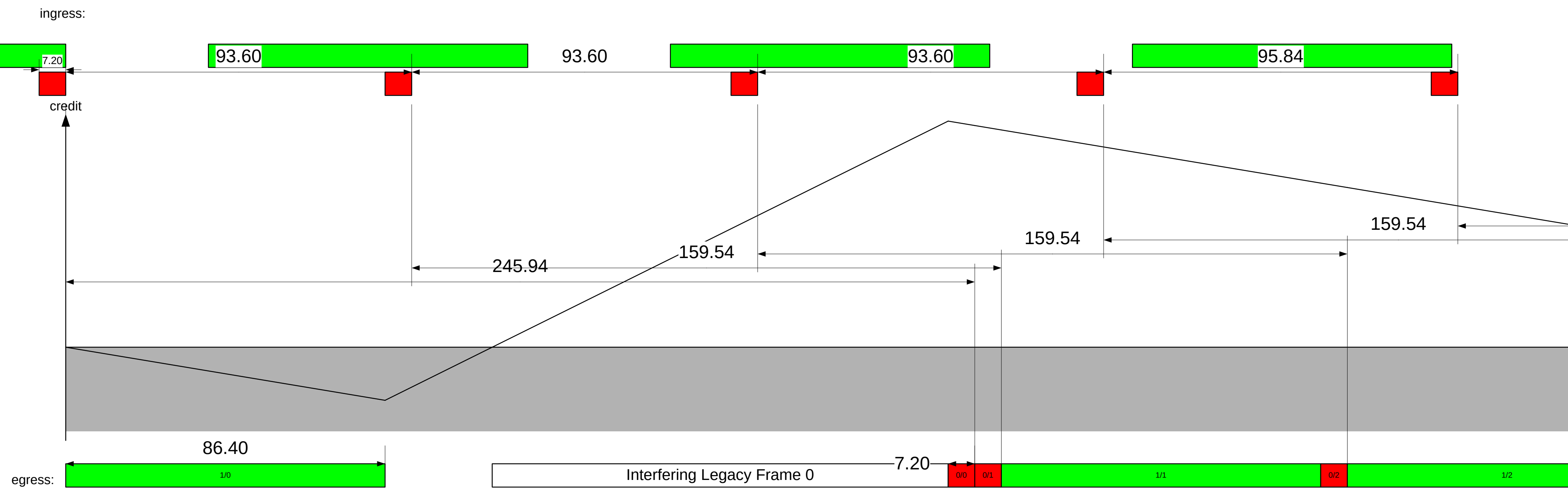
Example 2: Interfering Frame + Changing Position



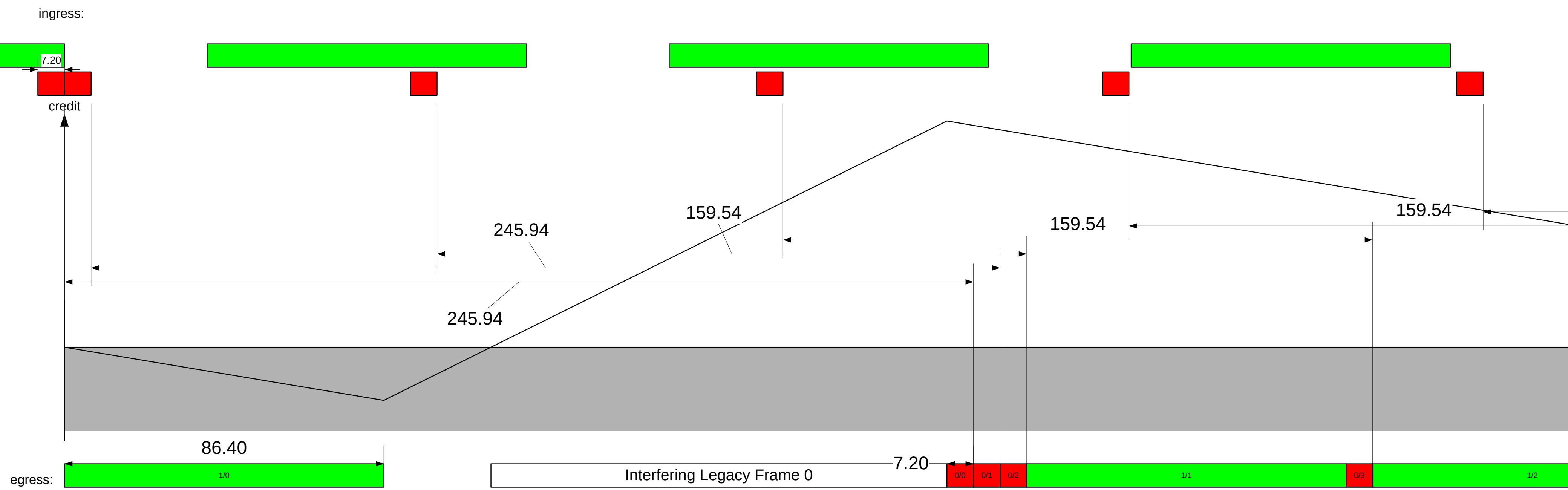
Example 3: Interfering Frame + Not Equally Spaced Frames (1)



Example 3: Interfering Frame + Not Equally Spaced Frames (2)

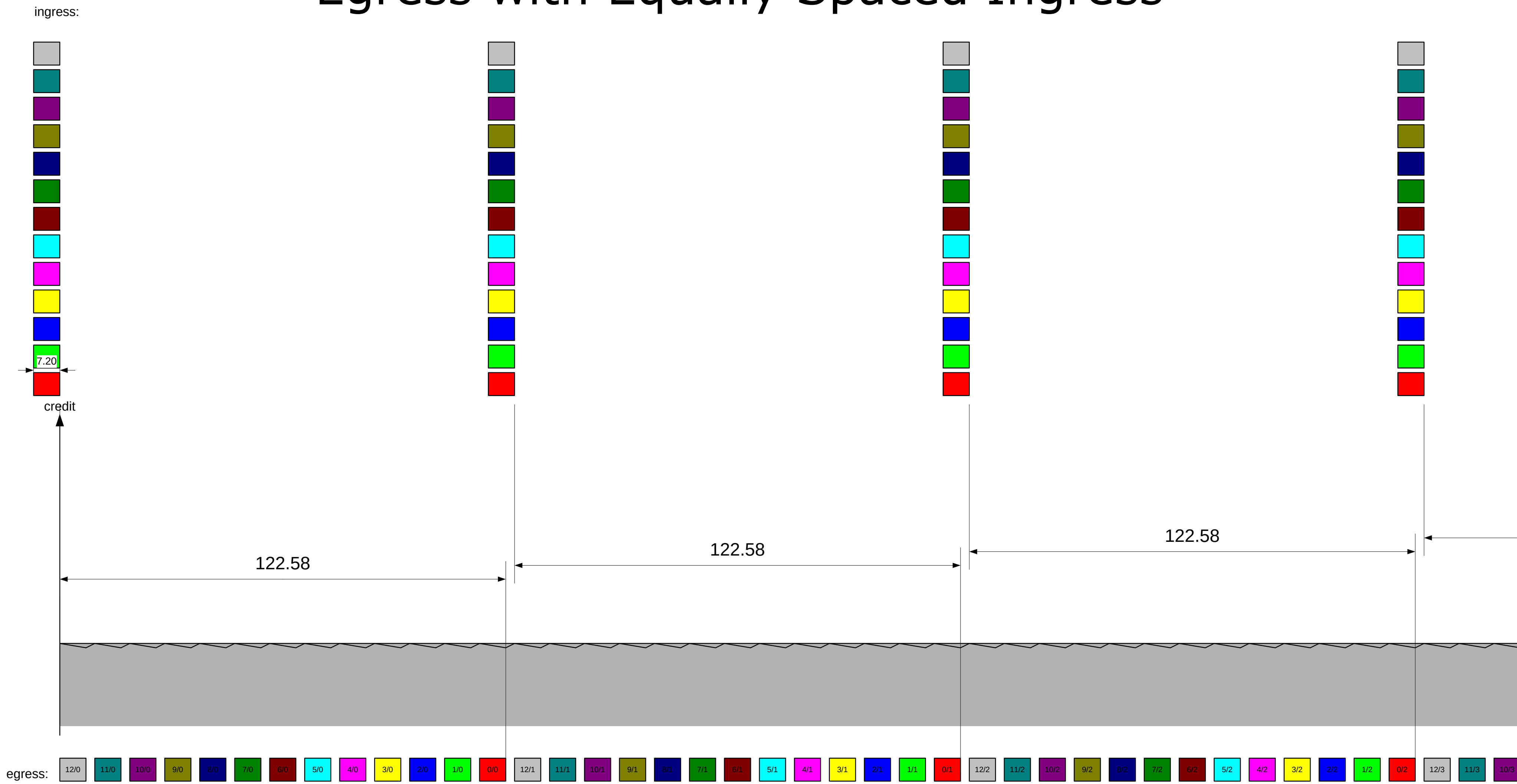


Example 3: Interfering Frame + Not Equally Spaced Frames (3)

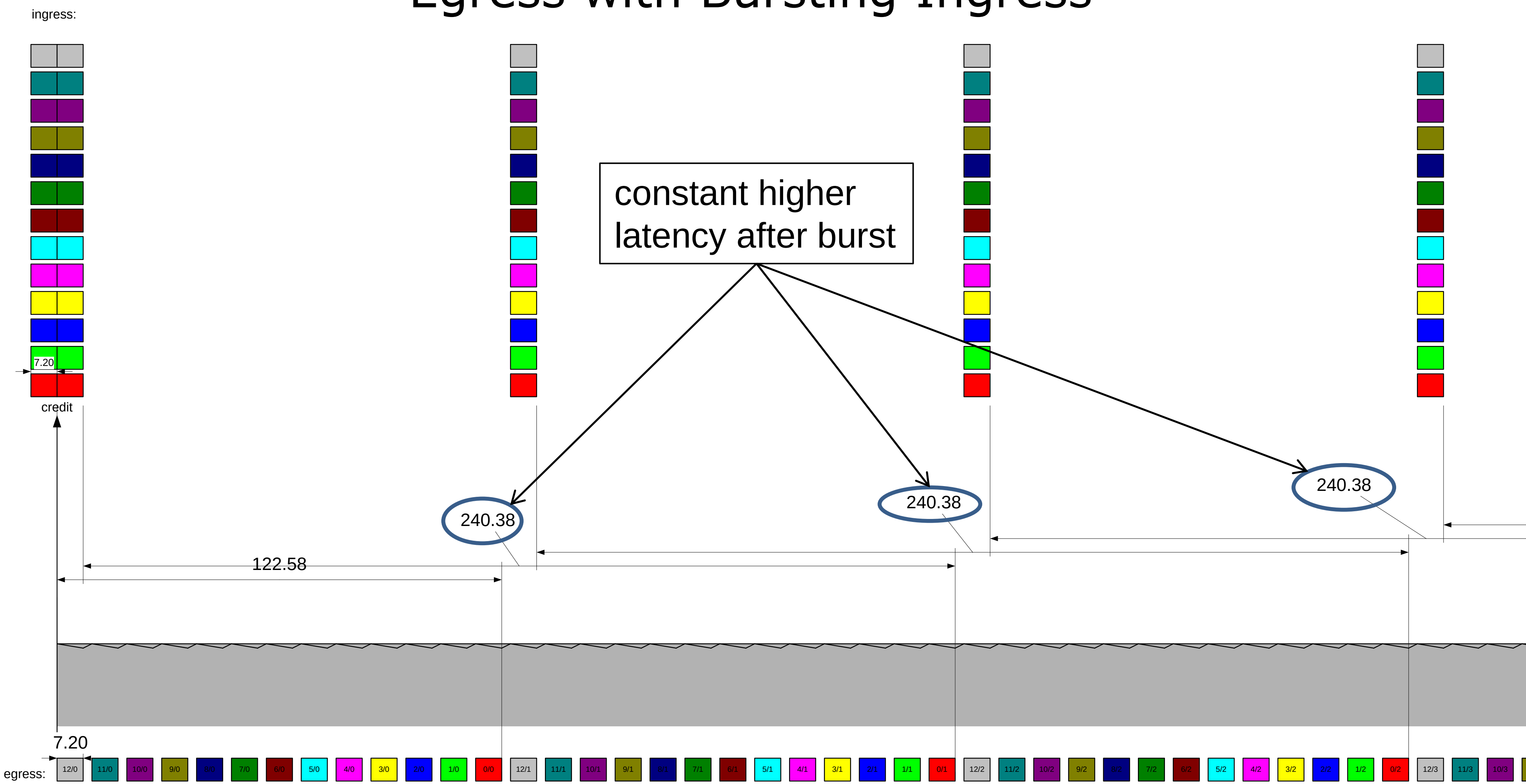


Secondary Effect 3: Constant Higher Latency

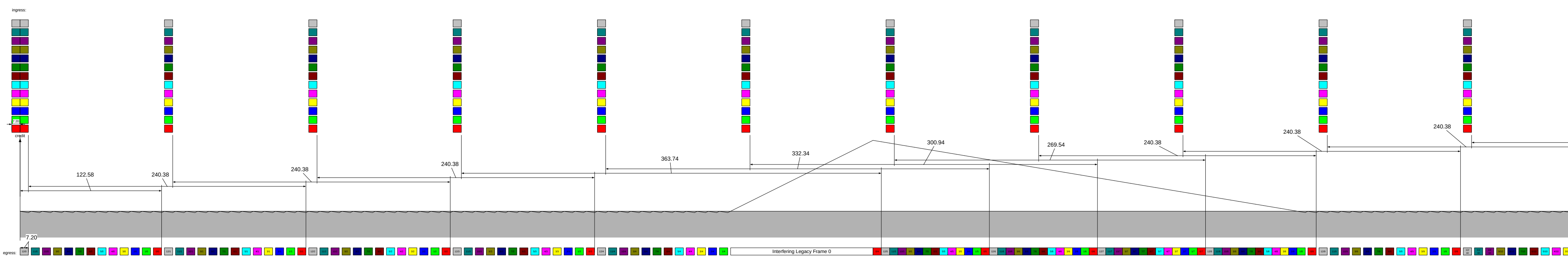
Egress with Equally Spaced Ingress



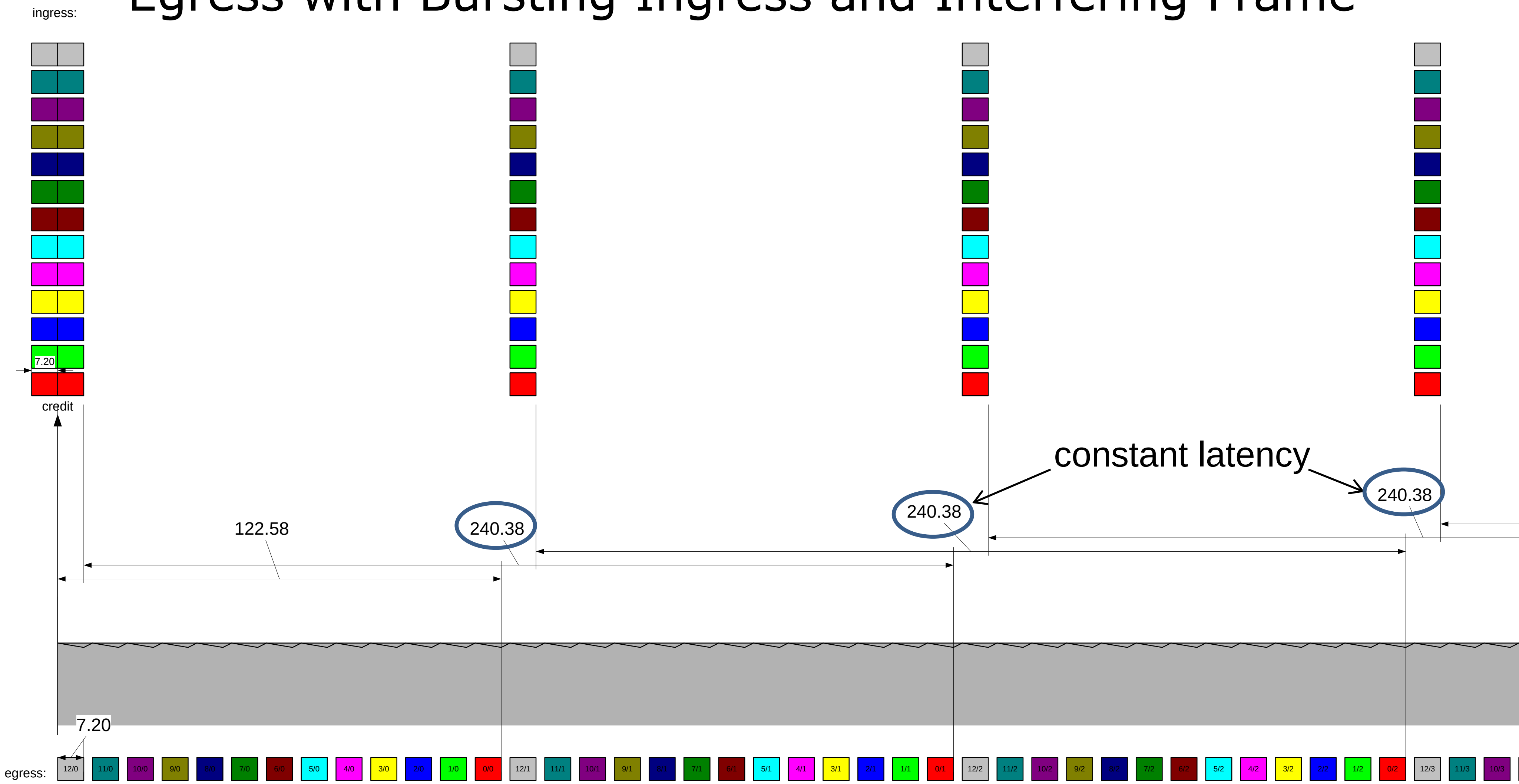
Egress with Bursting Ingress



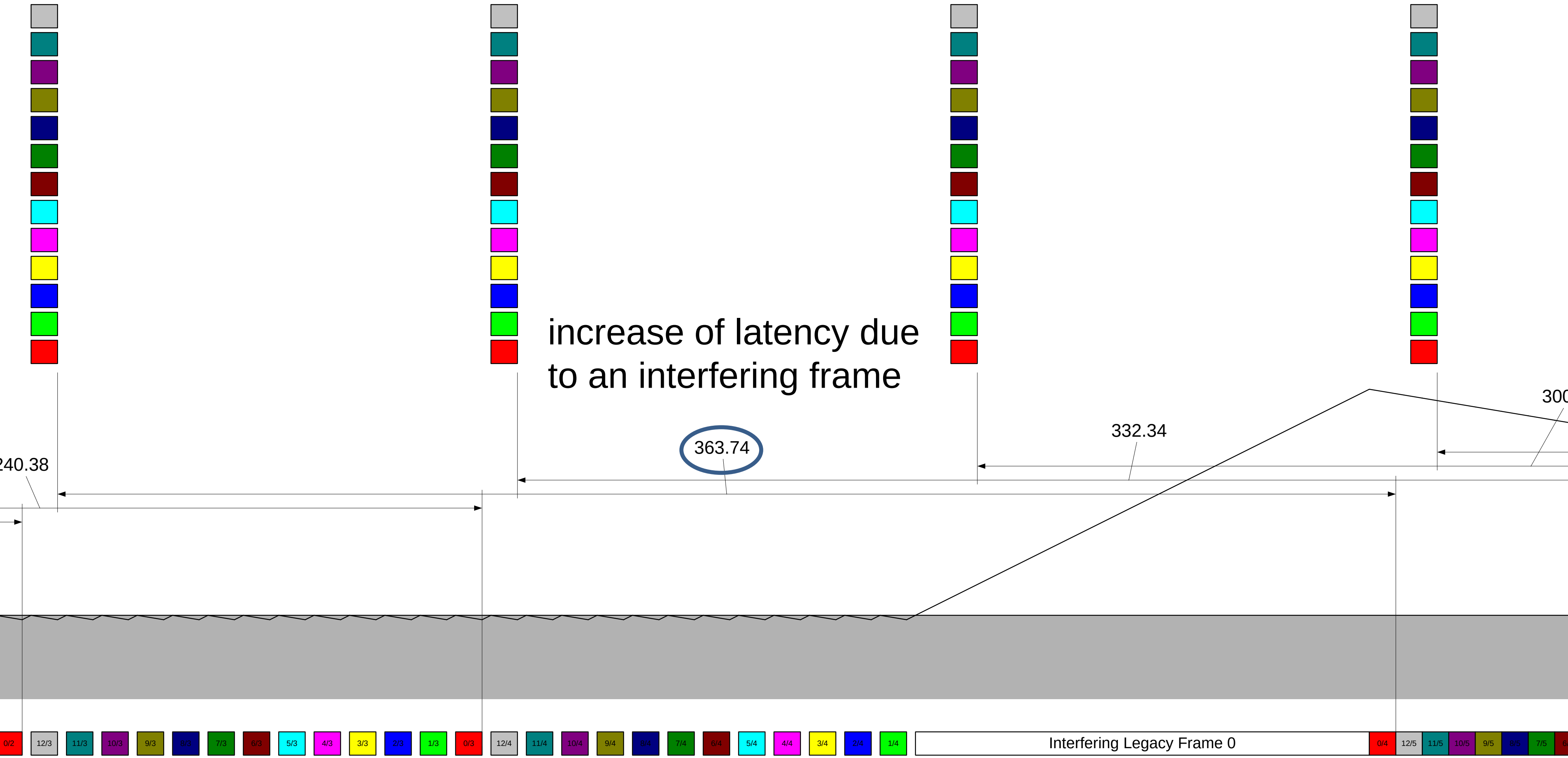
Egress with Bursting Ingress and Interfering Frame



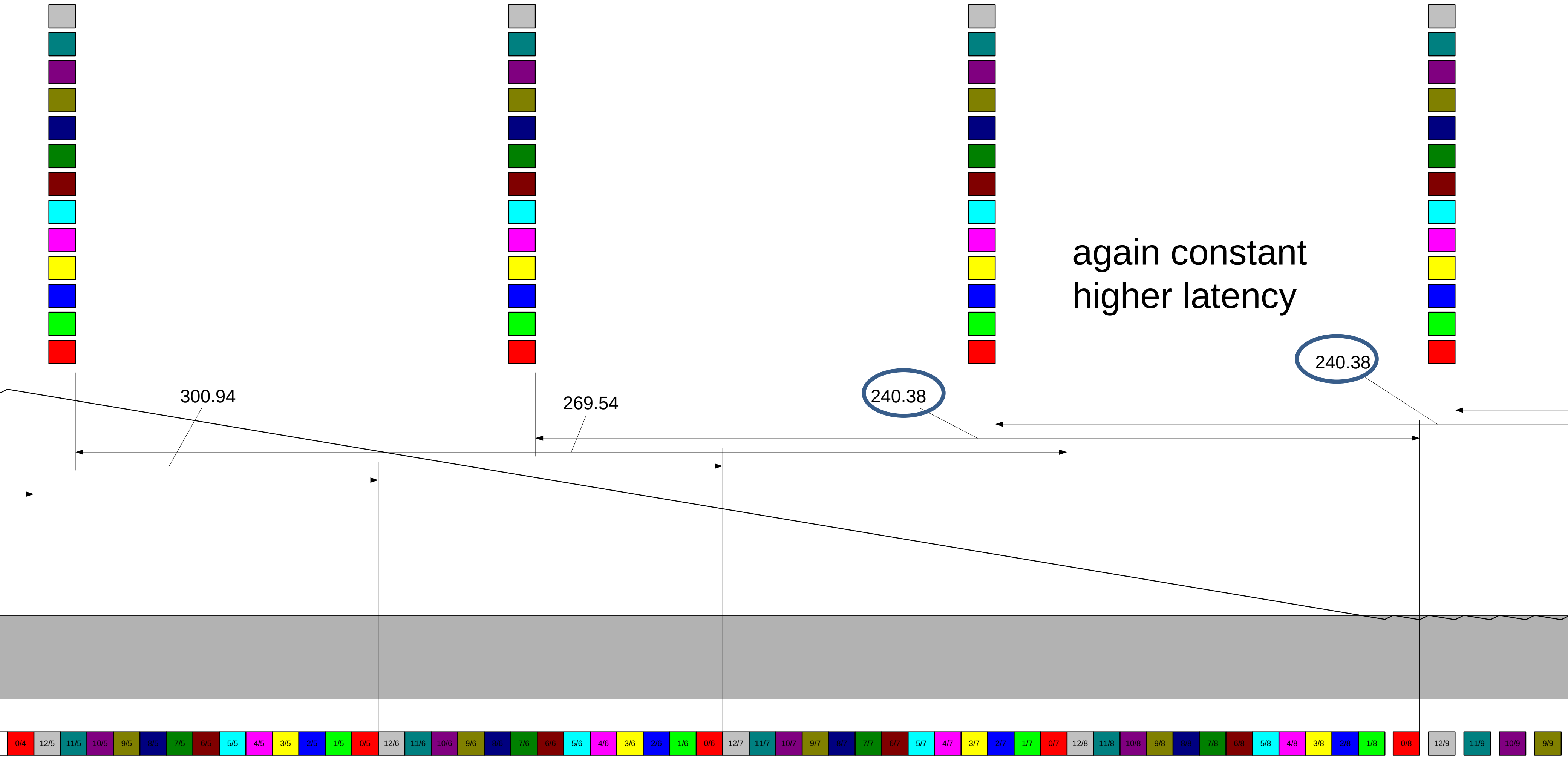
Egress with Bursting Ingress and Interfering Frame



Egress with Bursting Ingress and Interfering Frame



Egress with Bursting Ingress and Interfering Frame



Conclusions

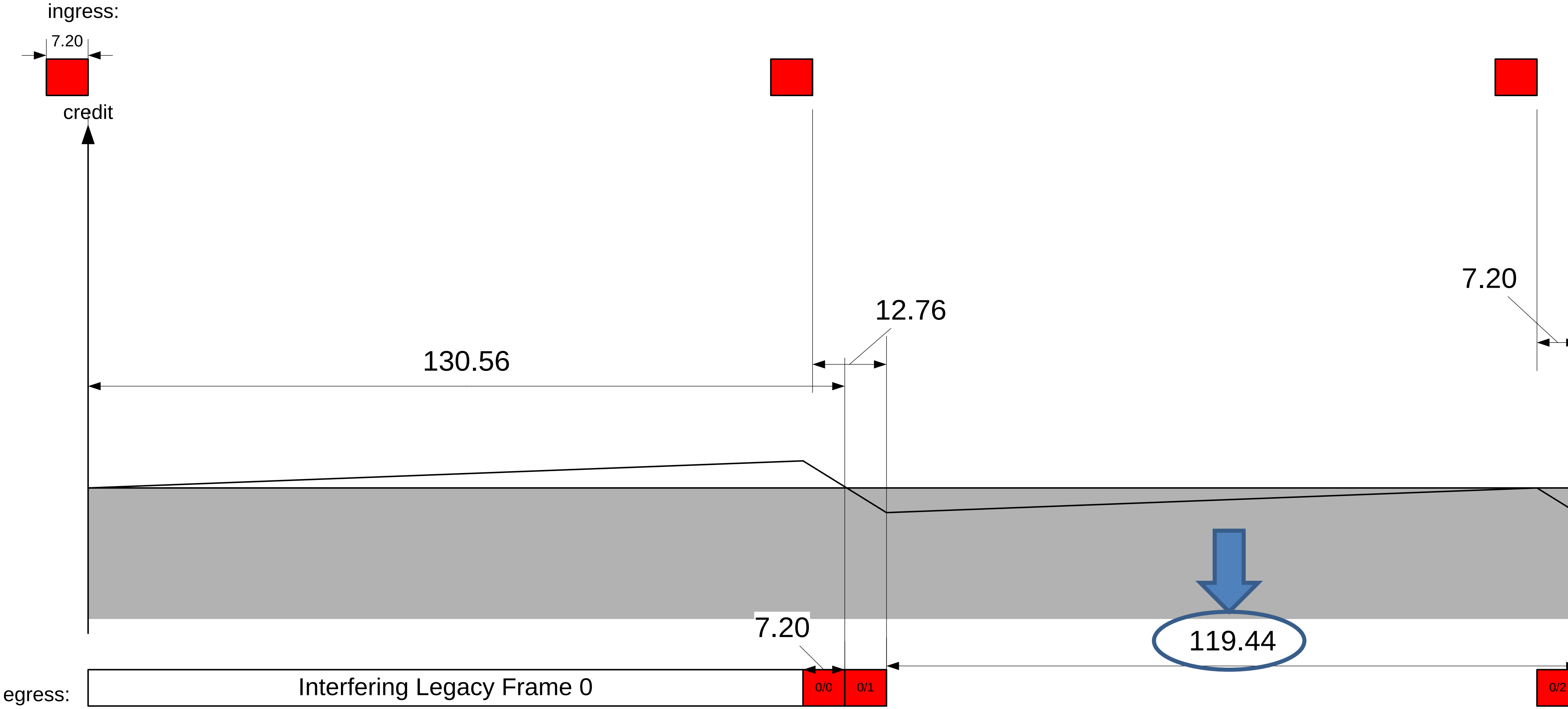
- A burst causes a permanent higher latency

- This higher latency is only reduced in the case of an “over allocation” of bandwidth (e.g. stream allocated but not used, slightly more bandwidth allocated than used, …)

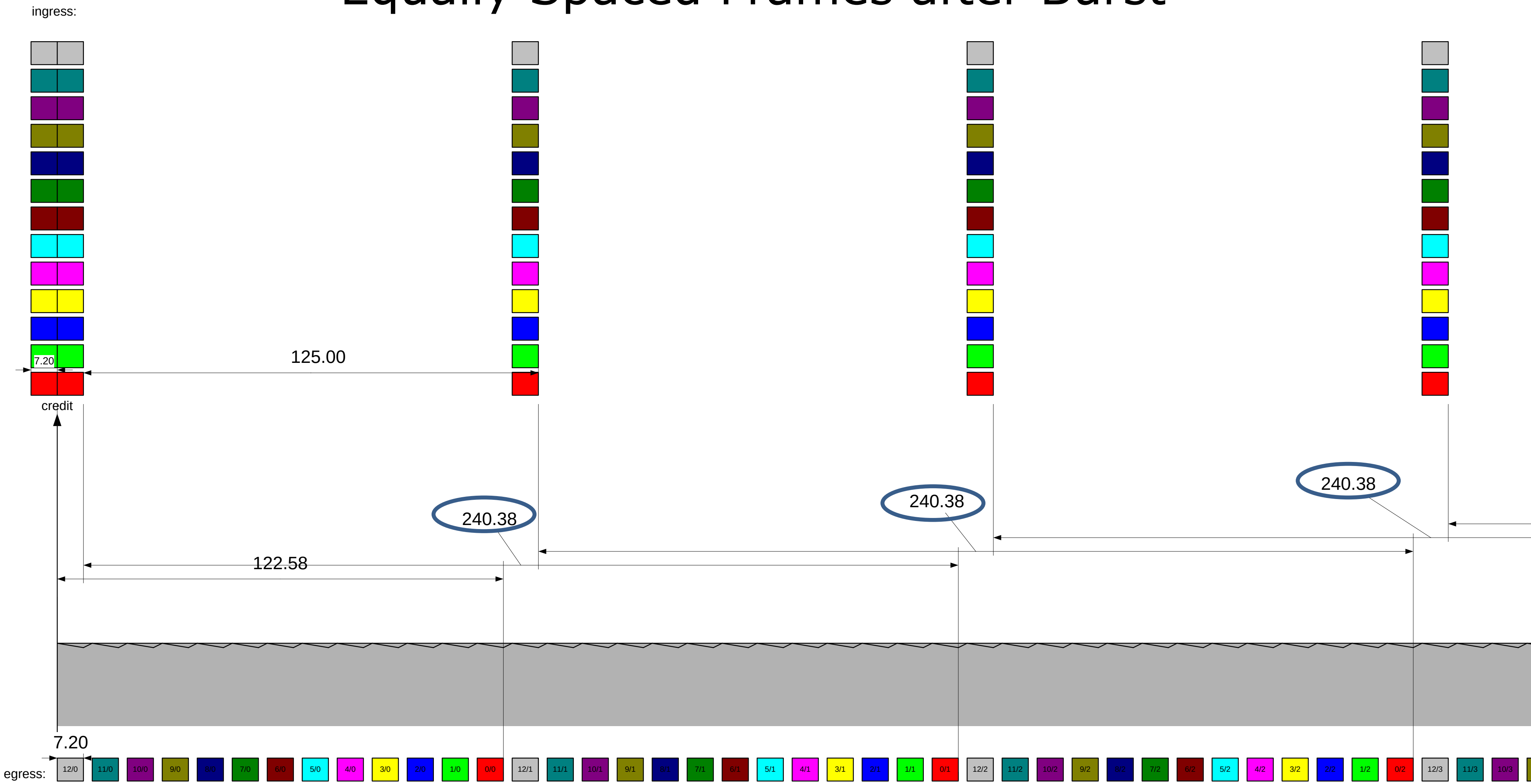
- The latency is reduced in the short period before the next burst but reaches the higher value again after the burst

Secondary Effect 4: Quasi-Burst

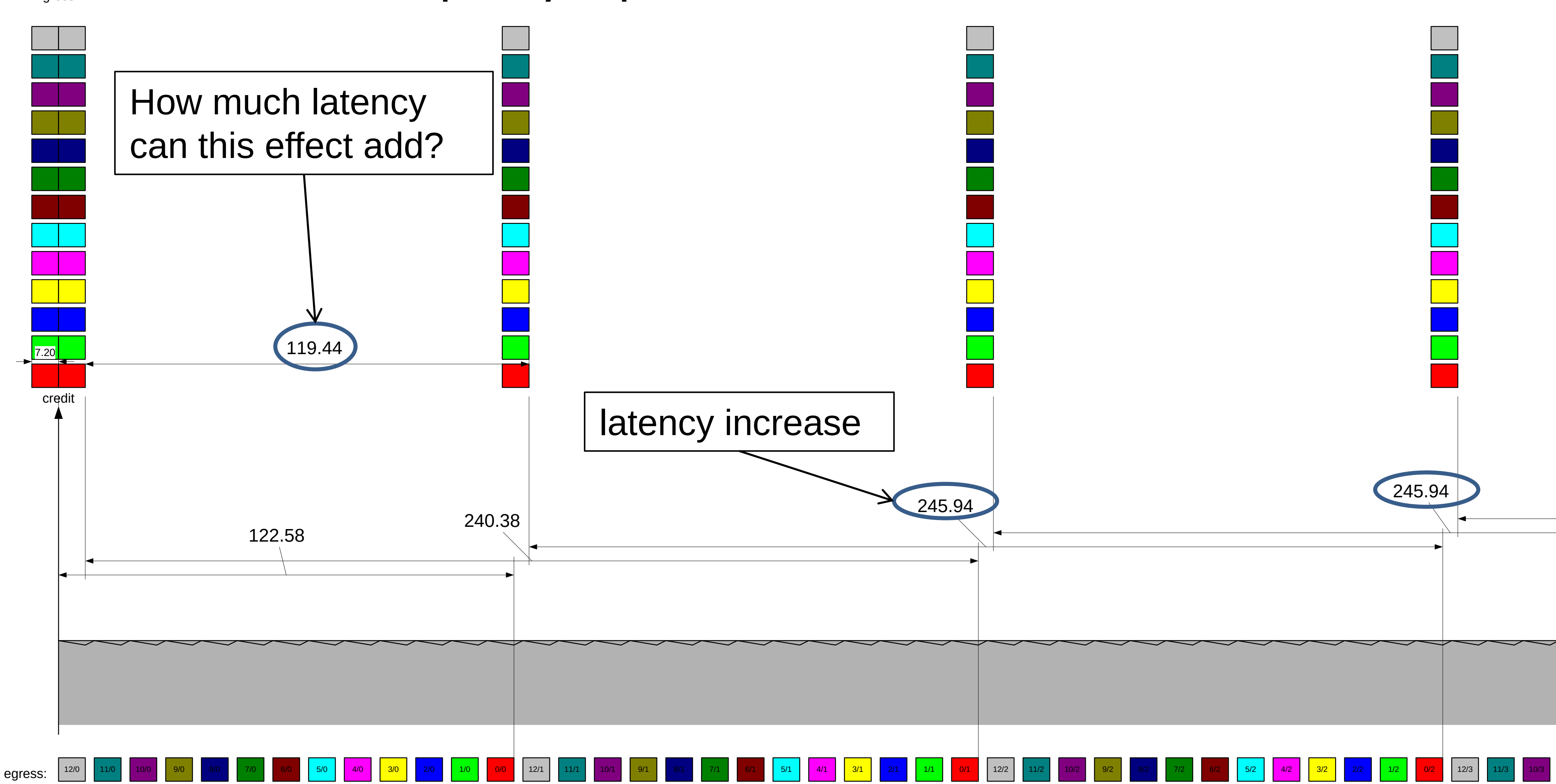
Bursting Talker



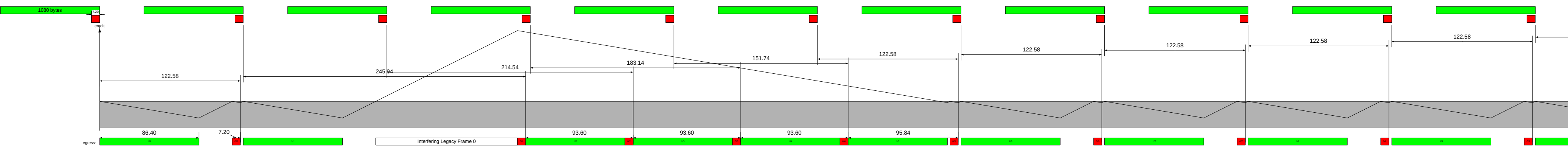
Equally Spaced Frames after Burst



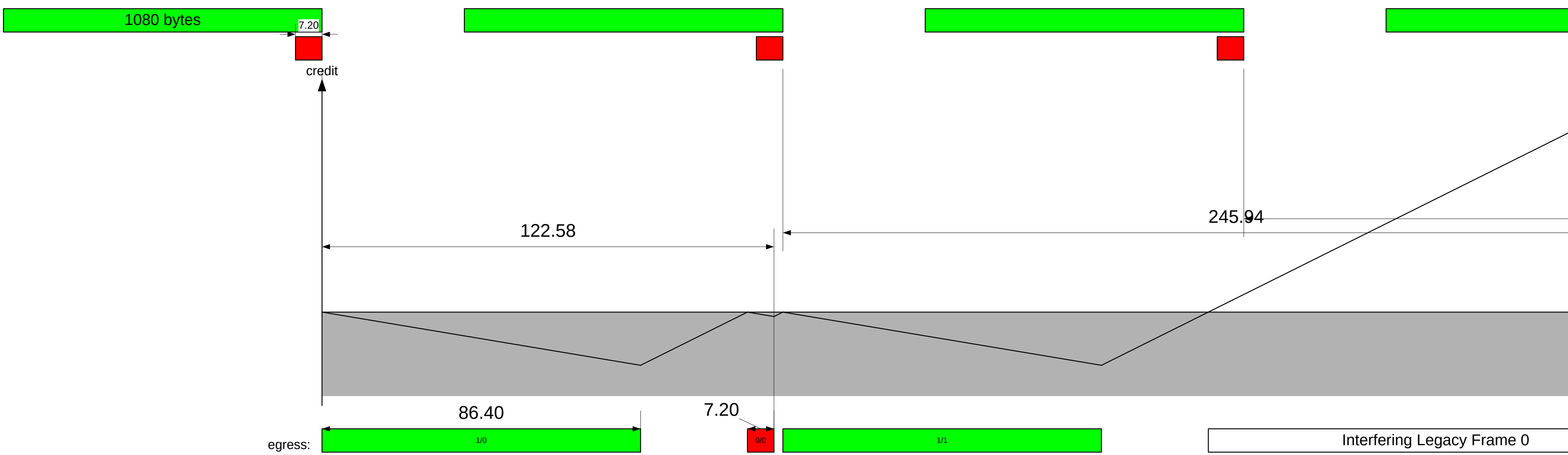
Not Equally Spaced Frames after Burst



Talker with two Streams (90, 1080 bytes)



Talker with two Streams (90, 1080 bytes) (1)



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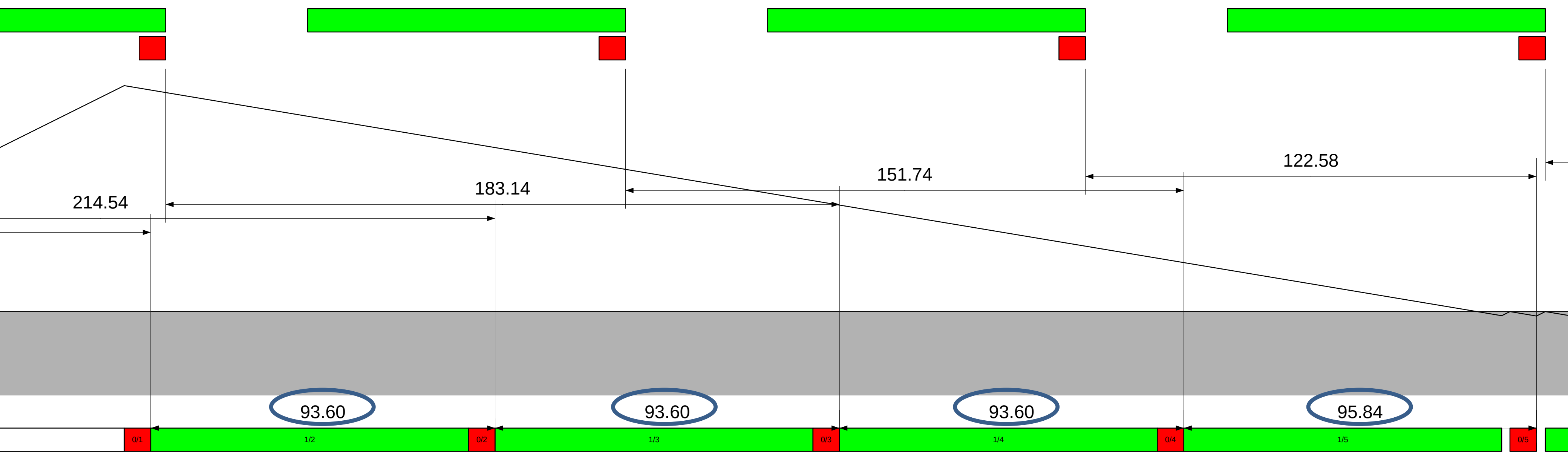
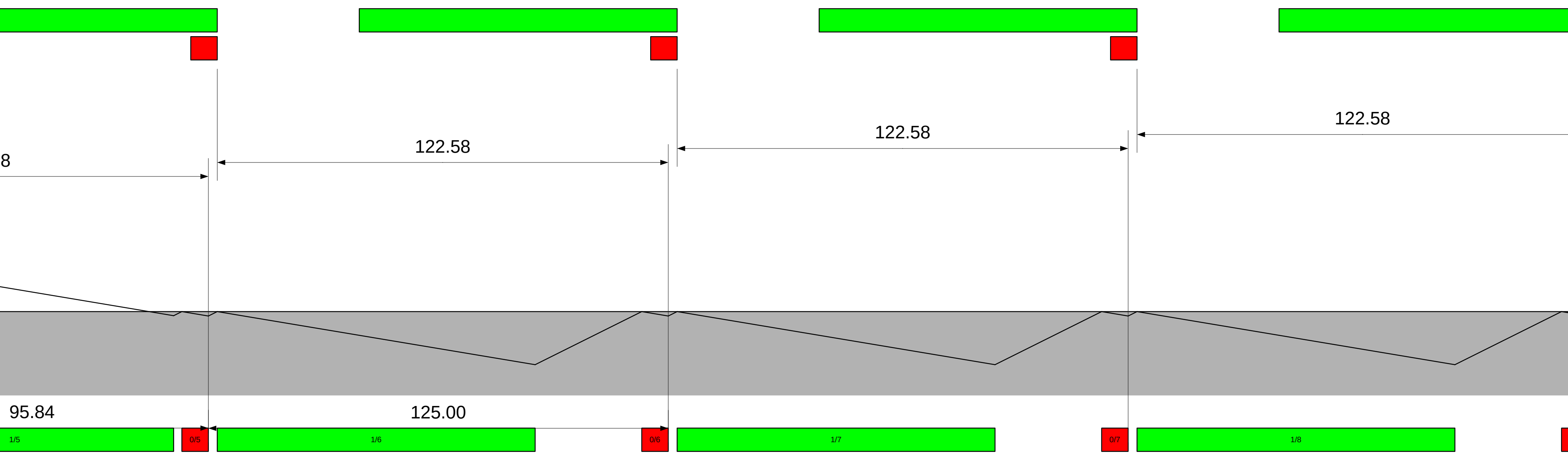
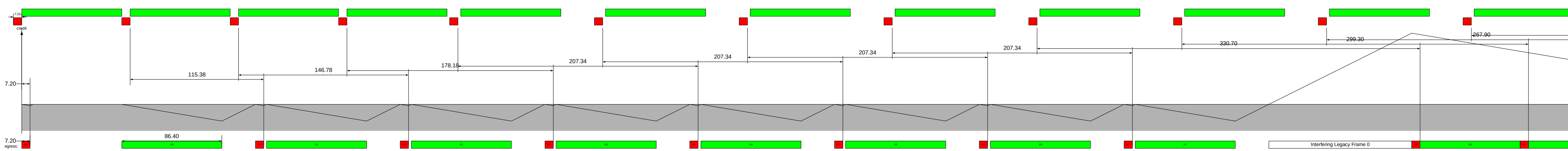
Talker with two Streams (90, 1080 bytes) (2)



Talker with two Streams (90, 1080 bytes) (3)

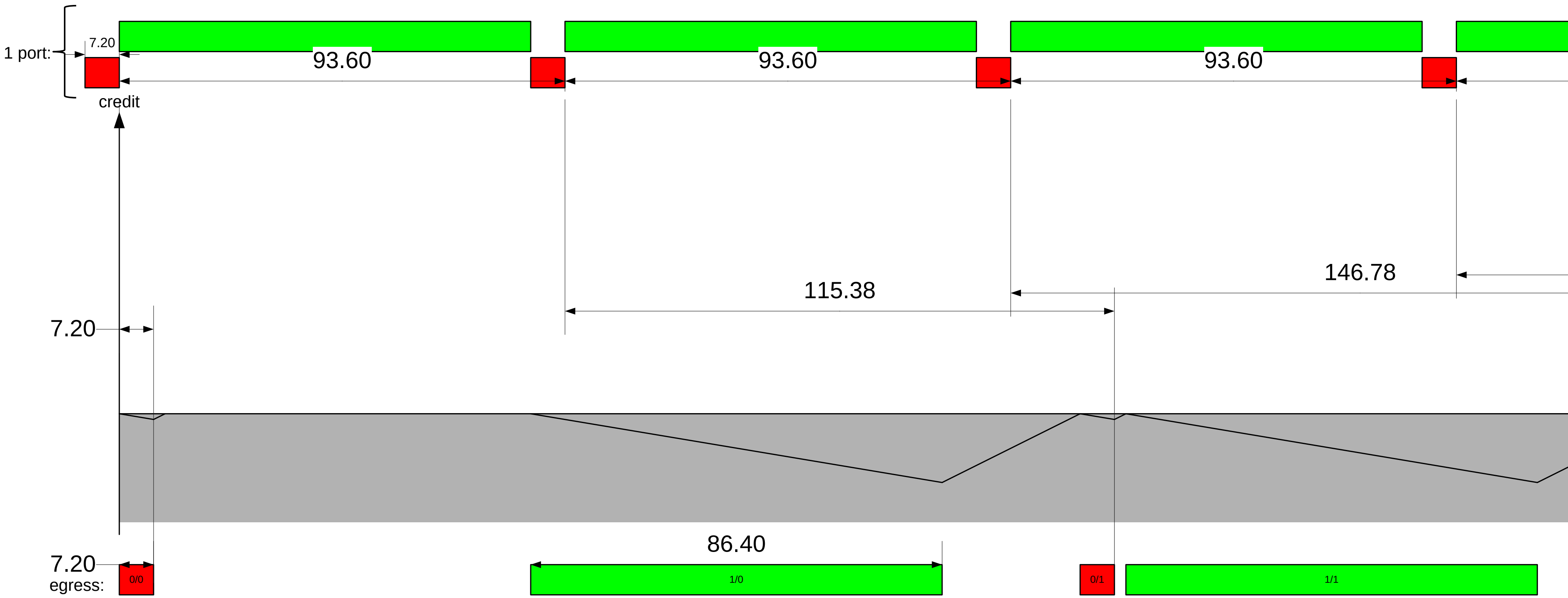


Bridge after this talker



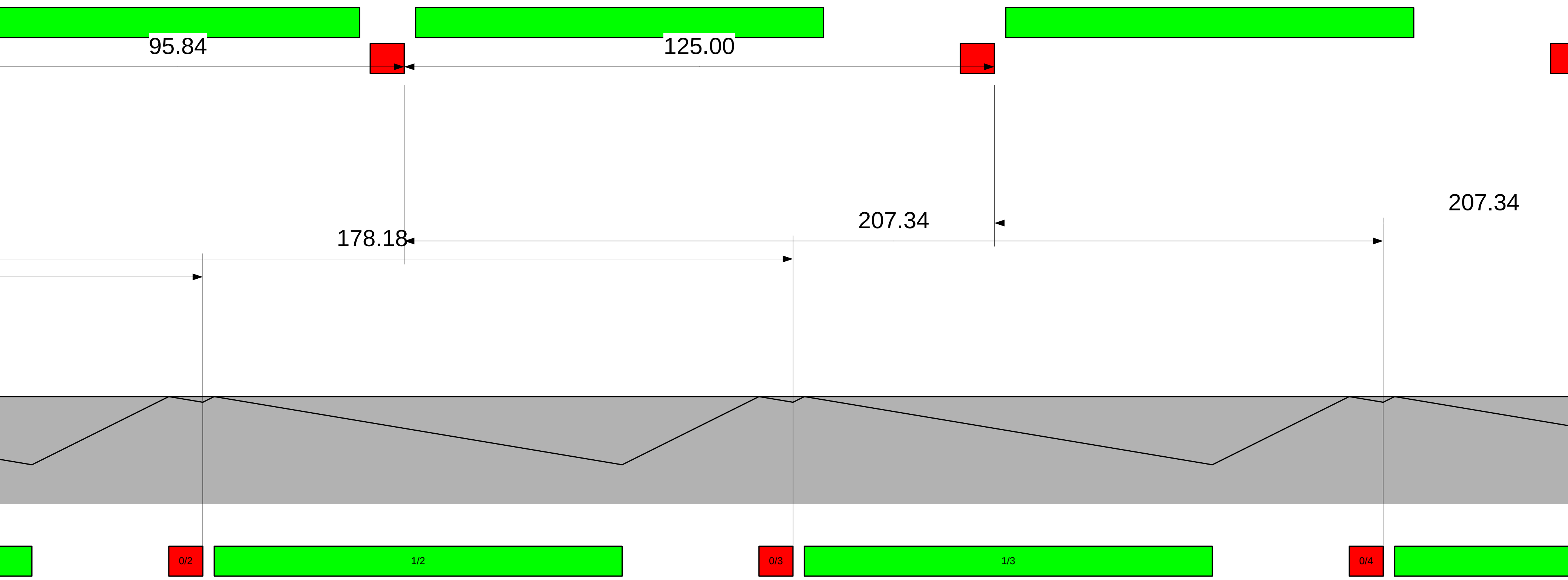
The two ingress streams are both from the same talker

Bridge after this talker (1)



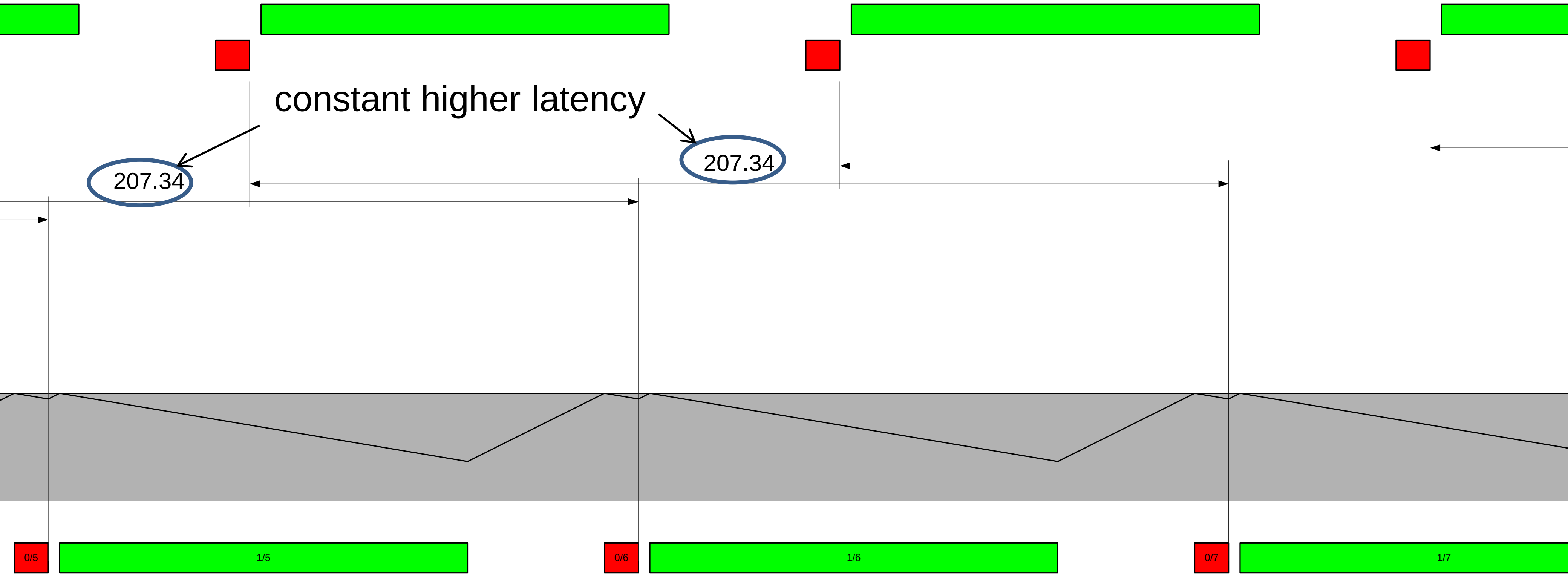
The two ingress streams are both from the same talker

Bridge after this talker (2)



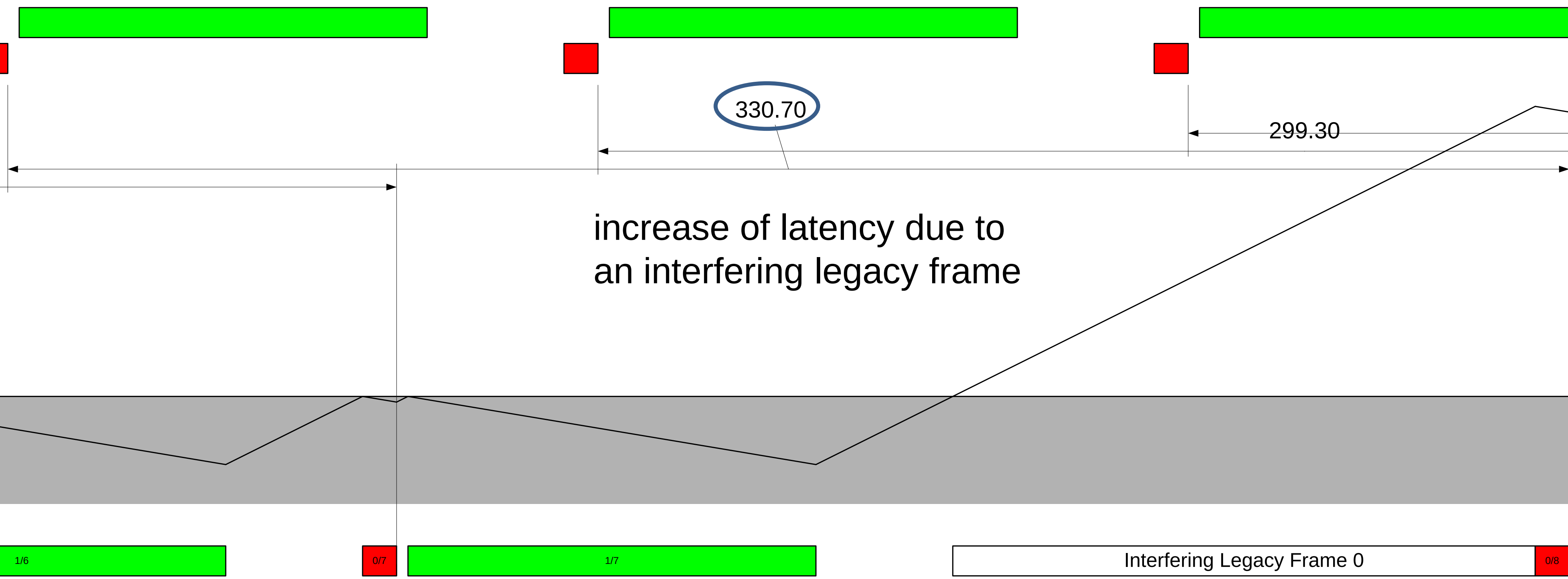
The two ingress streams are both from the same talker

Bridge after this talker (3)



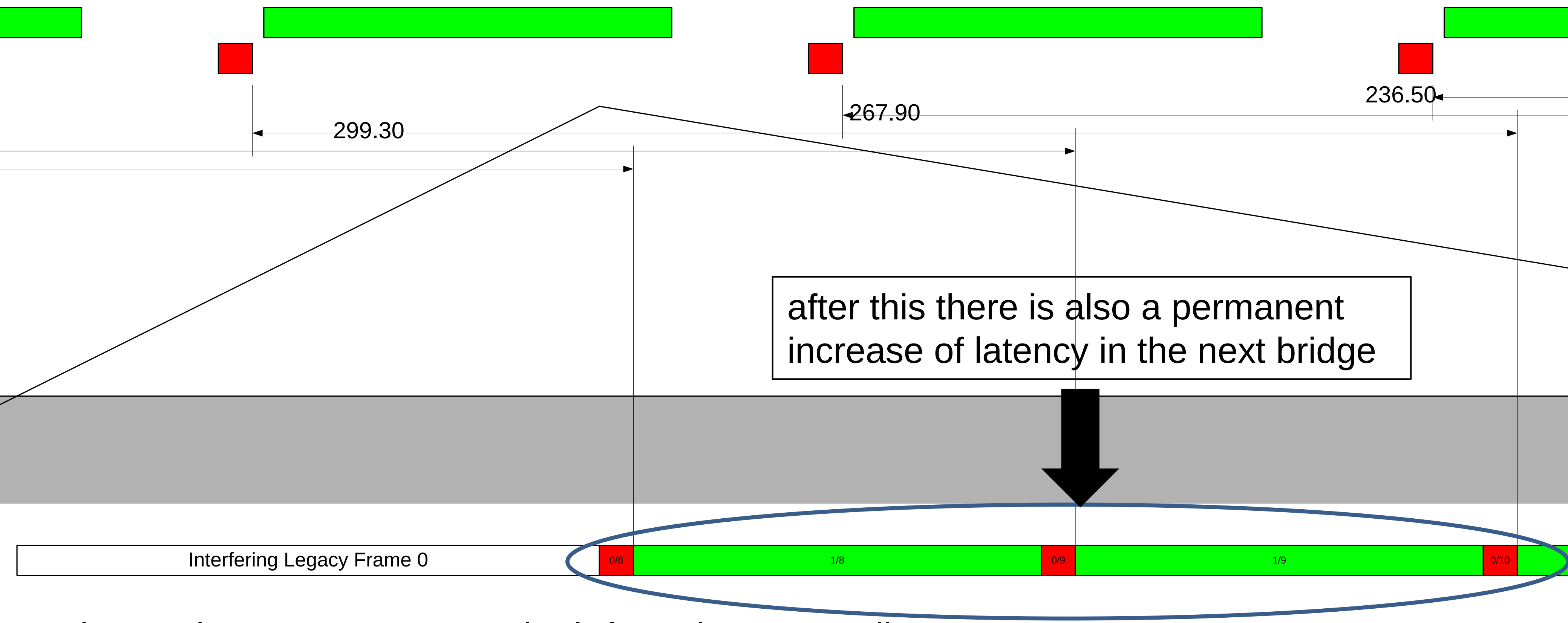
The two ingress streams are both from the same talker

Bridge after this talker (4)



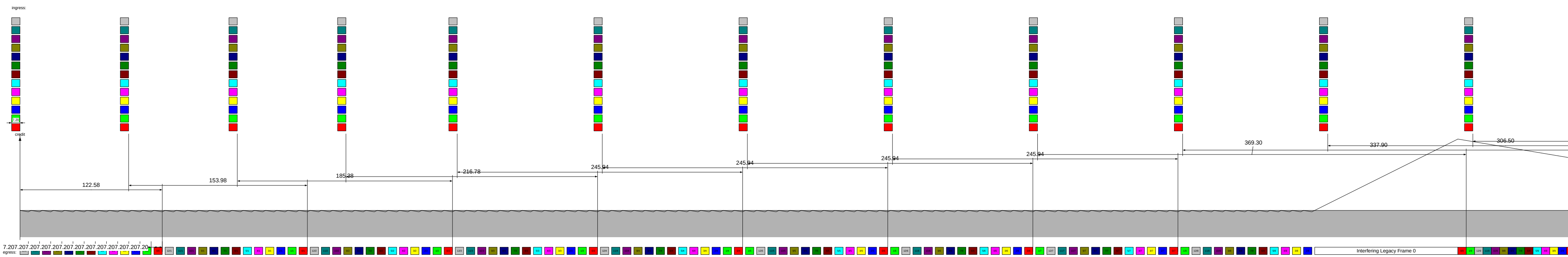
The two ingress streams are both from the same talker

Bridge after this talker (5)

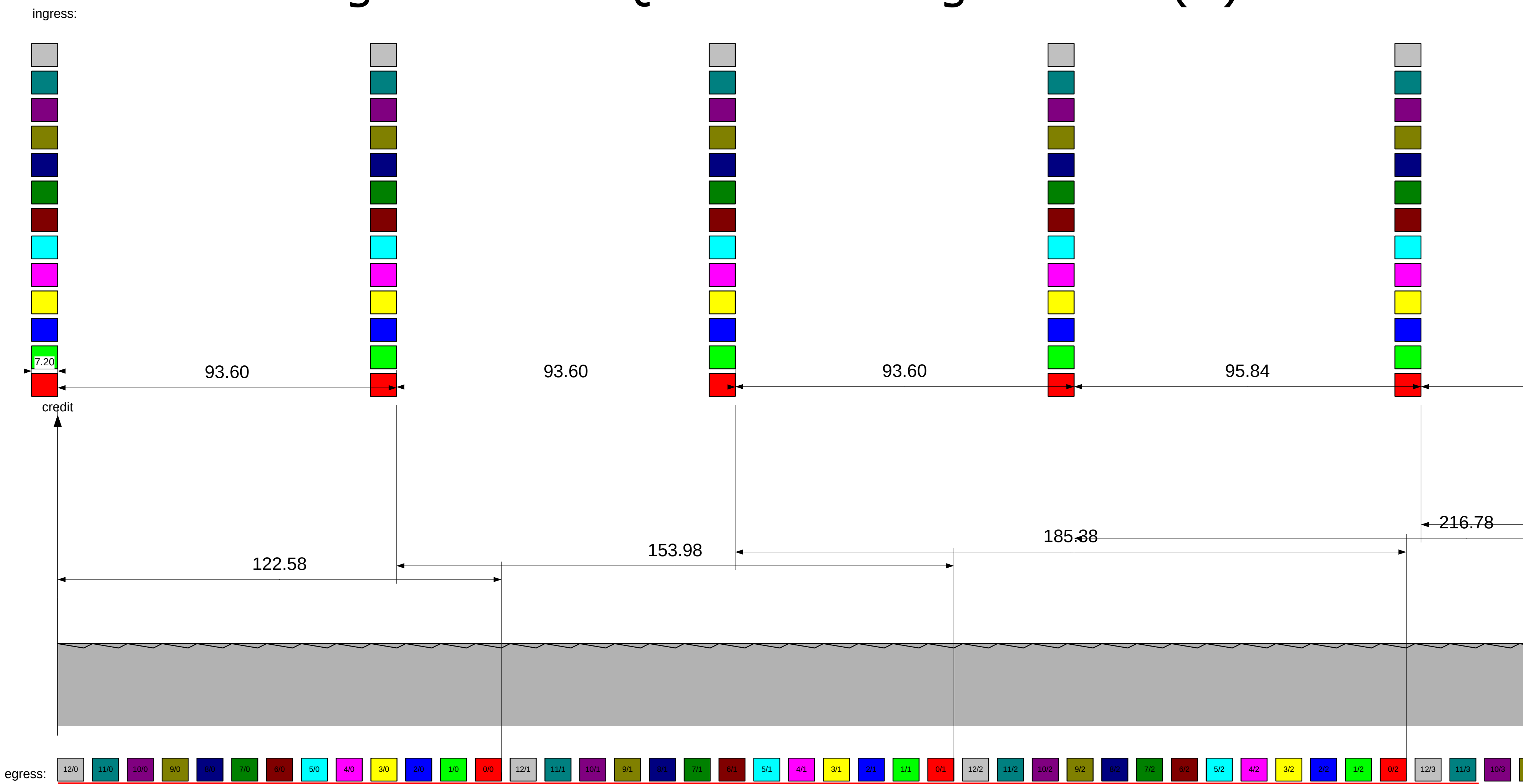


The two ingress streams are both from the same talker

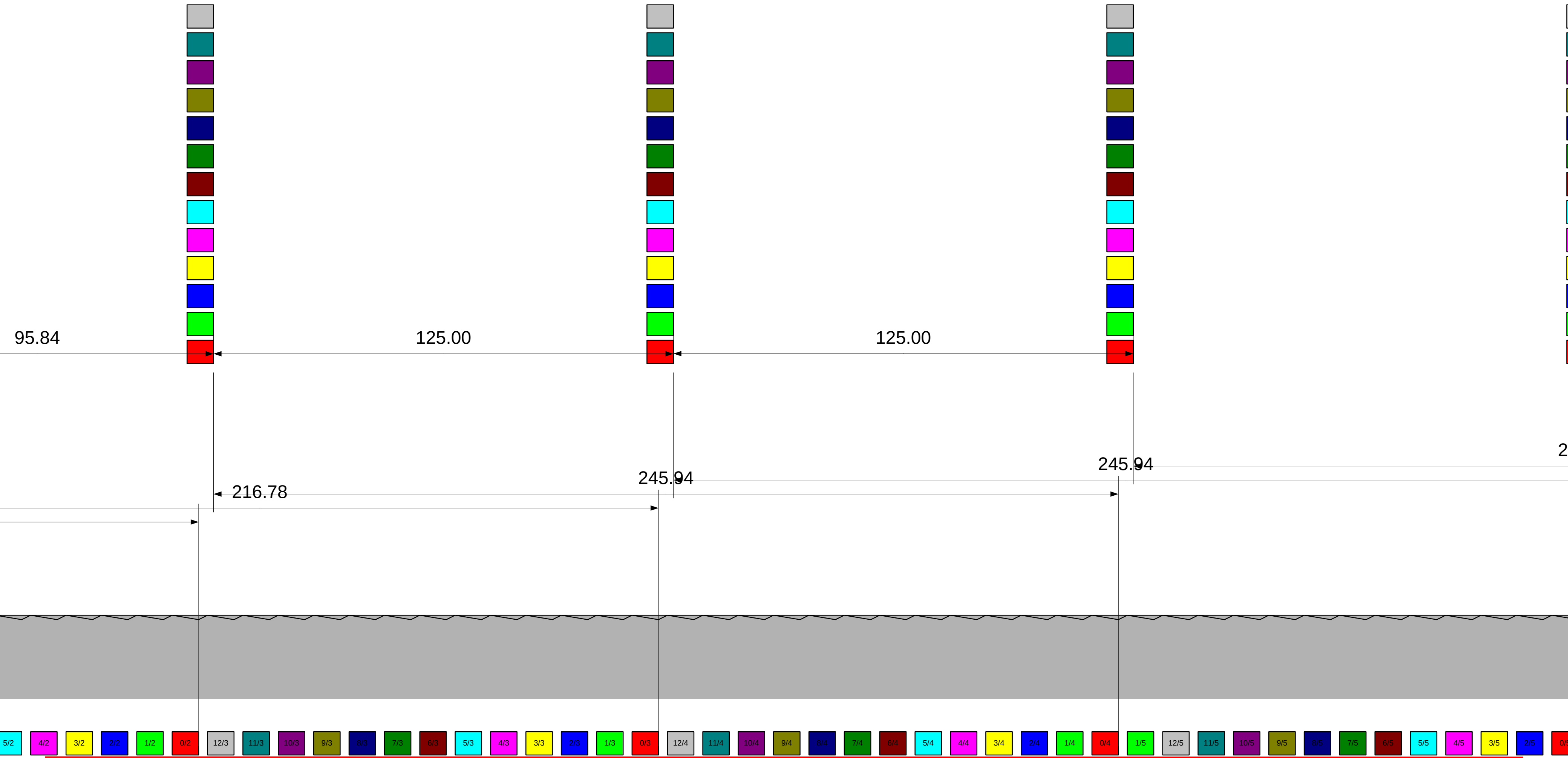
Bridge with 13 Quasi-Bursting Talkers



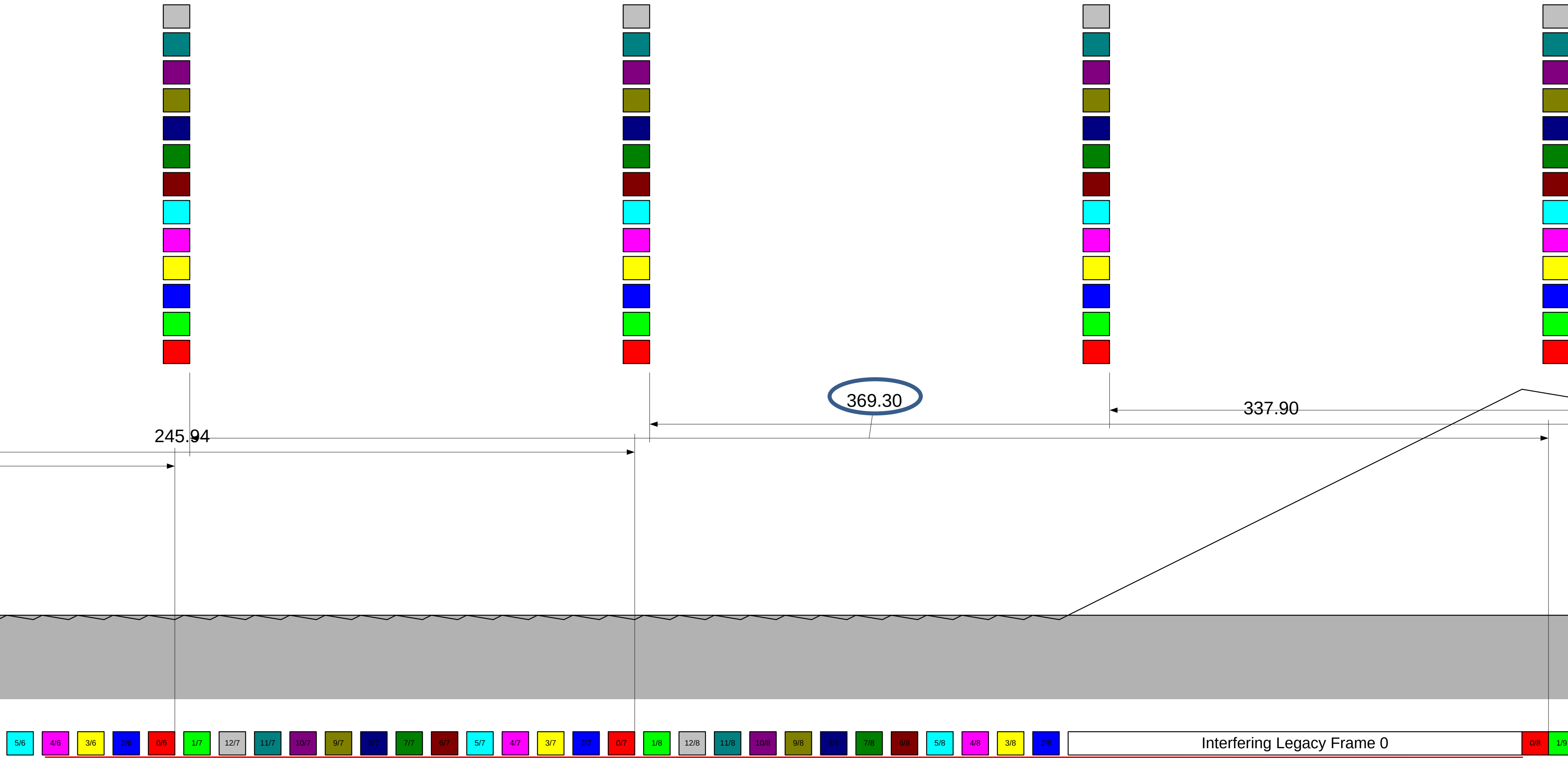
Bridge with 13 Quasi-Bursting Talkers (1)



Bridge with 13 Quasi-Bursting Talkers (2)



Bridge with 13 Quasi-Bursting Talkers (3)



Secondary Effect 5: Combined Burst and Quasi-Burst

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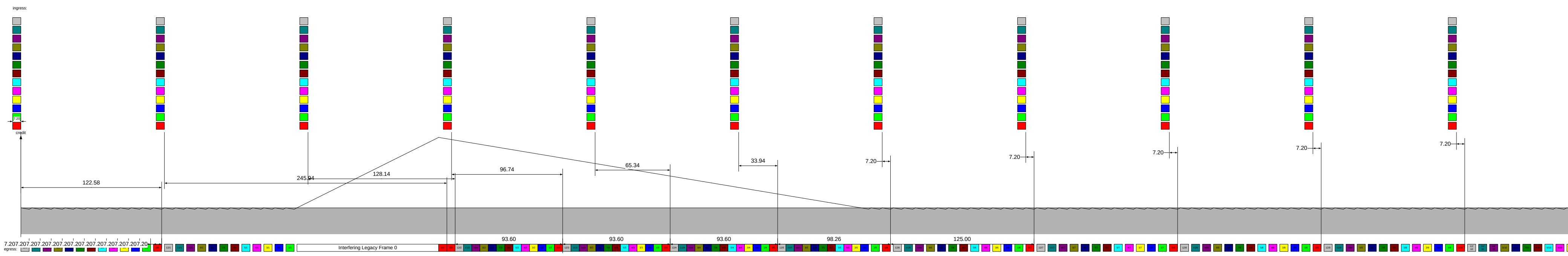
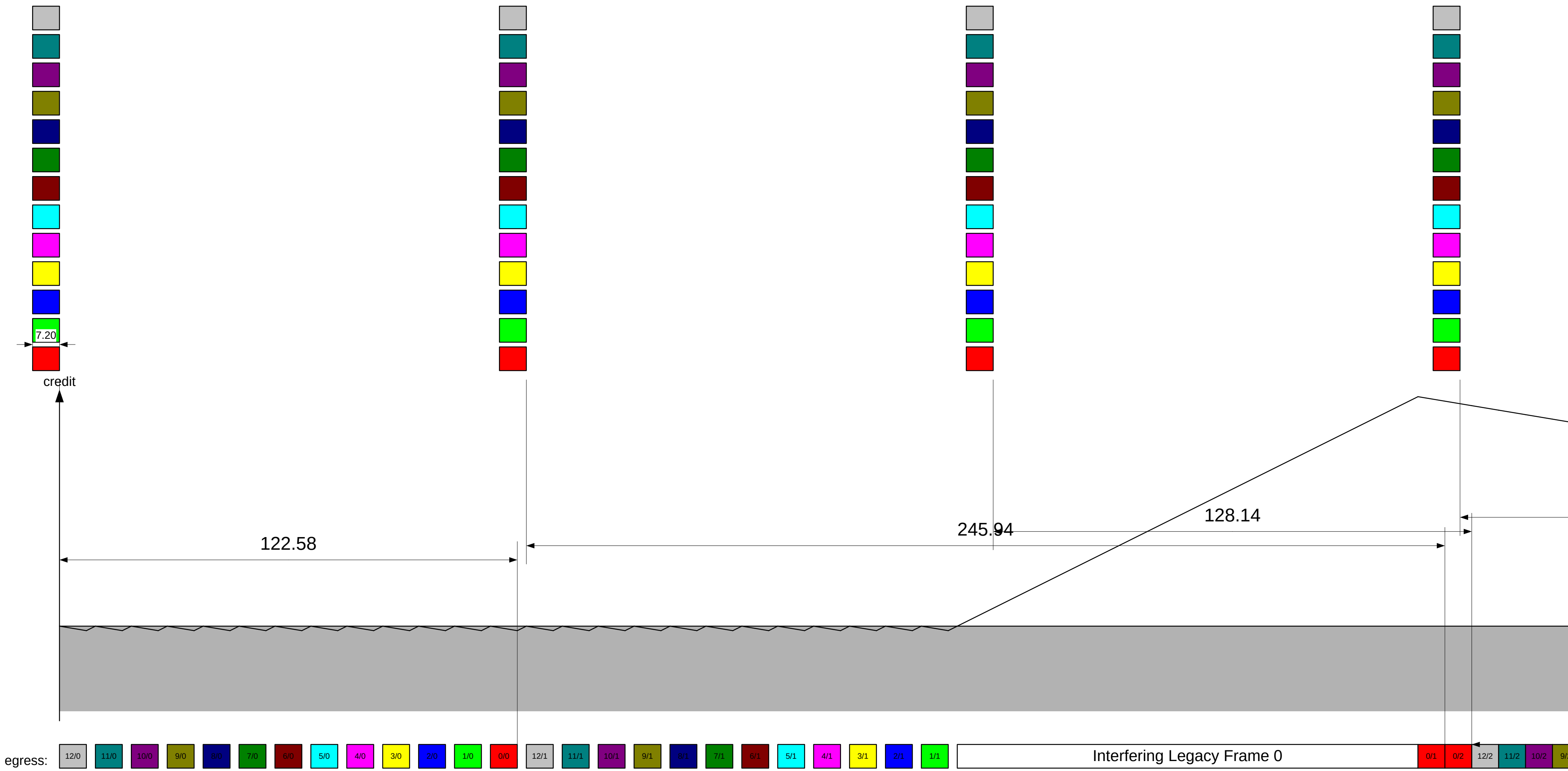
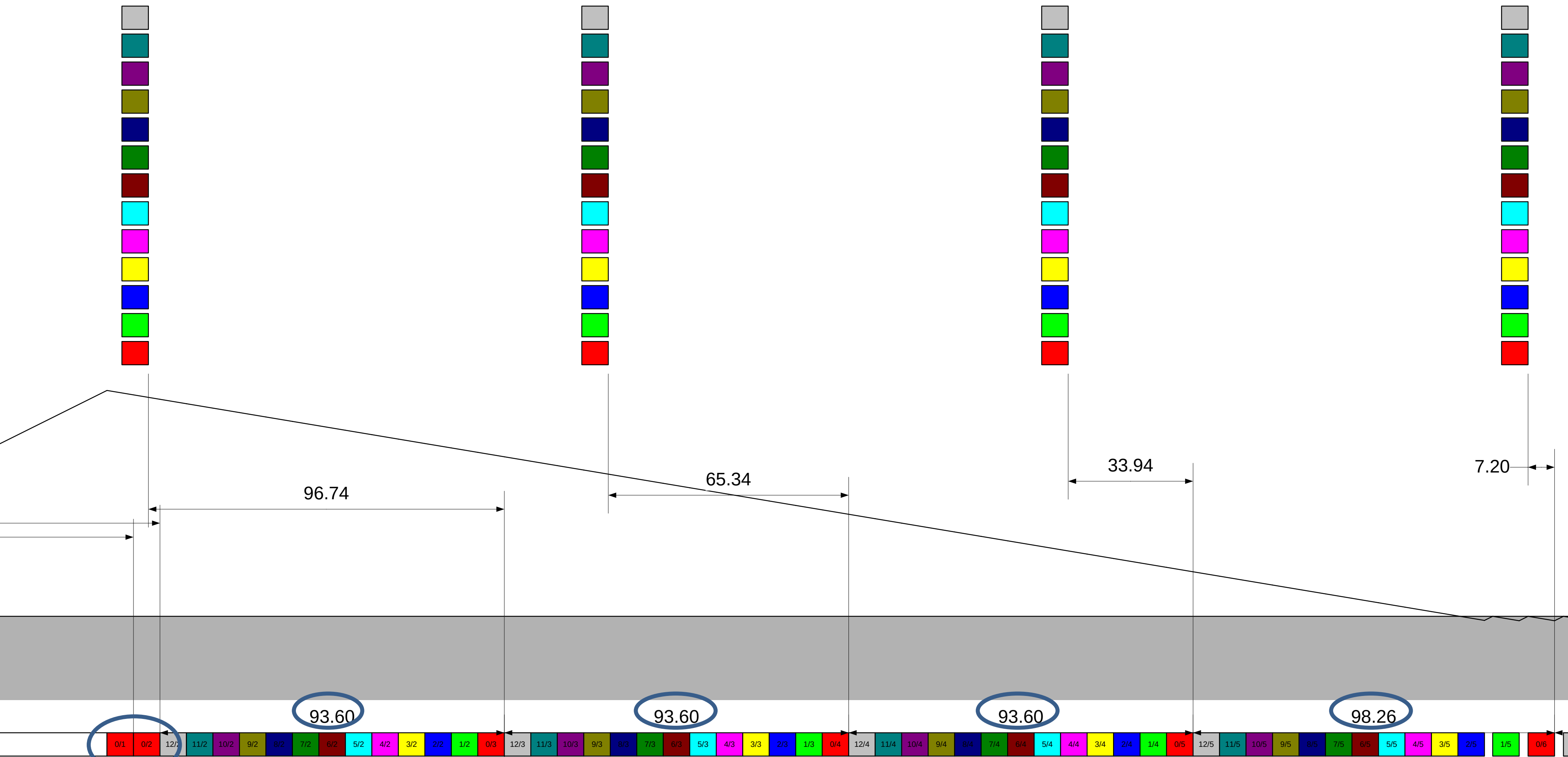
Combined Burst and Quasi-Burst - Talker



Combined Burst and Quasi-Burst – Talker (1)



Combined Burst and Quasi-Burst – Talker (2)



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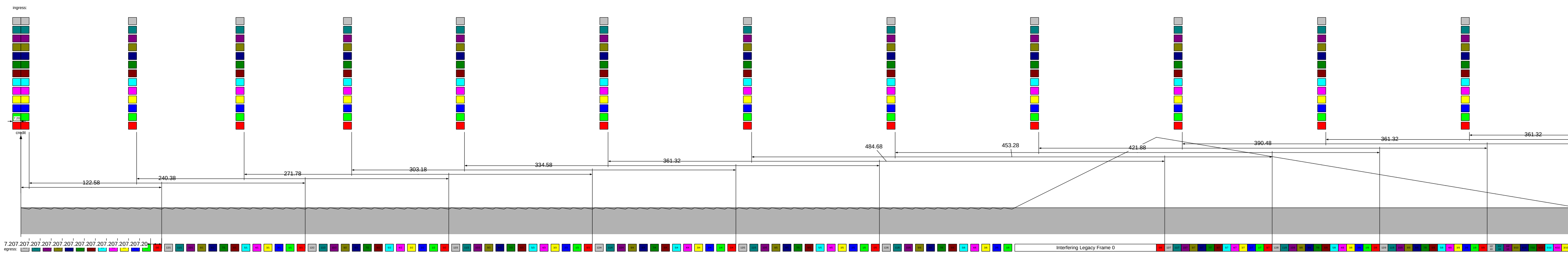
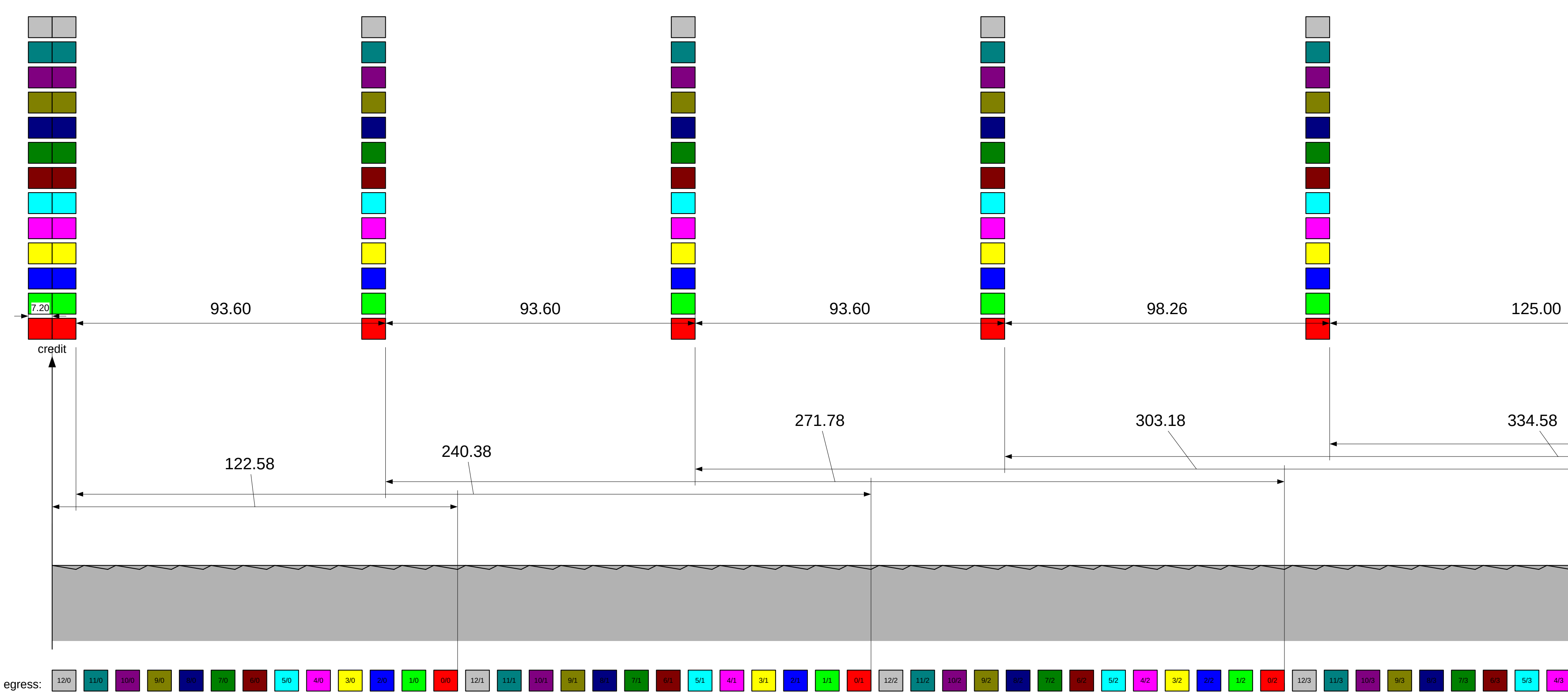
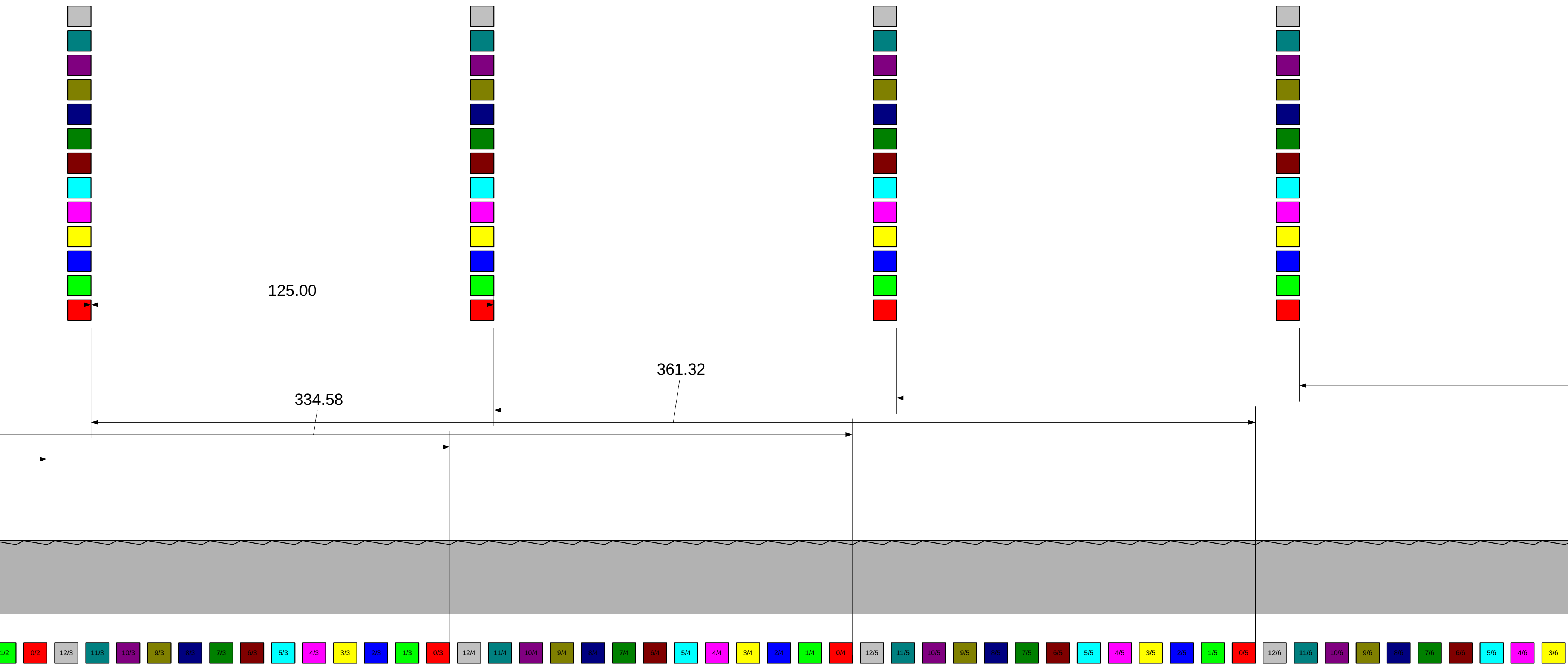
Combined Burst and Quasi-Burst - Bridge



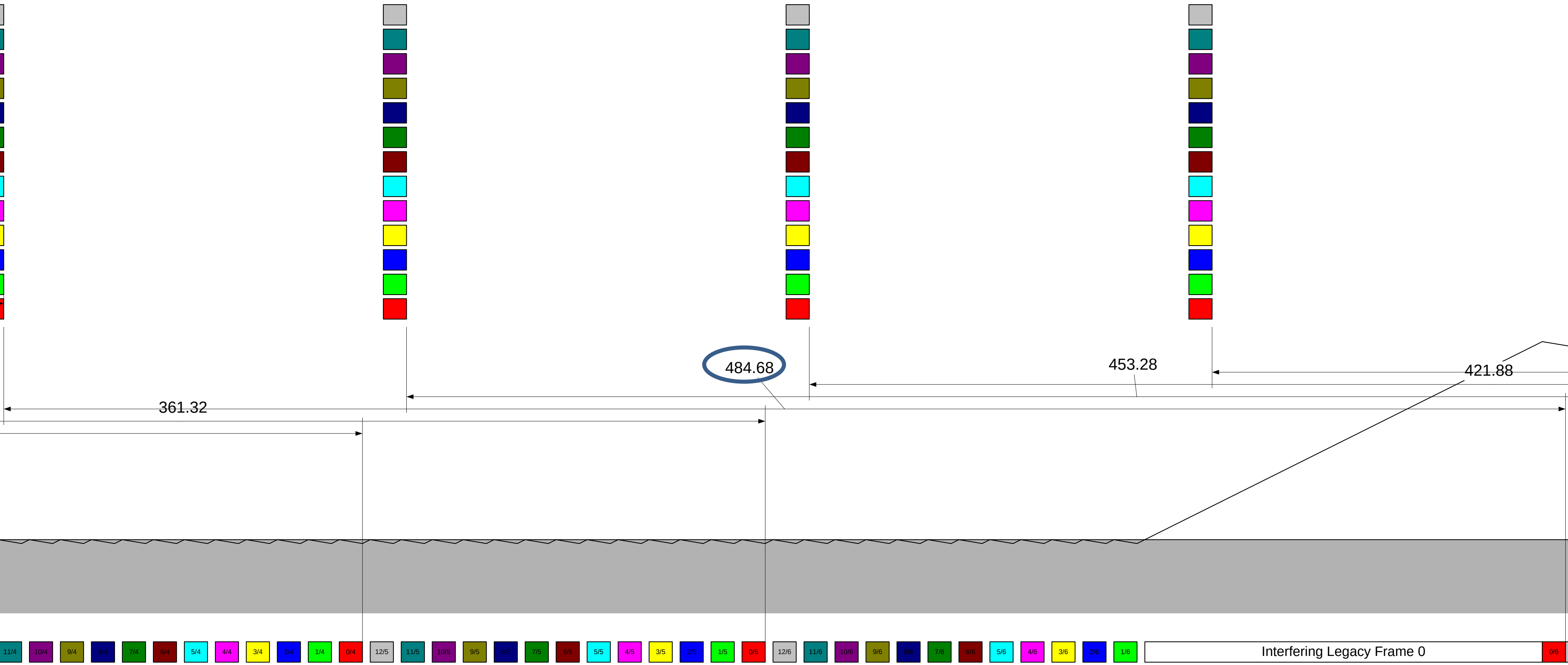
Combined Burst and Quasi-Burst – Bridge (1)



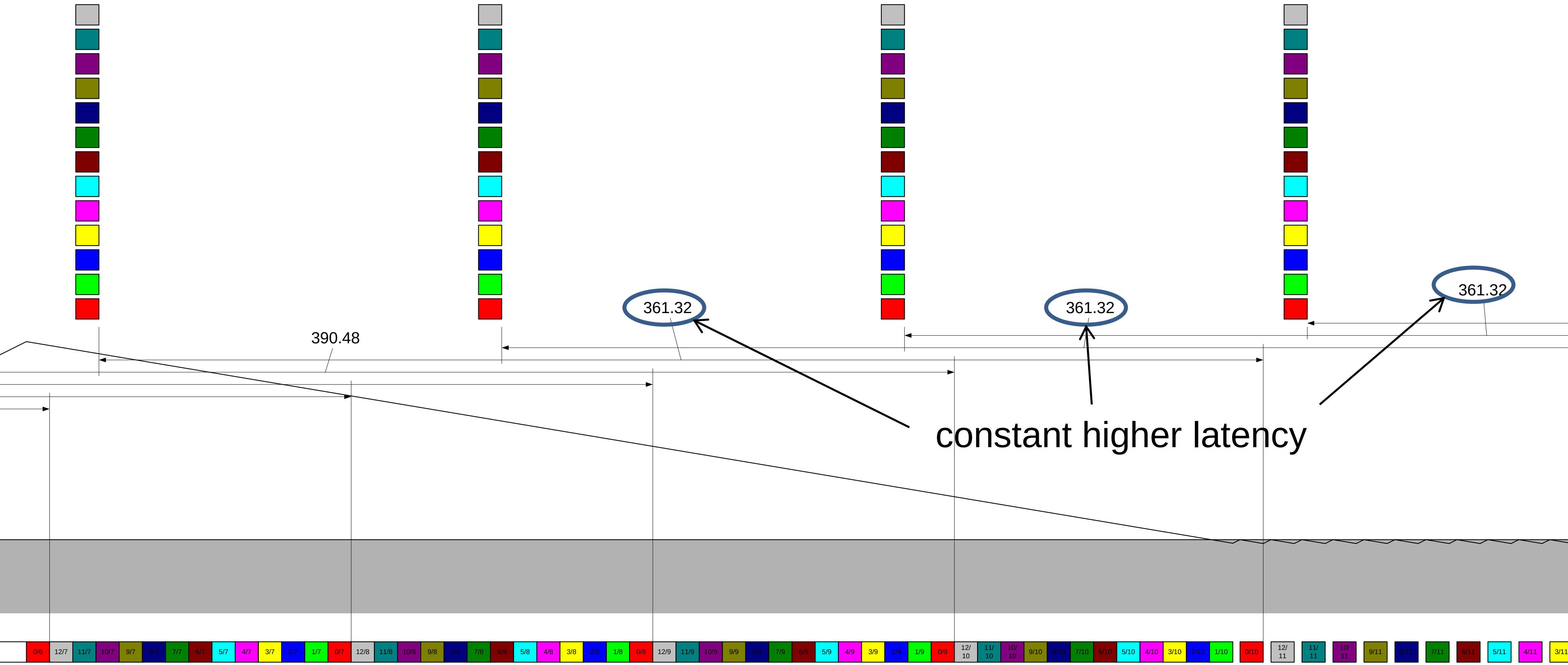
Combined Burst and Quasi-Burst – Bridge (2)



Combined Burst and Quasi-Burst – Bridge (3)

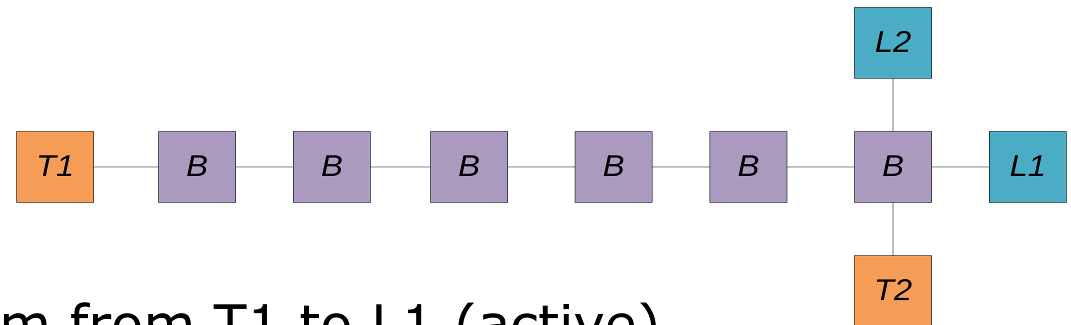


Combined Burst and Quasi-Burst – Bridge (4)

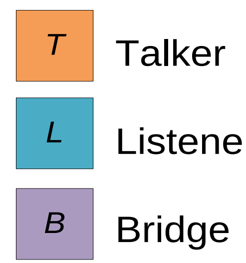


Simple
Fast Ethernet
Example

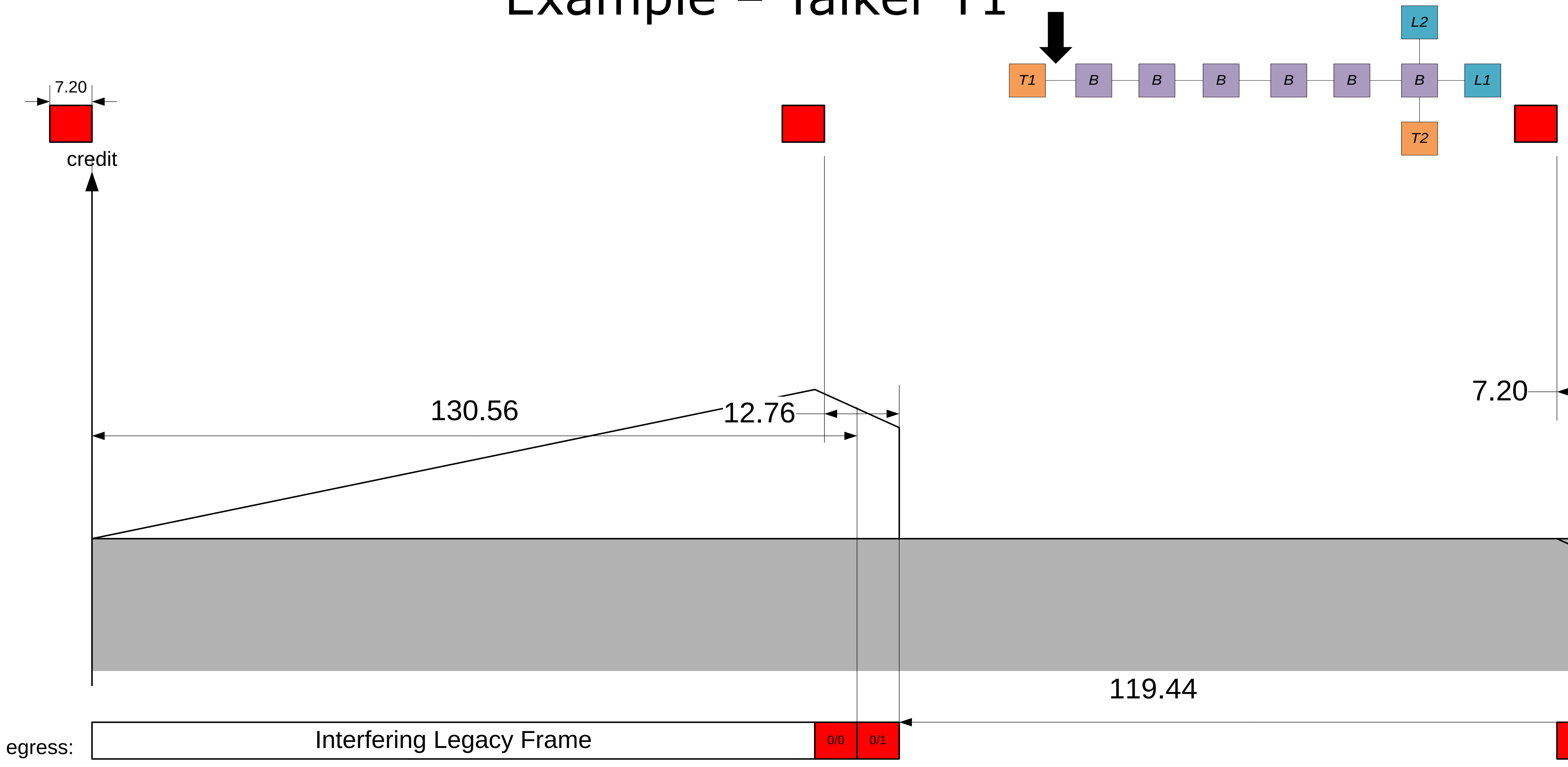
Example



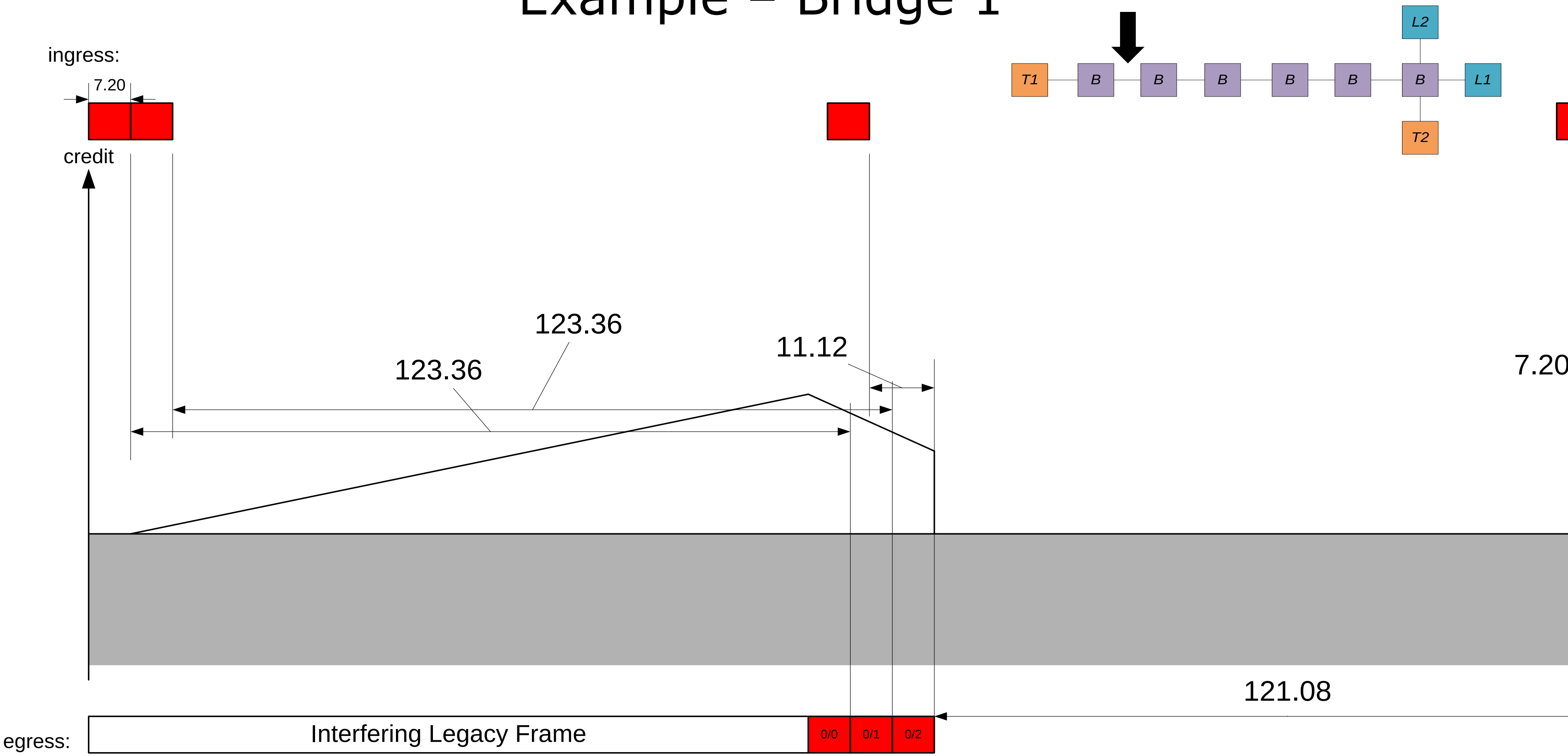
- 90 byte class A stream from T1 to L1 (active)
  - 7 hops
- 90 byte class A stream from T2 to L1 (active)
  - 2 hops
- 400 byte class A stream from T1 to L2 (allocated, but not (yet) used)
  - 7 hops
- Legacy frame is transmitted from T1 to L1 one clk cycle before the class A frame is ready to be transmitted



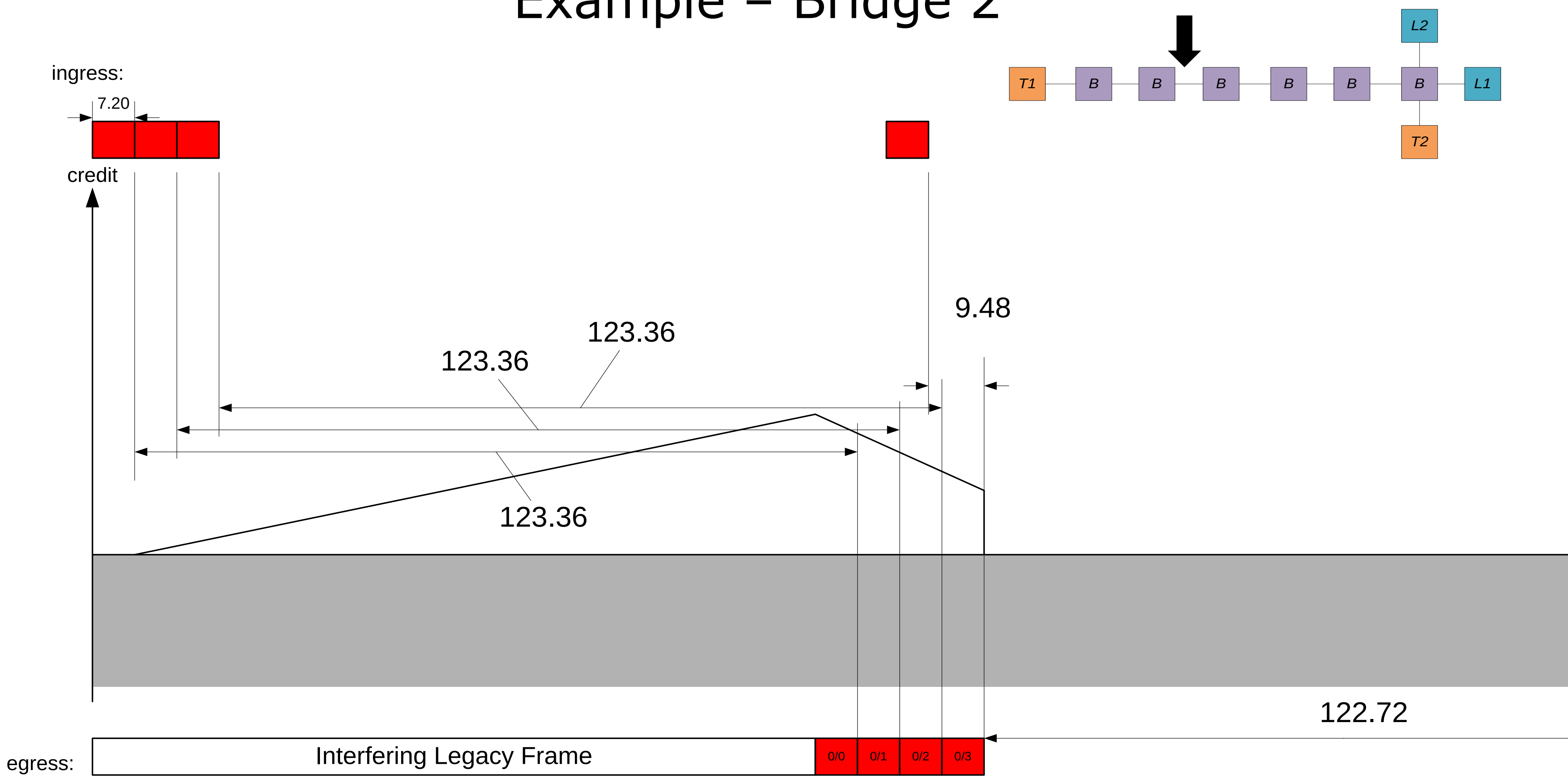
Example – Talker T1



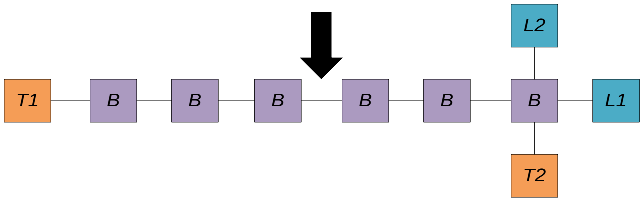
Example – Bridge 1

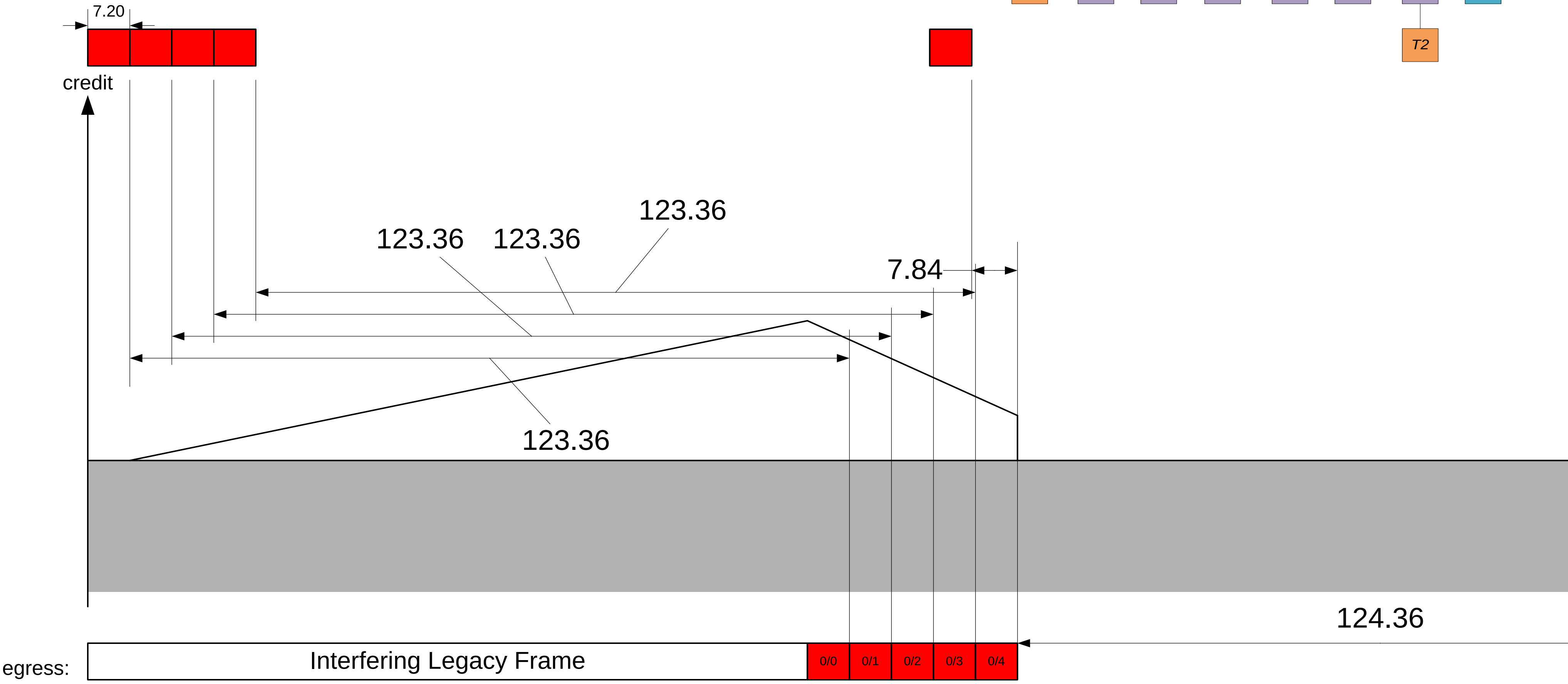


Example – Bridge 2

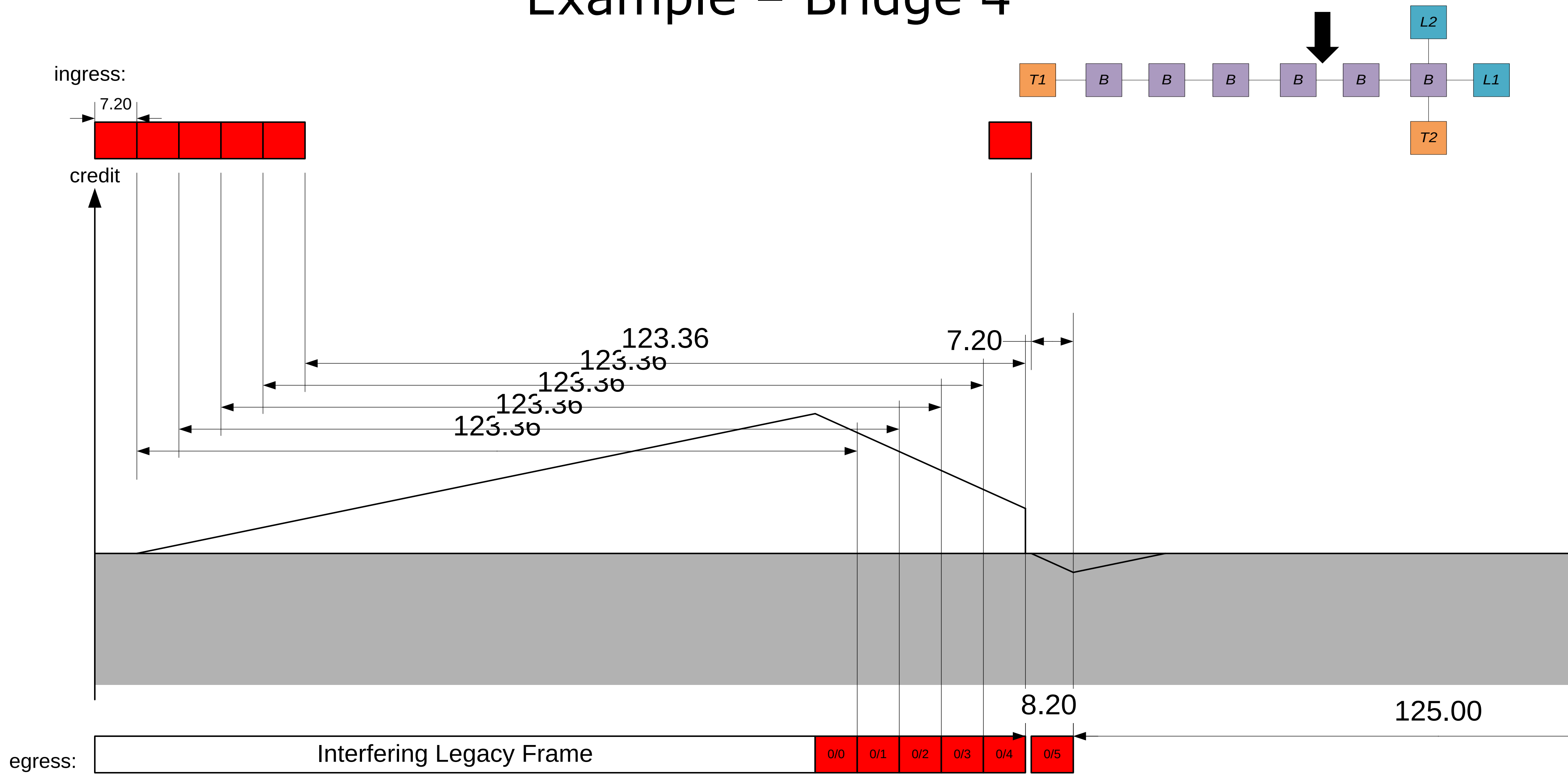


Example – Bridge 3

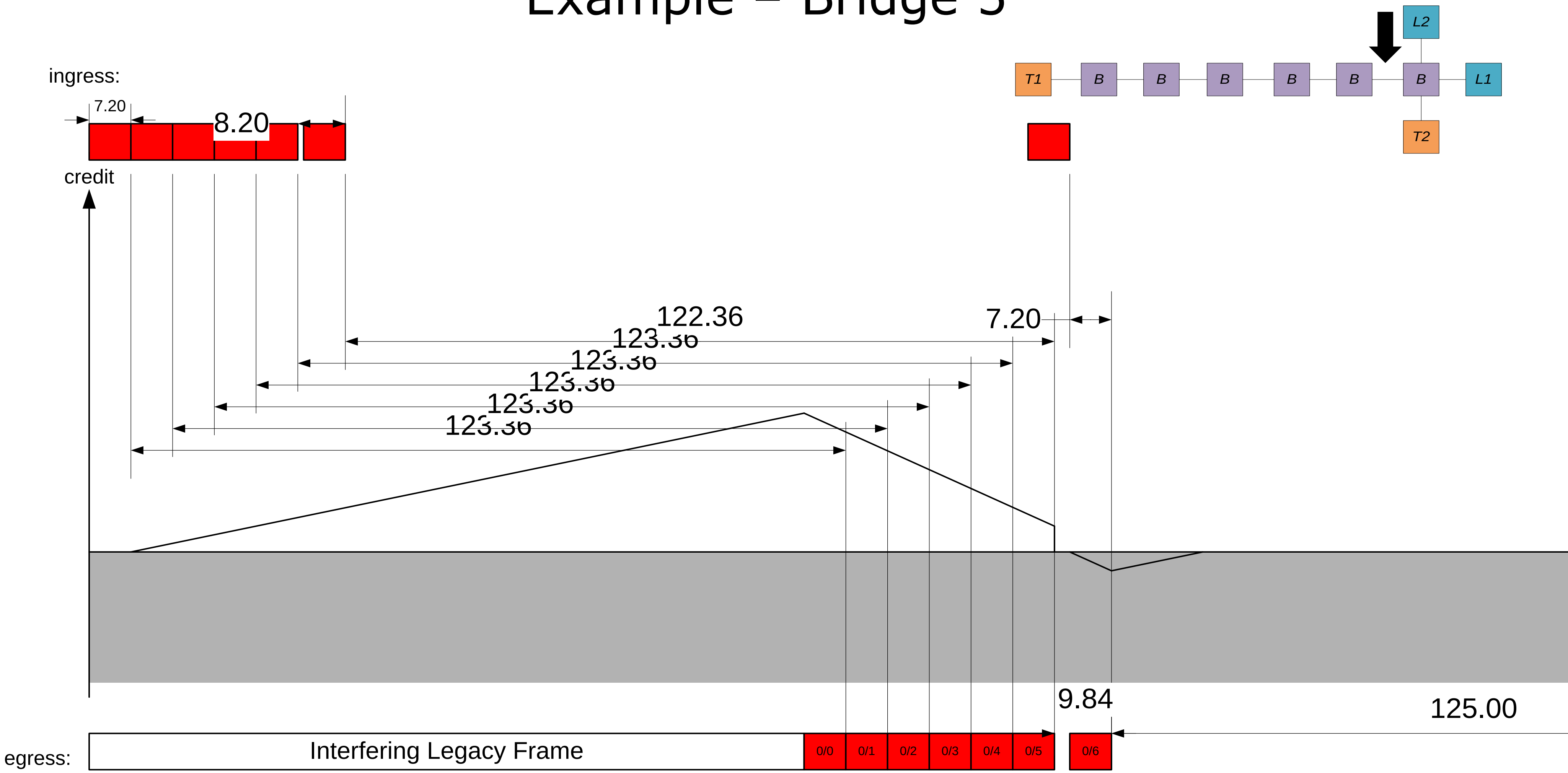




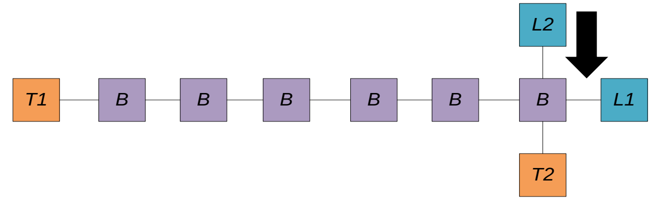
Example – Bridge 4

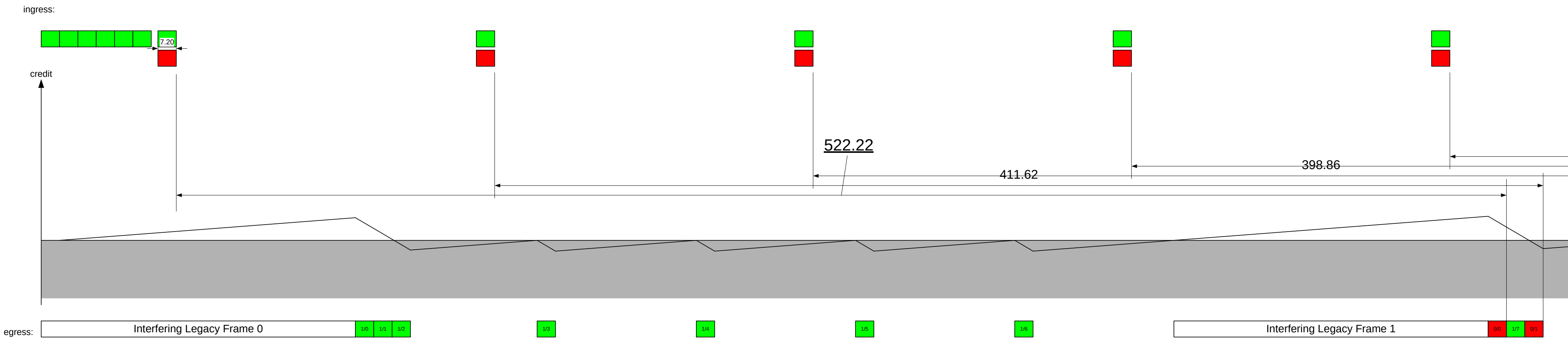


Example – Bridge 5



Example – Bridge 6





Example - Results

Even in a network with a “simple” topology a burst can cause a high latency

Is this scenario realistic?

- What has to occur to create the burst?
    1. More bandwidth than used has to be allocated
        1. Stream allocated but not (yet) used
        2. Allocated bandwidth not completely used
    2. There has to be a big interfering legacy frame

       In the shown case the interfering legacy frame (in talker T1) is transmitted 1 clk cycle before the class A frame is ready to be transmitted (worst case)

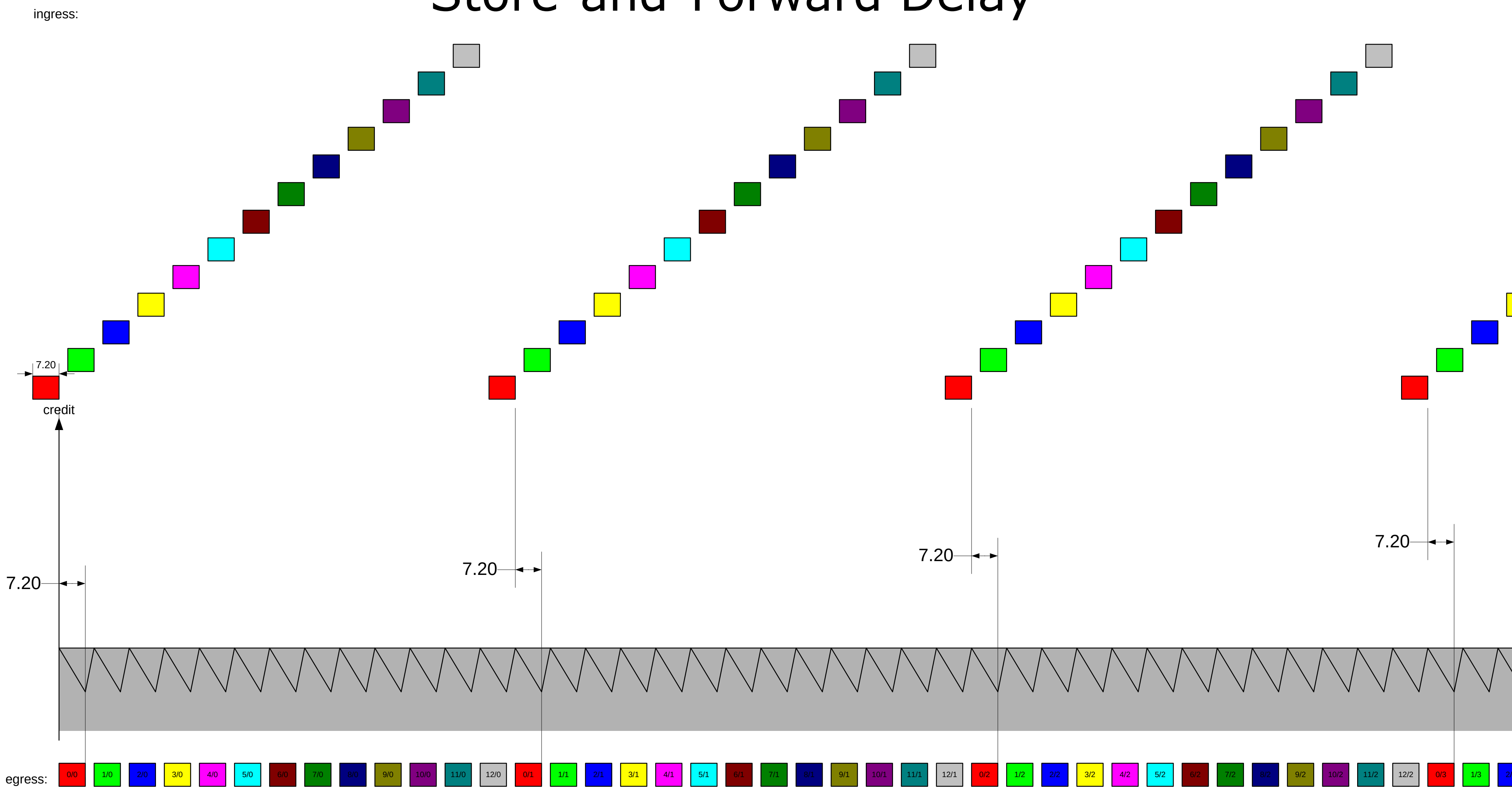
       → Even if this dose not happen a max legacy frame would automatically create a growing burst in the next bridges
- What has to happen in bridge 6?
    1. The stream packet from talker T1 has to arrive after the burst
    2. There has to be a “late interfering frame”

What latency should be reported by a bridge?

Gigabit Ethernet
Class A Latency

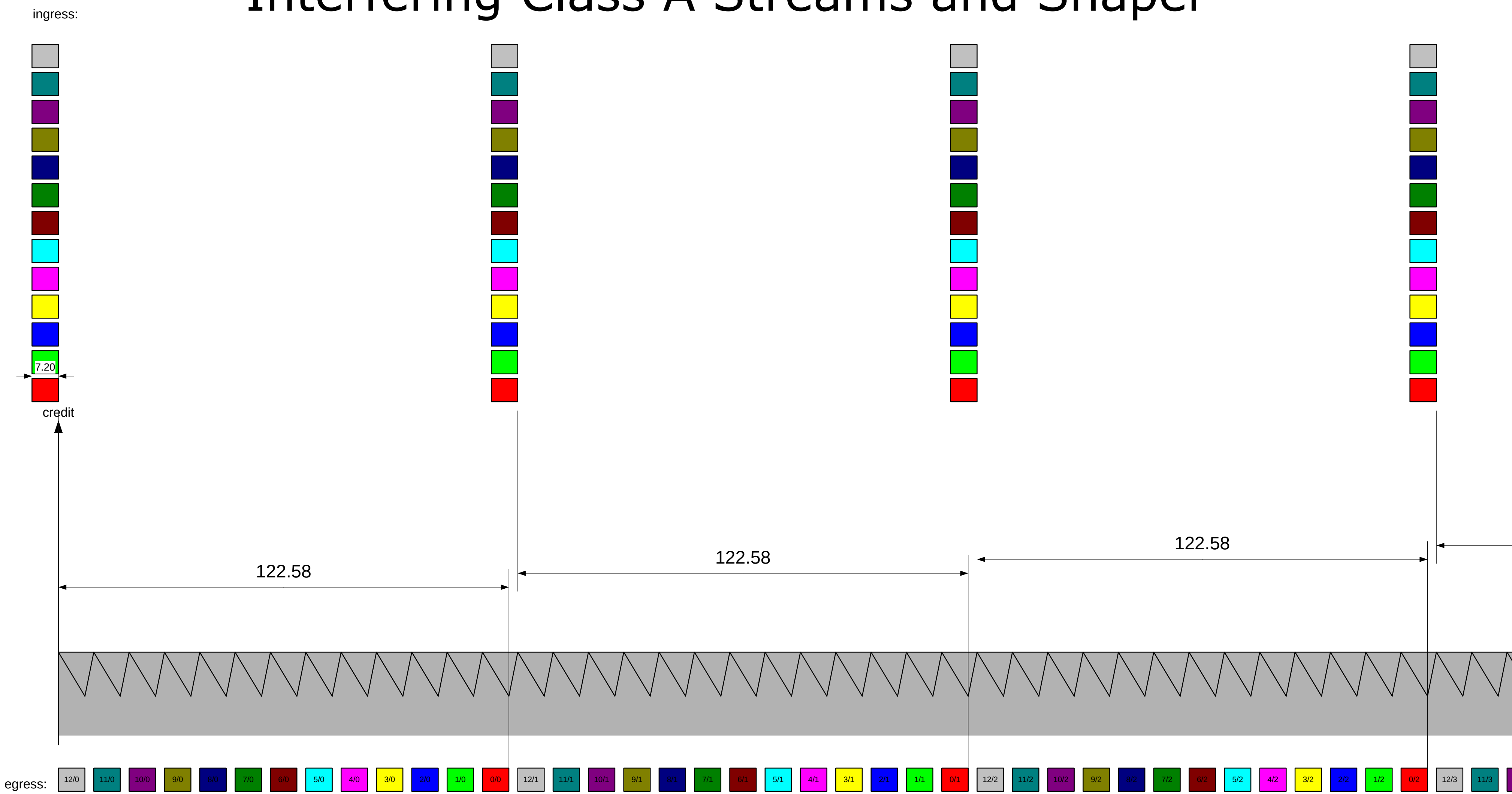
Primary Effect 1: Store-and-Forward Delay

Store-and-Forward Delay



Primary Effect 2: Interfering Class A Streams and Shaper

Interfering Class A Streams and Shaper



Primary Effect 3: Interfering Legacy Frame

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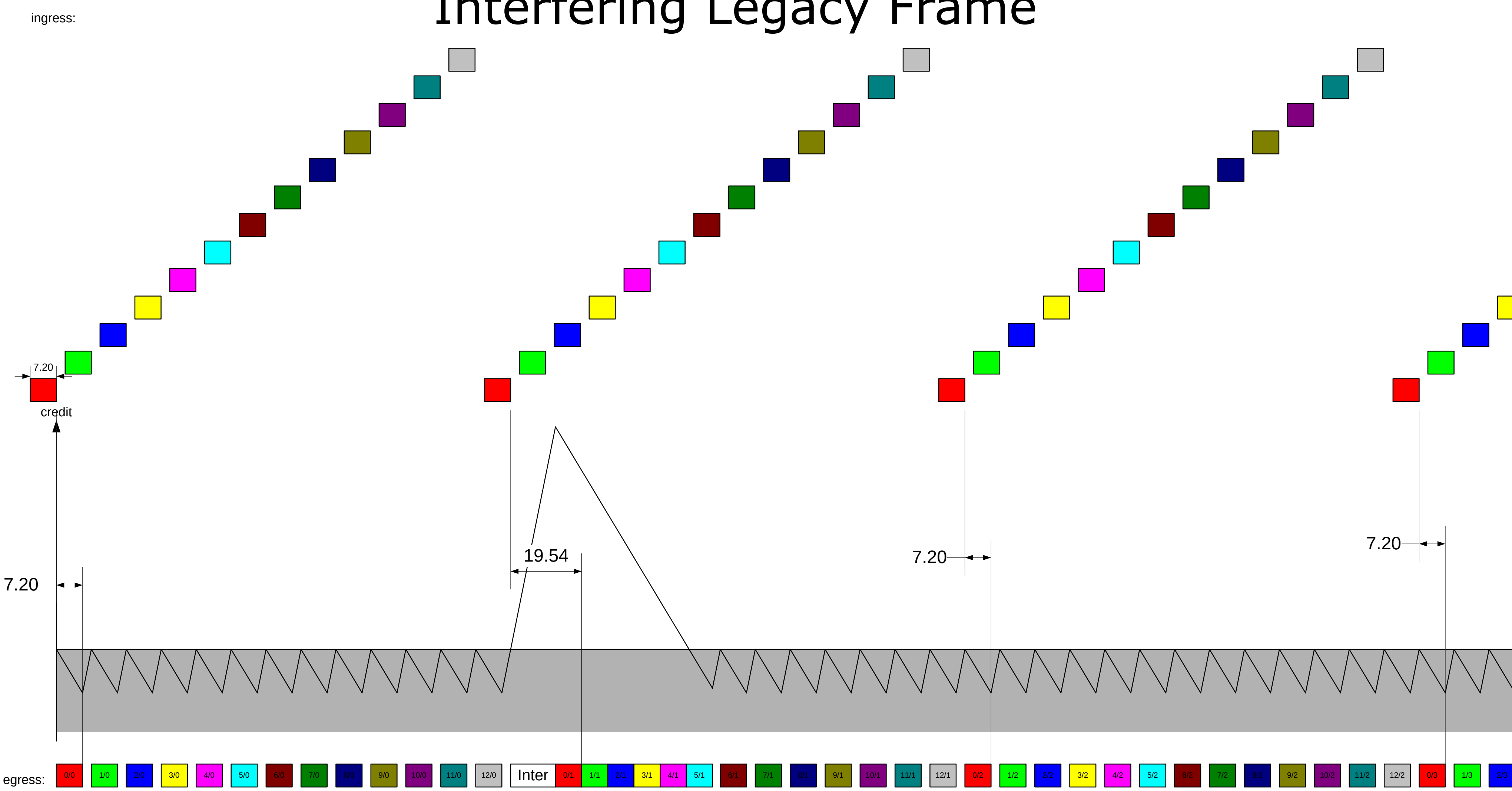
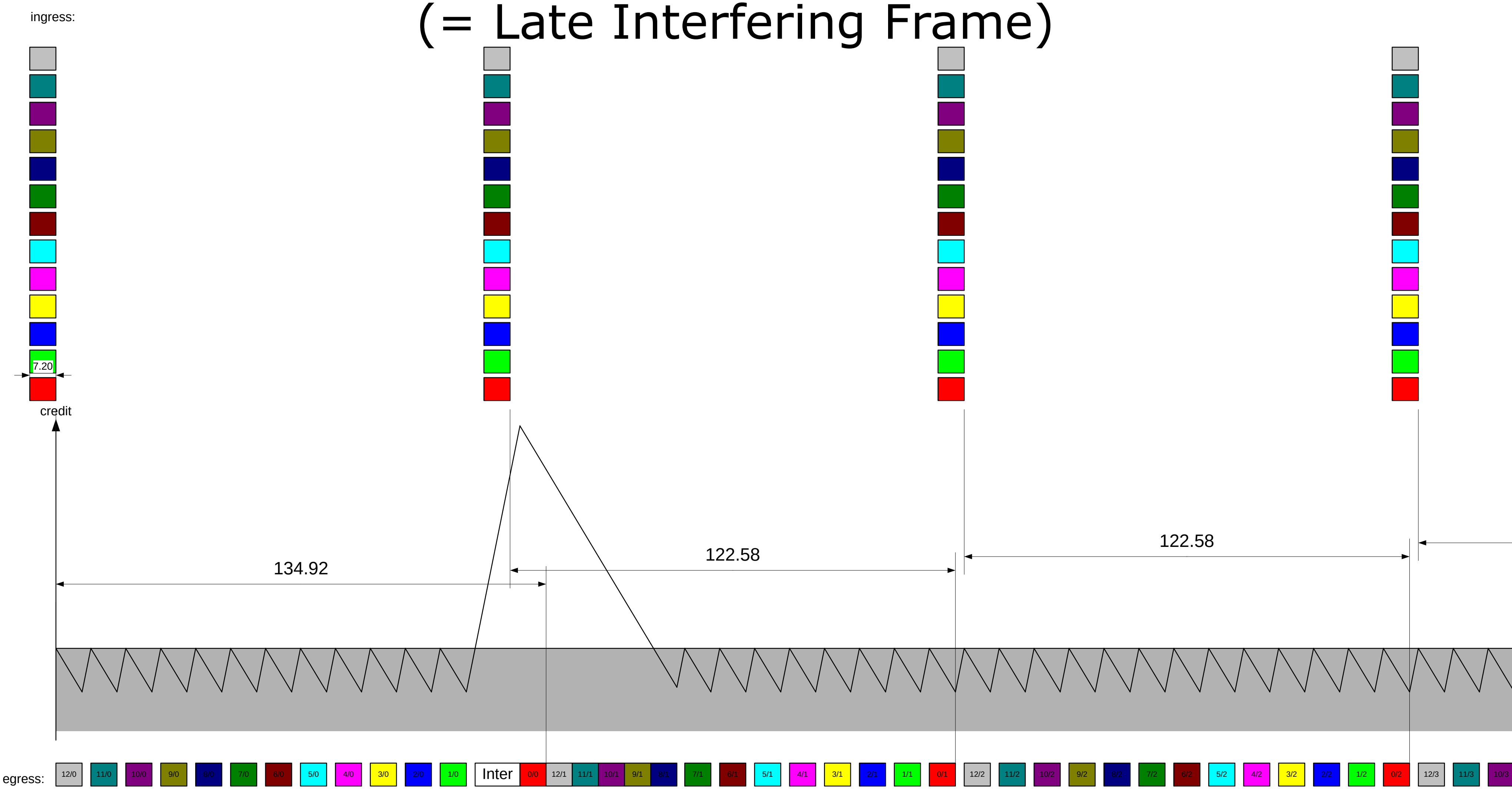
Interfering Legacy Frame



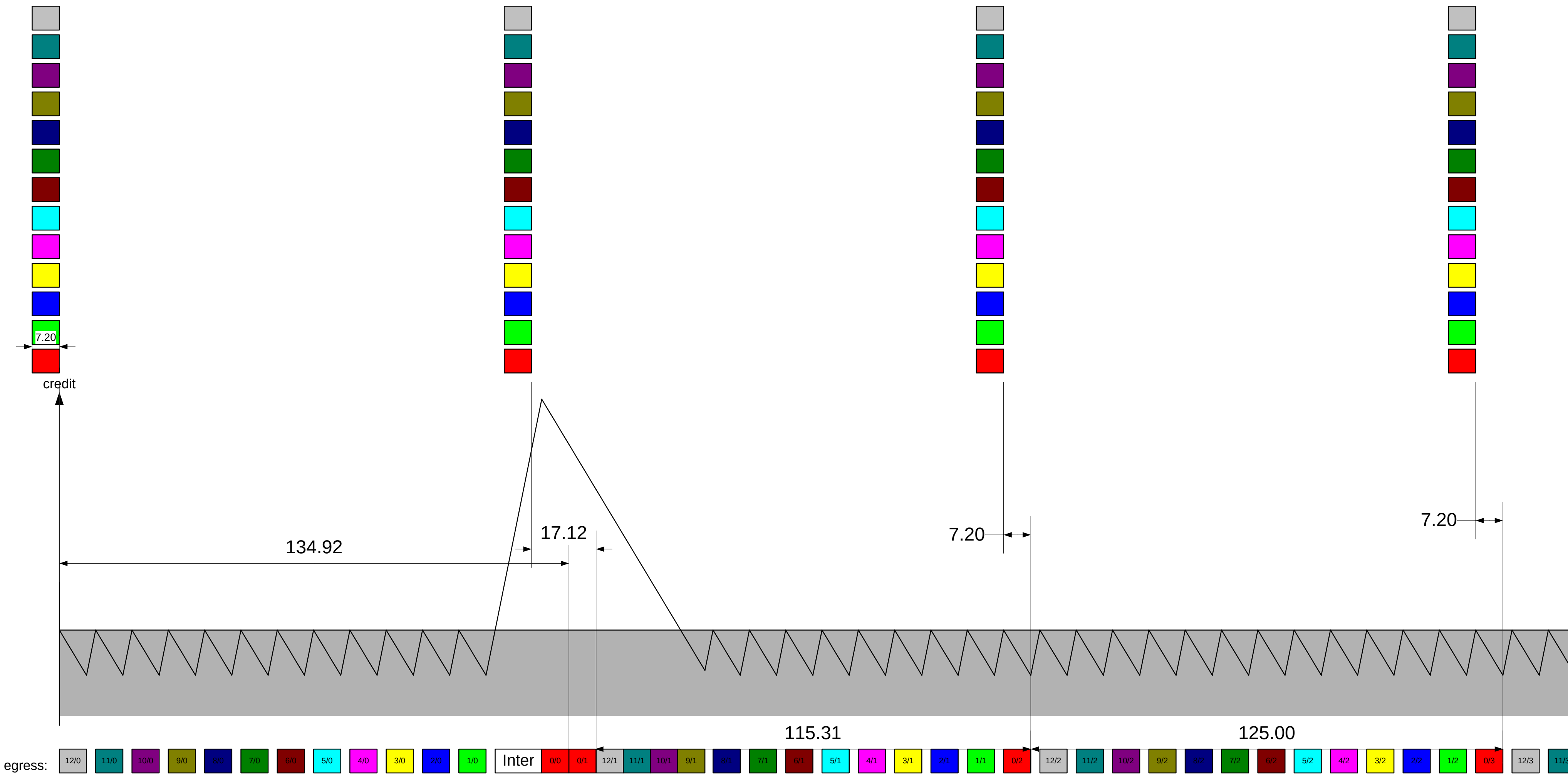
Interfering Legacy Frame + Interfering Class A Streams (= Late Interfering Frame)



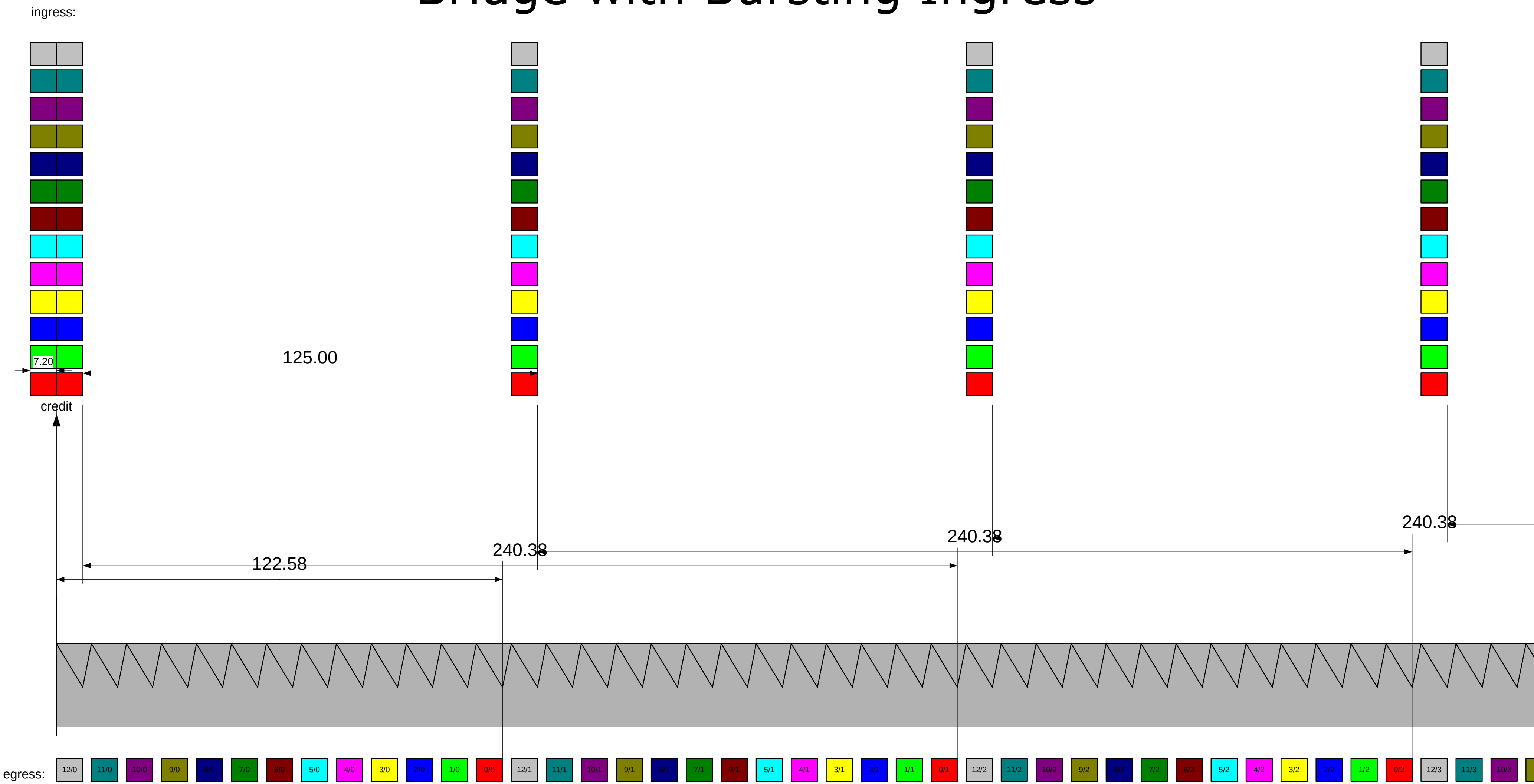
Secondary Effects

Secondary Effect 1: Burst

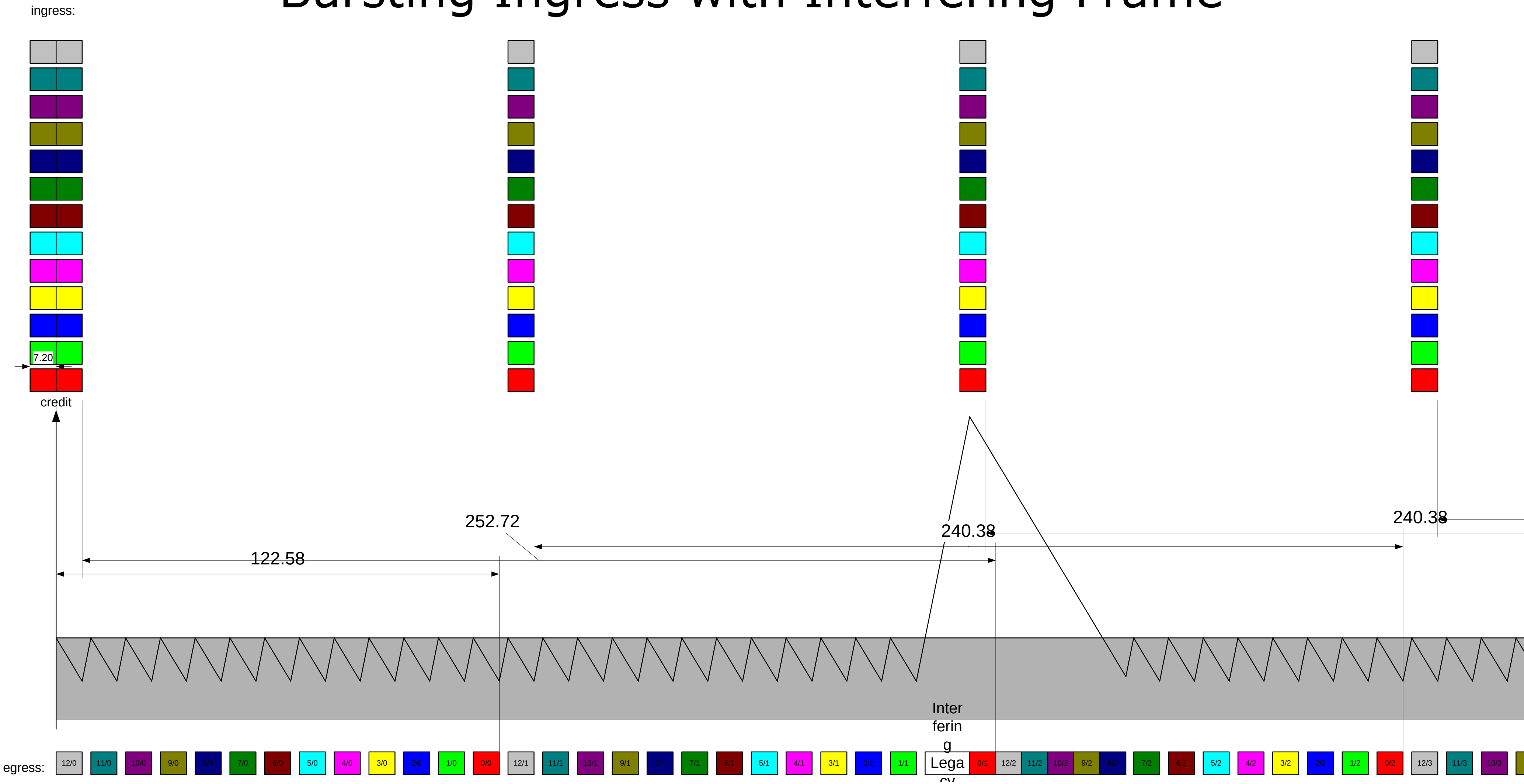
Bursting Talker



Bridge with Bursting Ingress

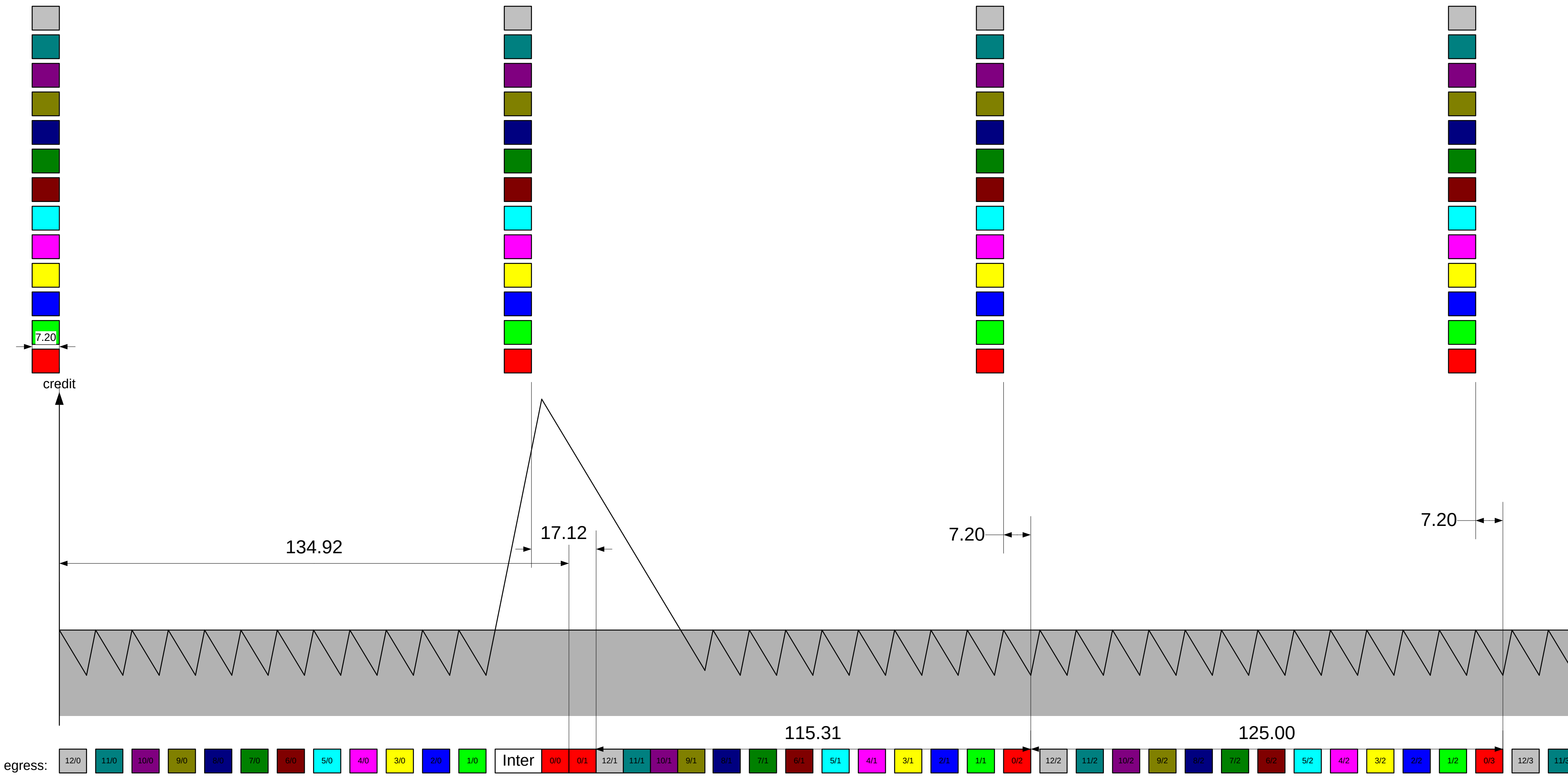


Bursting Ingress with Interfering Frame

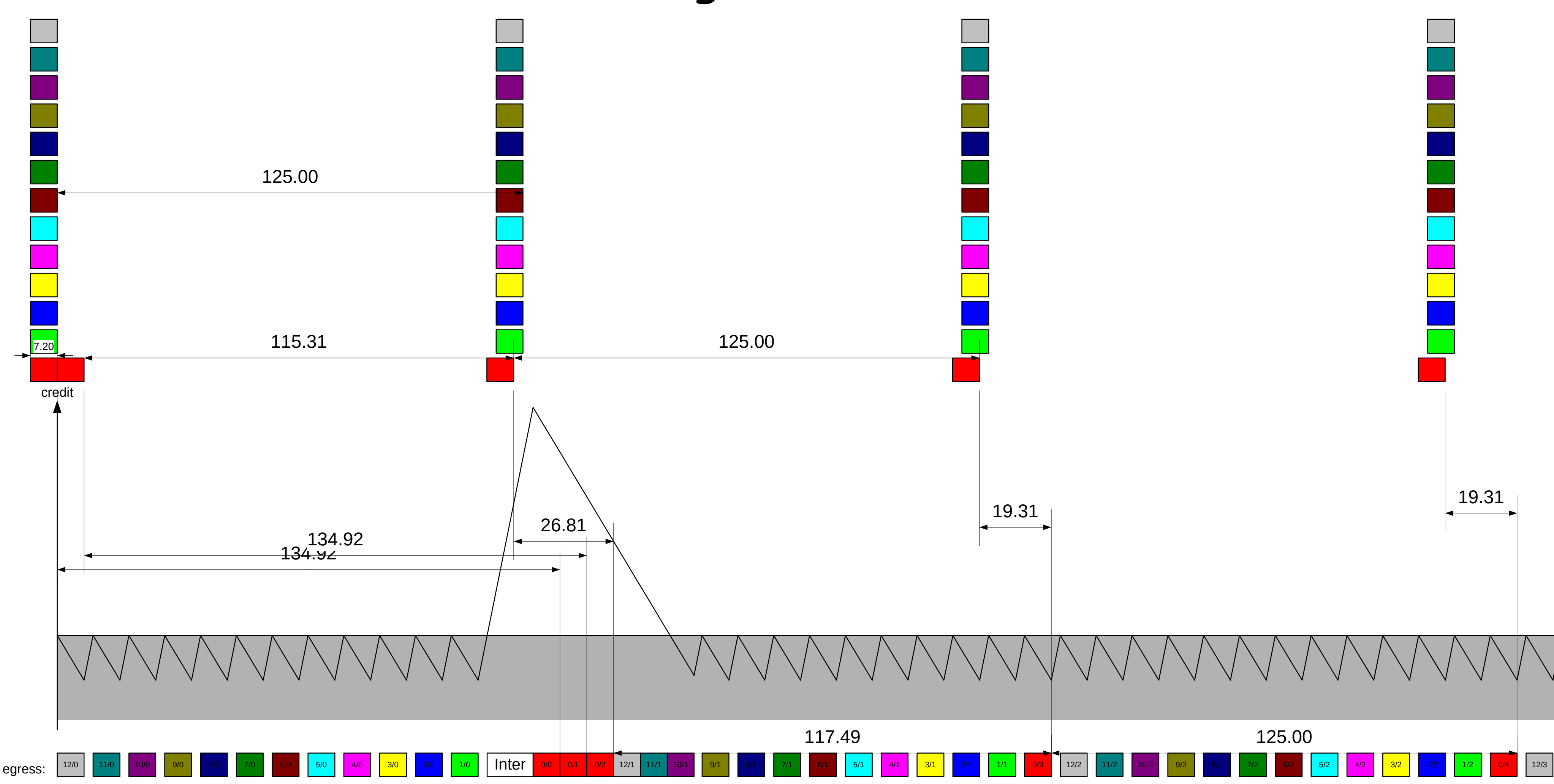


Secondary Effect 2: Growing Burst

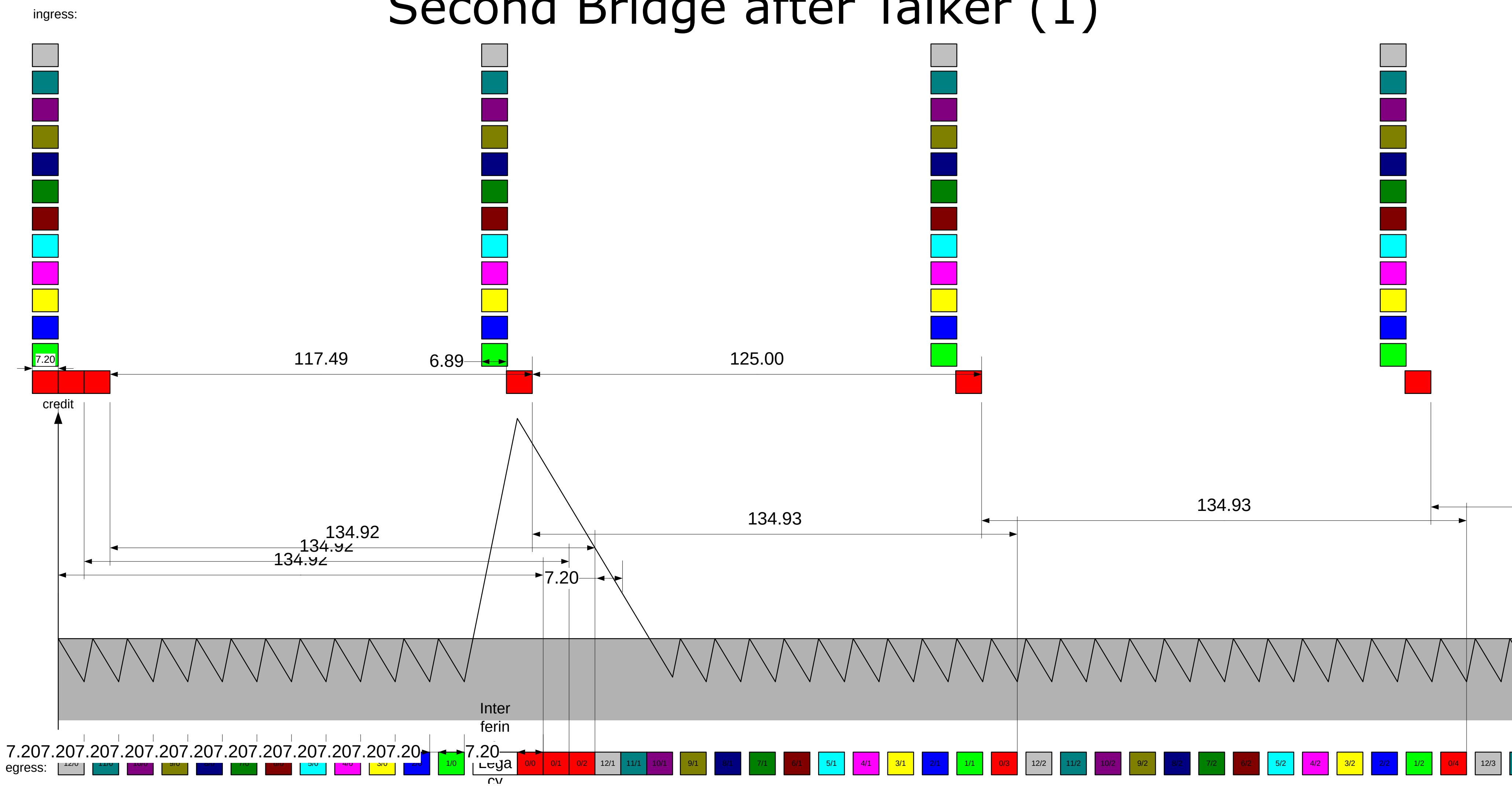
Bursting Talker



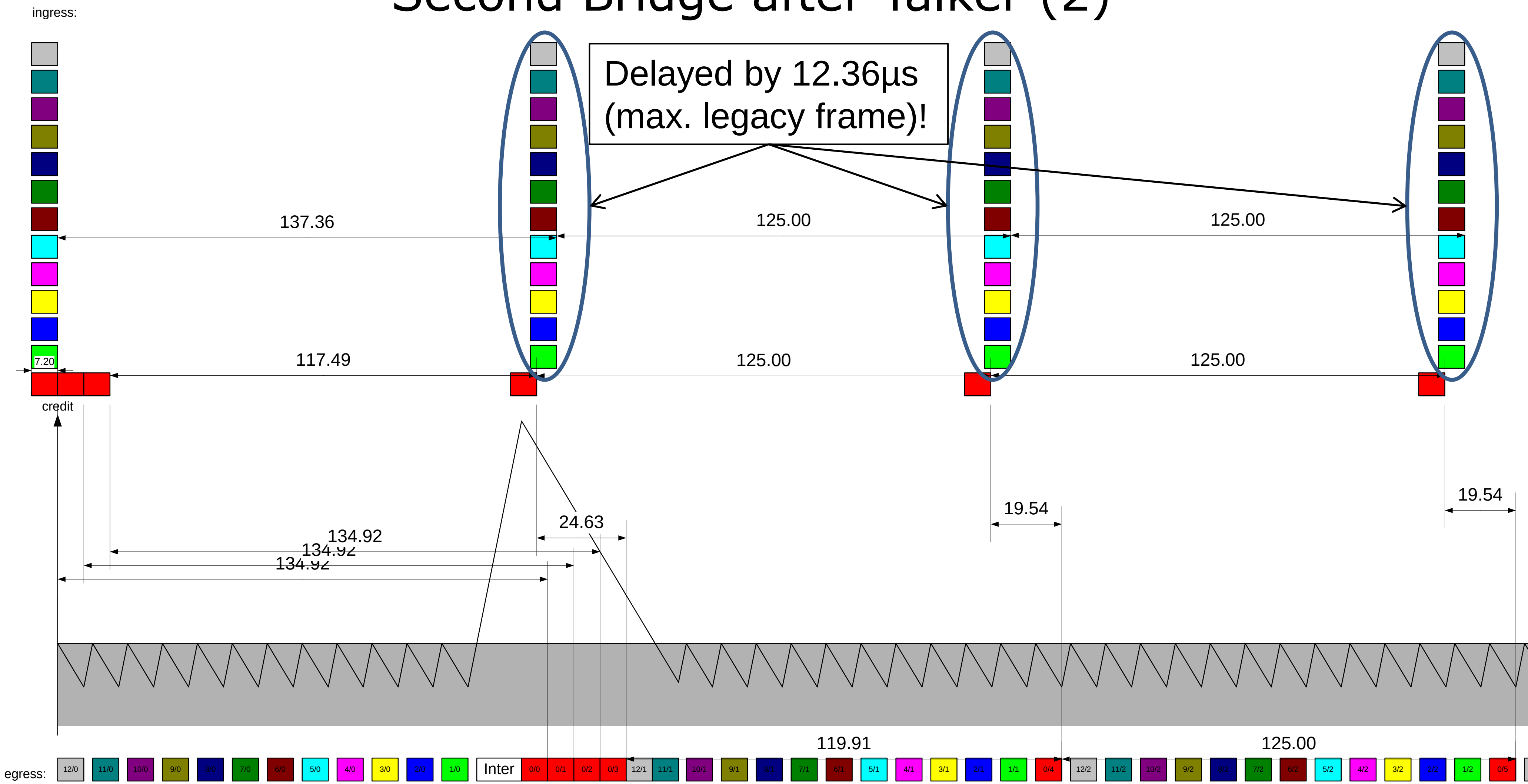
First Bridge after Talker



Second Bridge after Talker (1)



Second Bridge after Talker (2)



Conclusions

- Bursts and growing bursts are possible in GE but it is more unlikely that they happen compared to FE

- The consequences are the same as in FE

- It is also possible to create a short quasi-burst and even the combination of a burst and a quasi-burst

Thank You