



Distributed Alteration of Messages for On-Chip Network Debug

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Designing Correct NoCs

General router architecture

Route Computation (RC)

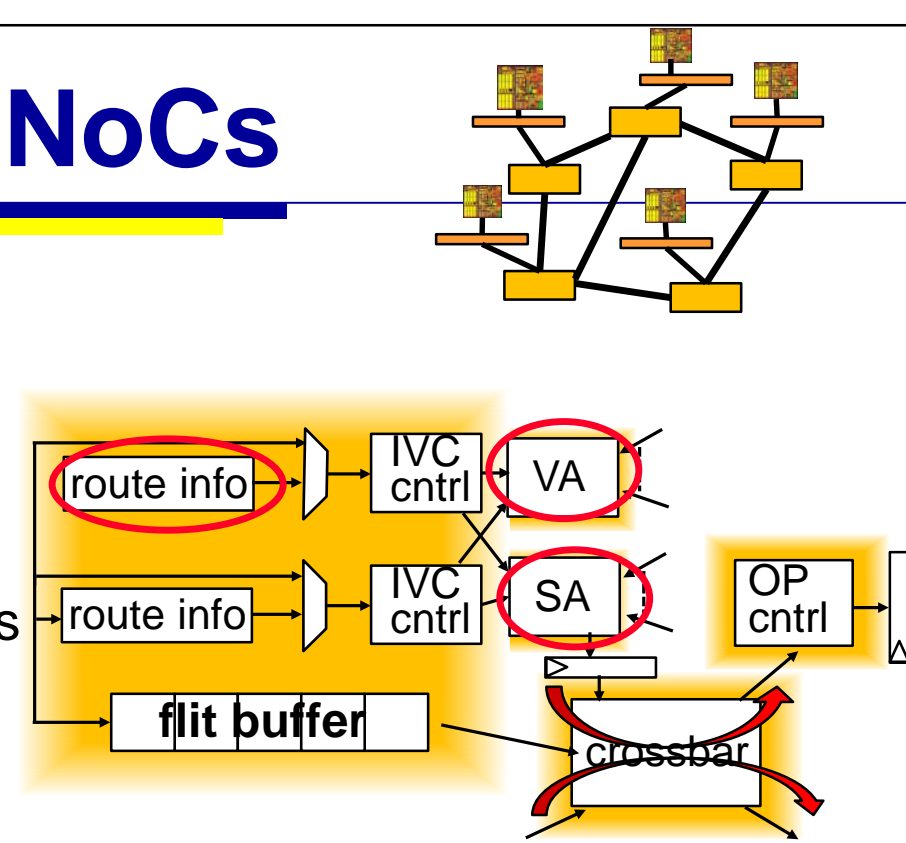
determine candidate output port(s)

Virtual Channel Allocation (VA)

assign output VCs to packets at input VCs

Switch Allocation (SA)

assign switch time slots to buffered flits



Challenges in NoC correctness

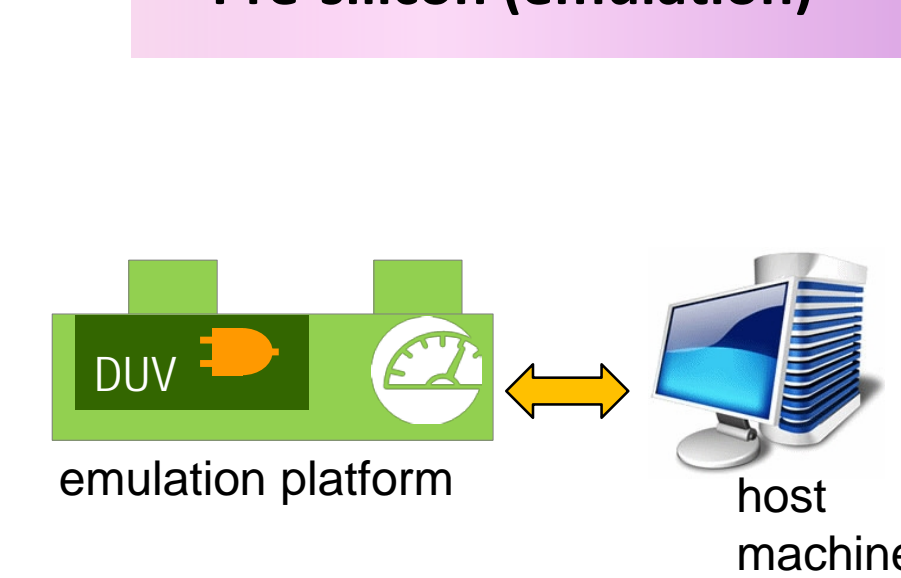
- Large and distributed system
- Intricate communication algorithms
- Router architectures with advanced features

Functional errors
Performance violations

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Verification with Hardware Platforms

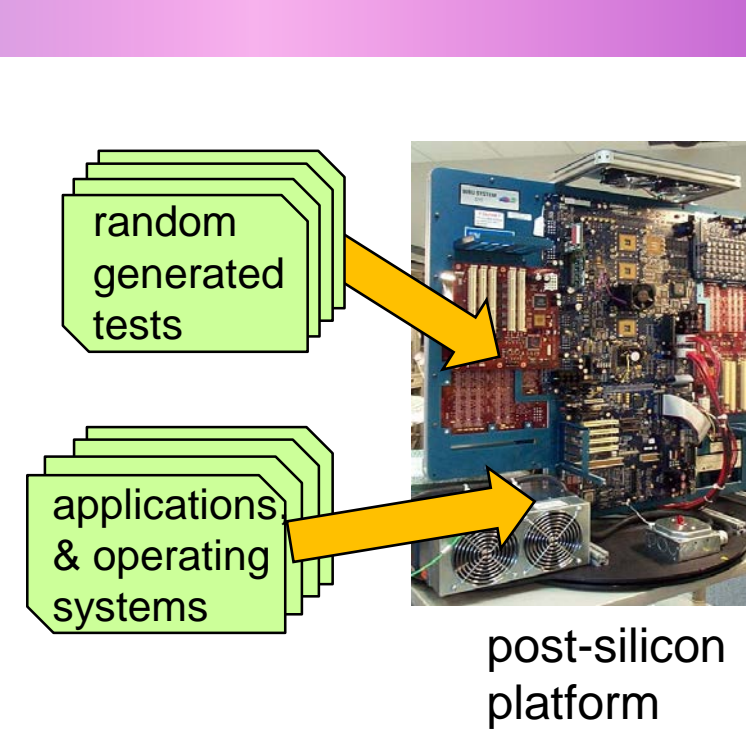
Pre-silicon (emulation)



limited observability of internal signals and design operations

difficult diagnosing and debugging of errors

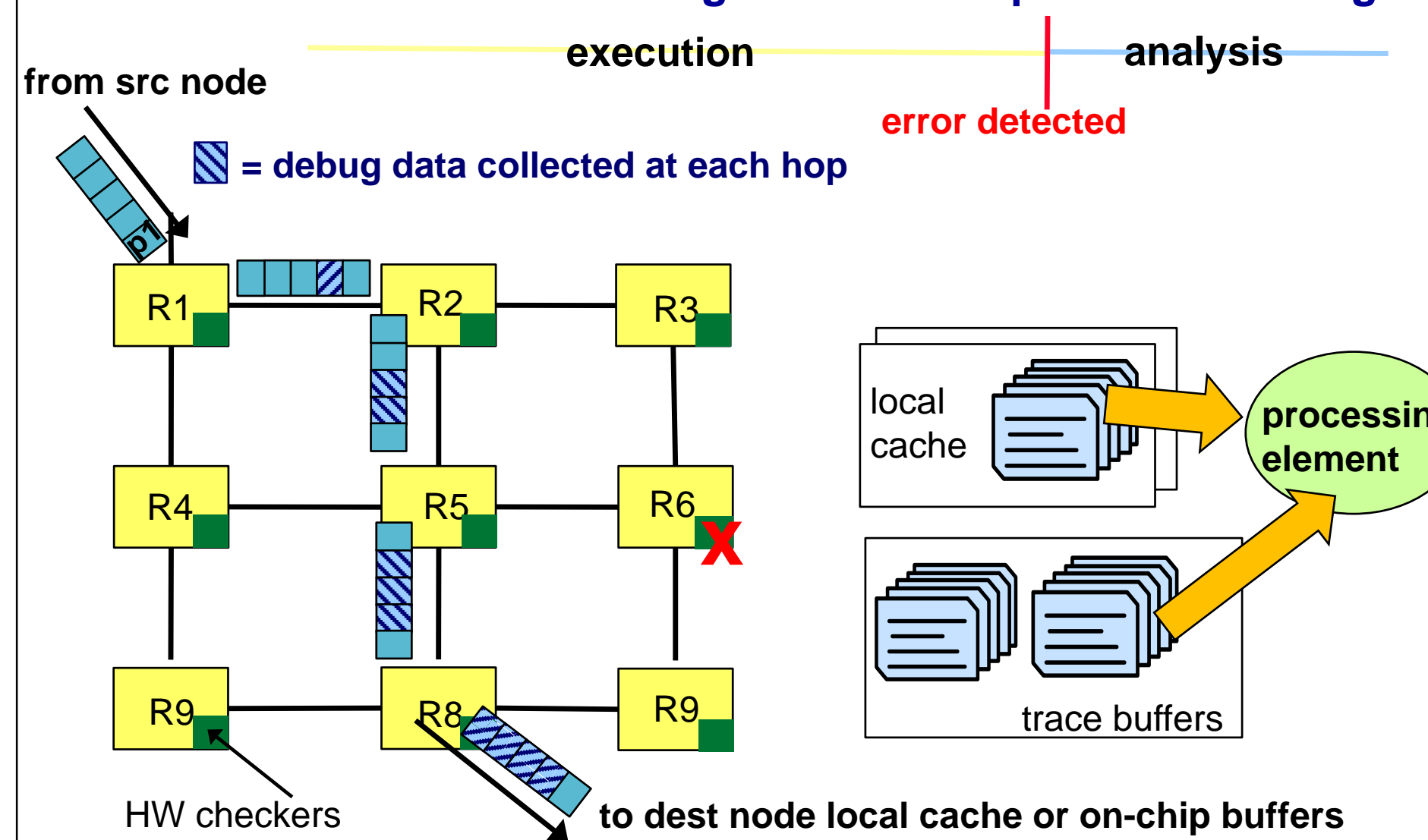
Post-Silicon



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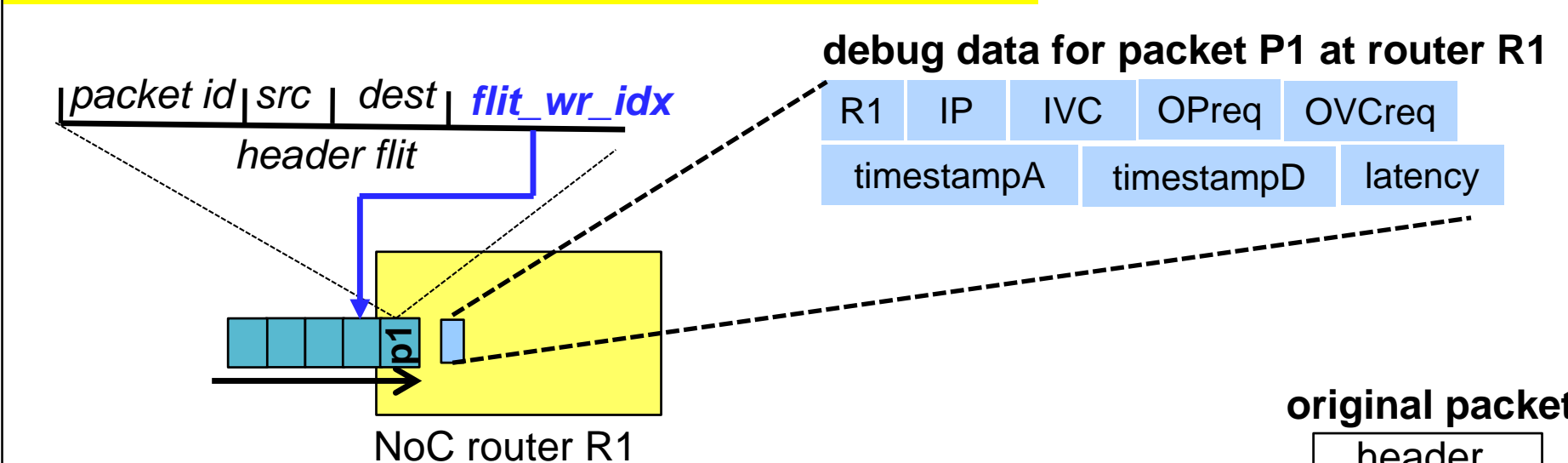
Our Solution: DiAMOND

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Debug Data Collection



What if packet does not have enough space?

1. Drop remaining

header	
1	2
3	4

2. Append

header	
1	2
3	4
5	6

3. Drop at alternate hops

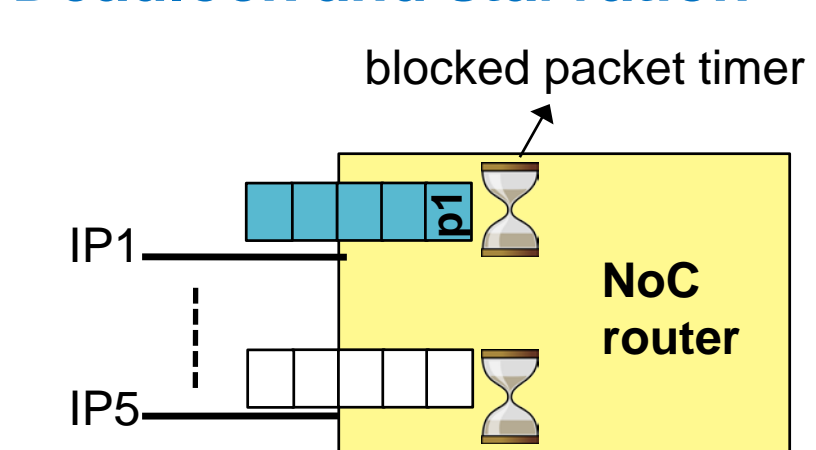
header	
1	2
3	4
5	6

4

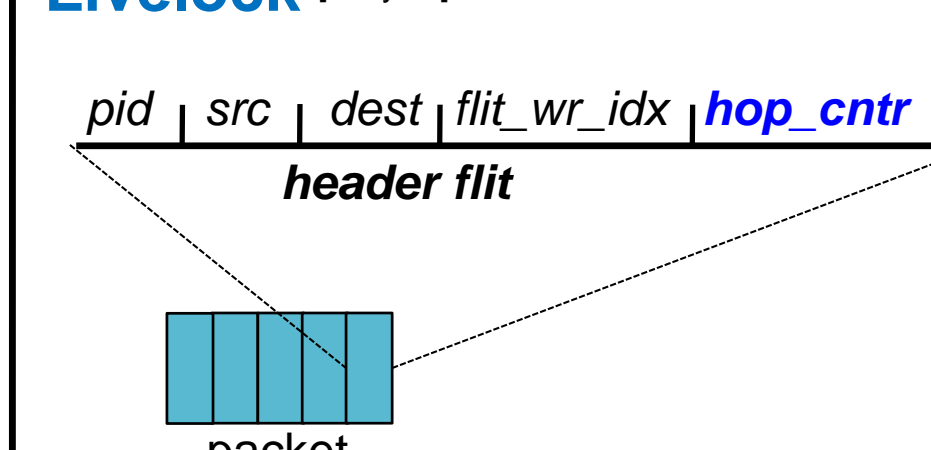
Error Detection Checkers

Fine-grain error detection targeting wide variety of errors:

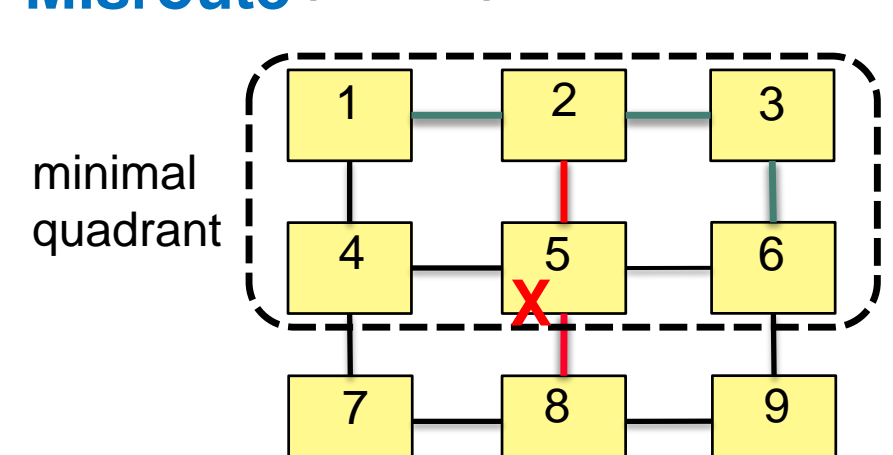
Deadlock and starvation [Anjan'95]



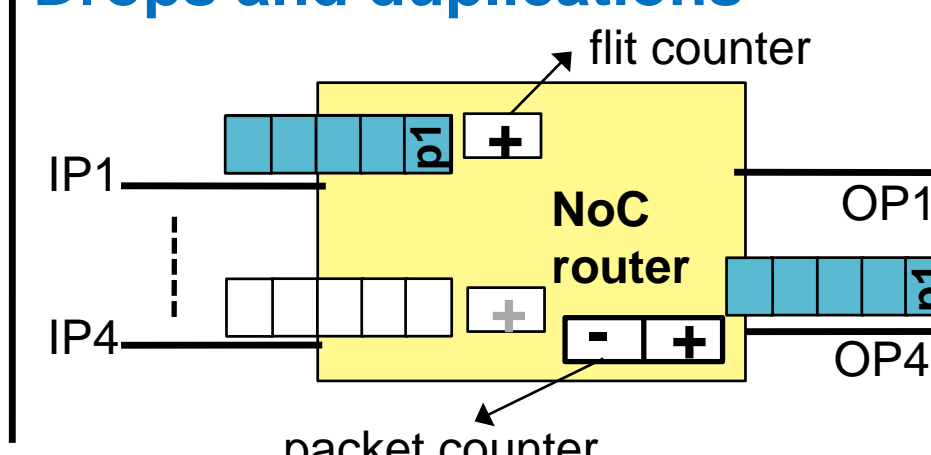
Livelock [Daily'03]



Misroute [Ghofrani'12]



Drops and duplications [Ghofrani'12]



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Debug Data Analysis

If an error is flagged, debug data is analyzed

Local Processing:

- Reconstruct each packet's path
- Analyze packet latencies within routers
 - determine routers and execution periods of interest
 - identify livelock bugs, starvations, misrouted segments, bugs in switch allocation and virtual allocation

Global Processing

- Reconstruct events within each router
 - generate a partial order of interactions across routers

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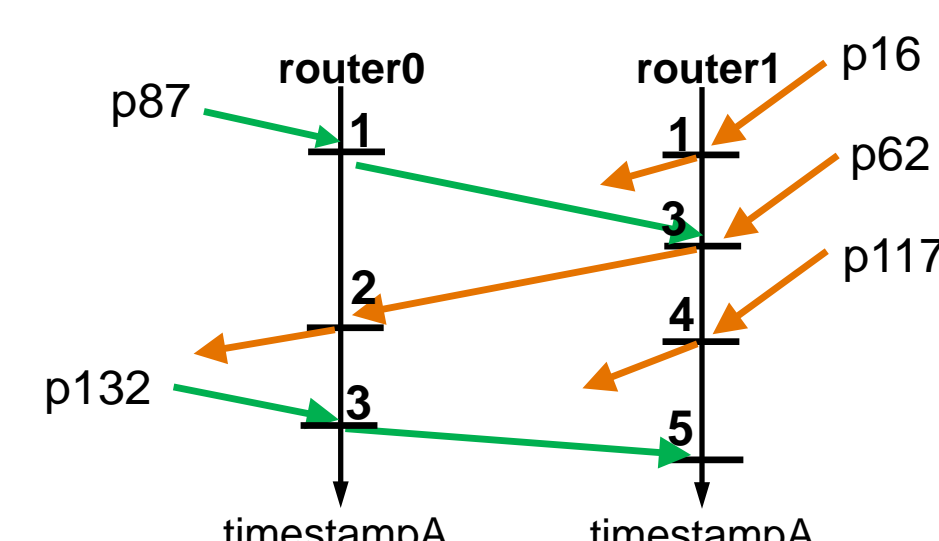
Evaluation: Enhanced Observability

Packet path reconstruction

	drop remaining	drop at alternate hops	append
PARSEC network flow	83.76%	96.54%	100%
Uniform traffic, 5 flits/packet	87.1%	97.6%	100%

Packet interactions

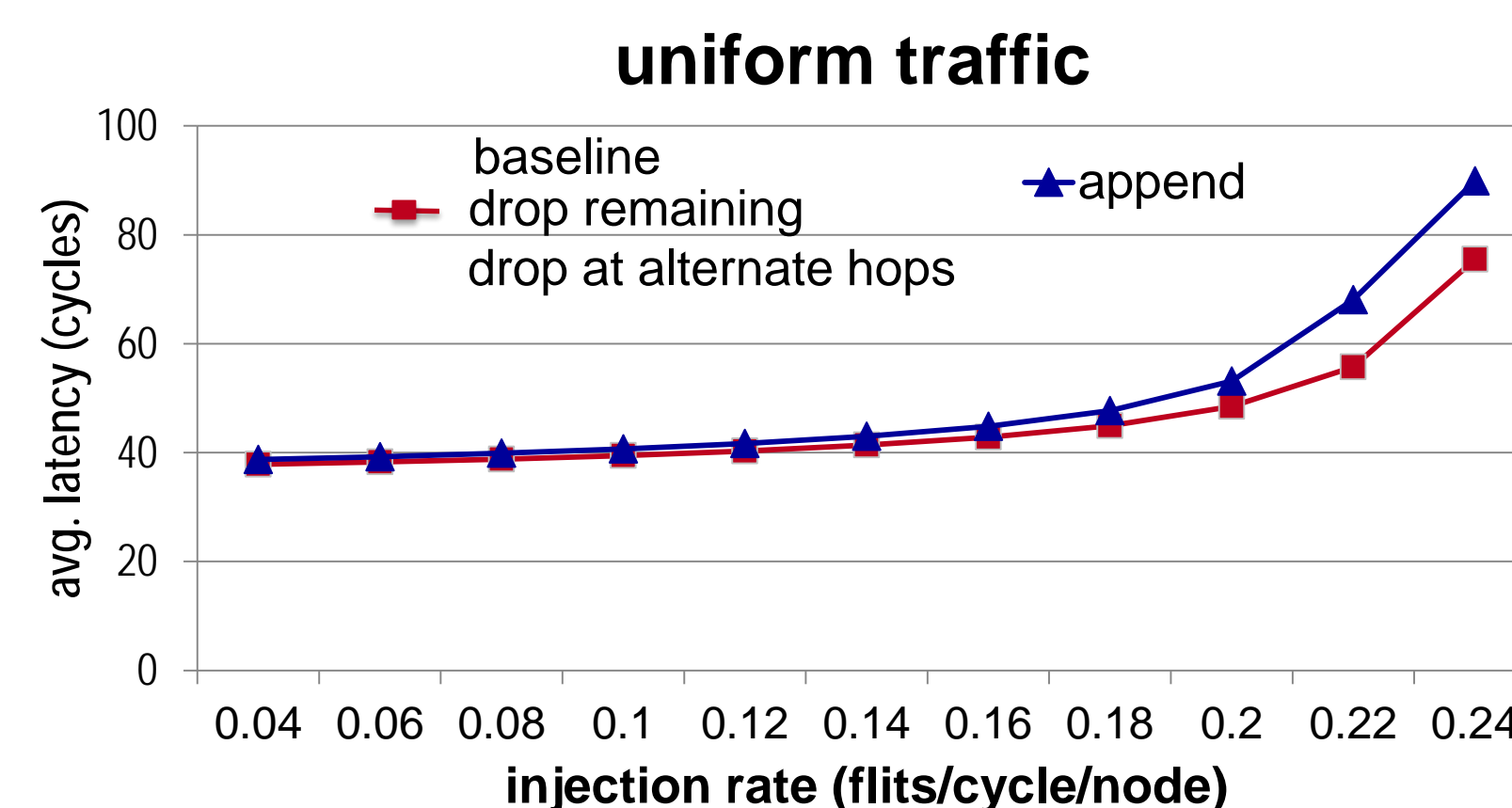
- packets ordered by increasing execution time (timestampA)
- common packets establish a partial order of events



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Network Latency with DiAMOND

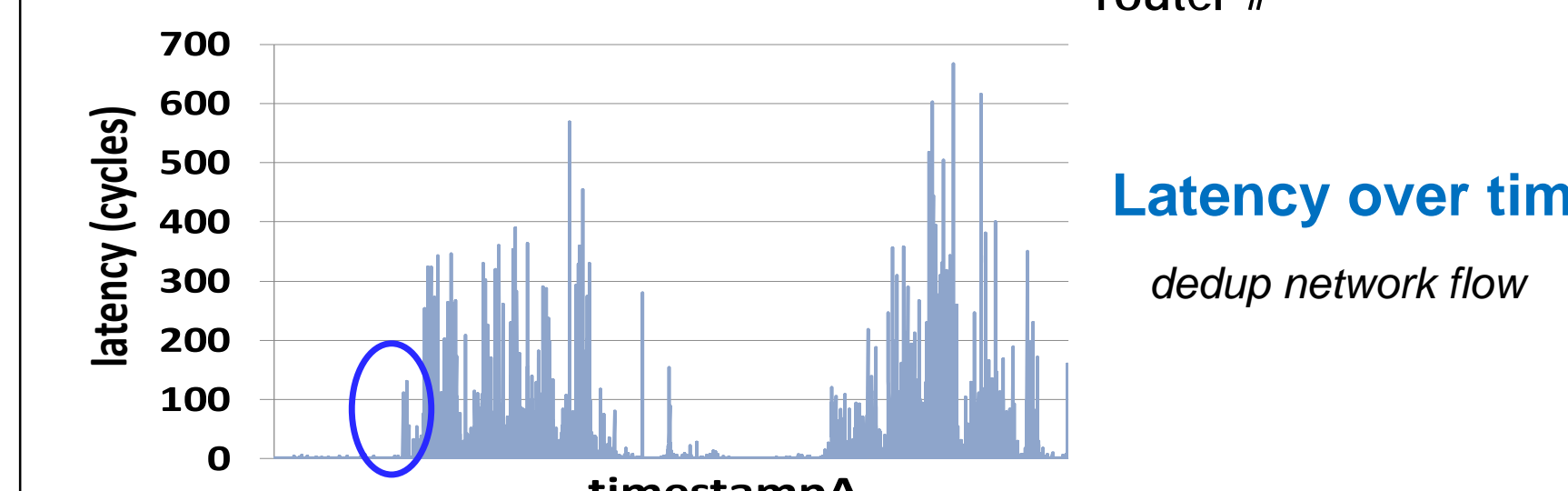
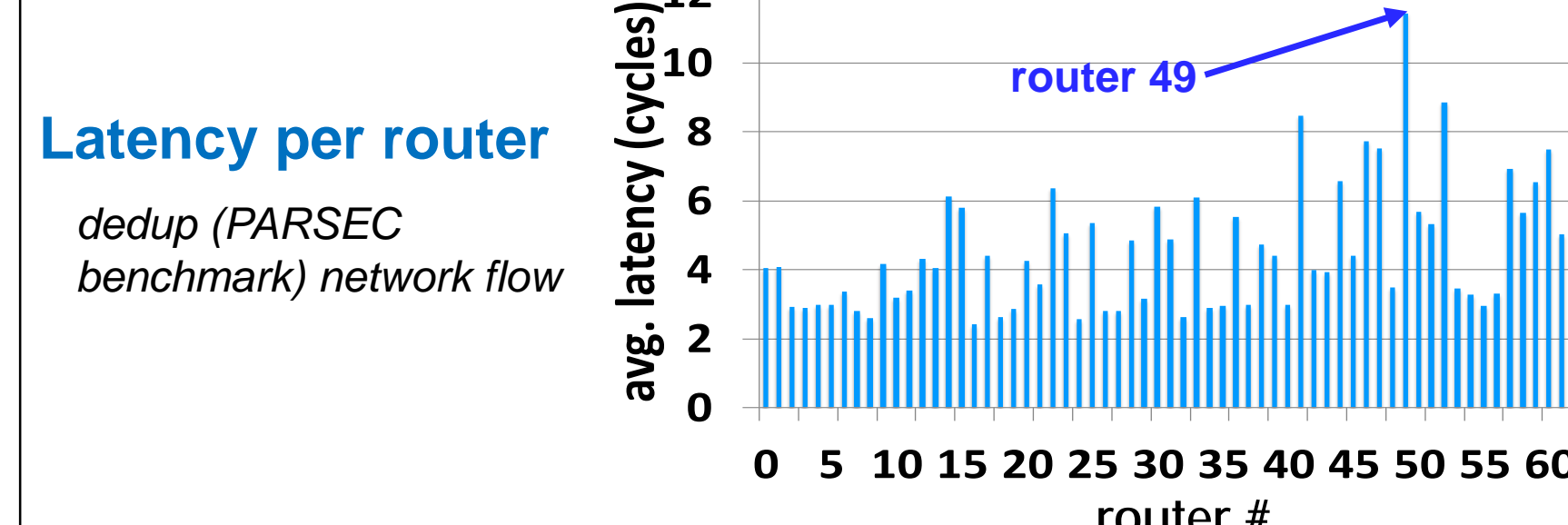
The append mode of operation increases the NoC average packet latency



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Case Study: Performance Analysis

Latency per router



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