

Breaking Barriers: Formal Verification in Complex Compressor Controller

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Outlines



Introduction



Design overview



Verification challenges



Strategies



Results



Conclusion



Future scope

Introduction



**Data as a
Catalyst**



**Storage
Limitation**



**Data
Compression**



**Compression
Controller**

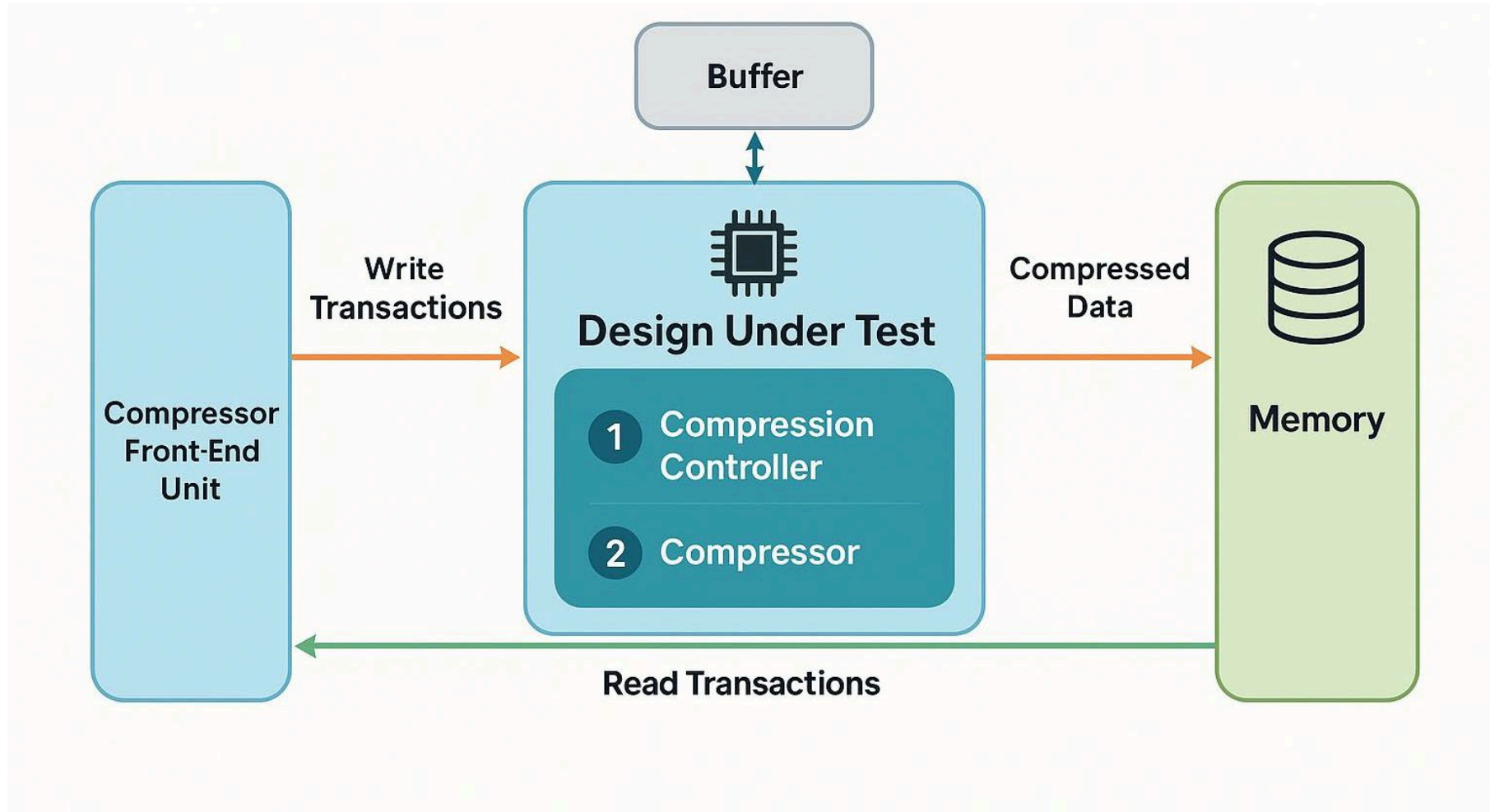


**Complex
Design**

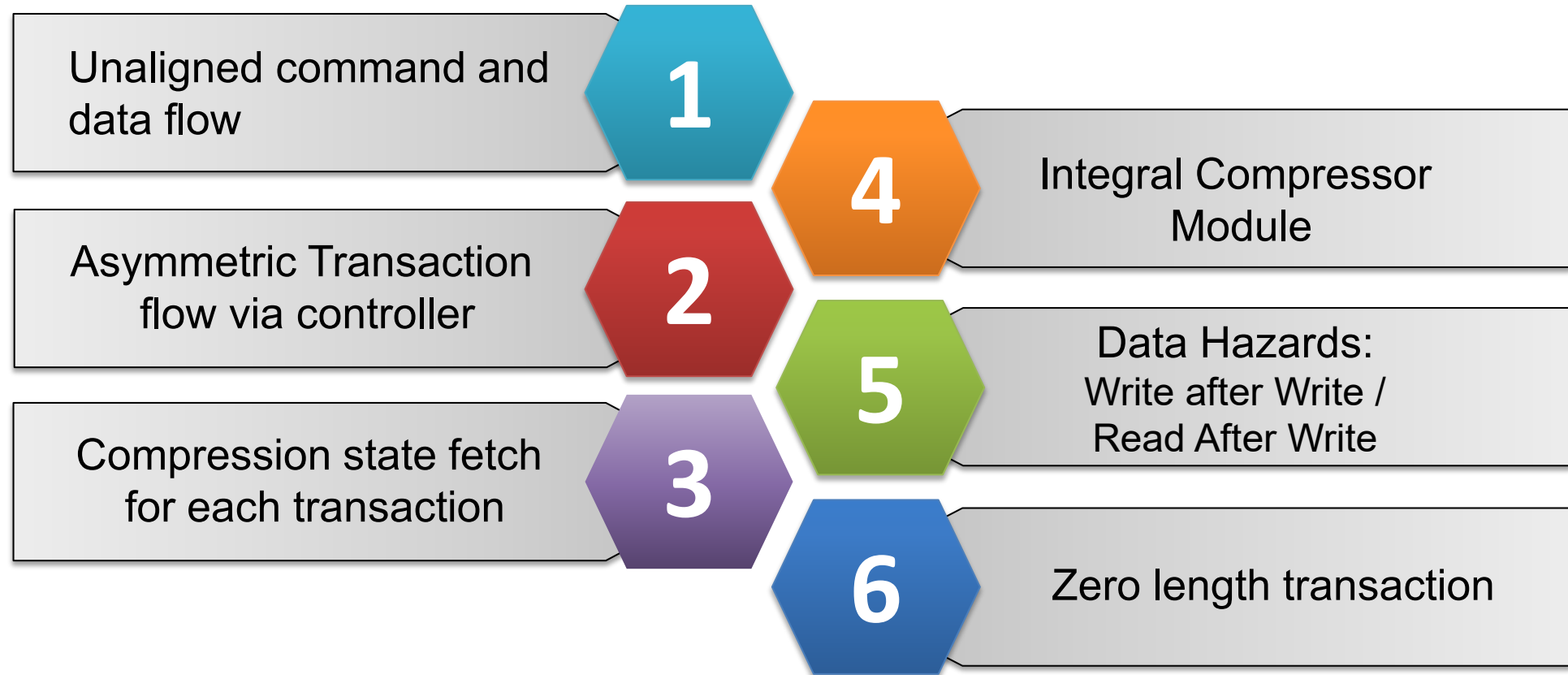


**Verification
& Complexity
Reduction**

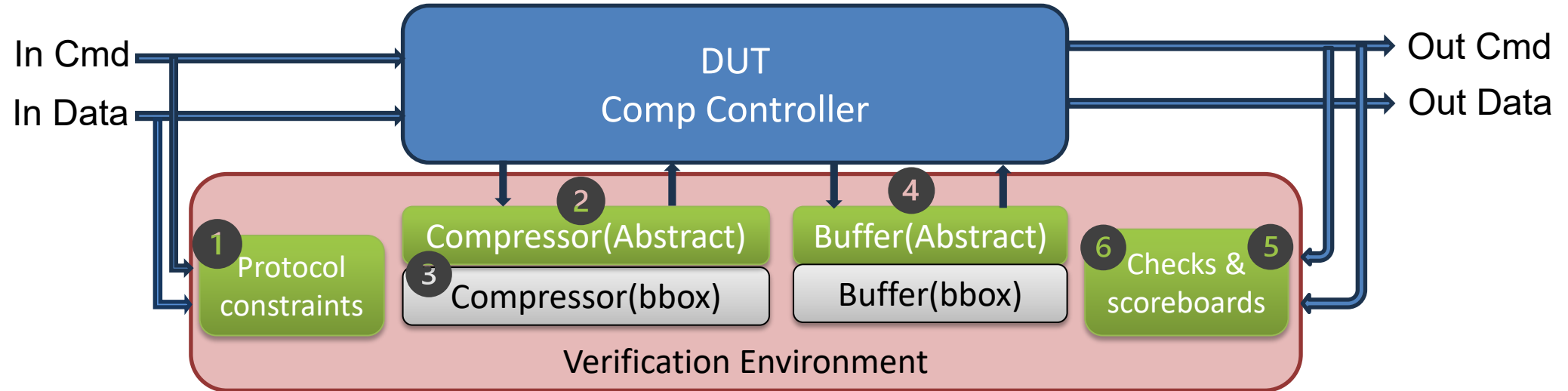
Design Overview



Design Complexity



Verification Strategy



Unaligned cmd and data flow
- Alignment model

1

Asymmetric transaction flow
- Color Coding Algorithm

2

Compression State for txn
- Symbolic & Abstraction

3

Integral compressor
- C2RTL verif. & Abstraction

4

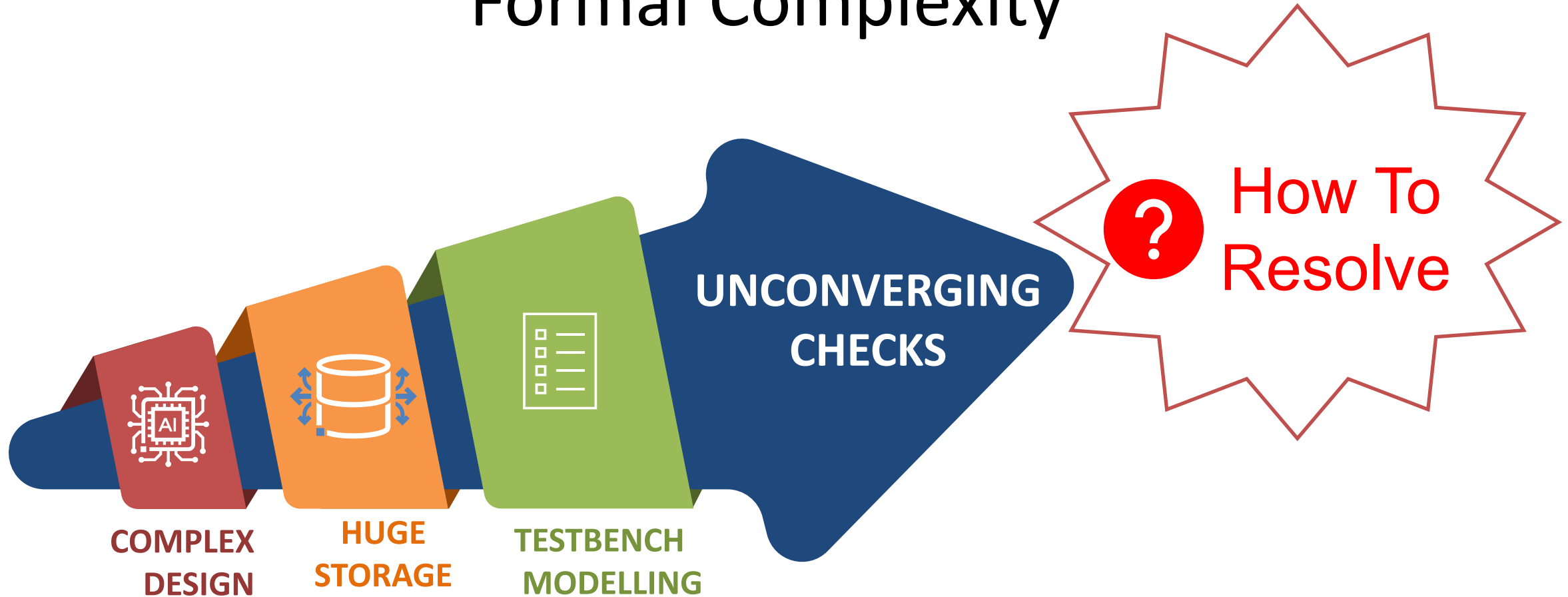
WAW/RAW Hazards
- Symb tracker & integrity

5

Zero Length transaction
- Symbolic txn tracker

6

Formal Complexity



Convergence Techniques

Parameter Reduction

- ❖ Optimizes State Space Exploration
- ❖ Deal with less transactions

1

Abstract Modelling

- ❖ Abstract model for compressor and Buffer
- ❖ Preserve essential properties
- ❖ Improve Scalability

2

Convergence Techniques (Cont.)

Symbolic Tracing

- ❖ Deal with a particular transaction at a time
- ❖ Helpful for E2E checks
- ❖ Reduce the testbench complexity

4

Incremental Flow Checks

- ❖ Multiple Transactions
- ❖ Multiple Paths
- ❖ Case Splitting
- ❖ Narrow down state space

3

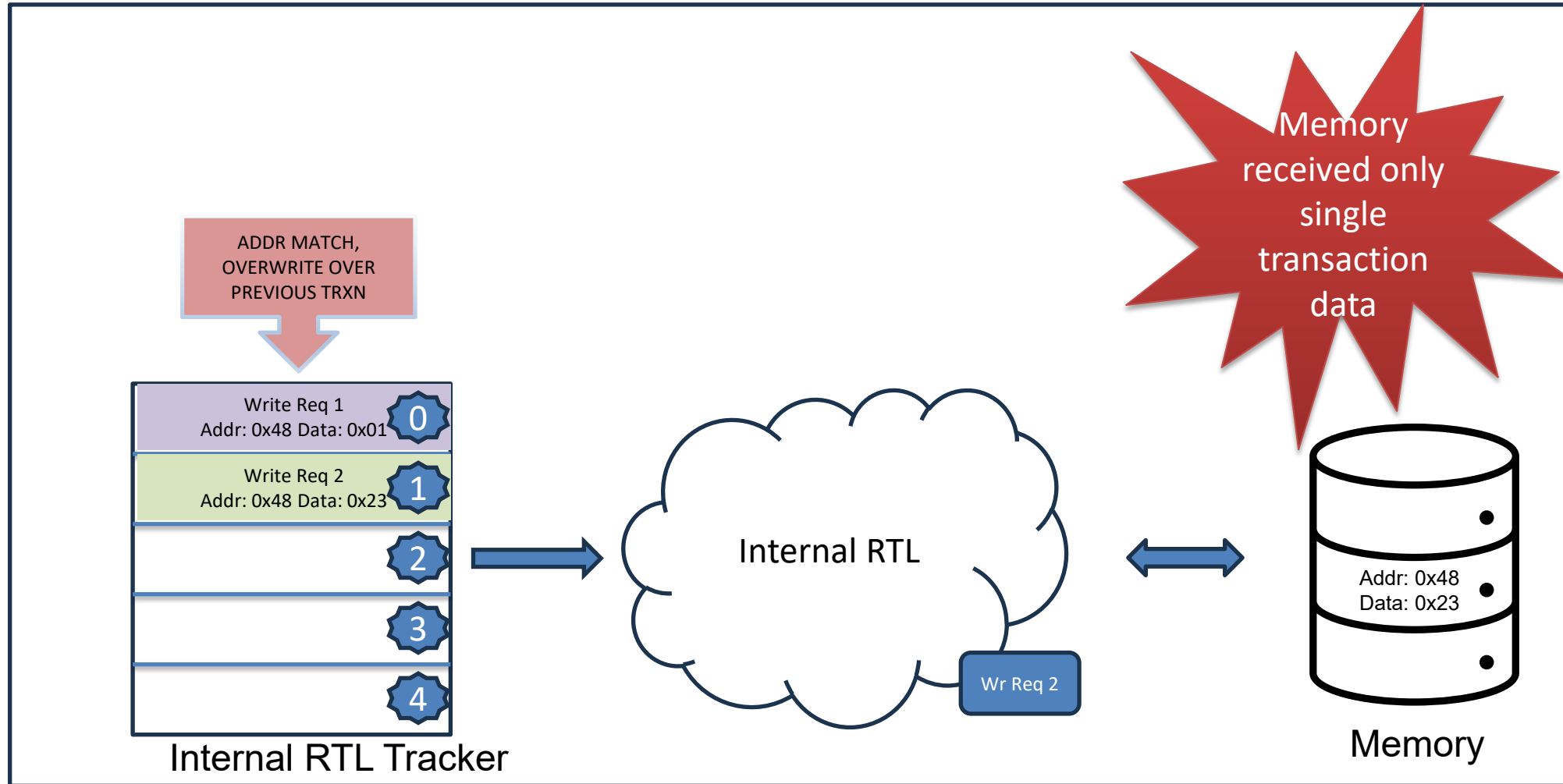
Helper Assertion

- ❖ Set related properties of checkers as helper
- ❖ Run on unbounded checker

5

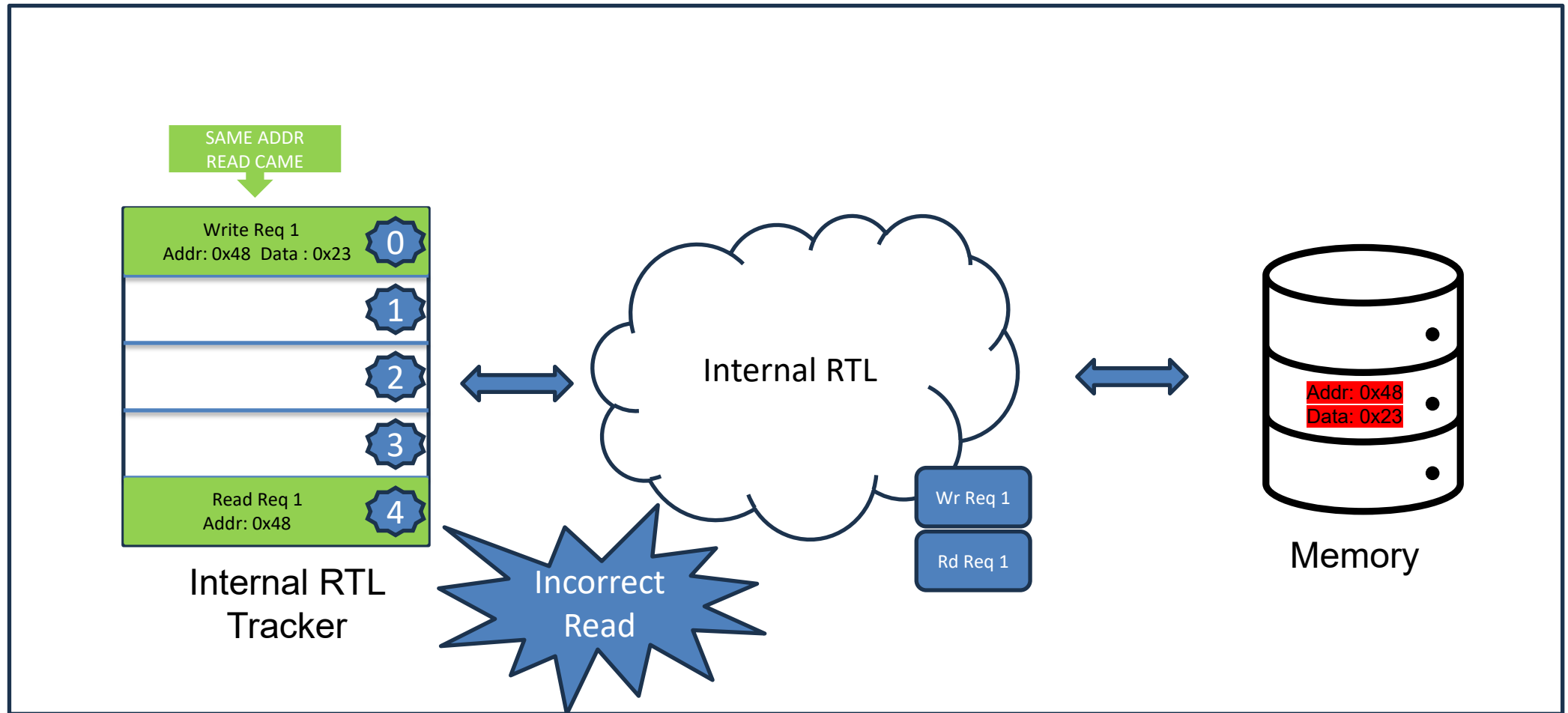
Bug Found Scenarios

WAW Hazard

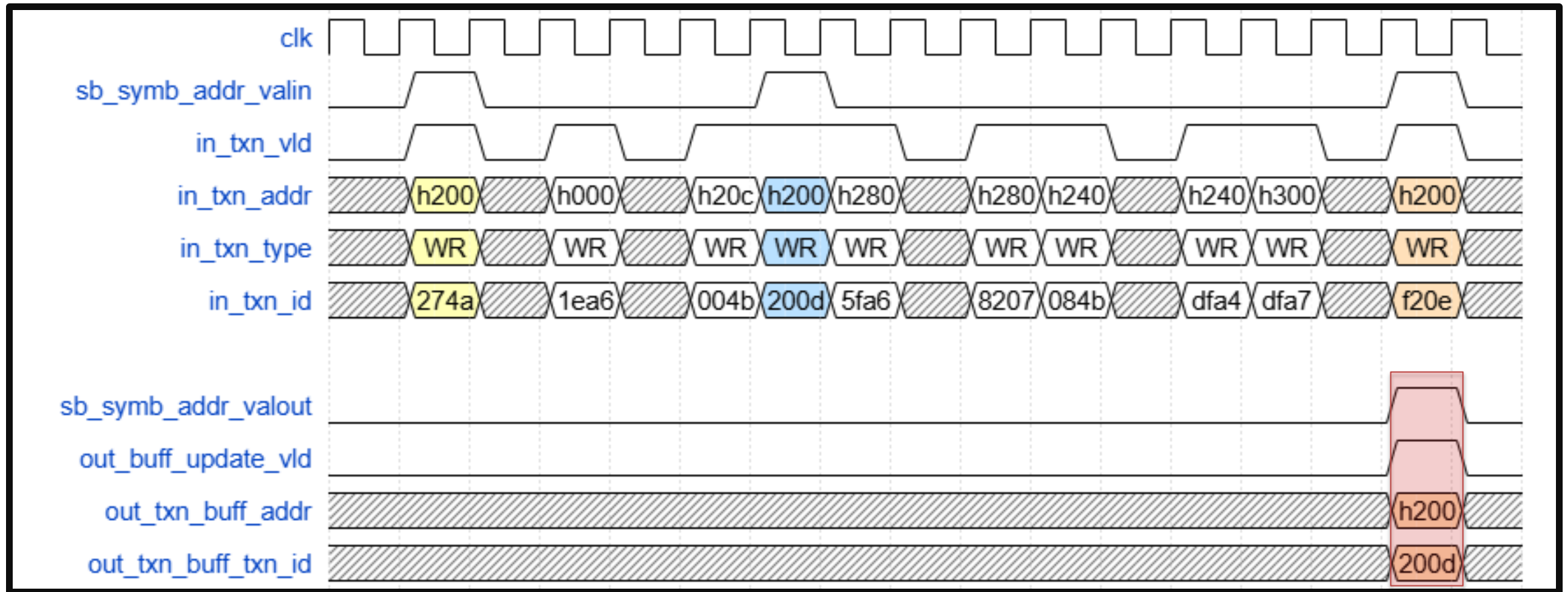


Bug Found Scenarios (Cont.)

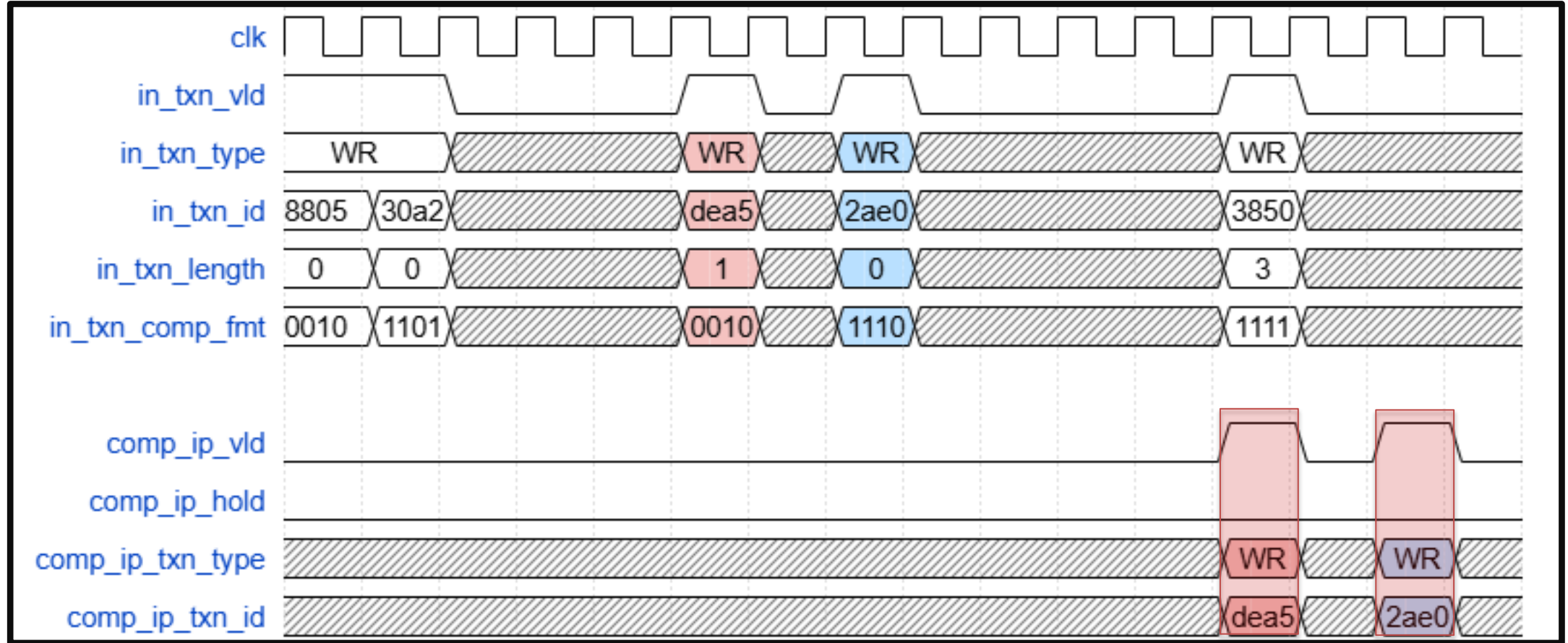
RAW Hazard



Waveform : WAW



Waveform: Missed Zero length



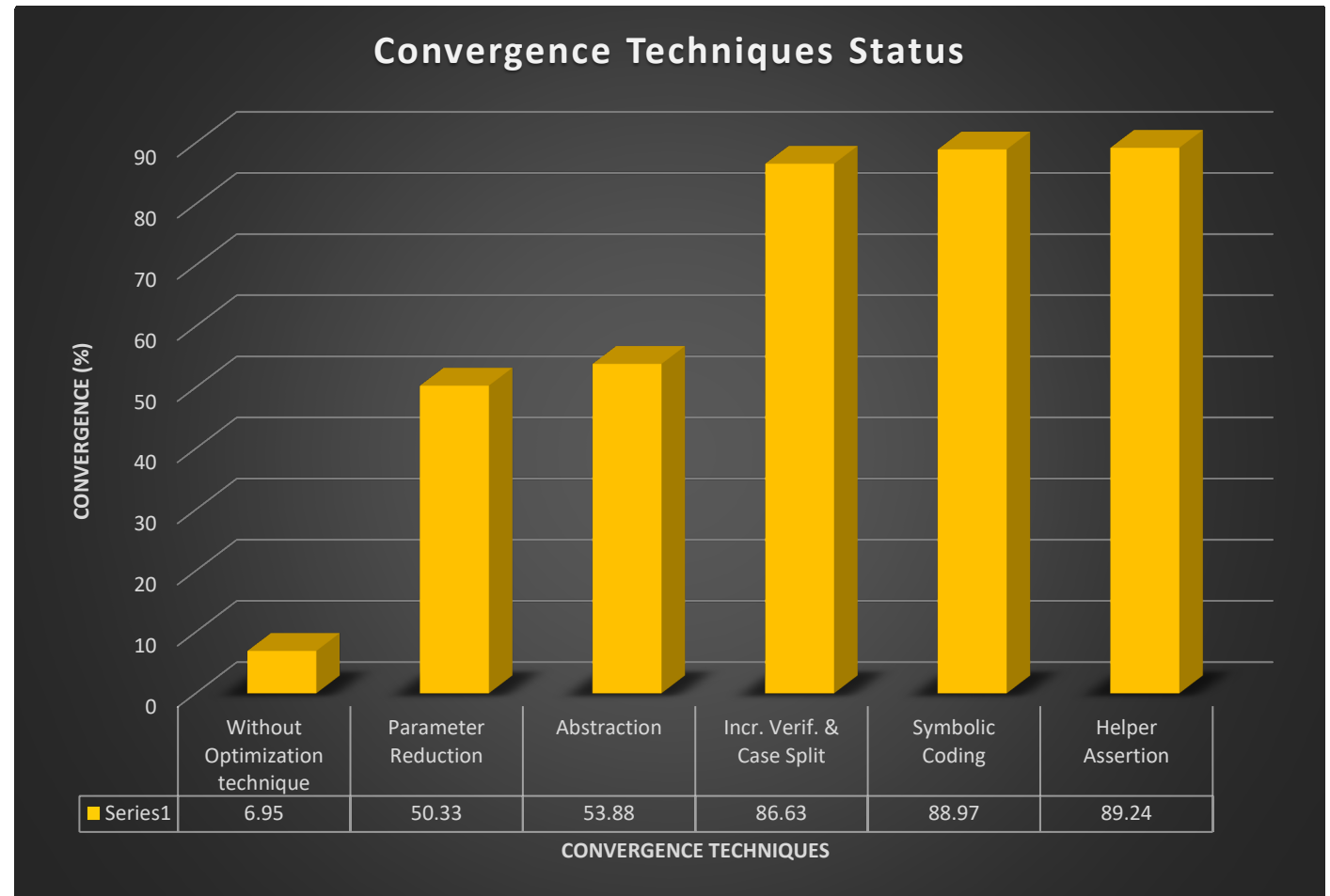
Results

Total Checks : 1496

Bug Counts : 8

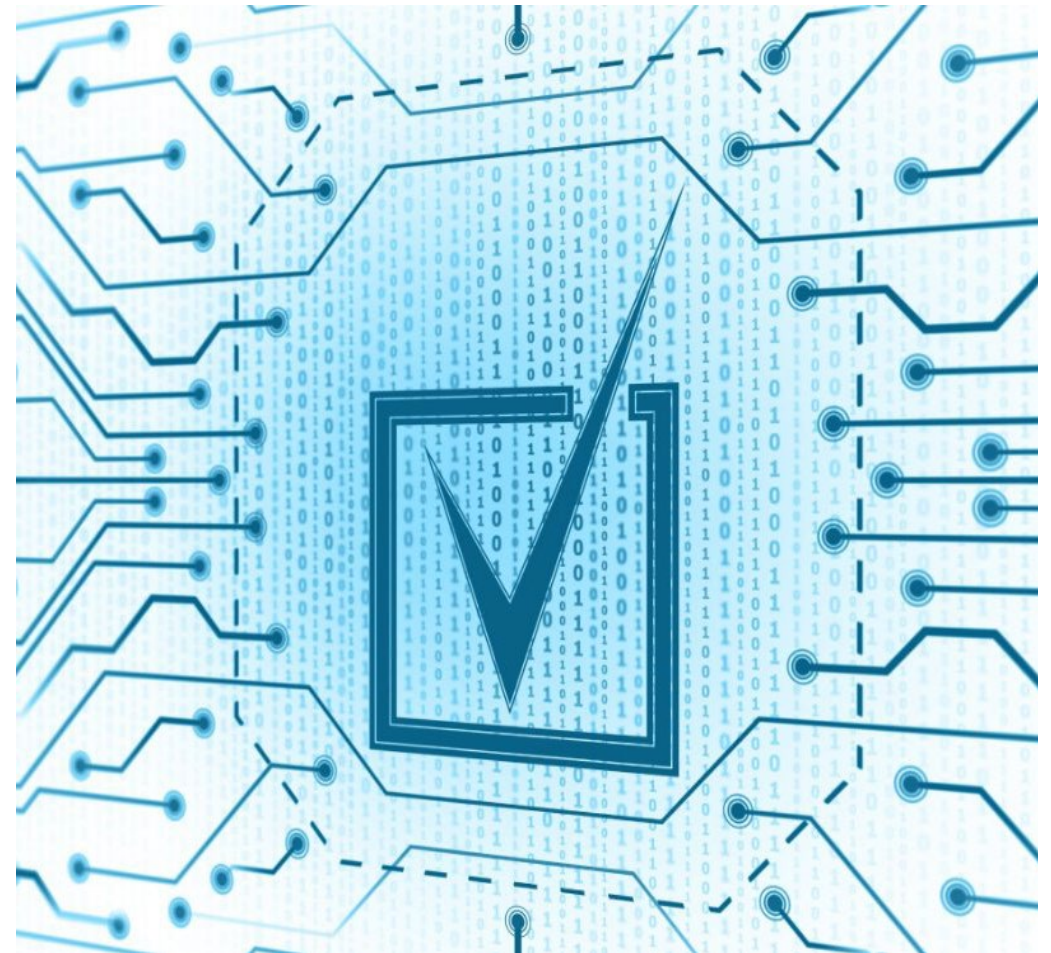
*Convergence Rate
boost up using
techniques: 82.29 %*

Overall effort 1.5 quarter



Conclusion

- **Verification Challenges**
 - Complex designs face issues.
- **Effective Verification Strategies**
 - Techniques simplify verification processes.
- **Advanced Convergence Methods**
 - build robust formal environments to catch corner-case bugs.
- **Confidence in Design Quality**
 - Systematic formal verification transforms complexity into confidence



Future Work



Explore other convergence techniques to achieve full convergence



Extend this verification strategy to other design with similar complexity



Use architecture formal for left shift

Questions ??

END