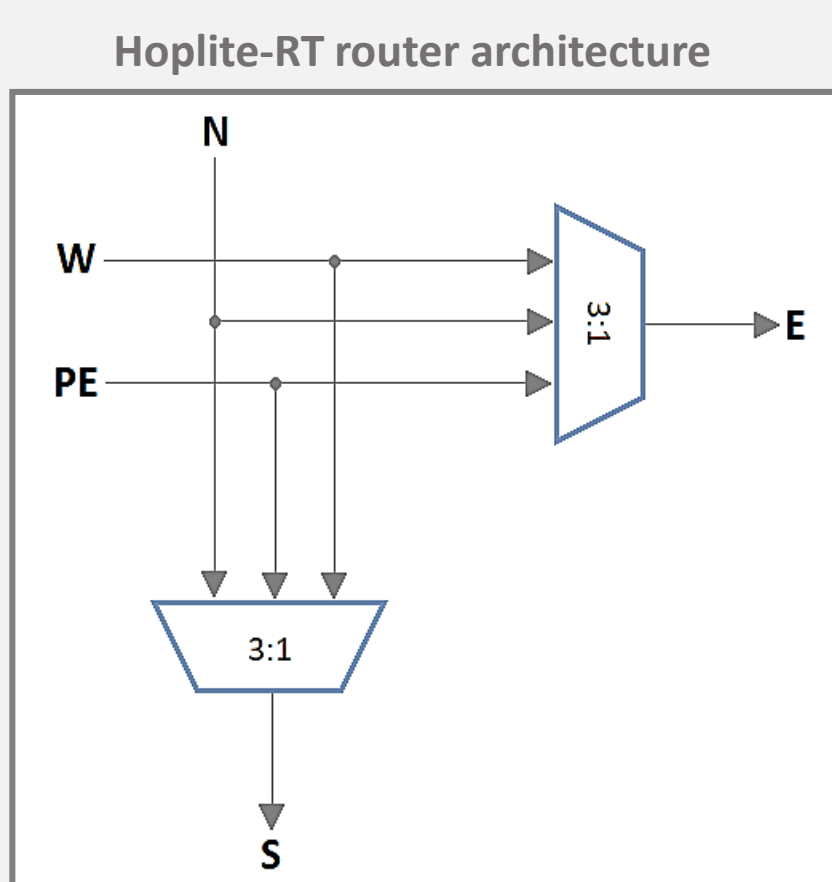


# Design and implementation of an FPGA-based NoC for Real Time Systems

## Motivation

- Most of the **NoC designs** found in the literature are **expensive** to implement in FPGA platforms and their complexity renders their **analysis very complex**.
- **Hoplite-RT** is a **new buffer-less NoC design** based on the notion of **deflection** (see below) with **bounded packet WCTT**. However, the **WCTT** may become **large** as the number of deflections grows.
- Hoplite-RT **does not** allow to **associate** different **priorities** to packets, and hence quality of services.

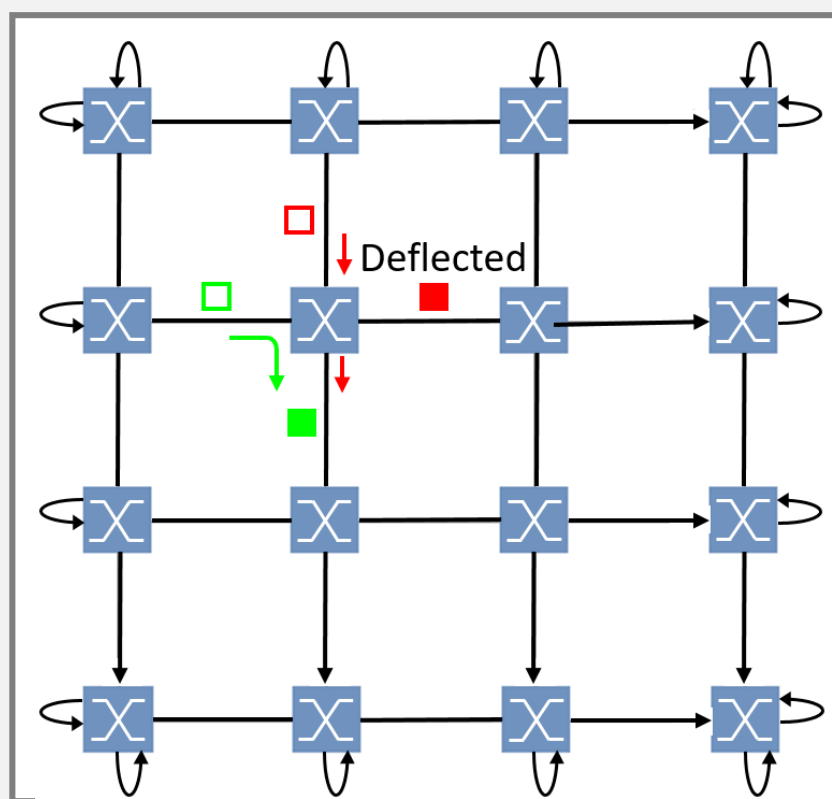
## Background on Hoplite-RT<sup>1</sup>



Network topology: **Unidirectional torus**  
Routing policy: Variant of **X-Y routing**

- If two packets coming from the West and North ports **conflict** for the South port, the North packet is **deflected** toward to the **East port**.
- A packet suffers at most **one deflection** after each hop on the Y-axis.

Hoplite-RT network topology + example of deflection



$$wc_{TT} = h_x + h_y + (h_y \times S_x) + 2$$

Distance travelled by the packet on the X-axis:  $h_x$   
Distance travelled by the packet on the Y-axis:  $h_y$   
Number of routers on the X-axis:  $S_x$

$$h_x = (x_d - x_o + S_x) \bmod S_x$$

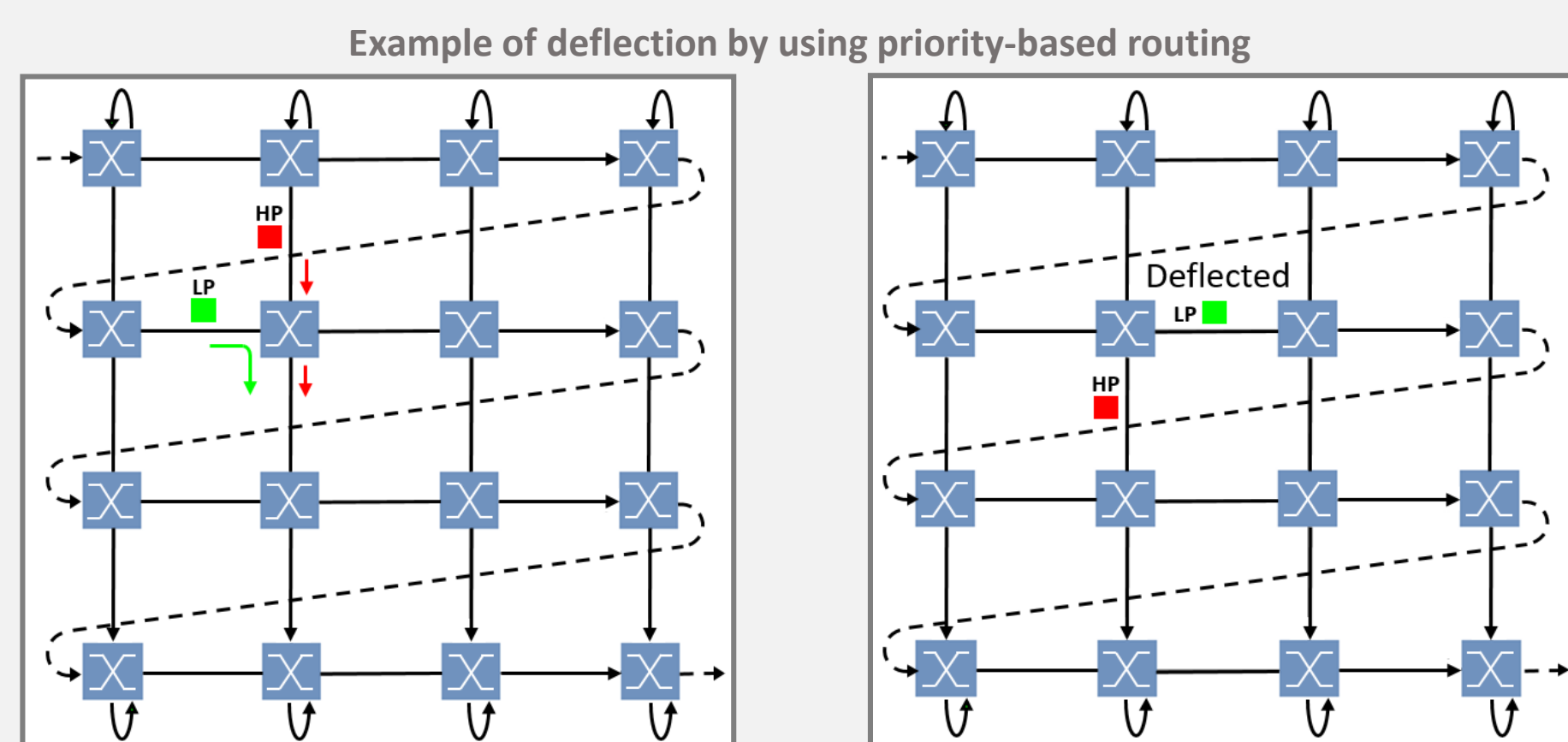
X coord. of the destination router:  $x_d$   
X coord. of the origin router:  $x_o$

$$h_y = (y_d - y_o + S_y) \bmod S_y$$

Y coord. of the destination router:  $y_d$   
Y coord. of the origin router:  $y_o$   
Number of routers on the Y-axis:  $S_y$

## Priority-based routing

- A two-priority level (Low and High) scheduling scheme.
- Each packet priority is encoded in its most significant bit.

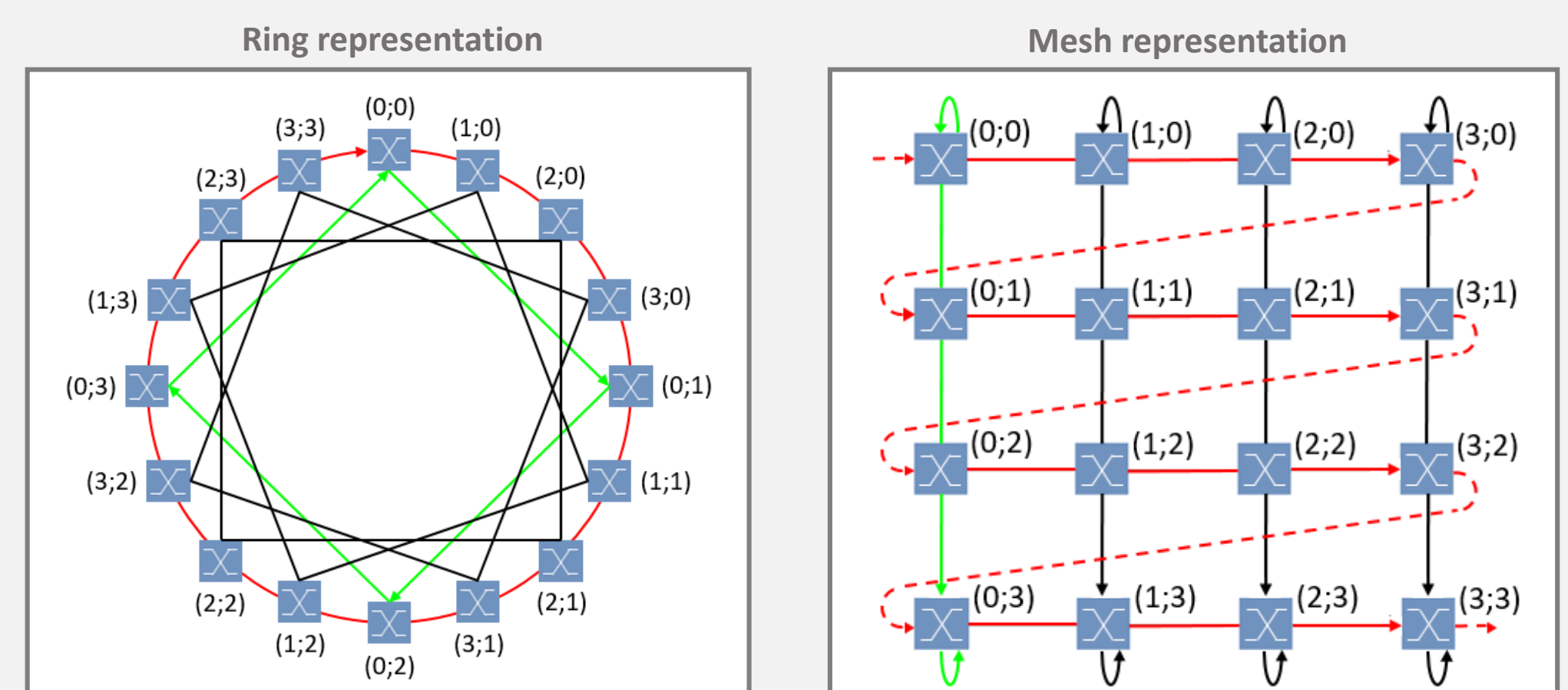


*WCTT of high priority packets is independent from low priority packets.*

## Contributions

### New network topology

- **Unidirectional ring with bypasses**.
- Packets always **move towards** their destination.



*WCTT of low priority packets remain bounded.*

### New WCTT bound

$$wc_{TT} = \underbrace{n_{hops}}_{\text{Number of hops in a network with zero load}} + \underbrace{n_{def}}_{\text{Maximum number of deflections}} \times \underbrace{c_{def}}_{\text{Cost of a deflection}}$$

- Number of hops in a network with zero load

$$n_{hops} = h_r + h_b + 2$$

Number of hops on the ring:  $h_r$   
Number of hops on the bypasses:  $h_b$

$$h_r = (x_d - x_o + S_x) \bmod S_x$$

$$h_b = (y_d - y'_o + S_y) \bmod S_y \quad y'_o = \begin{cases} y_o, & x_d \geq x_o \\ y_o + 1, & x_d < x_o \end{cases}$$

Y coord. of the router at which the packet stops travelling on the ring and starts using bypasses:  $y'_o$

- Maximum number of deflections

$$\text{For high priority packets } \left. \right\} n_{def} = \left\lfloor \frac{h_b}{2} \right\rfloor \quad \text{For low priority packets } \left. \right\} n_{def} = h_b$$

- Cost of a deflection

$$c_{def} = S_x - 1$$

*In most cases, the WCTT of high priority packets is divided by two and the WCTT of the low priority packets does not exceed that of the original Hoplite-RT.*

### Resources utilization

Router	LUTs	FFs
Hoplite-RT router	85	139
Hoplite-RT router + Priorities	86	139
Hoplite-RT router + Priorities + New network topology	88	139

*Very limited additional hardware cost.*

## References

[1] S. Wasly, R. Pellizzoni, and N. Kapre, "HopliteRT: An efficient FPGA NoC for real-time applications," in 2017 International Conference on Field Programmable Technology (ICFPT), Dec 2017, pp. 64–71.

## Future work

- We plan on developing solutions to ensure that packets received at the destination router are received in the same order as they were emitted at the origin router.
- We are also working on solutions to map applications on nodes and configure packet injection rates at each node.