

WCTT analysis of avionics Switched Ethernet Network with WRR Scheduling.

Aakash SONI ^{1,2} Xiaoting LI ²
Jean-Luc SCHARBARG ¹ Christian FRABOUL ¹

¹IRIT Toulouse

²ECE Paris

aakash.soni@irit.fr

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Institut de Recherche
en Informatique de Toulouse

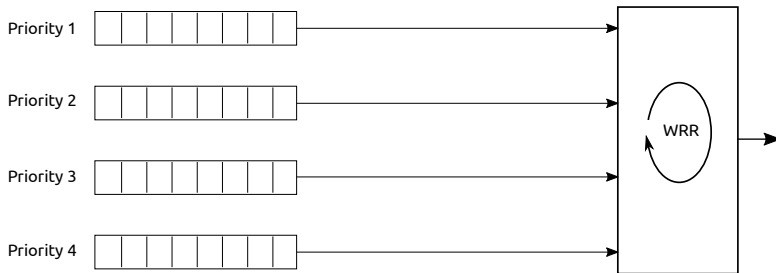


- Traditional aircraft network ARINC 429.
- **Avionics Full Duplex Switched Ethernet (AFDX)**
 - A backbone network for the avionics platform.
 - 100 Mbps.
 - FIFO/SP queues.
 - Lightly loaded network (up to 10 % only).
 - Possibility to share bandwidth among critical (avionic) and non-critical flow.
 - Example:
 - > Audio message from cockpit to cabin.
 - > Parking video.
- Bounding the delay is necessary for certification.

Context: Objective 1

How to make better use of available bandwidth?

- Implement Quality of Service (QoS) mechanism: Weighted Round Robin (WRR) scheduling.



Context: Objective 2

Reduce pessimism in analysis approach.

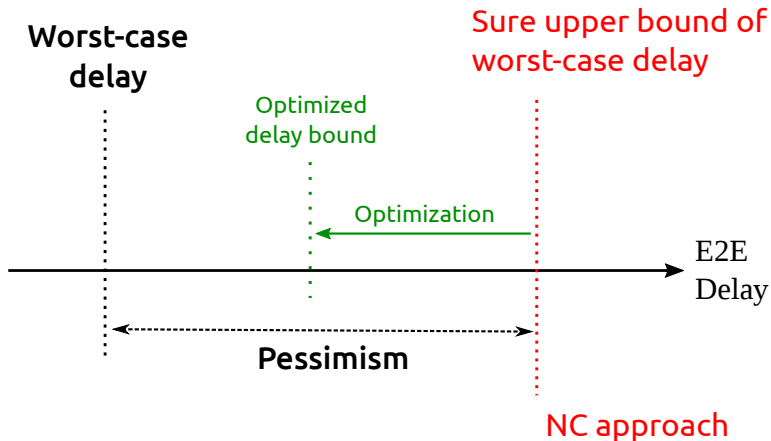


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- 2 Switched Ethernet Network
- 3 Network Calculus
- 4 Optimization
 - Pessimism in computed network service
 - Upper bound on interfering traffic
 - More accurate delay computation
- 5 Evaluation
- 6 Conclusion

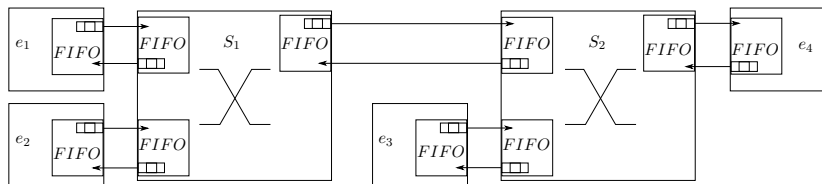
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Switched Ethernet Network : AFDX Network Model

Existing AFDX network model

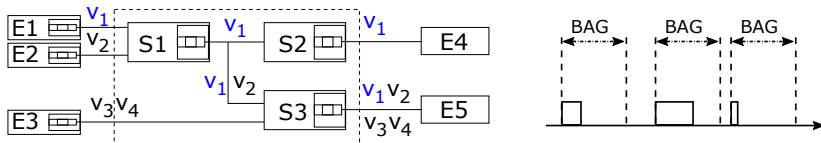
- End-Systems (e_x)
- Switches (S_x)
- FIFO output ports
- Virtual links (v_x)



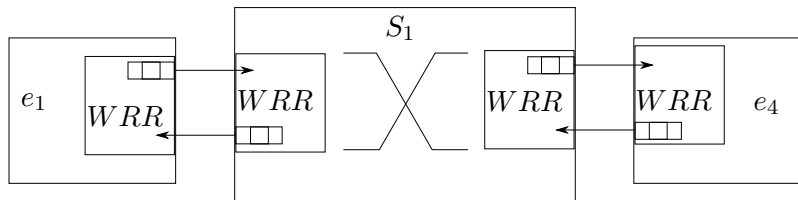
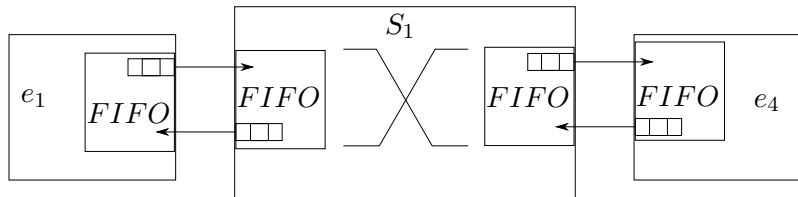
Switched Ethernet Network : AFDX Flow Model

Avionic flows are characterized as virtual links;

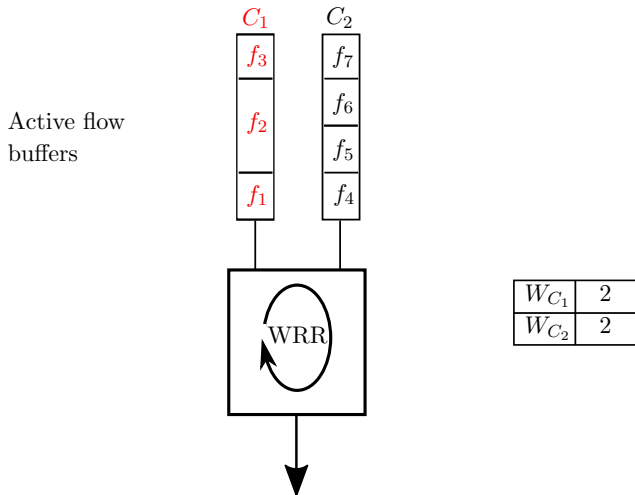
- Maximum frame length: S_{max}
- Minimum delay between two consecutive frames: BAG (Bandwidth Allocation Gap)
- Multicast routing



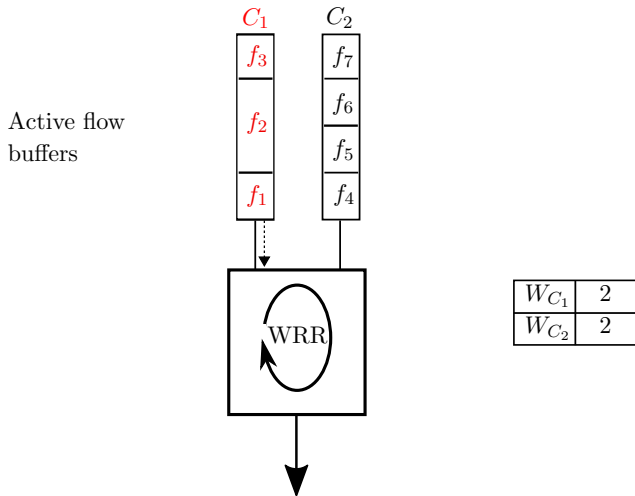
Switched Ethernet Network : AFDX Perspective



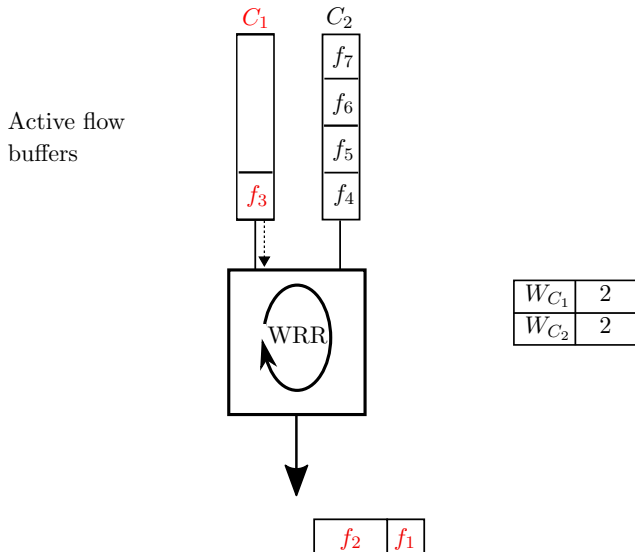
WRR Algorithm



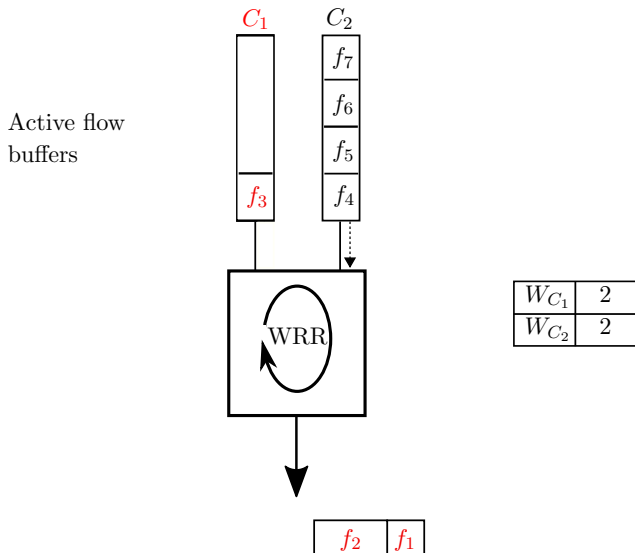
WRR Algorithm



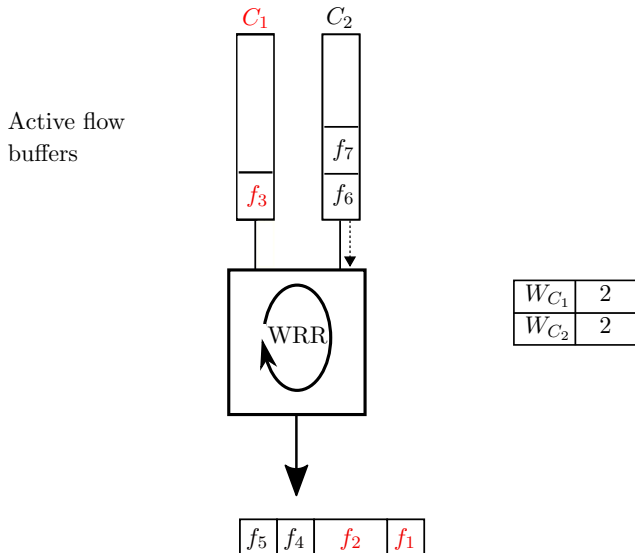
WRR Algorithm



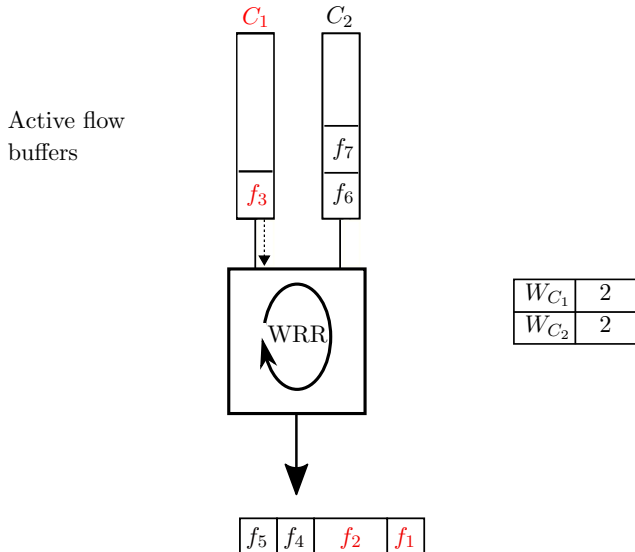
WRR Algorithm



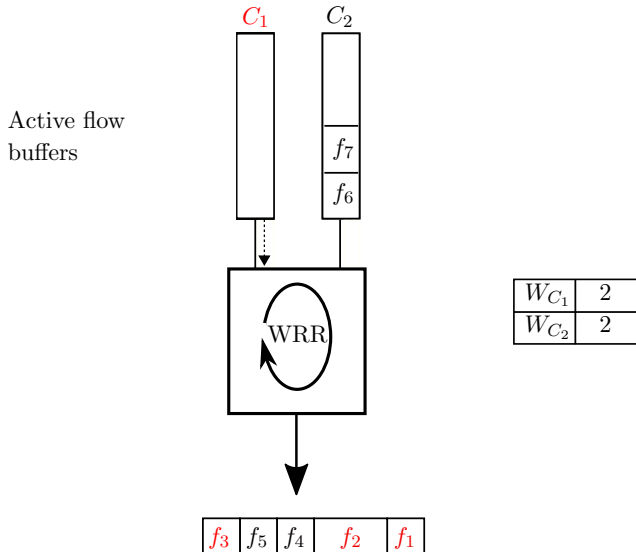
WRR Algorithm



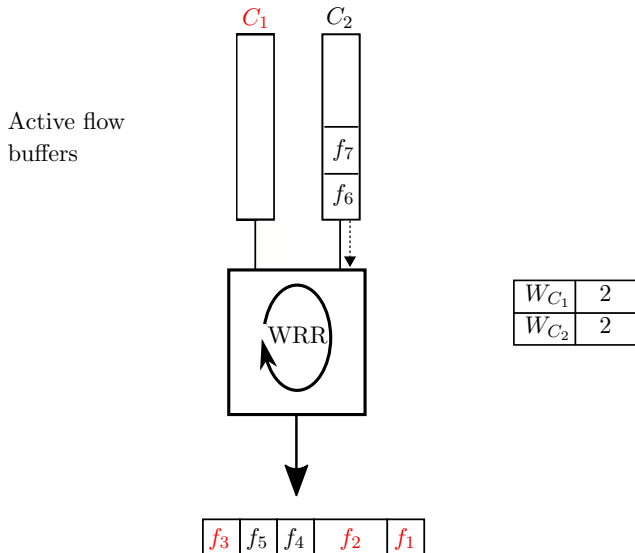
WRR Algorithm



WRR Algorithm



WRR Algorithm



WRR Algorithm

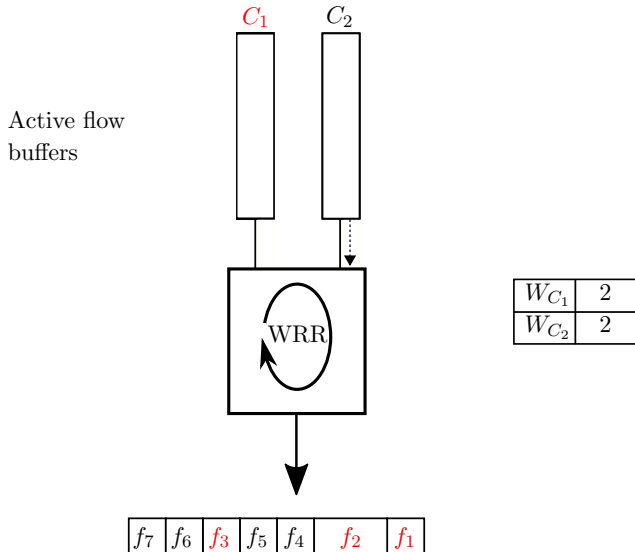


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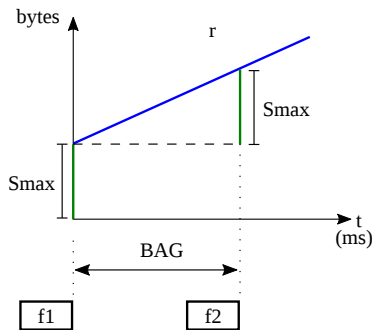
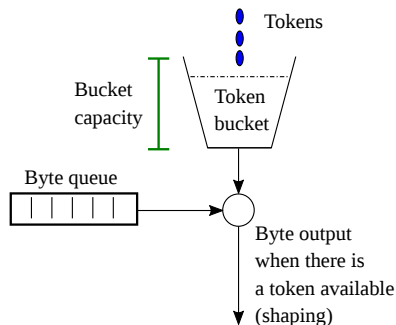
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Network calculus

- Computes **upper bounds** on:
 - End-to-end delay.
 - Jitter.
- Pessimism: models network based on **traffic envelopes**.
 - Overestimated flow traffic.
 - Underestimated network service.

Network Calculus: Arrival Curve (α)

- Token bucket constraint for traffic shaping.



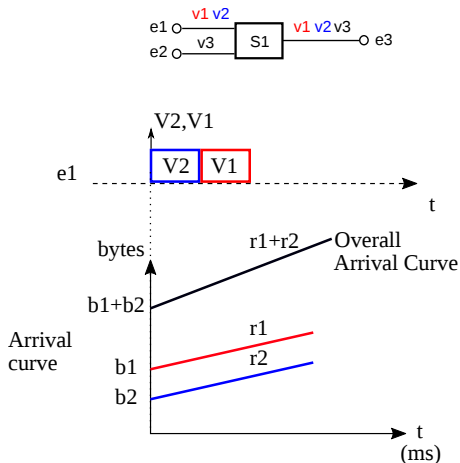
$$\alpha(t) = (r \times t) + b$$

$$r = \frac{S_{max}}{BAG}, \quad b = S_{max}$$

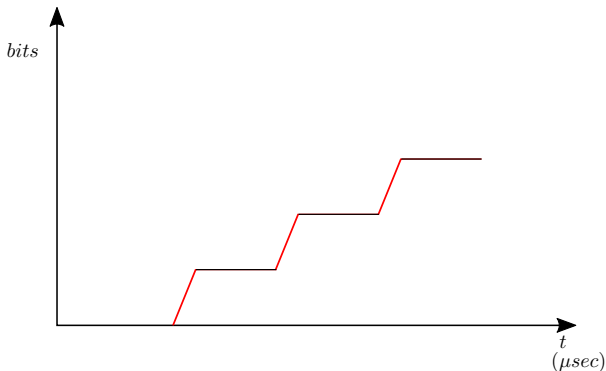
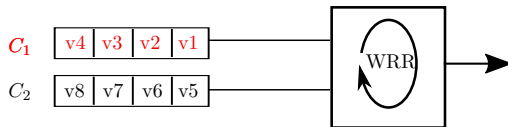
Network Calculus: Overall Arrival Curve (α_o)

At an output port:

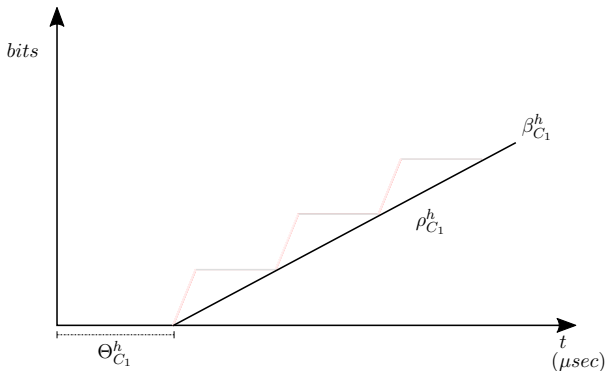
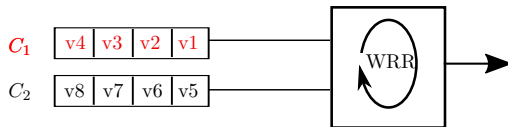
- All the frames arrive at the same time = **Increased burst**



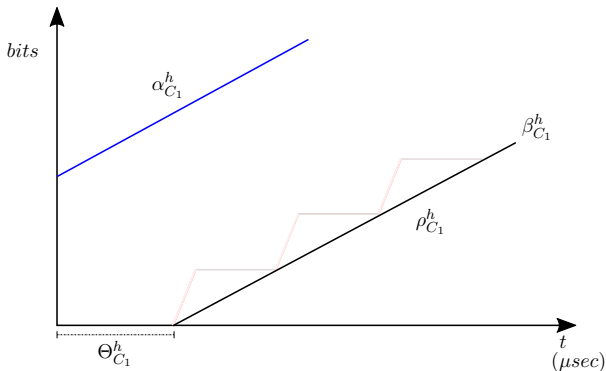
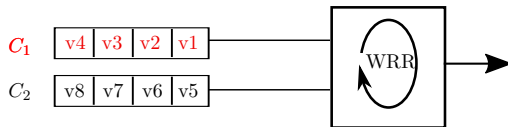
Network Calculus: Service Curve (β) & Delay Bound



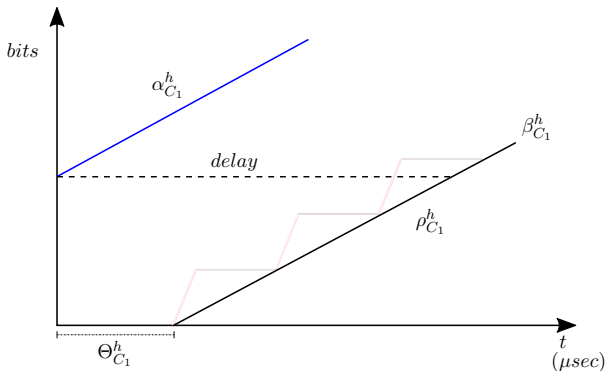
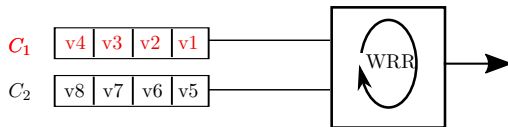
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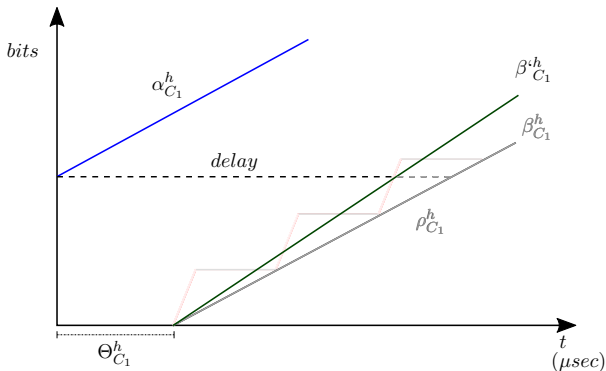
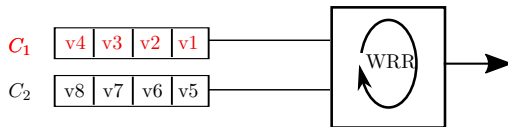
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Network Calculus: Service Curve (β) & Delay Bound

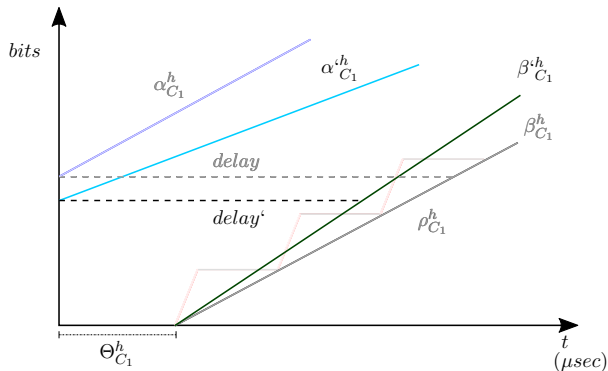
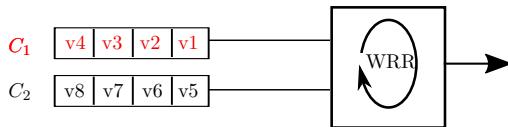
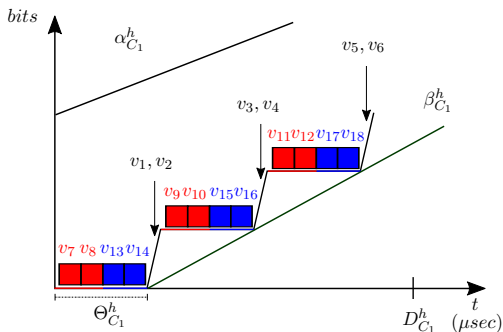
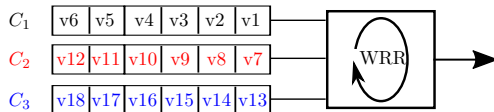


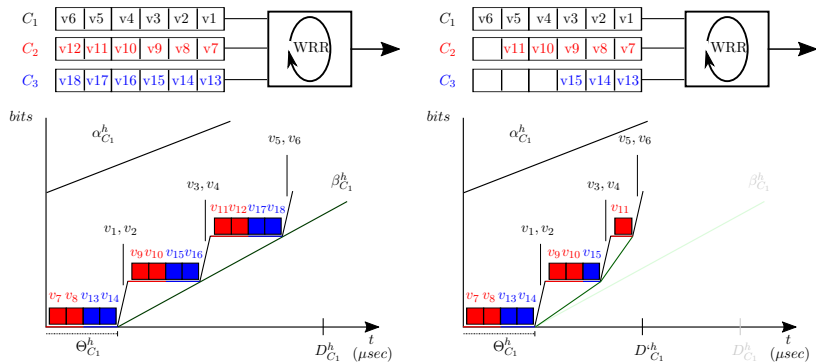
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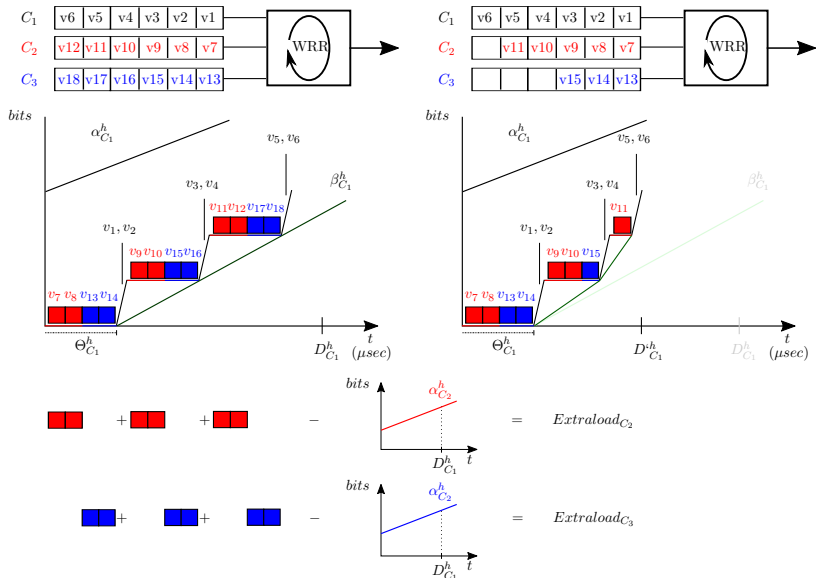
Pessimism in computed network service



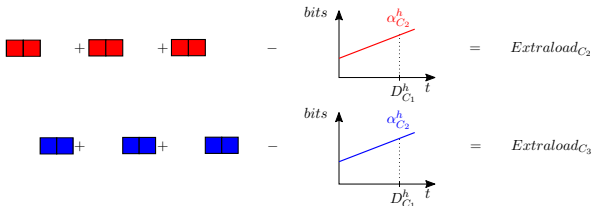
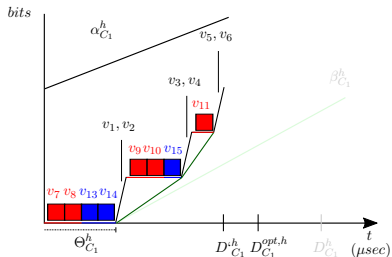
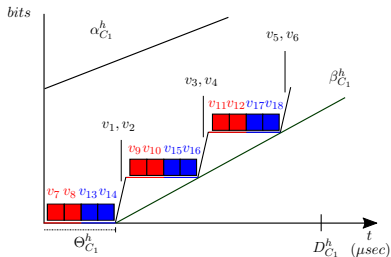
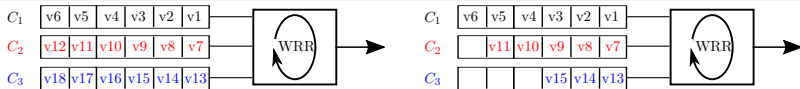
Pessimism in computed network service



Upper bound on interfering traffic



More accurate delay computation



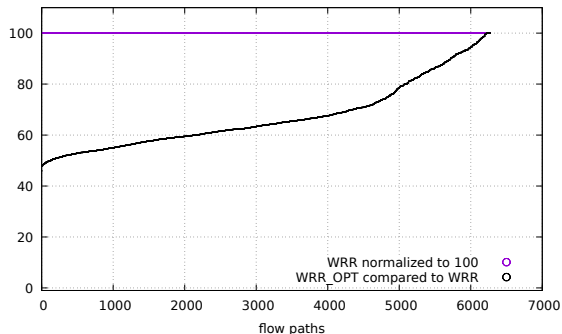
$$D_{C_1}^{opt,h} = D_{C_1}^h - tr\{\text{Extraload}_{C_2} + \text{Extraload}_{C_3}\}$$

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Evaluation

- Airbus A350 configuration
- 984 flows, 96 end systems, 8 switches, 6276 paths



- Average gain: 32.7%.
- Max gain 54%.

Class	Flows	S_{max} (byte)	w_x	Category
C_1	718	475	4	Critical
C_2	194	971	2	Multimedia
C_3	72	1535	1	Best-effort

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Conclusion

- NC on AFDX network with mixed criticality
- QoS: WRR scheduling.
- Evaluation of improved NC approach.
- What's next?
 - Optimization of NC for DRR scheduler. [RTSS 2018]
 - Service curve
 - Exact worst case delay using model checking approach.
 - Evaluation of pessimism of NC for avionic network with DRR and WRR scheduler.
 - Weight/Quantum allocation in Round Robin scheduler (WRR/DRR)

- Thank you for your attention!

Aakash SONI - aakash.soni@irit.fr