Contention management for Deterministic Networking

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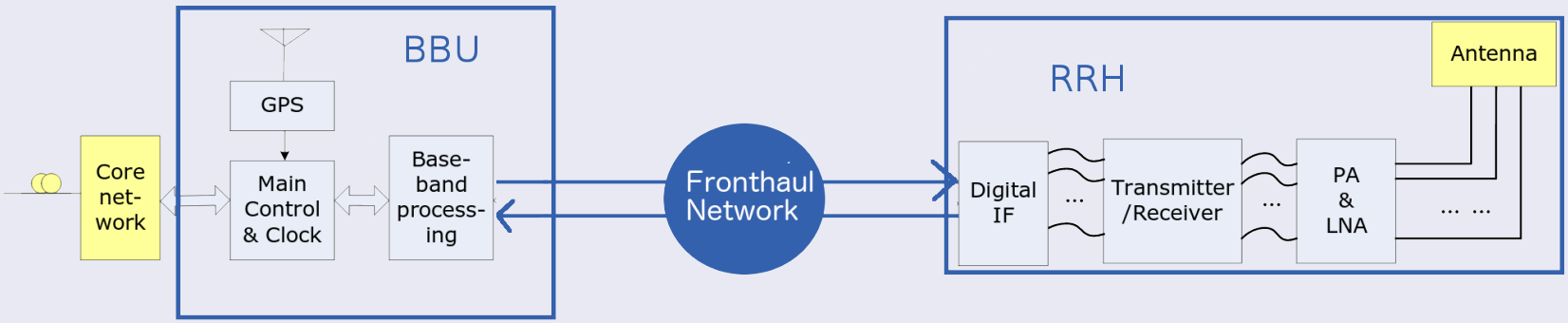
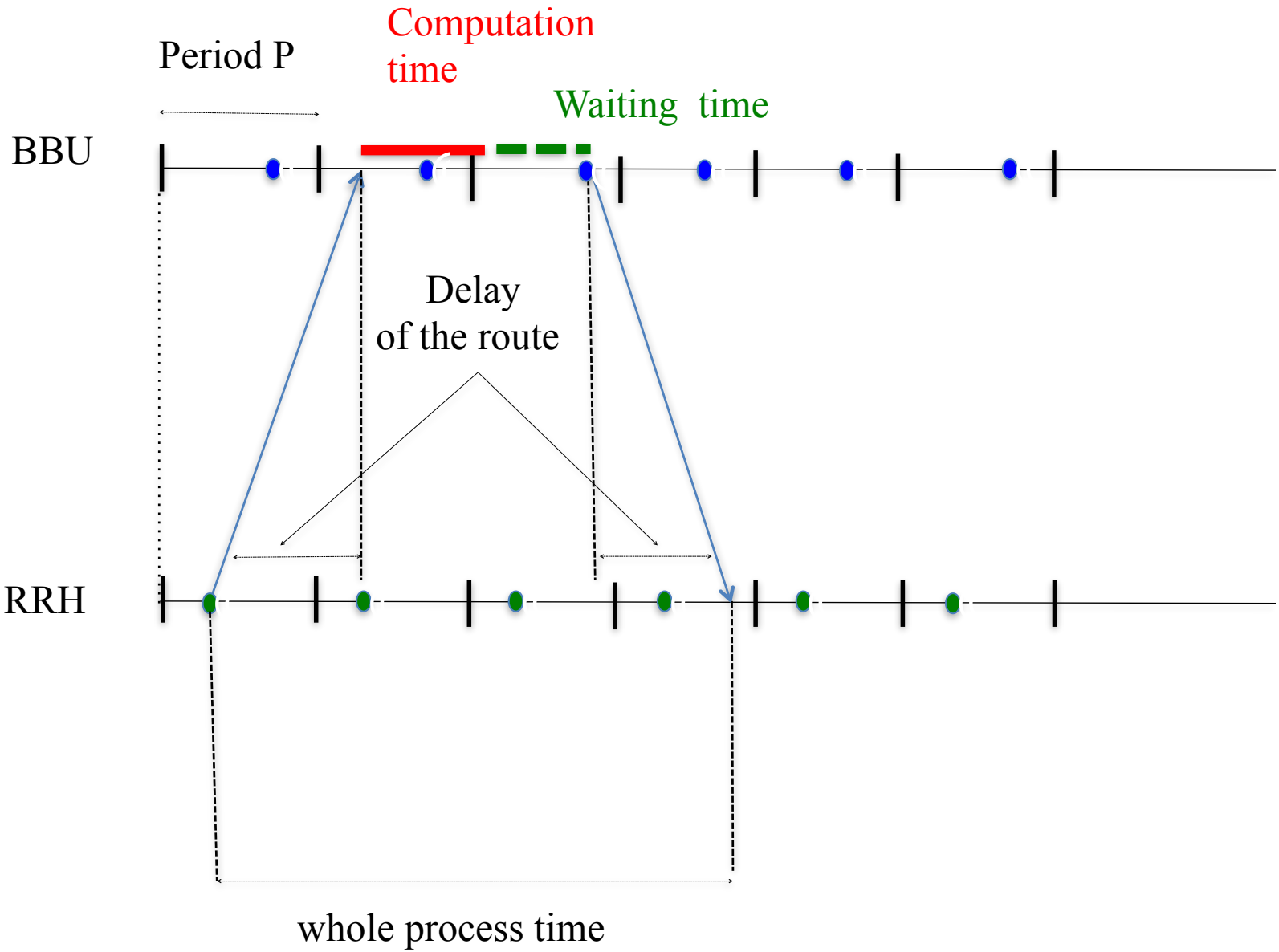
Problematic

- Latency critical application (C-RAN, ...).
- Stochastic networks could not ensure a low latency.
- NP-hard

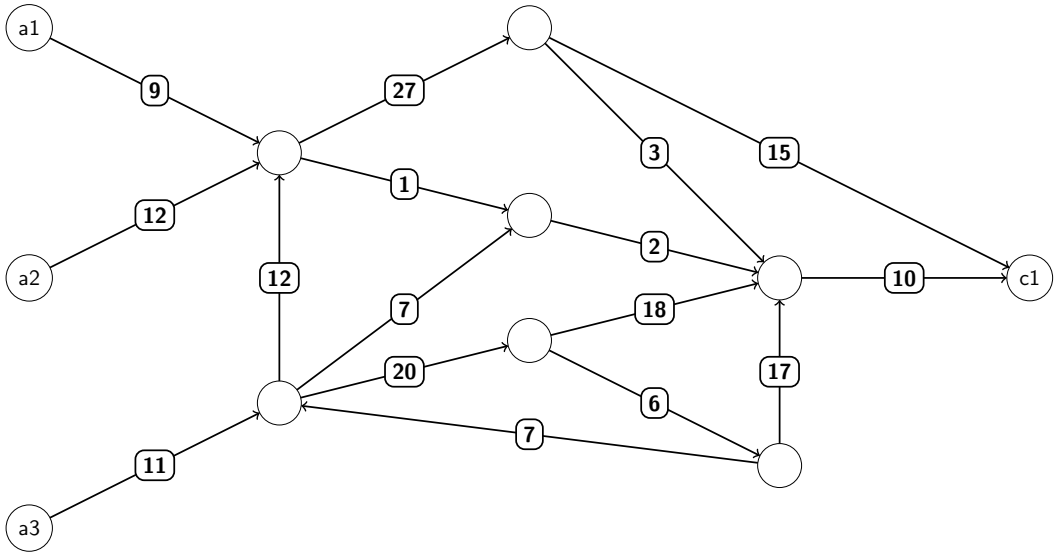
Periodic Process



- Contention in the fronthaul network
- Need to guarantee the latency


Period P
Computation time
Waiting time
BBU
Delay of the route
RRH
whole process time

Model



- Network : Directed Graph
- RRH / BBU $\rightarrow$ set of vertices A (Antennas) and C (Computation)
- Physical Delay of a link $\rightarrow$ Weight on arcs

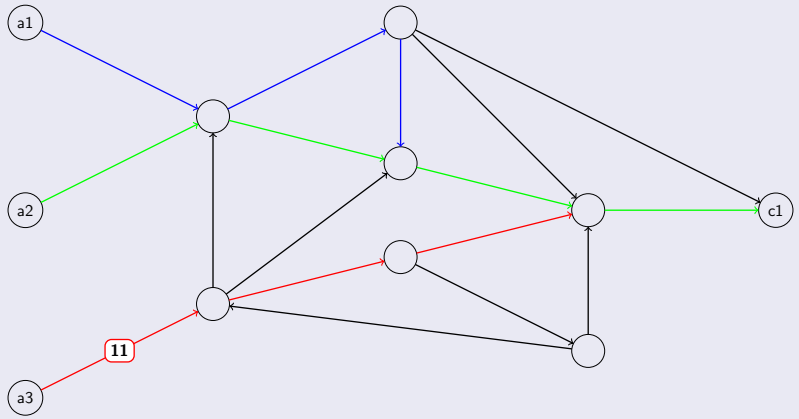
Model

Slotted time

The time is discrete.

- Slot $\rightarrow 1\mu$s.
- Step by step.

Message sending



Block of one or several slots used by the messages.

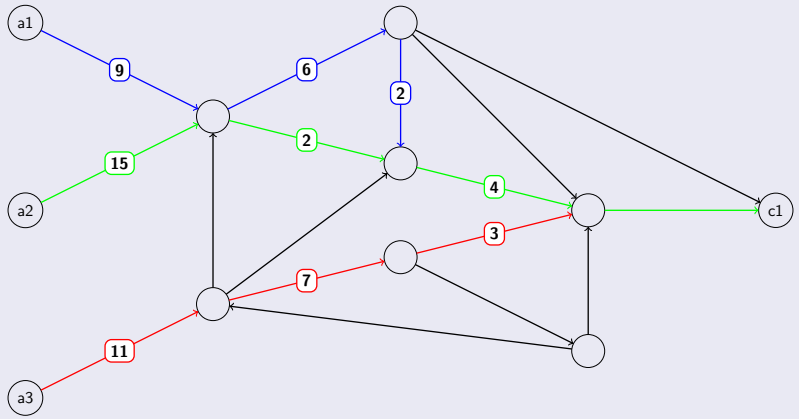
Latency

Latency

3 factors increases the latency

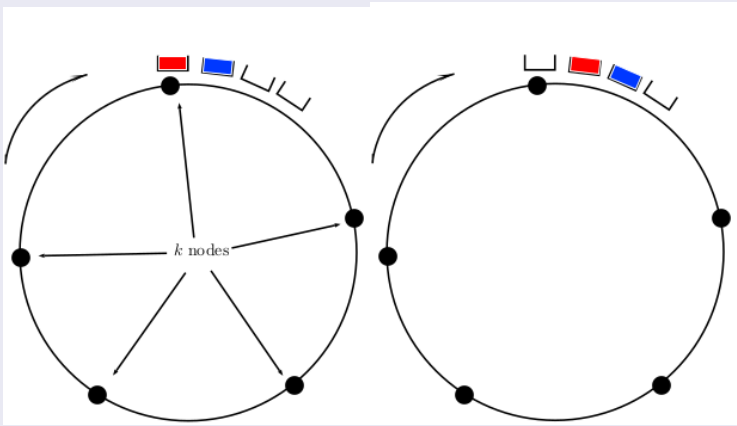
1. The physical delay of the links (not alterable).
2. The time before inserting a messages in the network.
3. The buffering time of the messages in the network.

Collisions

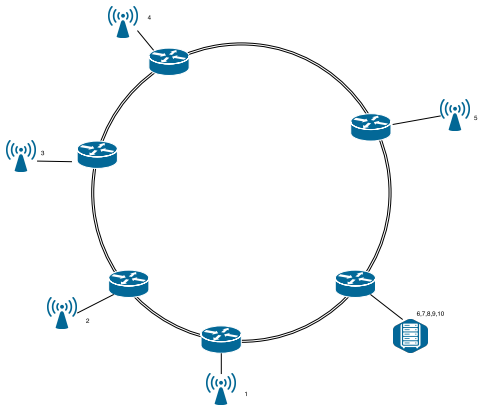


Optical ring

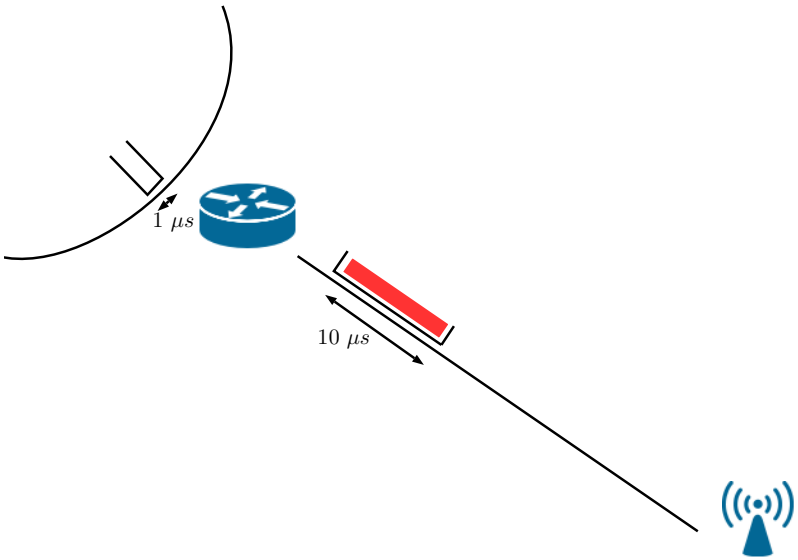
Model

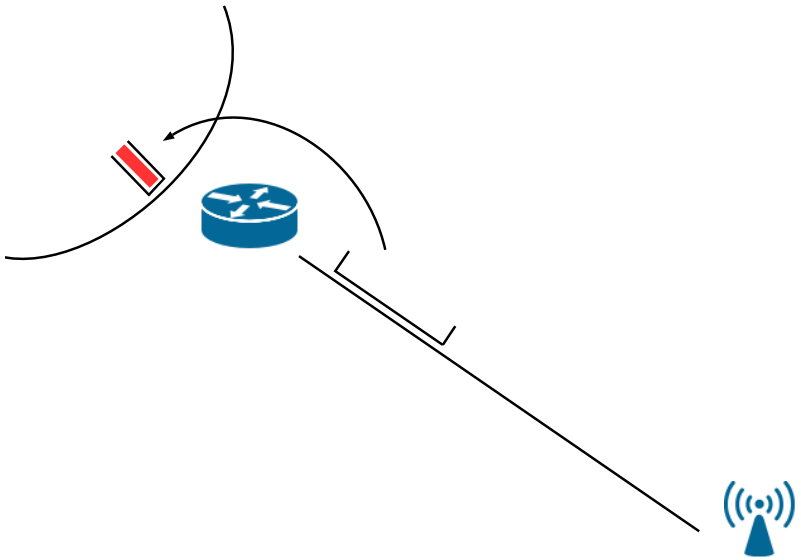


Waiting only at the insertion

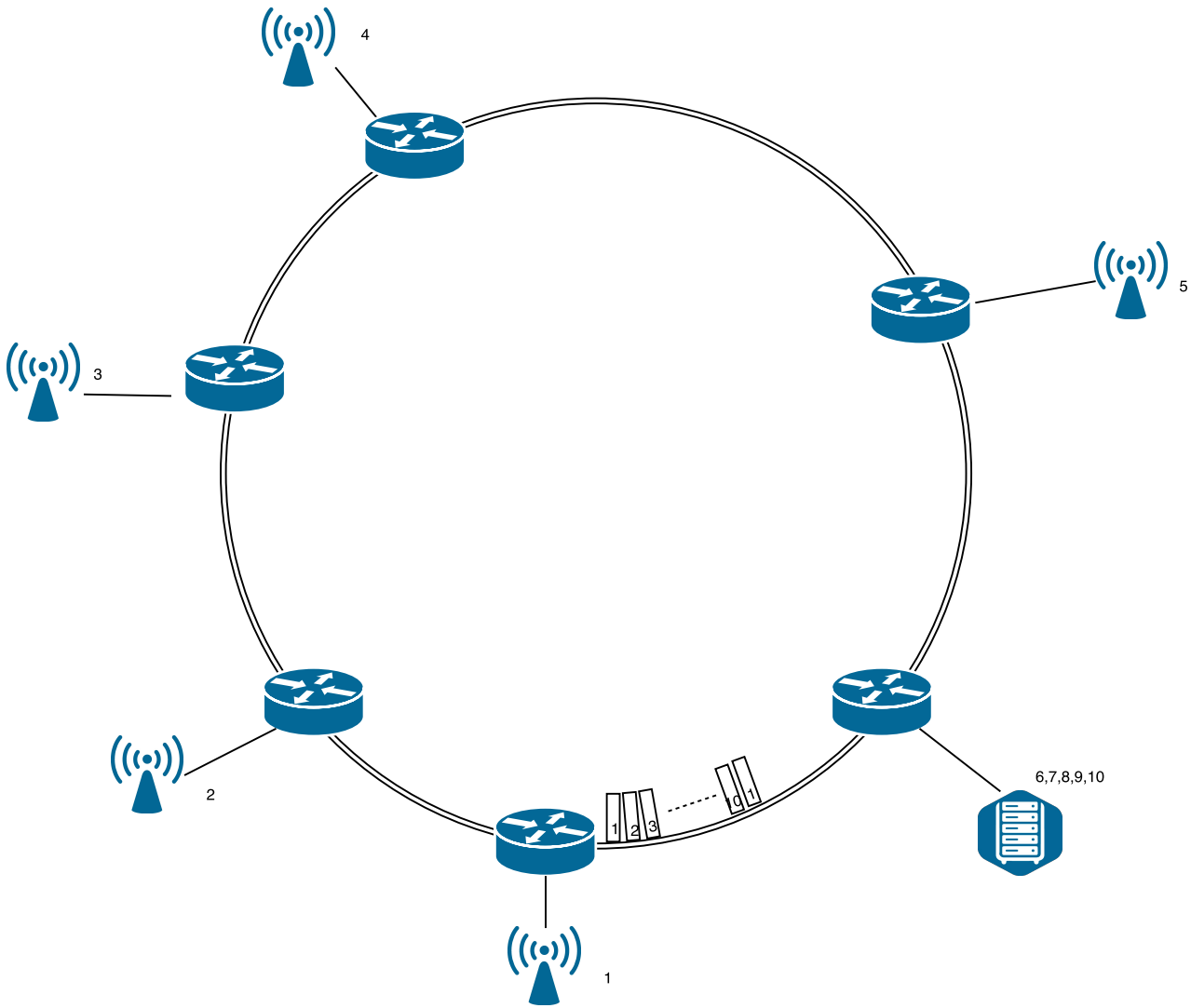


Insertion

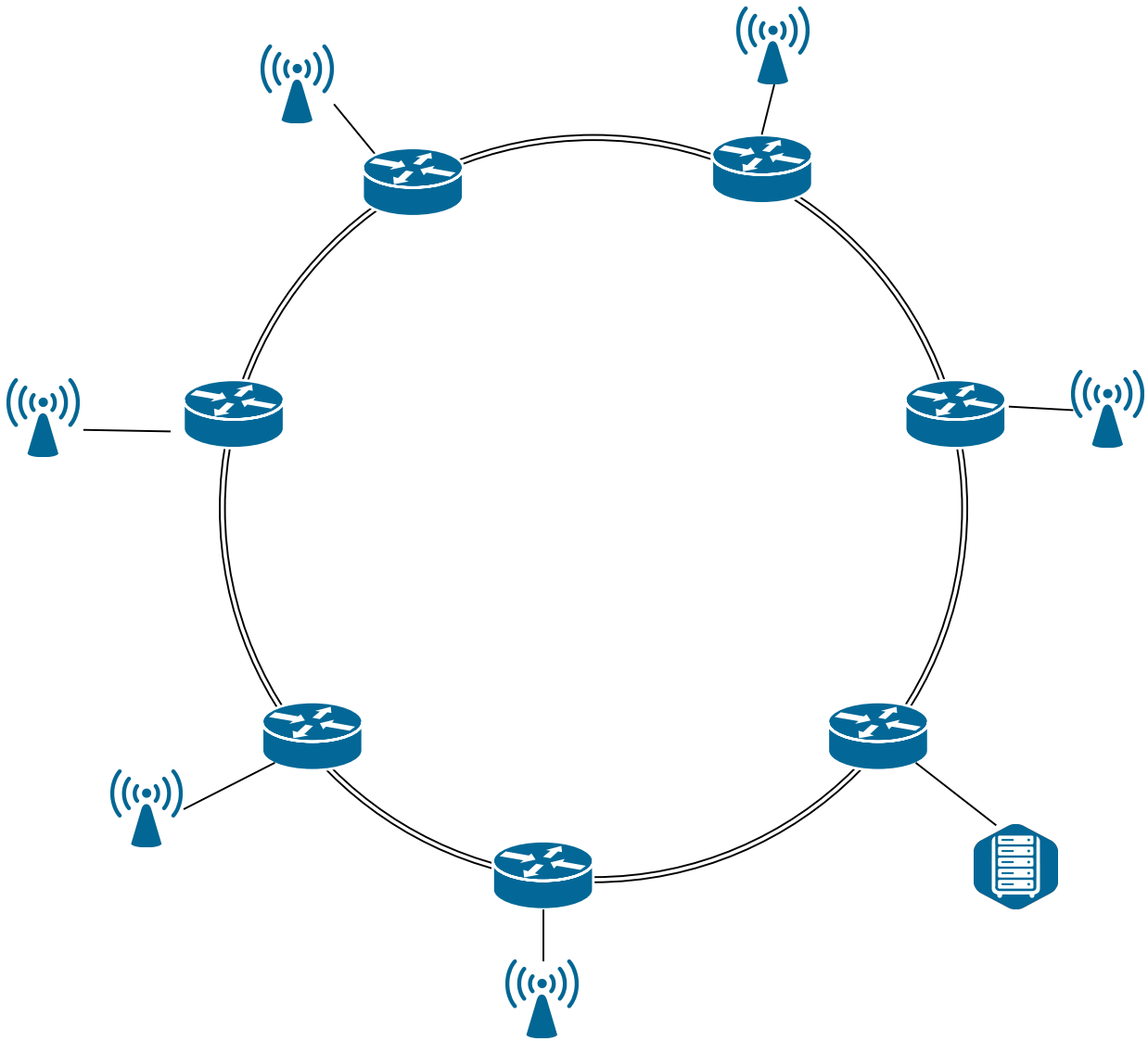




Deterministic policy



An harder topology



Parameters

Broadcast and select Policy

Parameters

Length of the ring	20km	100 slots
Number of nodes	3 -10	
Duration of a slot	1μs	-
Bandwidth	100 Gbps	-
Period	1ms	1000 slots
Capacity of a packet	100 kb	-
Flow of an antenna	-	0,5 packet/Every 1000 slots

Optical ring problematic

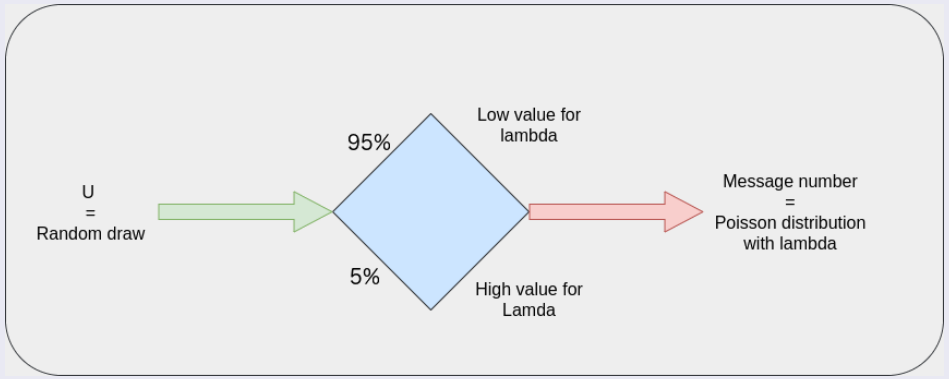
- We got two kinds of traffic : CRAN - high priority, Best effort
- We want to observe the behavior of the ring and analyze the latency of CRAN
- We will try to find some methods to decrease the CRAN latency without increasing the Best effort latency too much

Two kinds of messages

CRAN messages

- Periodicity
- Representing 50% of a packet capacity

Best effort



- Custom generation
- Representing 0.5% of a packet capacity
- Higher variance (27)
- More realistic generation

Loads

Best effort load

$$\text{Load}_{\text{Best Effort}} = \text{Average number of messages generated} \cdot 0.005 \cdot \#\text{Best effort flows}$$

High priority traffic load

$$\text{Load}_{\text{CRAN}} = 0.5 \cdot 2 \cdot \frac{\text{Number of antennas on the ring}}{\textit{Period}}$$

Those loads are lower bounds.

Packing policy

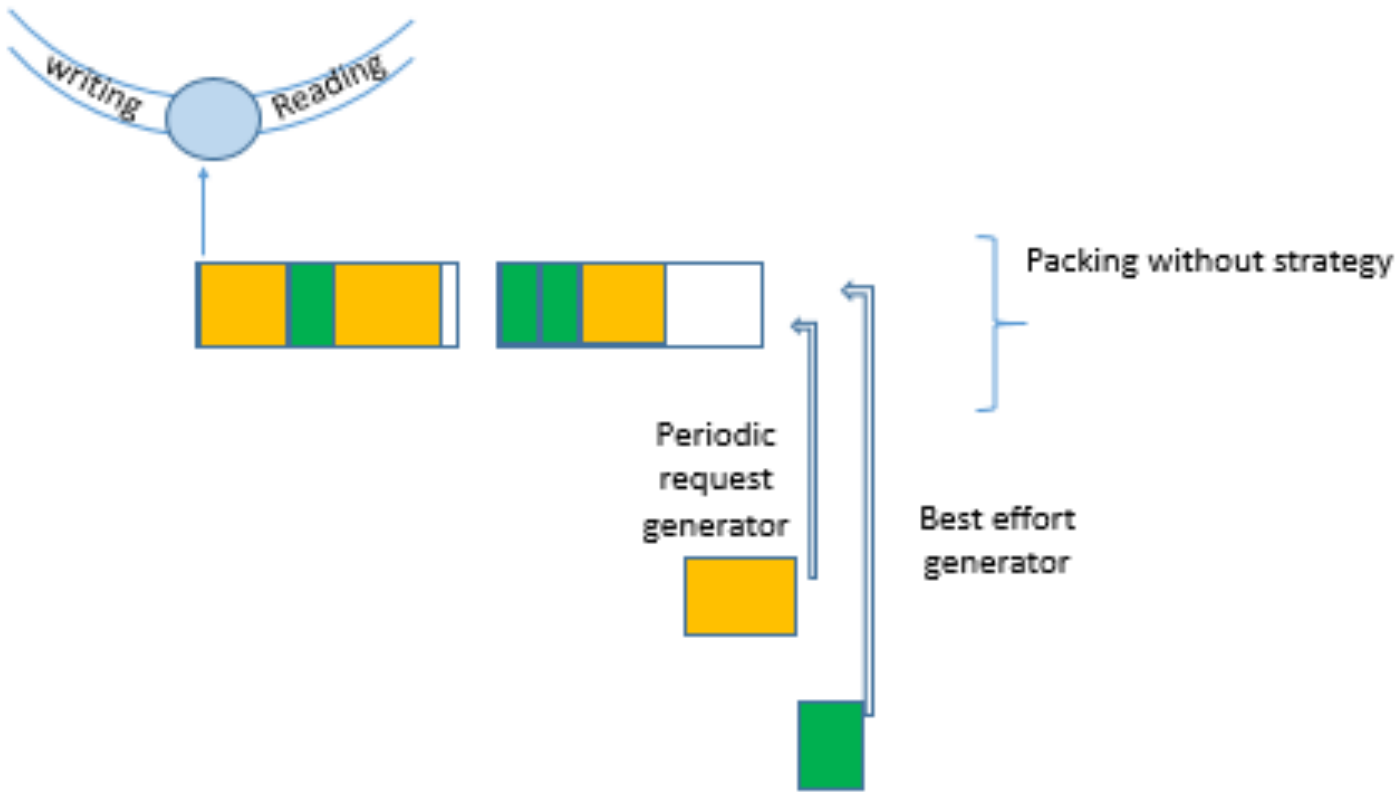


Figure: Without distinction

Minimum Fill rate β before sending.

Packing policy

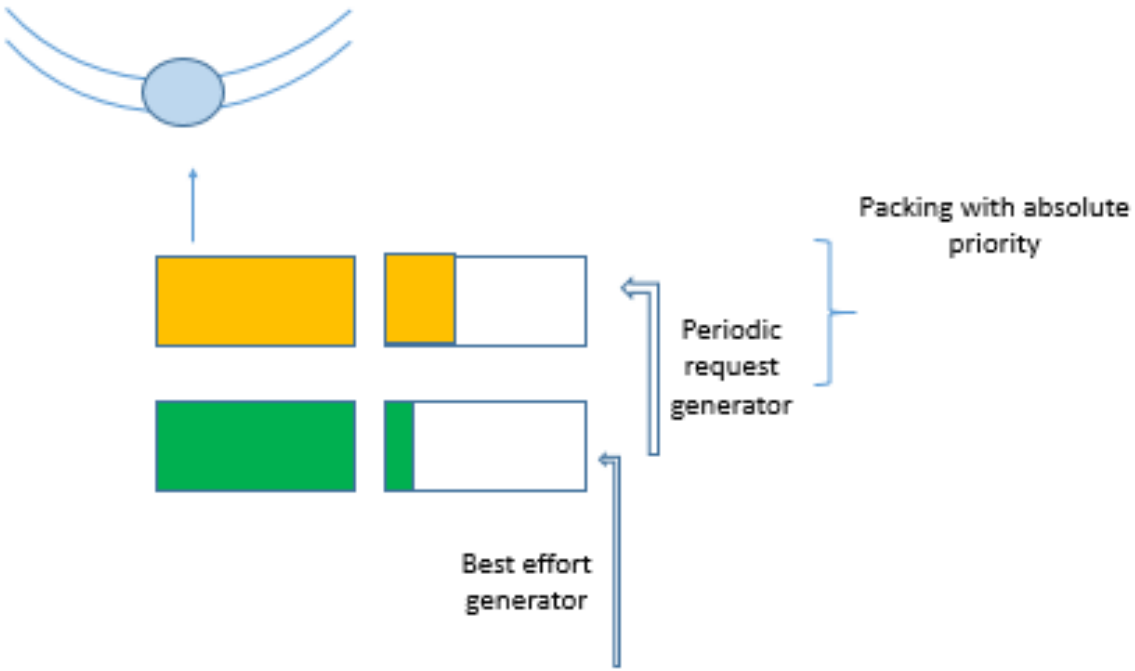


Figure: Absolute priority

Packing policy

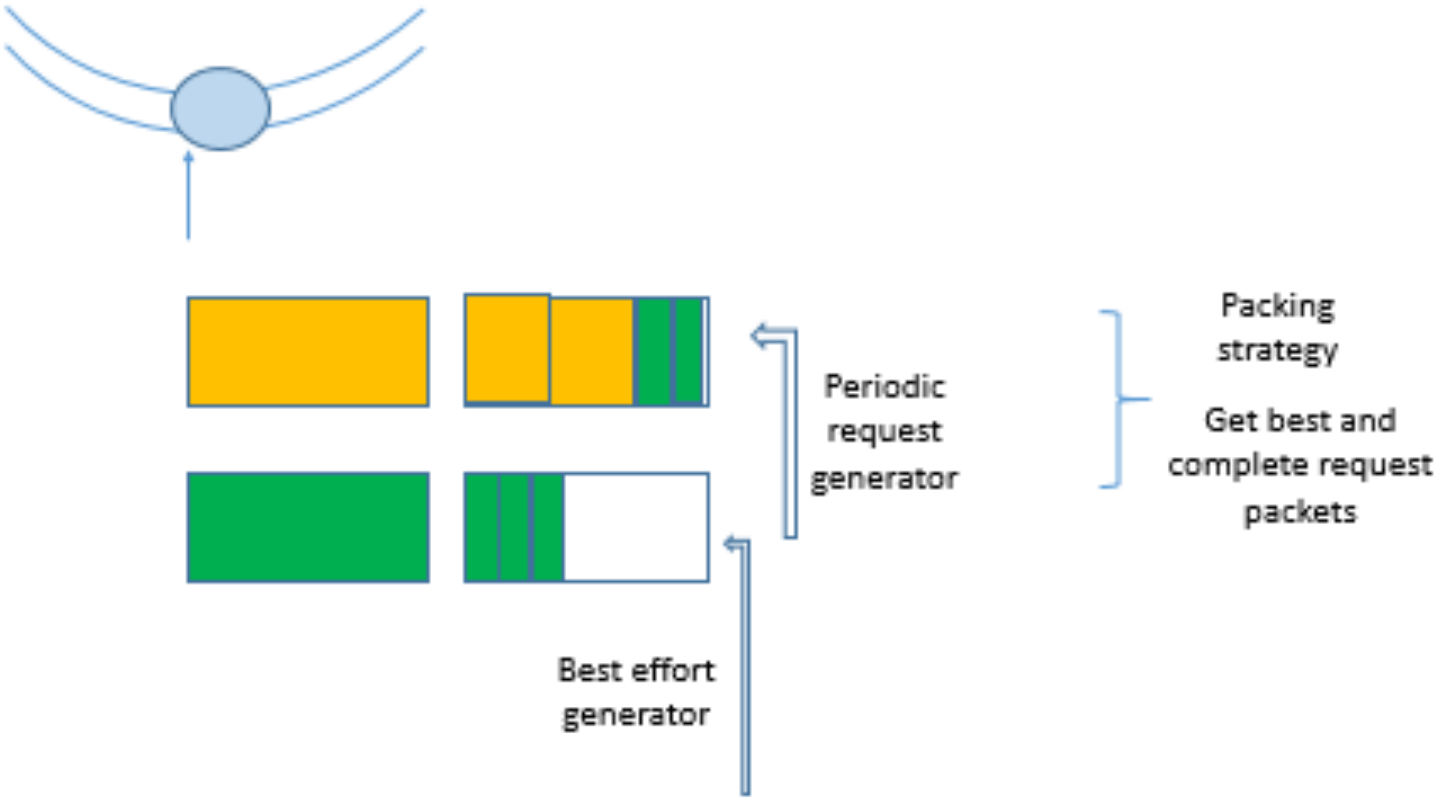
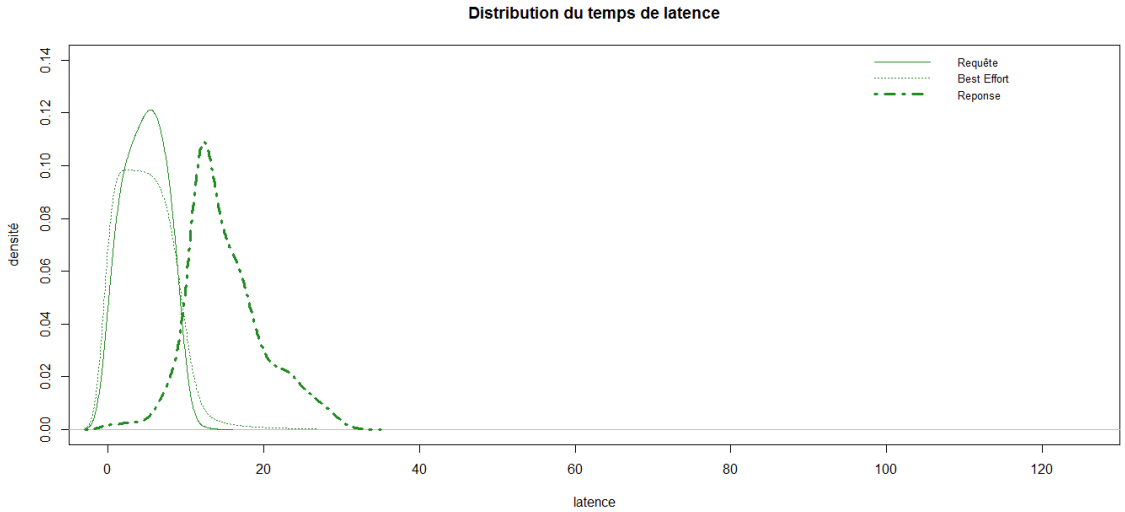
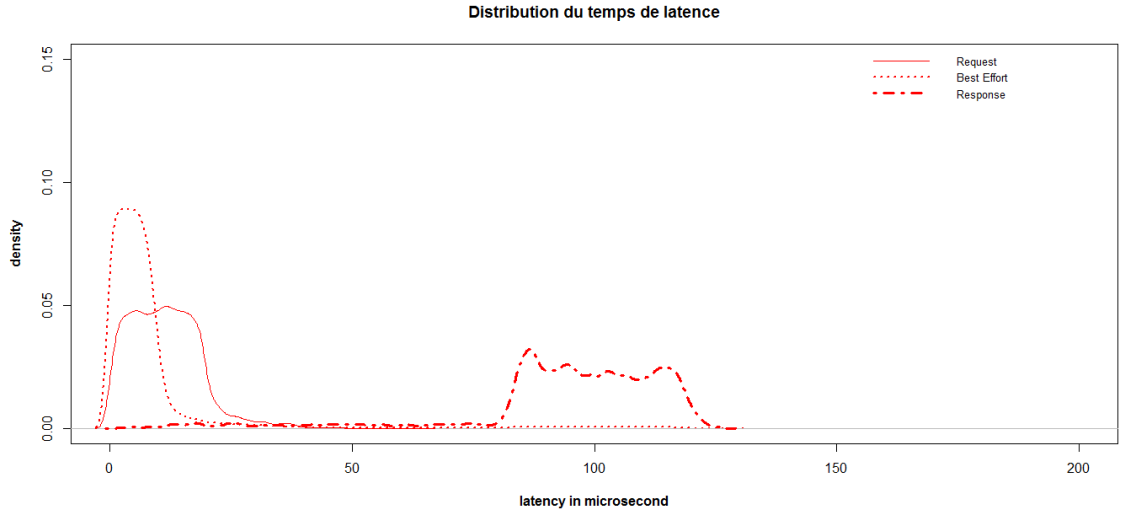


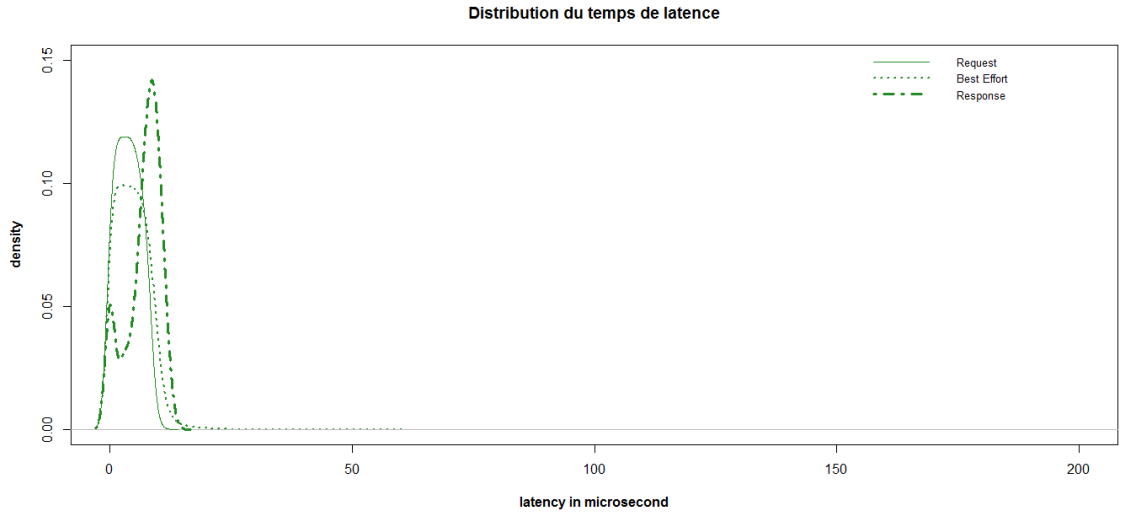
Figure: Mixed priority

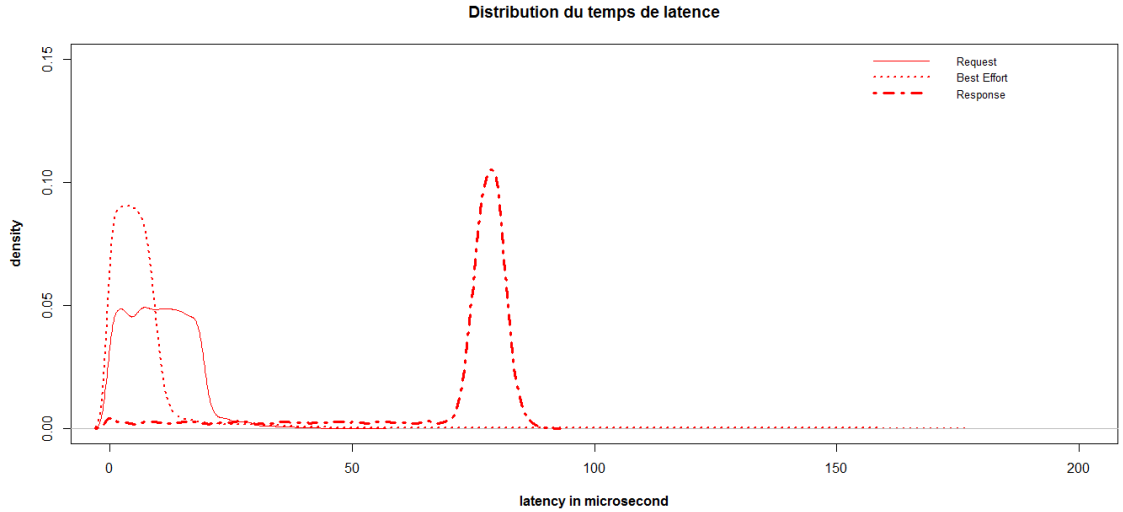
No priority Distribution



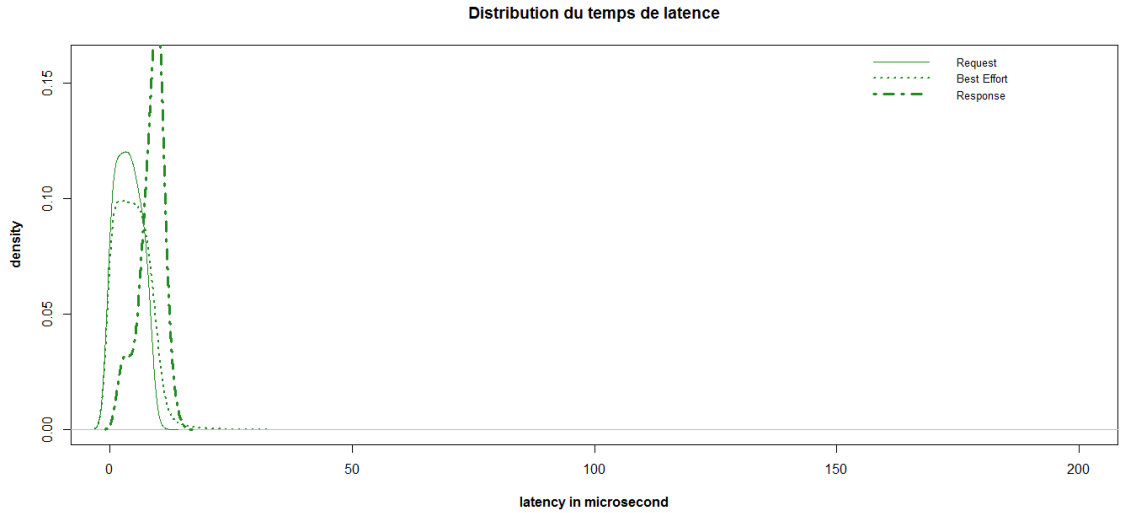


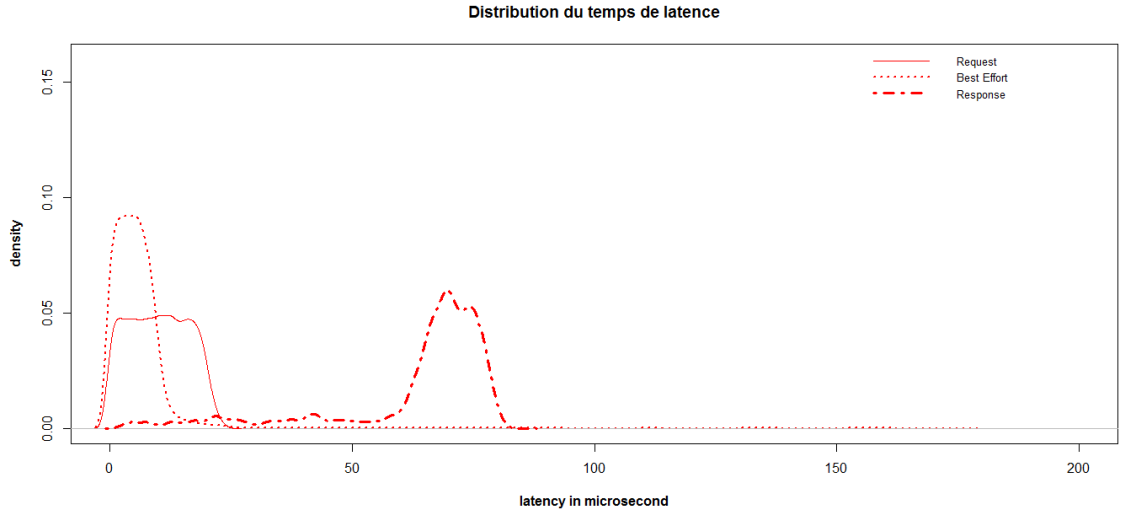
Absolute Priority Distribution





Absolute Priority Distribution

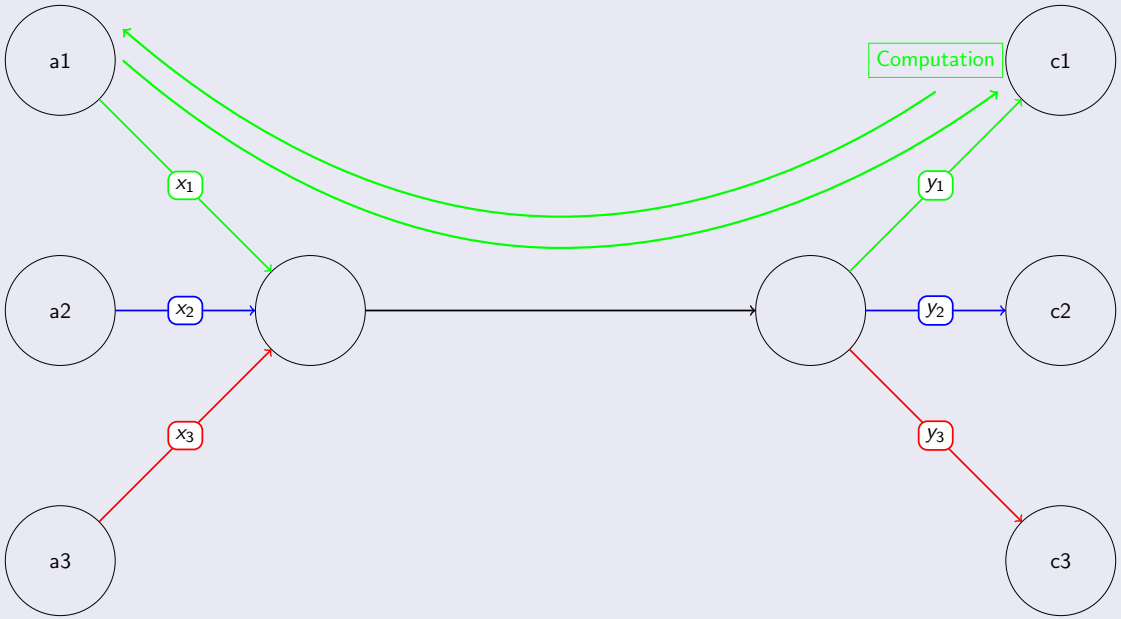




Deterministic sending

Control of the contention : reserving slots on routes.

Some first results on an easier topology



Problem

Problem

Find some time at which send the messages from the BBU/RRH, such that there is no collisions in the network.

NP-hard

On topology with restricted parameters.

Main ideas

No buffering in BBU

- Greedy Policy : ensure a solution for small loads
- Shortest-Longest : ensure a solution for similar length of routes
- Exhaustive search : optimal solutions for few routes

Allowing buffers in BBU

Two greedy parts:

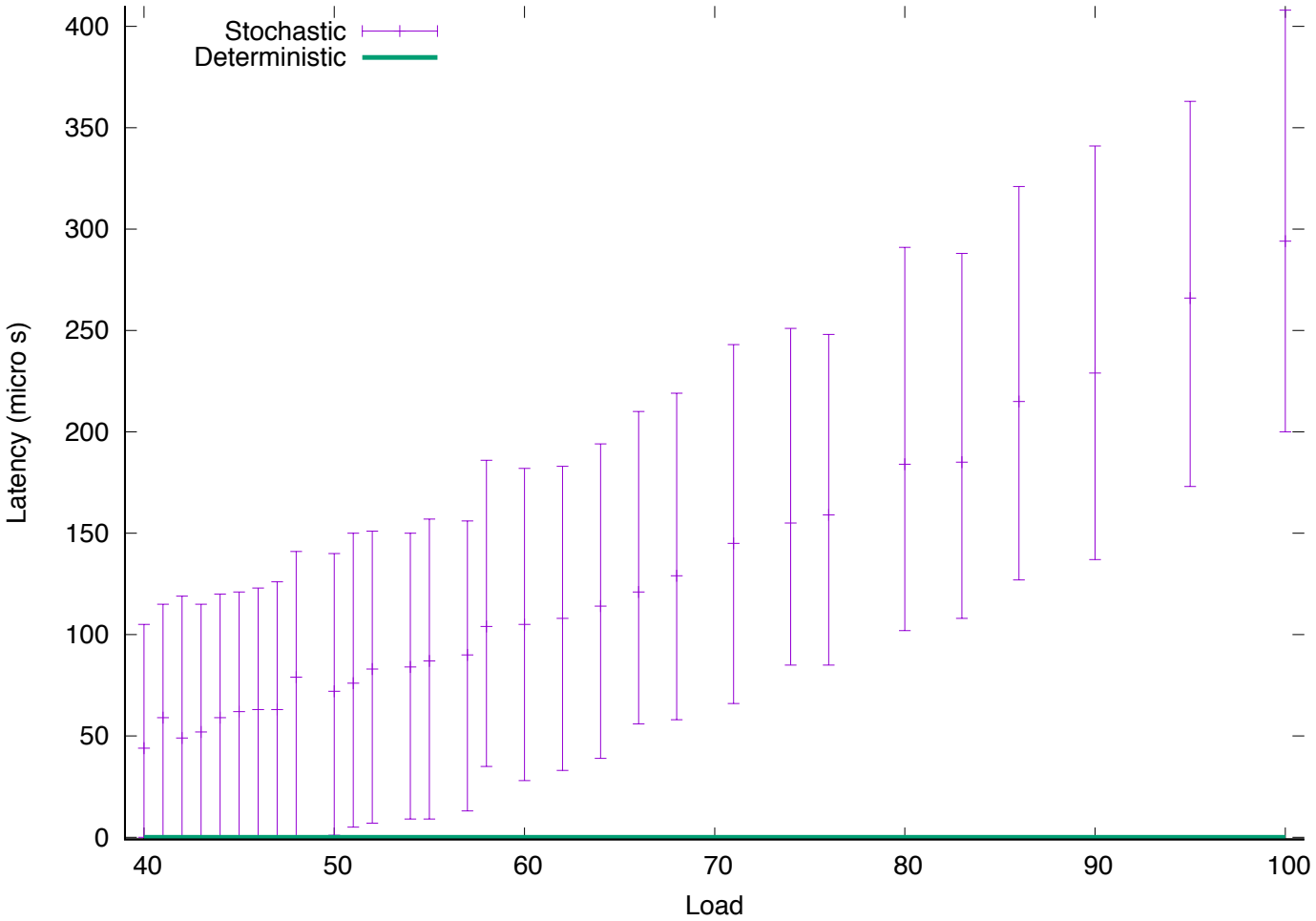
Way forward

- Multiple random sendings

Way backward

- Greedy Algorithm
- Adapted scheduling algorithm

Deterministic vs Stochastic



Future work

1. Adapt the previous algorithms to the ring.
2. Study the impact of reservation on the best effort traffic.