



# Factors Limiting the Modularity of xTFA

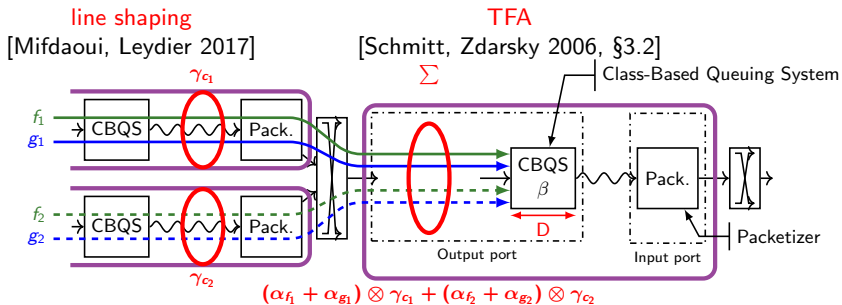
Dagstuhl Seminar on Network Calculus

Ludovic Thomas (CNRS/LORIA)

April 3rd, 2024

## Experimental modular Total-Flow Analysis (xTFA) in a few words

xTFA is a Python tool (GPLv3) for computing network-calculus delay bounds in networks.  
Arrival-curve oriented

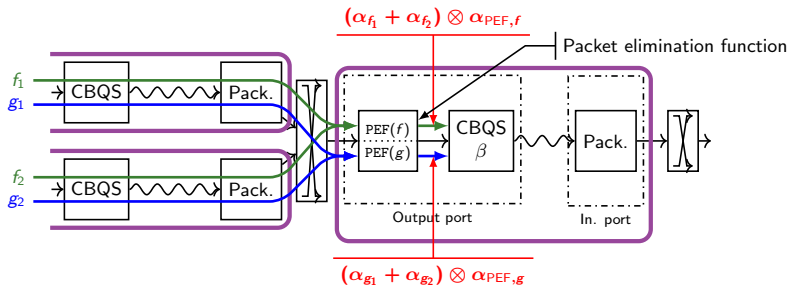


– [Schmitt, Zdarsky 2006] Jens B. Schmitt and Frank A. Zdarsky [Oct. 11, 2006]. “The DISCO Network Calculator: A Toolbox for Worst Case Analysis”. In: *Proceedings of the 1st International Conference on Performance Evaluation Methodologies and Tools*. New York, NY, USA: Association for Computing Machinery. ISBN: 978-1-59593-504-5. DOI: 10.1145/1190095.1190105

– [Mifdaoui, Leydier 2017] Ahlem Mifdaoui and Thierry Leydier [Dec. 2017]. “Beyond the Accuracy-Complexity Tradeoffs of Compositional Analyses Using Network Calculus for Complex Networks”. In: *10th International Workshop on Compositional Theory and Technology for Real-Time Embedded Systems (Co-Located with RTSS 2017)*. Paris, France

## Why a new tool ? Origin of xTFA.

Packet Replication and Elimination Functions [Thomas, Mifdaoui, Le Boudec 2022]  
Or TSN FRER: Frame Replication and Elimination for Reliability



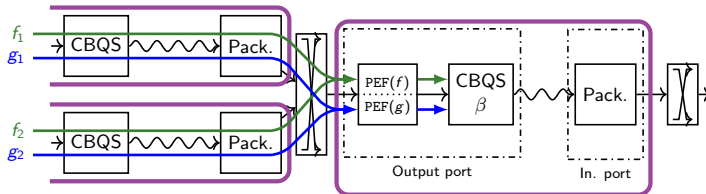
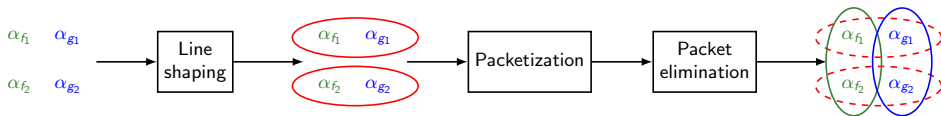
January 2021: *“Implementing FRER in TFA looks easy because it is very similar to the input shaping. But for this reason, both steps look incompatible”*

– [Thomas, Mifdaoui, Le Boudec 2022] Ludovic Thomas, Ahlem Mifdaoui, and Jean-Yves Le Boudec [2022]. “Worst-Case Delay Bounds in Time-Sensitive Networks With Packet Replication and Elimination”. In: *IEEE/ACM Transactions on Networking*. DOI: [10.1109/TNET.2022.3180763](https://doi.org/10.1109/TNET.2022.3180763)

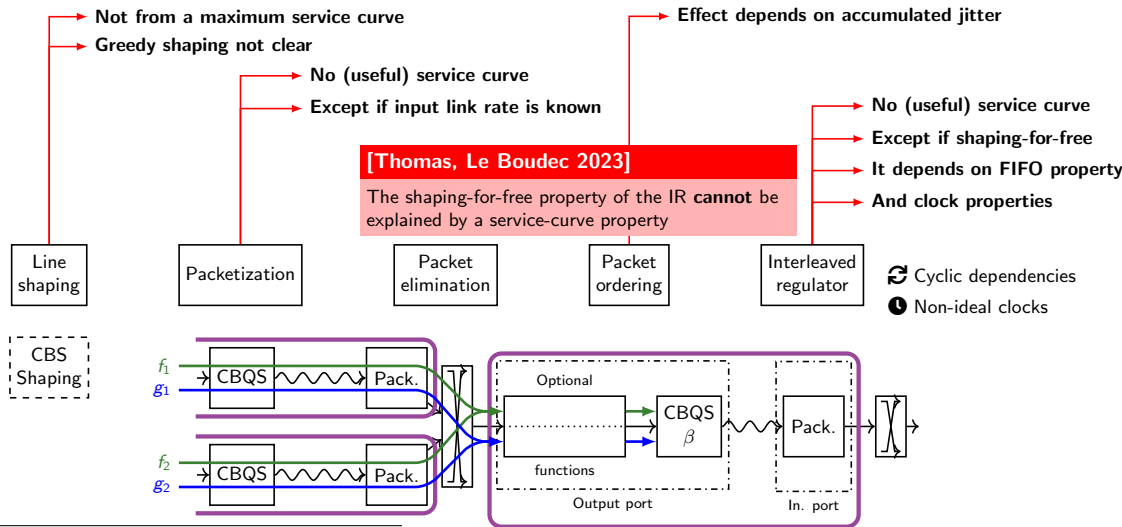
## “Towards a unification of NC improvements applied on TFA”

```
def compute_aggregate_arrival_curve(output_port, network_info):
    if(input_shaping_activated):
        # do some stuff...
    if(frer_is_active):
        # do some other stuff ...
```

Closed-form expressions 🤔



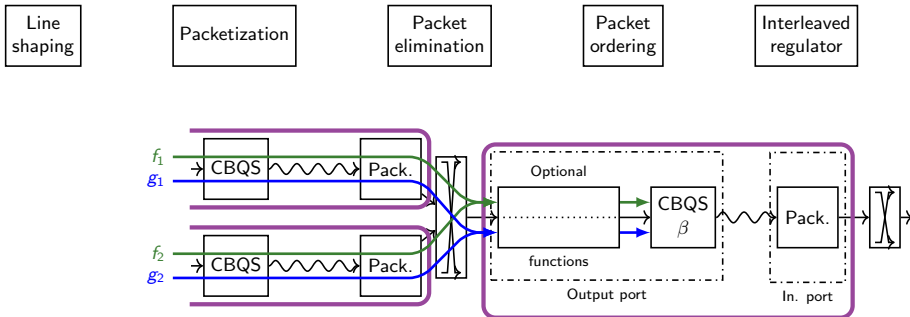
## Fast forward...



– [Thomas, Le Boudec 2023] Ludovic Thomas and Jean-Yves Le Boudec [Sept. 2023]. “Network-Calculus Service Curves of the Interleaved Regulator”. In: *35th International Teletraffic Congress (ITC-35)*. Torino, Italy

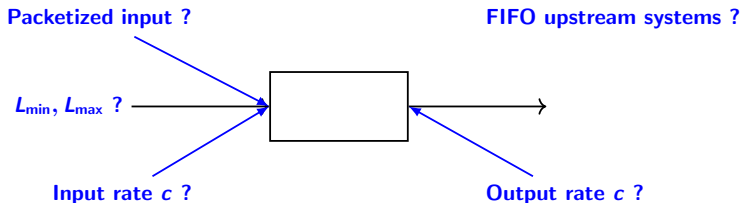
## The reality

- The effects of some network elements on arrival curves and end-to-end latencies **do not derive** from service-curve properties.
- Some service-curve properties and most non-service-curve properties of network elements depend on various, sometimes non-local assumptions.
- Experimental modular ☹️ TFA



## What could be useful for xTFA

- A hierarchy/terminology of service curves with respect to **their assumptions**.



In [Thomas, Le Boudec 2023], concept of *context-agnostic service curves*.

- More locally available information for flows. *Exemple, current xTFA*:
  - Arrival curve
  - Packet sizes  $L_{\min}, L_{\max}$
  - List of key ancestors
  - Vector of RTO (Reordering Time Offset) values with respect to key ancestors
  - Vector of  $D_{\min}, D_{\max}$  values from key ancestors
  - Observing clock
- Some model for the service of "weird" network elements ?

## Bibliography I

- [Mifdaoui, Leydier 2017] Mifdaoui, Ahlem and Thierry Leydier (Dec. 2017). “Beyond the Accuracy-Complexity Tradeoffs of Compositional Analyses Using Network Calculus for Complex Networks”. In: *10th International Workshop on Compositional Theory and Technology for Real-Time Embedded Systems (Co-Located with RTSS 2017)*. Paris, France, pp. 1–8. URL: <https://hal.archives-ouvertes.fr/hal-01690096> (visited on 09/27/2022).
- [Schmitt, Zdarsky 2006] Schmitt, Jens B. and Frank A. Zdarsky (Oct. 11, 2006). “The DISCO Network Calculator: A Toolbox for Worst Case Analysis”. In: *Proceedings of the 1st International Conference on Performance Evaluation Methodologies and Tools*. Valuetools '06. New York, NY, USA: Association for Computing Machinery, 8–es. ISBN: 978-1-59593-504-5. DOI: 10.1145/1190095.1190105. URL: <https://doi.org/10.1145/1190095.1190105> (visited on 02/13/2023).
- [Thomas, Le Boudec 2023] Thomas, Ludovic and Jean-Yves Le Boudec (Sept. 2023). “Network-Calculus Service Curves of the Interleaved Regulator”. In: *35th International Teletraffic Congress (ITC-35)*. Torino, Italy, pp. 1–9.
- [Thomas, Mifdaoui, Le Boudec 2022] Thomas, Ludovic, Ahlem Mifdaoui, and Jean-Yves Le Boudec (2022). “Worst-Case Delay Bounds in Time-Sensitive Networks With Packet Replication and Elimination”. In: *IEEE/ACM Transactions on Networking*, pp. 1–15. ISSN: 1558-2566. DOI: 10.1109/TNET.2022.3180763.