DETERMINISTIC6G

TSN Cloudification

FRER Extensions to Support Cloudification

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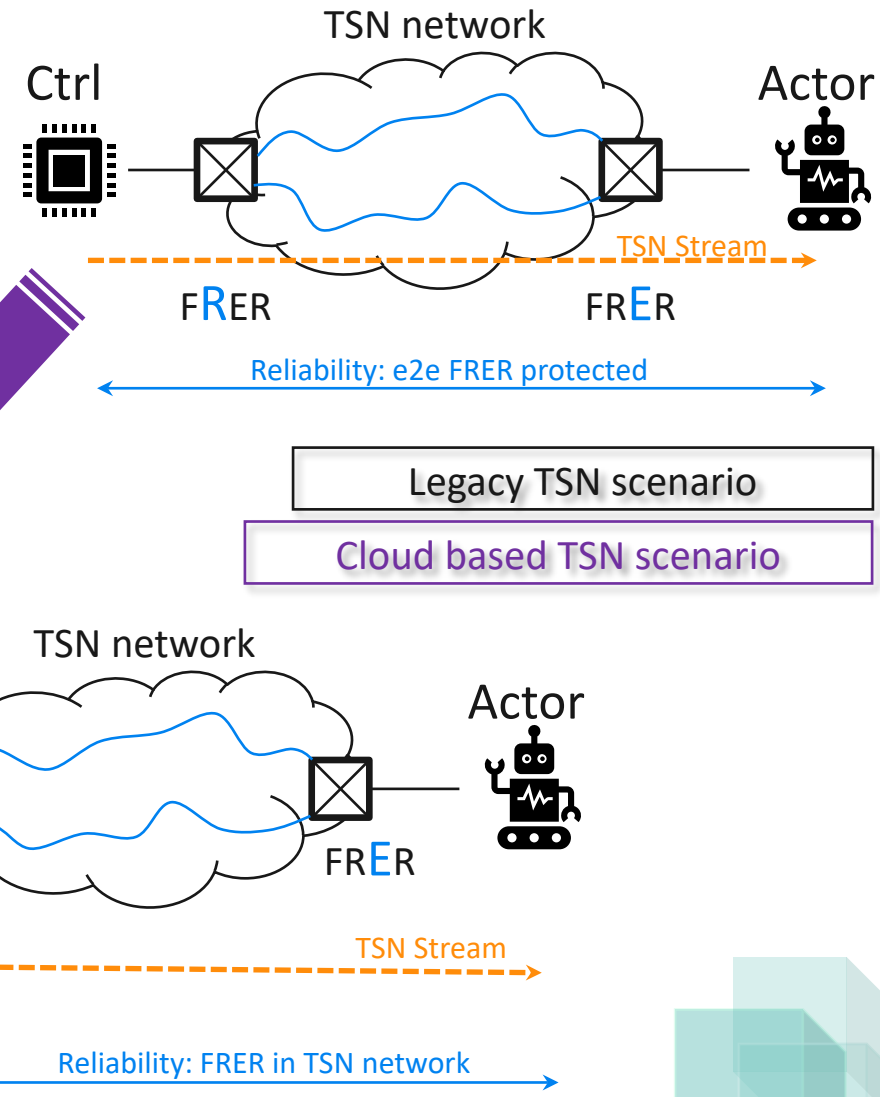
Topics

- Cloudification of TSN:
  - Situation analysis
- Cloudification of FRER
  - Replication/Elimination (R/E) action points in the Cloud
- Issue:
  - “State propagation” between R/E points via SeqNum
  - Measurement example
- Proposed Solution

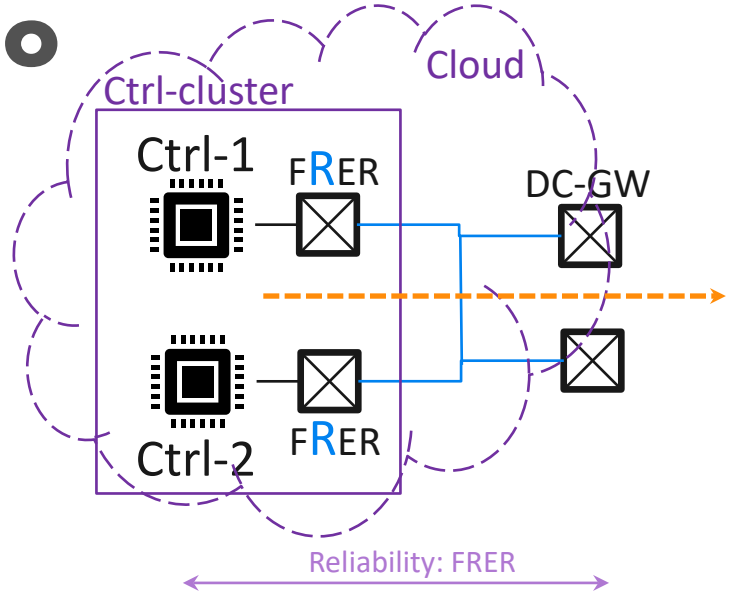
Moving towards Virtualized Environments
TSN in a Cloud-based Scenario

Scenario: Talker/Listener in the Cloud

- TSN functions must go with the endpoints
  - Replication/Elimination must work inside Cloud …
  - FRER can be an instance in a Ctrl-cluster …
- Typical Cloud actions
  - Run multiple VMs/instances
  - Create a VM/instance
  - Move a VM/instance
  - Reset a function
  - Remove a VM/instance
  - Etc.



Moving towards Virtualized environments Using FRER in a Cloud based scenario

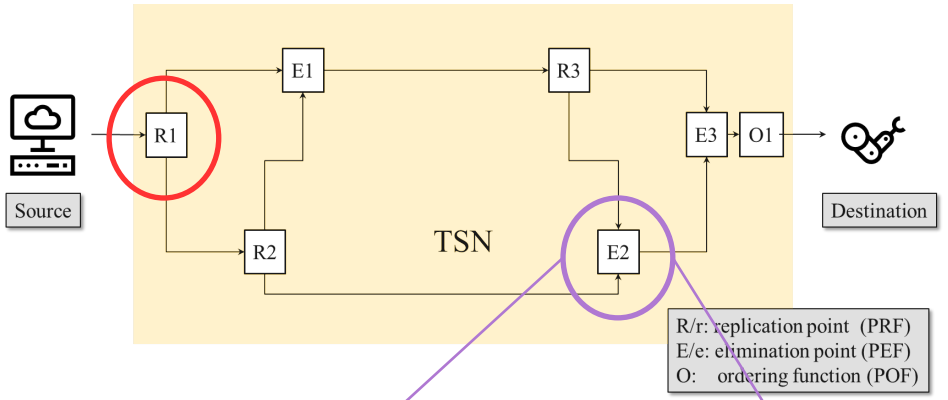


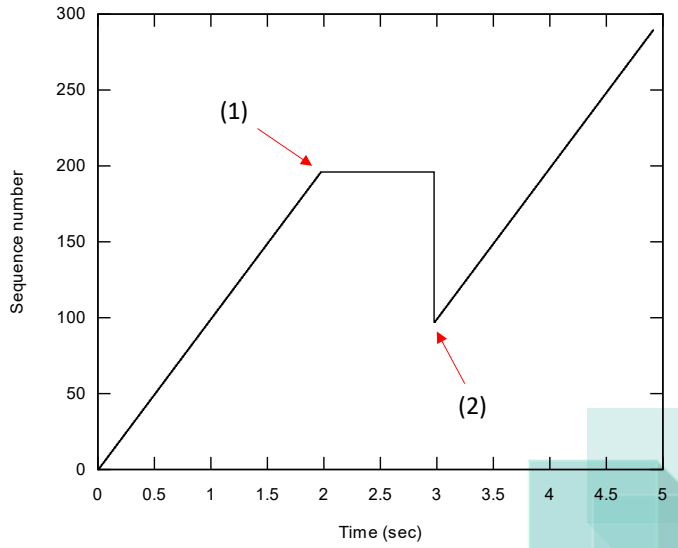
- Cloud-based reliability solutions
  - Are optimized for Web-based non-TSN applications
  - Definition of SLA parameters significantly differs from TSN service parameters
- TSN solution for reliability: FRER
  - How to extend FRER for Cloud ???
- Challenges/Requirements:
  - For e2e redundancy place FRER (first R, last E function) as close as possible to “Application instance”
    → Network Function Virtualization (NFV) for FRER
    (e.g., FRER for a stream to be orchestrated on same server as Application instance)
  - Any Cloud orchestration action (set, move, remove, …) on Application instance must be followed by the virtualized FRER instance
    → FRER is not stateless (SeqNum, History window, Timers, etc.)

Measurement Results
The Stateful Nature of FRER

- Impact of Sequence generator reset
  - Sequence generation function is reset (1) on node "TSN-R1" at 2 sec
  - Packets sent after the reset (1) are out of the history window at "TSN-E2" and are dropped by the elimination function until it is reset by the timeout* mechanism (2).
  - The flat period between 2-3 sec shows the packet drop
  - The stream's packets (with new sequence number) are forwarded again after the timeout at 3 sec.
  - The stream has a 1 second outage despite the error-free operation of network nodes and links.
  - The outage is just because of the "jump" caused by the reset in the sequence number values.

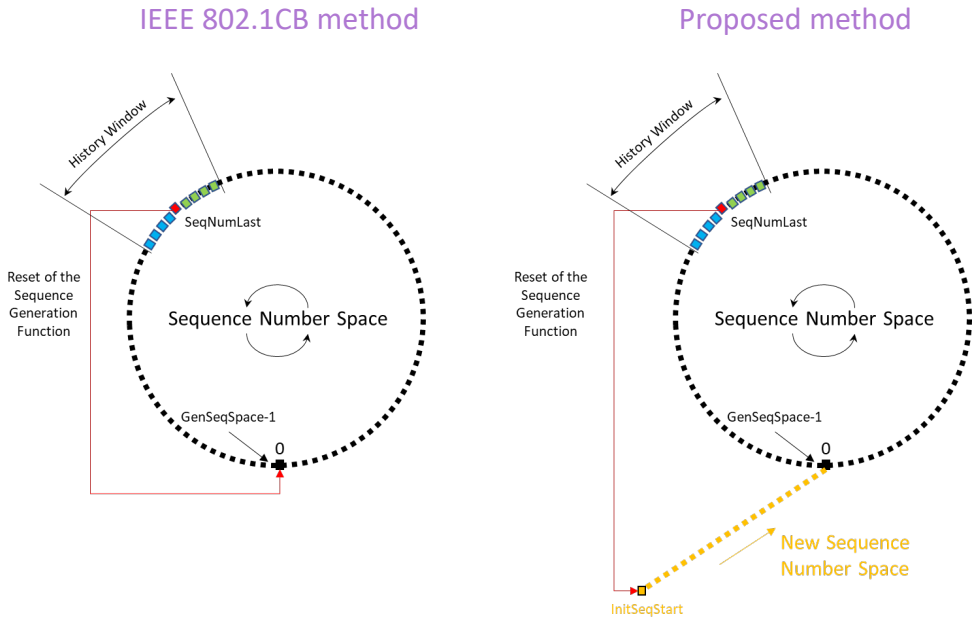
*Note: timeout was set to 1 sec for demonstration purposes





TSN Introduces Meta-data Carried with the Frame, i.e., Sequence Number Carried in R-Tag

- FRER functions need meta-data to travel with the frame
  - 802.1CB-2017 defines the Redundancy Tag
  - Meta-data: Sequence Number for Replication/Elimination



- History:
  - Improvements were suggested to generalize Replication/Elimination functionality and cope with some limitations. These improvements need additional meta-data to be added to frames
  - [1] https://www.ieee802.org/1/files/public/docs2019/new-varga-FRER-improvements-0719-v01.pdf
  - [2] https://www.ieee802.org/1/files/public/docs2020/new-varga-FRER-seamless-reset-0320-v02.pdf
  - [3] https://www.ieee802.org/1/files/public/docs2020/new-varga-FRER-RTag-0920-v02.pdf

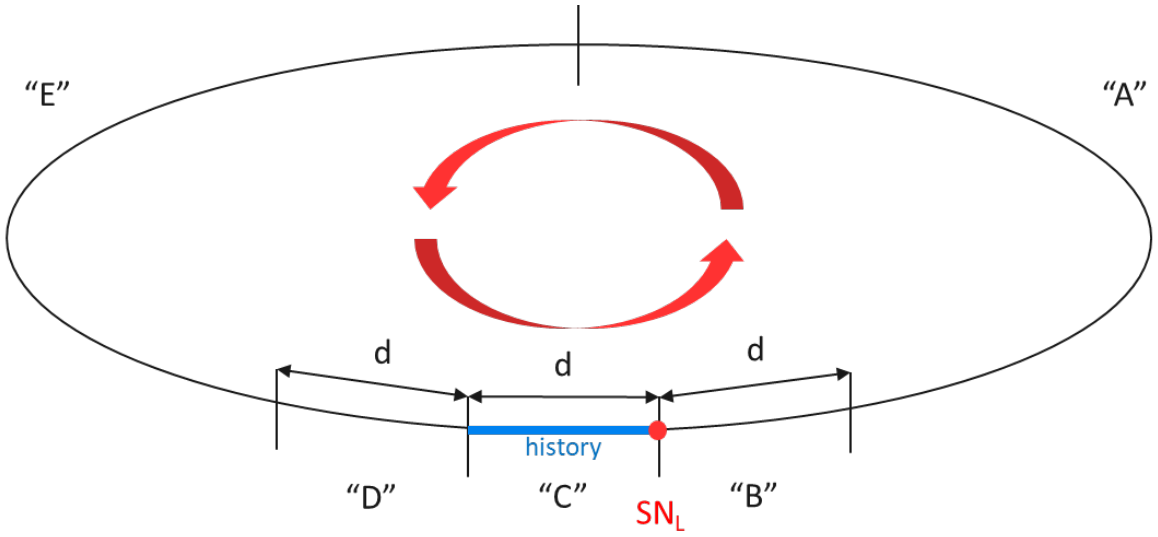
Statefulness of FRER (IEEE 802.1CB-2017) State propagation between R/E points

- Scenario: Controller in Cloud, Downstream direction, First hop R point (as close as possible)
- Many Cloud orchestration actions result in “BEGIN” event for a Sequence generation function
  - FRER action points (R/E) must follow the endpoint (application instance)
  - 7.4.1.3 SequenceGenerationReset
    - “It resets GenSeqNum (7.4.1.2.2) and increments frerCpsSeqGenResets (10.8.2).”
    - I.e., GenSeqNum = 0

- Issue: “state propagation” due to alignment between corresponding R/E functions
  - E point has to be in-line (“in step”) with the state of the corresponding R point
  - R and E functions relate to each other via the sequence number, whose bookkeeping is via the history window at the E point
  - 7.4.3.4 VectorRecoveryAlgorithm
    - “If a Base recovery function somehow gets out of step with its corresponding Sequence generation function, then after frerSeqRcvyResetMSec milliseconds, the Base recovery function will be reset and data will again be passed.”

Loss analysis in case of SeqGen reset Sequence number ranges

Notation:
SN_L: last seen highest SeqNum)
SN_R: SeqNum sent after reset)
d: frerSeqRcvyHistoryLength)

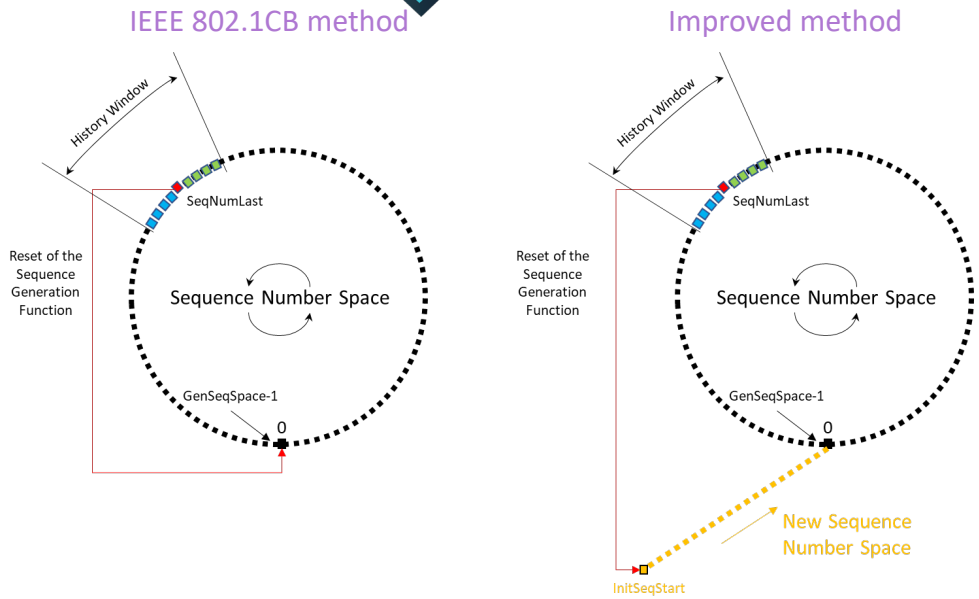


- A: $SN_R > SN_L + d$
  packets are dropped until timer expires or the SeqNum of packets reaches $SN_L + 1$
- B: $SN_L + d >= SN_R > SN_L$
  no packet drop, SN_R is accepted
- C: $SN_L >= SN_R > SN_L - d$
  packets are dropped until SeqNum of packets reaches $SN_L + 1$
- D: $SN_L - d >= SN_R > SN_L - 2d$
  packets are dropped until SeqNum of packets reaches $SN_L + 1$
- E: $SN_L - 2d >= SN_R$
  packets are dropped until timer expires or the SeqNum of packets reaches $SN_L + 1$

802.1CB defines $SN_R = 0$, so for example if d=100, there is high probability of packet drop (99.8%) in most cases until timeout triggers the accept of the next packet.

FRER Improvements Overview

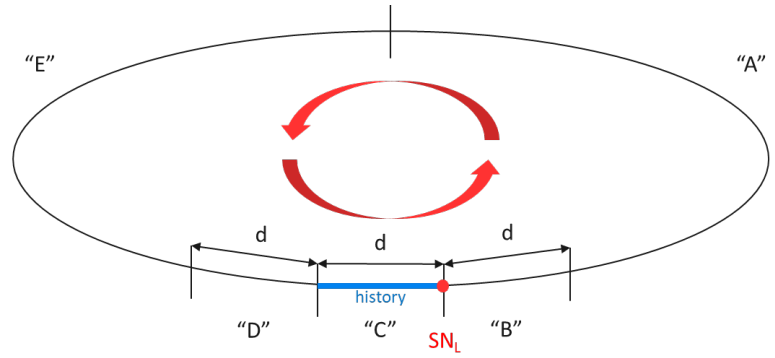
- Problem: high probability of packet loss due to reset of Sequence Generation function
- Goal: seamless reset of Sequence Generation function



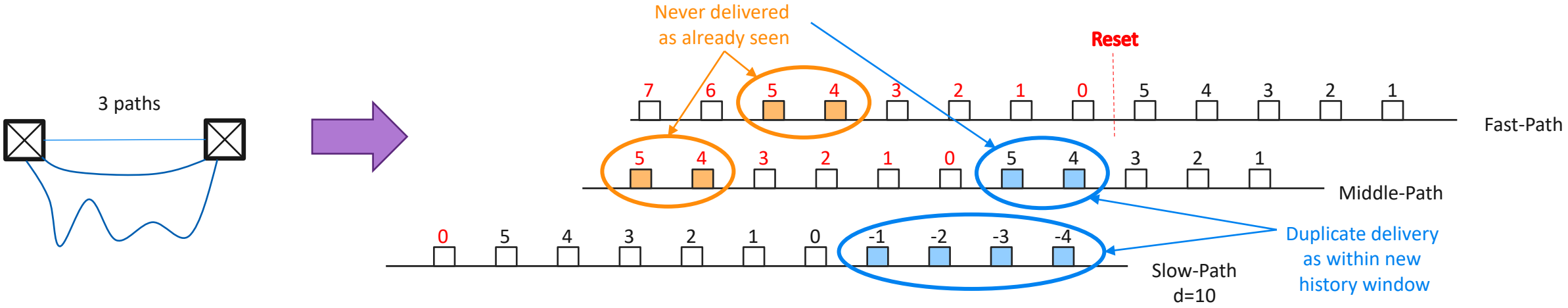
- Proposal: change Sequence Number Space characteristics
  1. explicit notification of the reset event, and
  2. extension to the sequence number space (additional new linear initial sequence number space)

- Explicit notification of the reset event can be encoded, e.g., in a flag in the R-TAG (see the “SeqResetFlag” in former contribution [1] on slide 6). The usage of the new linear initial sequence number space (“InitSeqNumSpace”) is noted via a new flag included in the R-TAG, namely the “InitSeqFlag”. Sequence values of the new number space (“InitSeqNumSpace”) can be also included in the R-TAG (using the existing sequence number field).

FRER Improvements Details



- Reset signaling
  - Solves scenario A, B, E: no packet drop, SN_R accepted
  - C, D: Issue with "duplicates & drops"



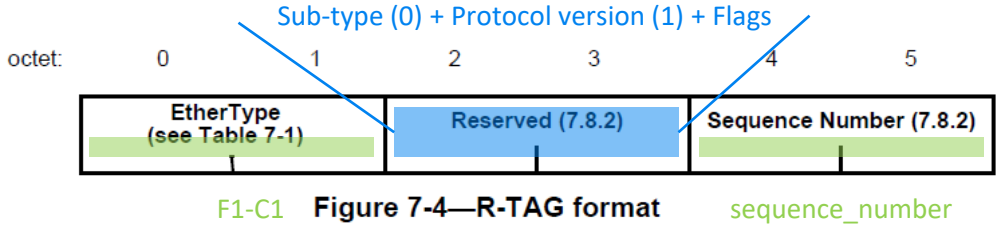
- Reset signaling + New SeqNumSpace (to be able to distinguish before/after reset frames)
  - Solves scenario A, B, C, D, E: no packet drop

Conclusions
Cloudification of TSN function (FRER)

- Integration of FRER and Virtualized network (Cloud) specific reliability technologies
  - Requires improvements to cope with “state propagation” of FRER

- FRER related improvements proposed (so far) include:
  - Extensions to Replication/Elimination functions
  - Some new indicators (meta-data) carried with the frames

- A potential example for the use of the reserved field of the R-Tag
  - (n)-bit: sub-type field (FRER = “0”)
  - (16-n)-bit: protocol version (+ Flags)
    - FRER protocol version: “1” (Seamless-FRER)
    - Flags: “SeqResetFlag”, “InitSeqFlag”



F1-C1 **Figure 7-4—R-TAG format** sequence_number

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