CBS Configuration for Delay-Constrained Flow Allocation in TSN

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THE CONCEPT

- TSN – firm Delay Requirements only with Time-Triggered Gates?
- Instead: Use the Credit-Based Shaper

Result:

- Configuration and Flow Allocation by
  - Finding Routes for new Flows
  - Assigning Priorities to each Flow
  - Setting IdleSlopes per Queue
- while guaranteeing
  - per-flow delay requirements
  - per-queue maximum buffer sizes

No predefined
- routes
- priorities
- sending intervals

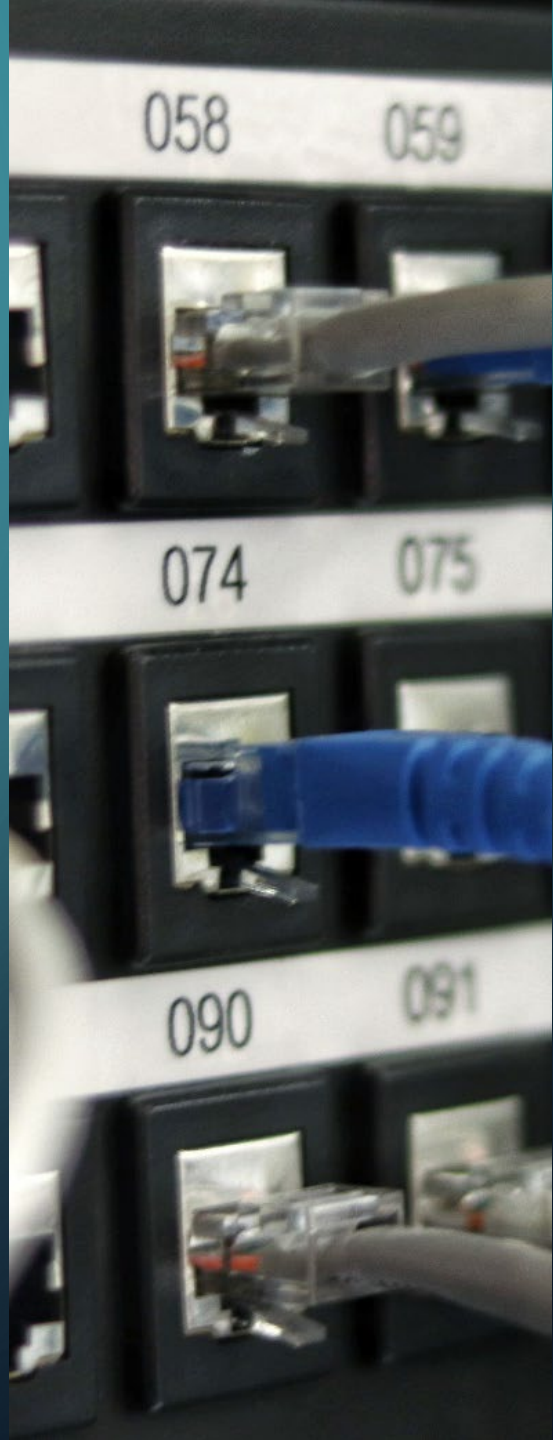
Applicable in
- arbitrary topologies and number of CBS queues
- large scales

Not for Ultra-Low Latencies (only TT-Gates)

IMPLEMENTATION

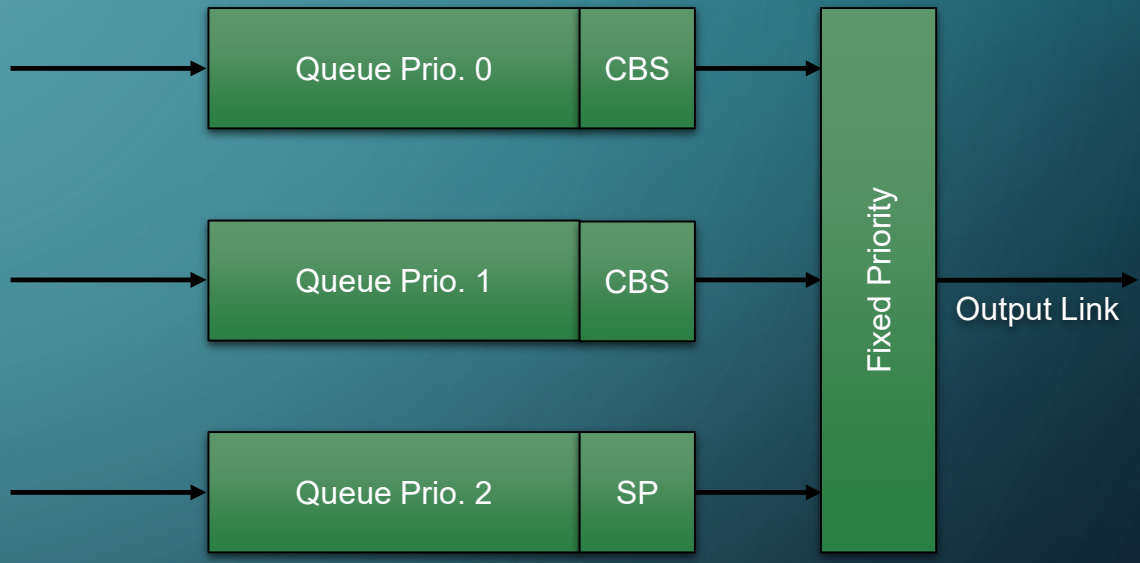
- Central Network Controller (CNC)
- Network Configuration Protocol (NETCONF) defined in RFC 62411

- „Online“ Approach:
  - add and remove flows during runtime
  - fast calculation



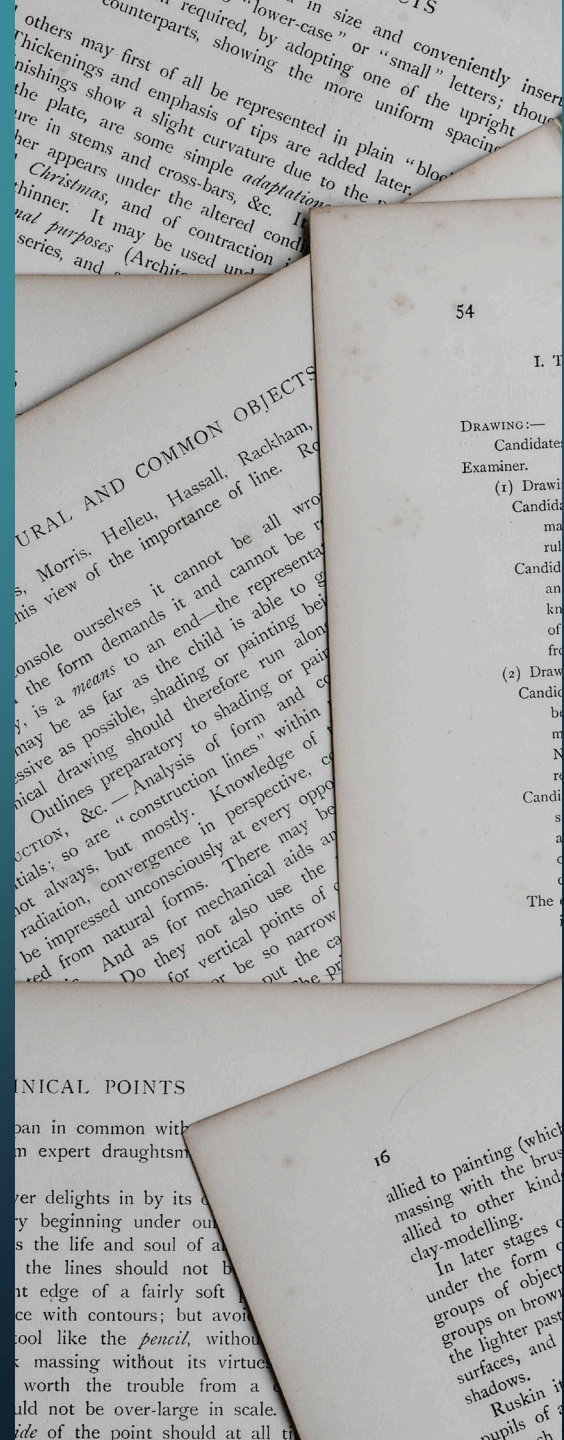
WHY CBS?

- complete usage of bandwidth
- reduces delay for lower priority queues
- reduces required buffer size
- multiple different traffic types



RELATED WORK

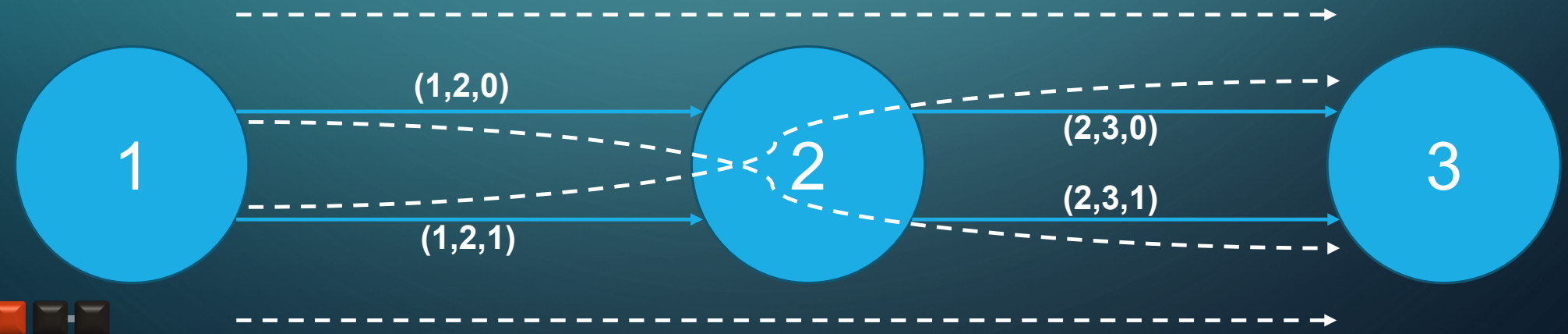
- Strict Priority ⟷ Credit-Based Shaper
- leftover service ⟷ manually configured IdleSlopes
- link rate shaping ⟷ link rate and CBS shaping



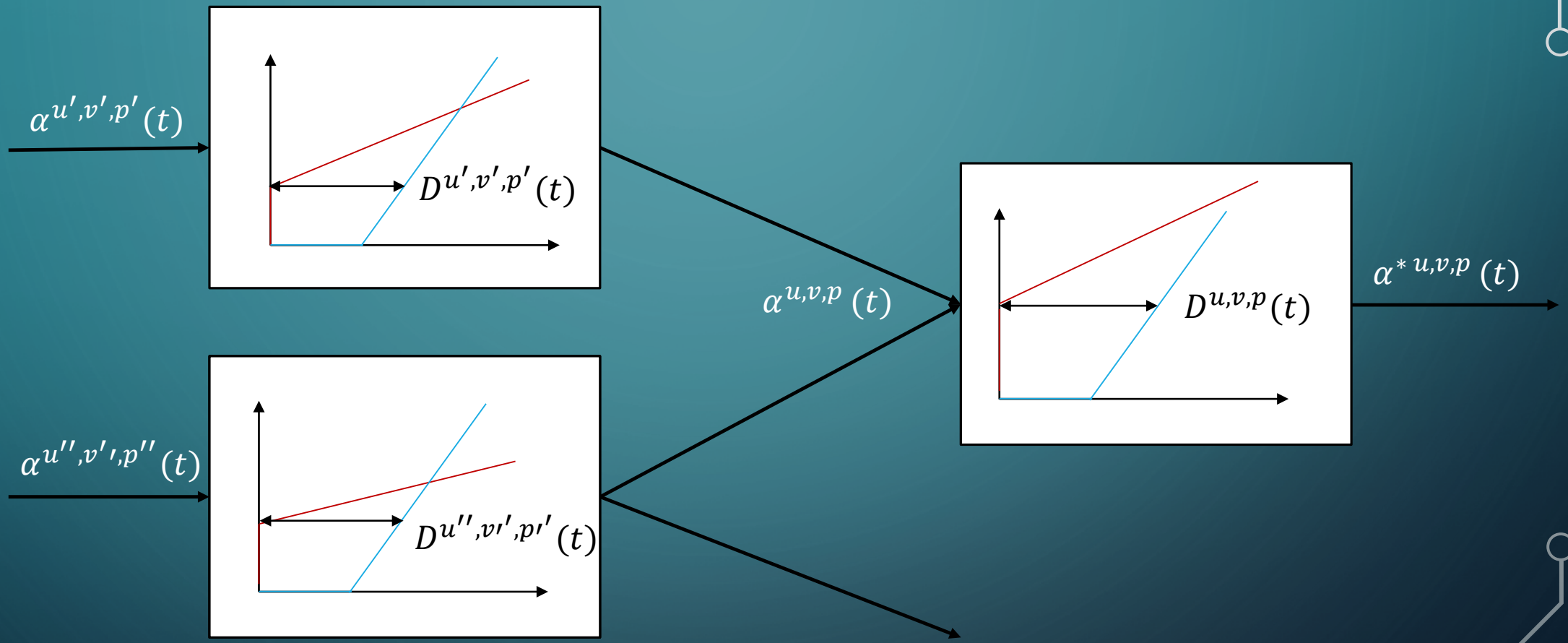
Jochen W. Guck, Amaury Van Bemten, and Wolfgang Kellerer. 2017.
DetServ: Network Models for Real-Time QoS
Provisioning in SDN-Based Industrial Environments.
IEEE Transactions on Network and Service Management 14, 4
(Dec. 2017), 1003–1017. https://doi.org/10.1109/TNSM.2017.2755769

DYNAMIC PRIORITIES

- stream filter:
  - internal priority value (IPV)
  - (alternative to VLAN ID tag)
- for each flow:
  - find all routes which keep deadline
  - sort e.g., to
    - balance reservations over network
    - closest deadline (prioritize lower queues)



CONSTANT FLOW VALIDITY



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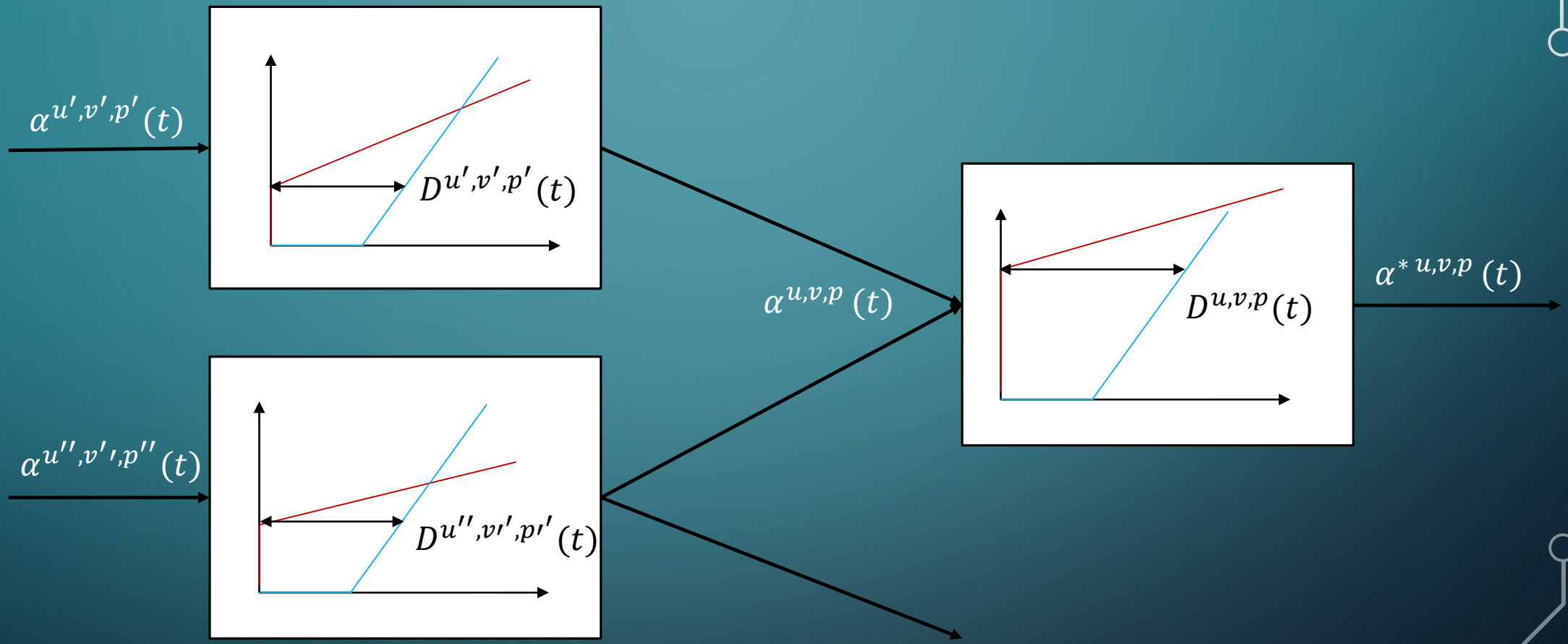

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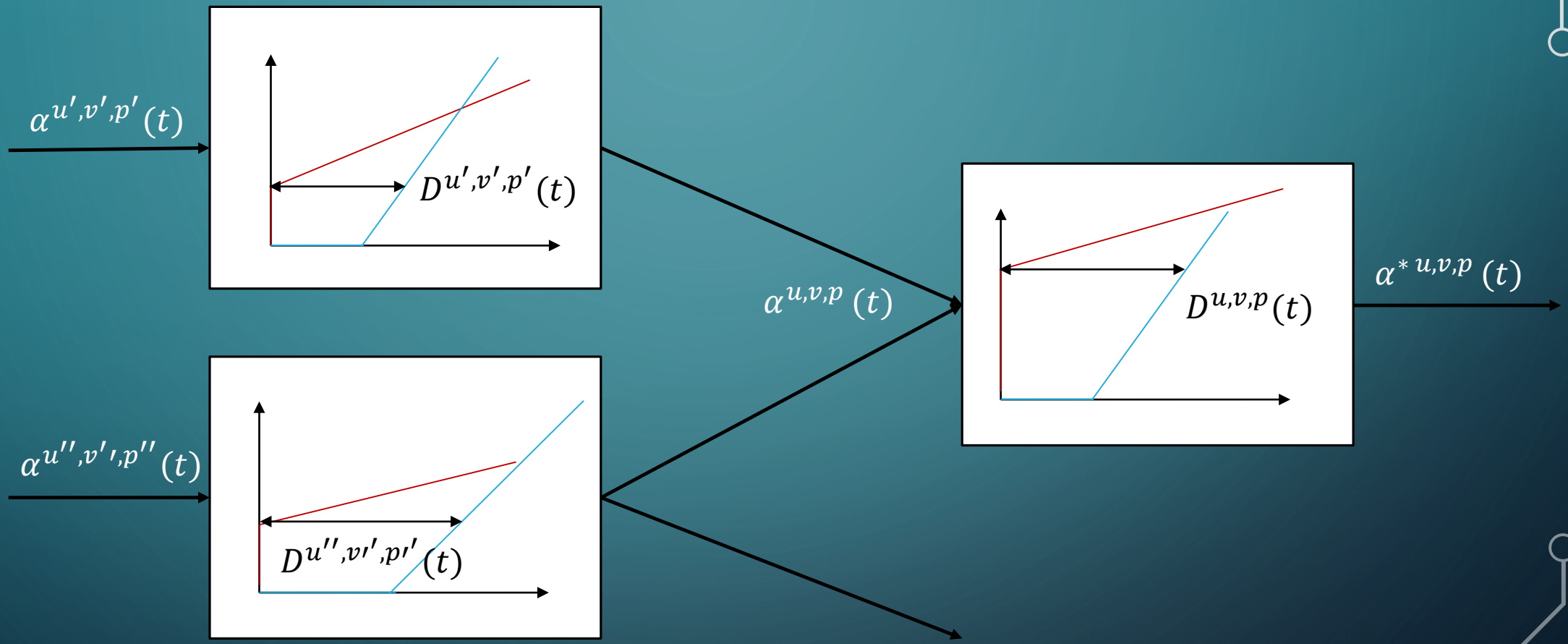


depending on approach:

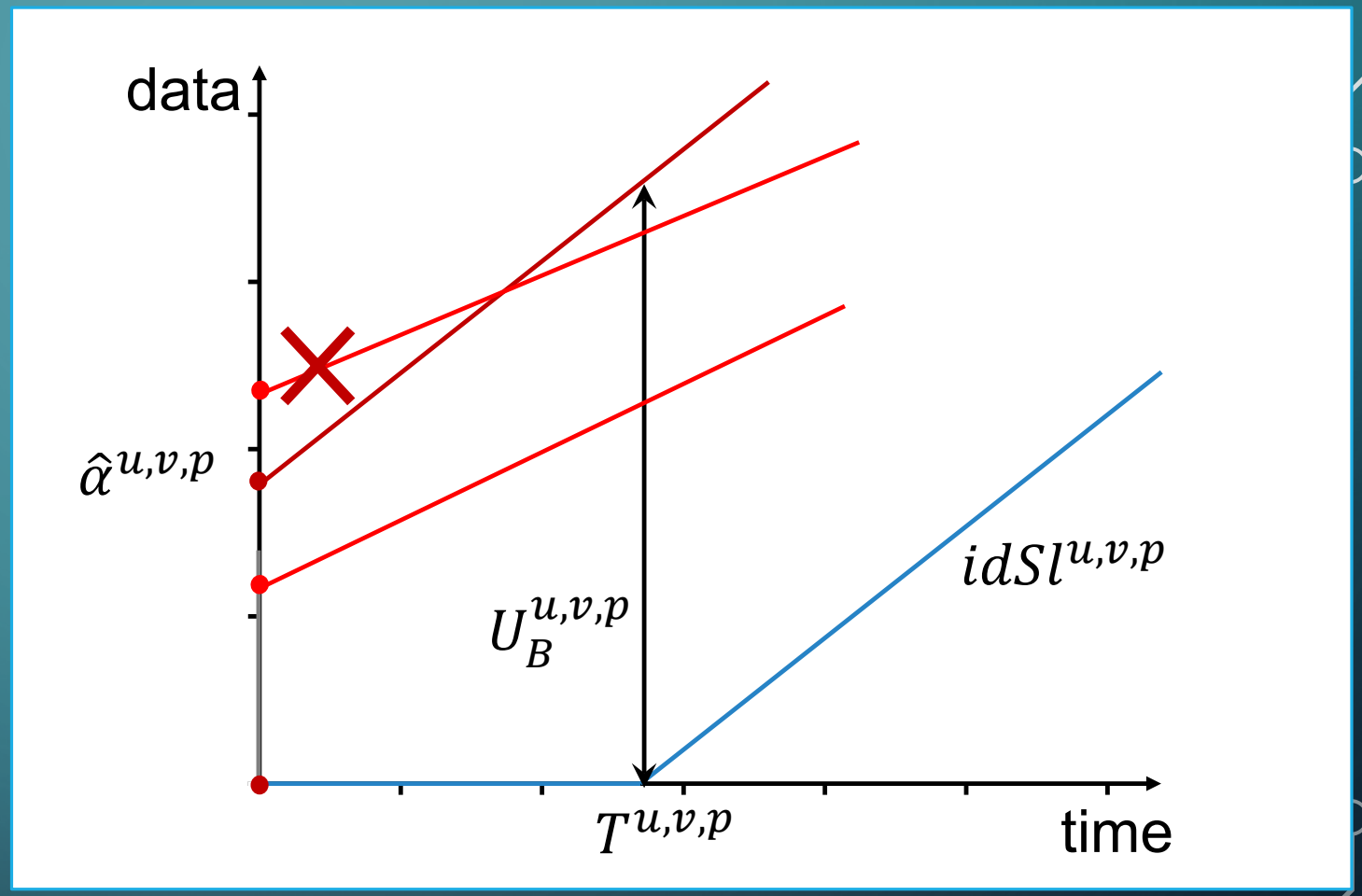
we design/apply reservation independent shaper and output curves

CONFIGURATION APPROACH

```
successively for all routes:
    for each hop:
        check reservation
    if reservation possible:
        choose route
        return
```

FIXED SLOPES (FS)

- Input: Idle Slope per Queue
- define maximum arrival curve
- dynamically reserve flows up to maximum arrival curve [a)]
- $\alpha^*(t) = \alpha(t + T)$ [b)]



[a)] in contrast to previous works, we also shape the real arrival curves

[b)] this is a simplification, for the actual computation see, e.g., J.-Y. L. Boudec and P. Thiran, *NETWORK CALCULUS: A Theory of Deterministic Queuing Systems for the Internet*. 2012.

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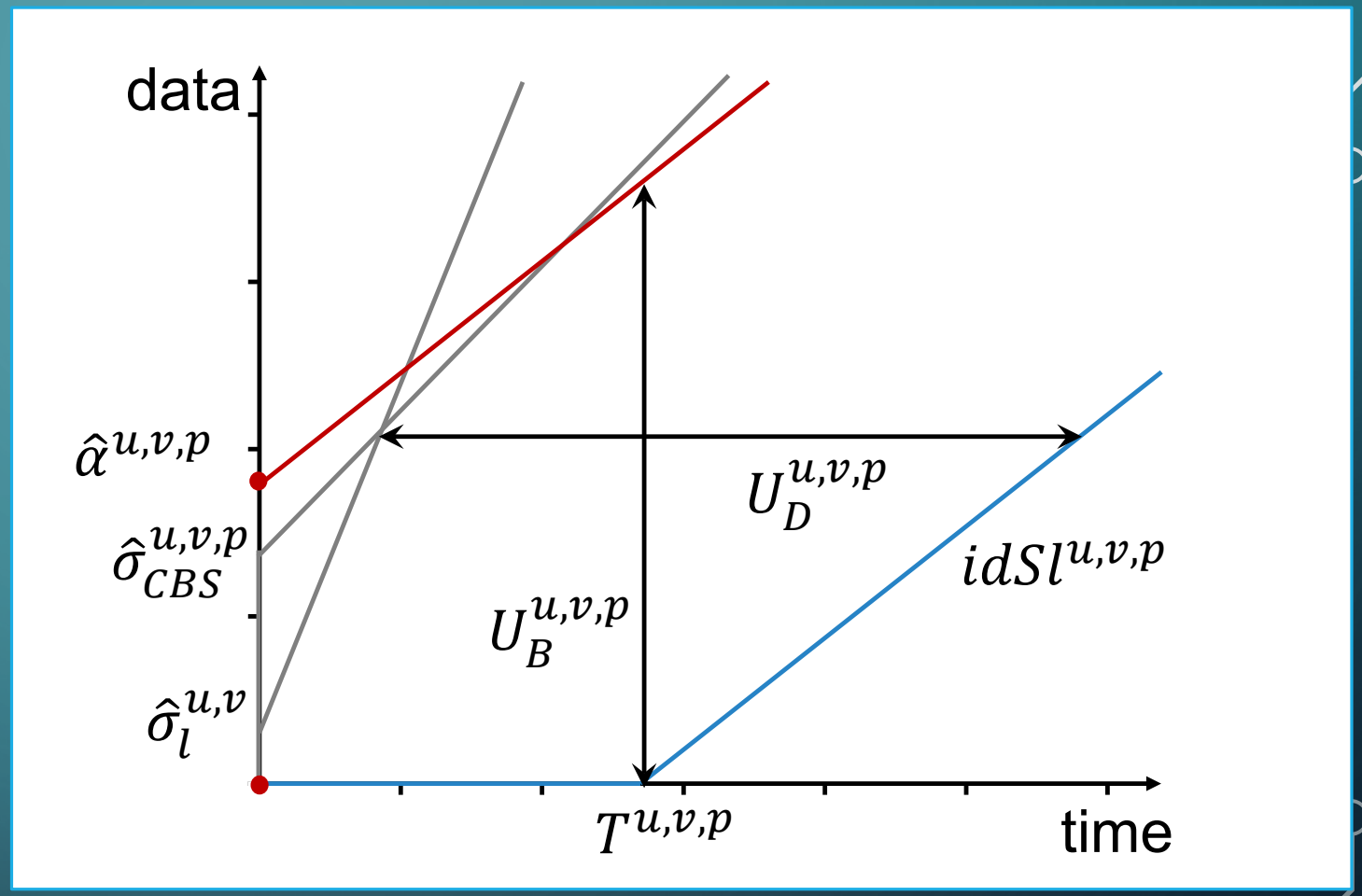

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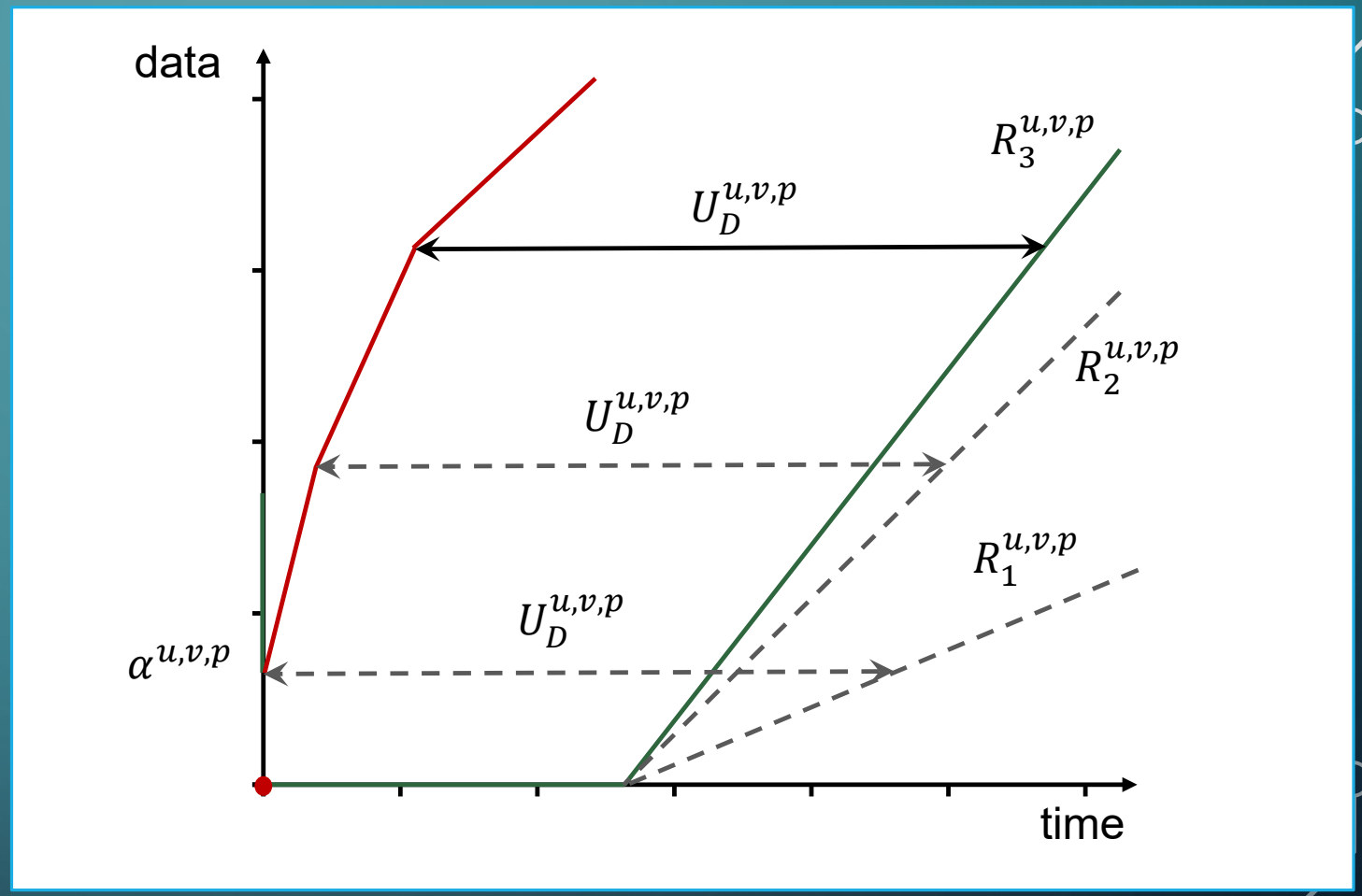
FIXED DELAY (FD)

- Input: max. Delay per Queue

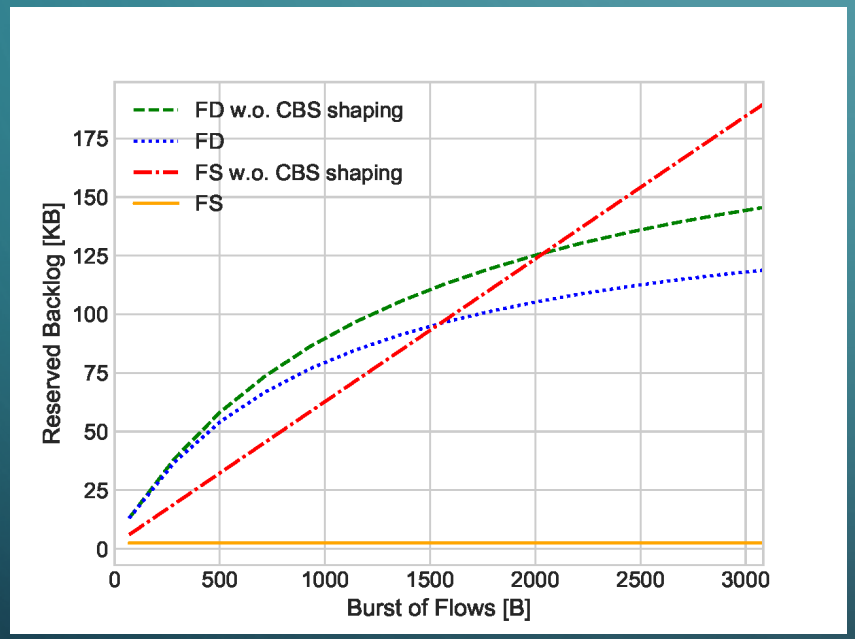
- dynamically reserve flows
  as long as delay is guaranteed
- $\alpha^*(t) = \alpha(t + D)$ [a)]

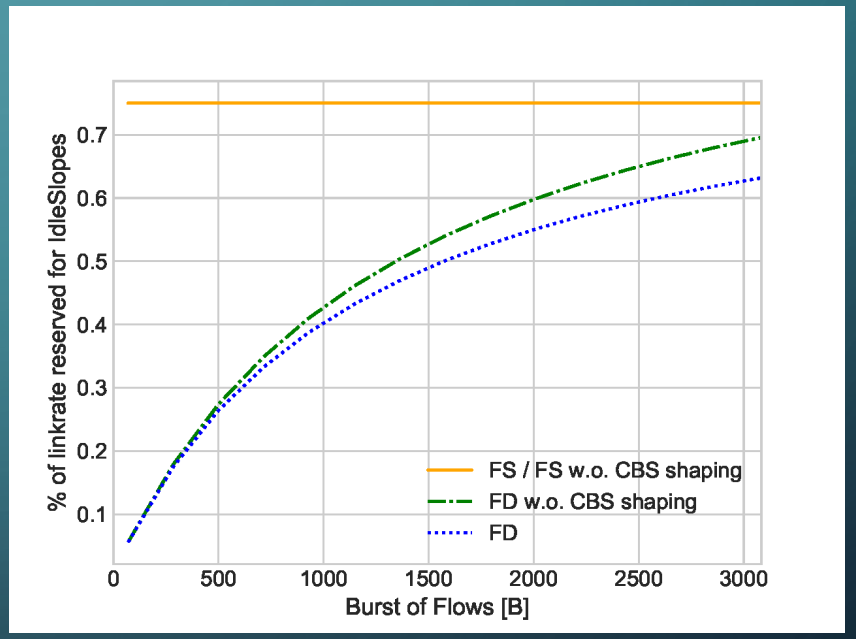


[a)] same simplification as before

EVALUATION

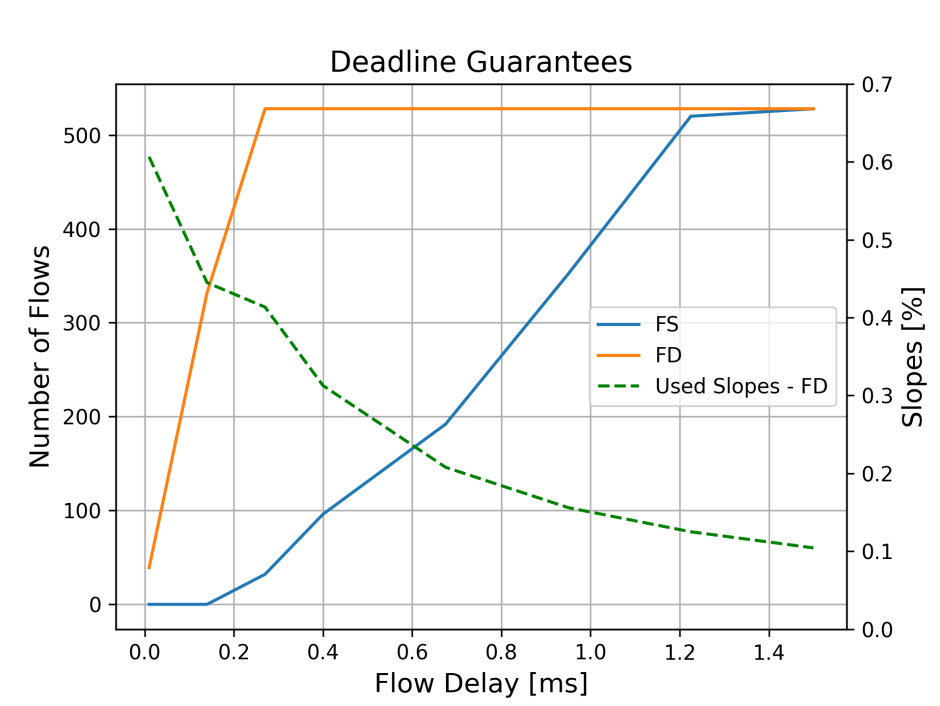
- CBS Shaping Effect
- Backlog vs. Idle Slopes





EVALUATION

- Industrial Scenario – Deadline for Flows



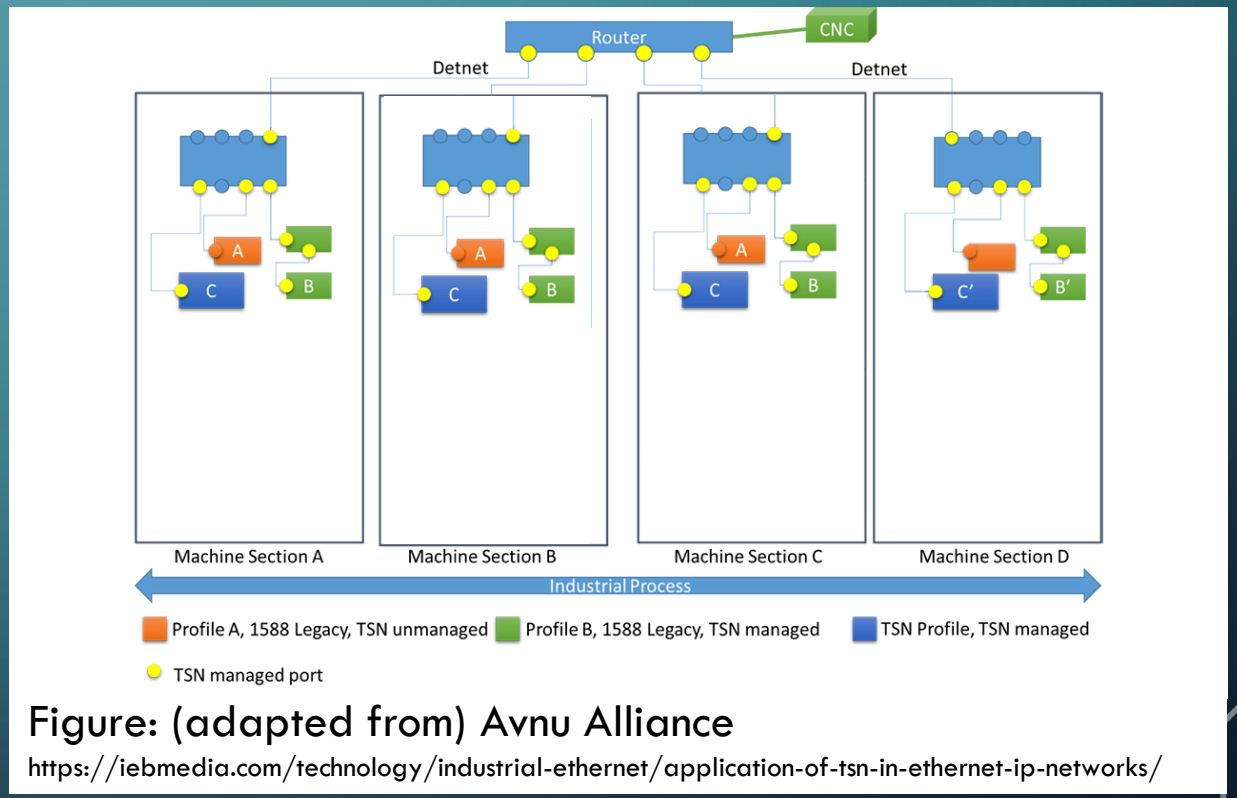
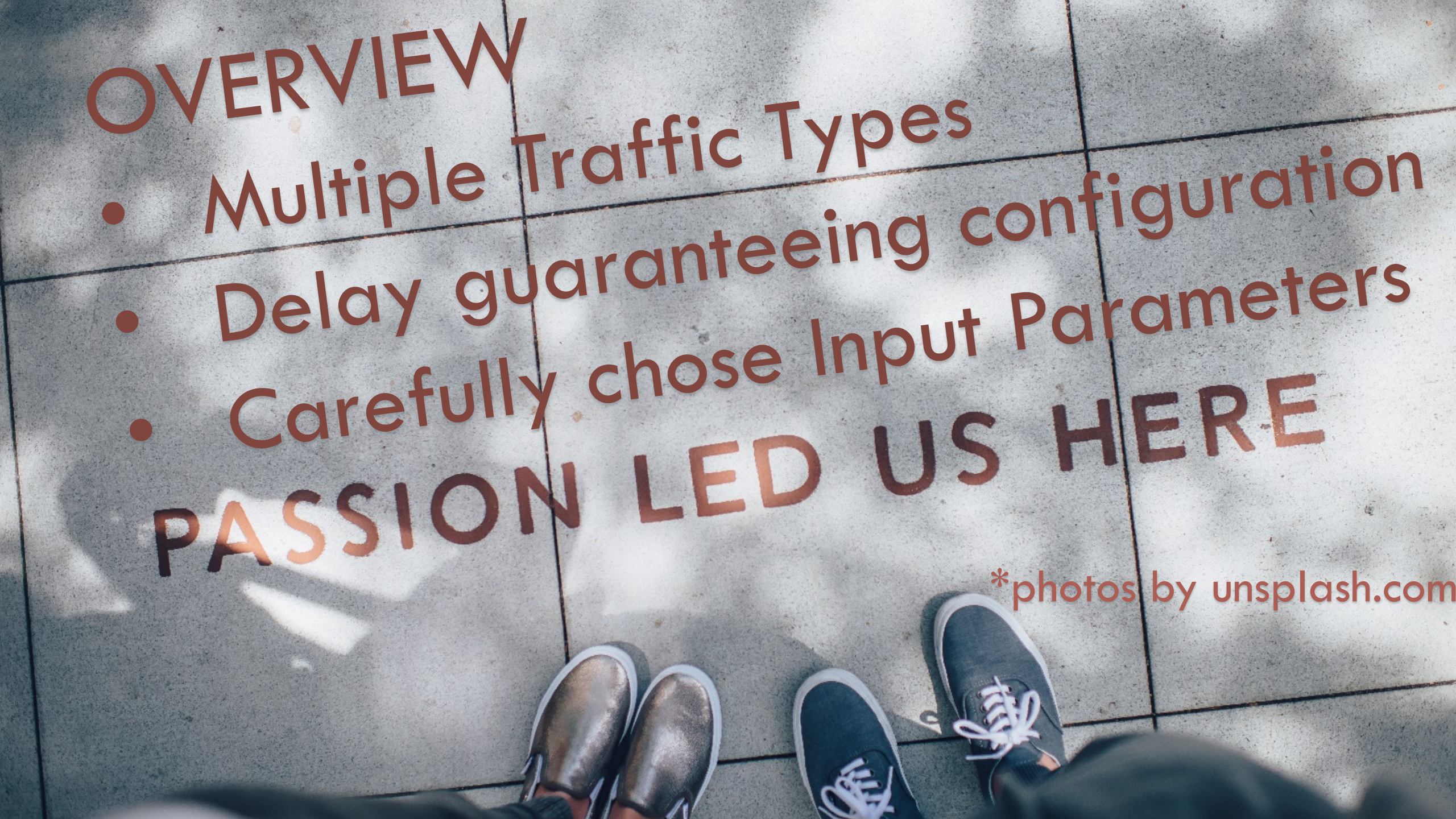


Figure: (adapted from) Avnu Alliance
https://iebmedia.com/technology/industrial-ethernet/application-of-tsn-in-ethernet-ip-networks/

OVERVIEW

- Multiple Traffic Types
- Delay guaranteeing configuration
- Carefully chose Input Parameters



*photos by unsplash.com