A Meta-Model-Based Approach for Semantic Fault Modeling on Multiple Abstraction Levels

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Outline

- Motivation
- Objectives
- Limitations
- Concept
- Simulation
- Conclusion

Motivation - Applications


[2]


[1]

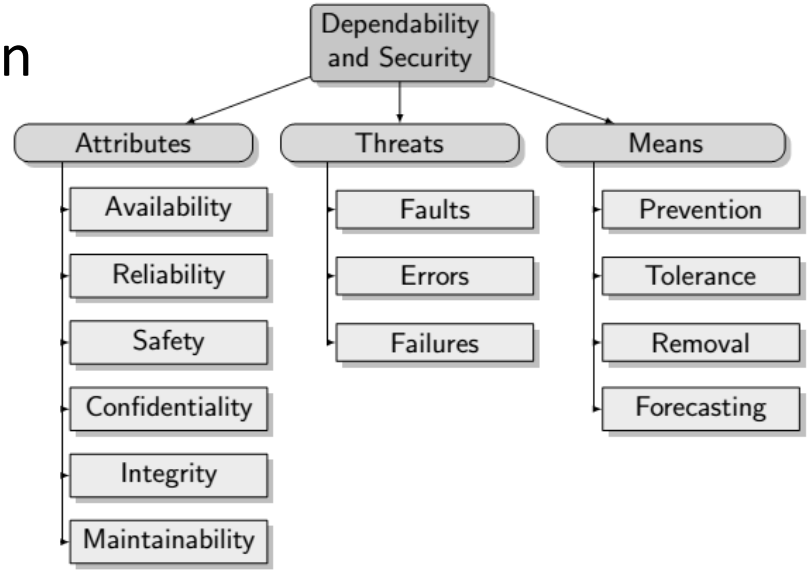
[3]

Electronic devices are crucial in many aspects of modern society, such as:

- Mobility
- Communication
- Health care
- Finance

Motivation - Challenges

- Error prone transistors, due to technology scaling
- Constant or increasing dependability requirements
- Increasing complexity in design & verification
- Early detection of sensitive

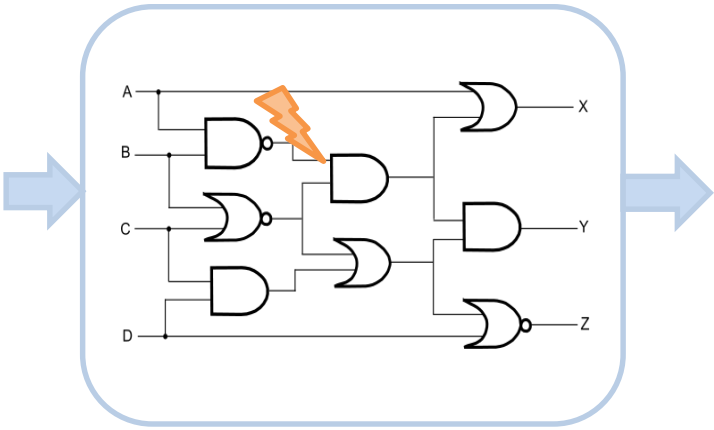


Dependability taxonomy after Laprie [1]

Motivation – Fault Injection

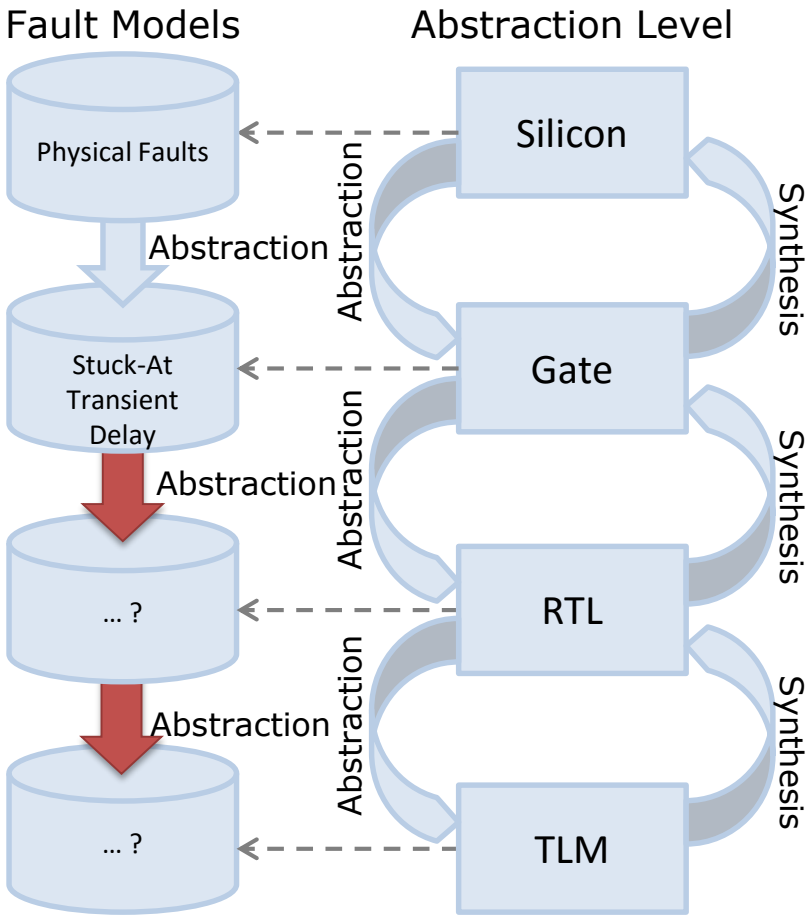
Well-known technique to measure the impact of resilience techniques [2]

- Deliberate insertion of faults into a system
- Determine system's response
- Widely used at the logic gate level
- Missing fault models at higher abstraction levels



Logic Gate Level

Objectives



A structured approach to define fault models:

- Enable early incorporation in the design process
- Reduce time-to-market
- Evaluate fault tolerance techniques at the fitting abstraction level.
- Enhance fault injection for RTL- and TLM-layer

Limitations - Abstraction

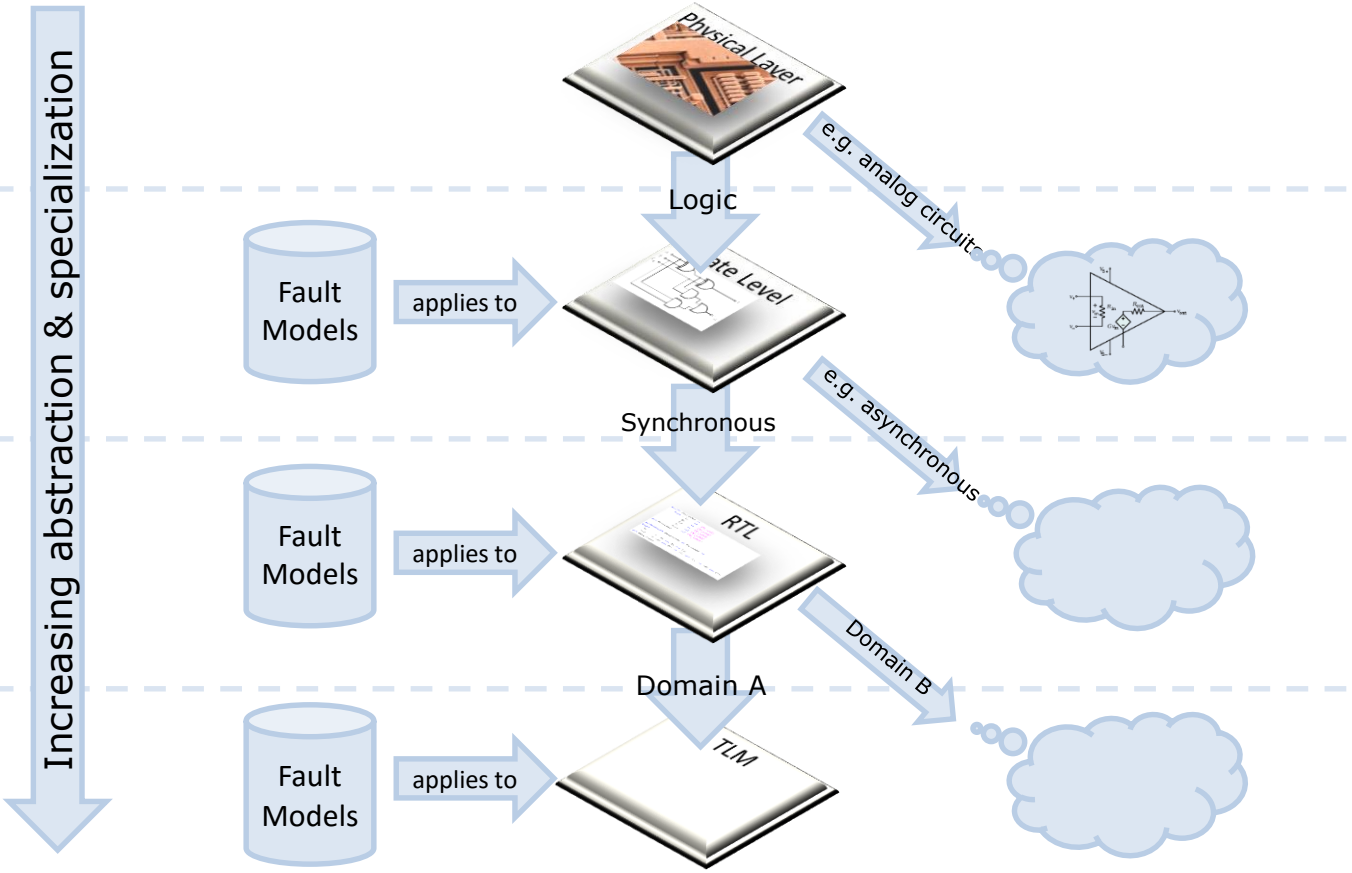
"The action of factoring out unnecessary details, identifying relevant similarities between objects and synthesizing those facts into a concept or class"

Primary goals:

- Get a better understanding of complex structures
- Simplify tasks performed on complex structures

Abstraction is performed with a given field of application in mind

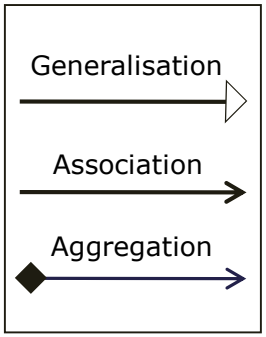
Limitations – Domain Specialization

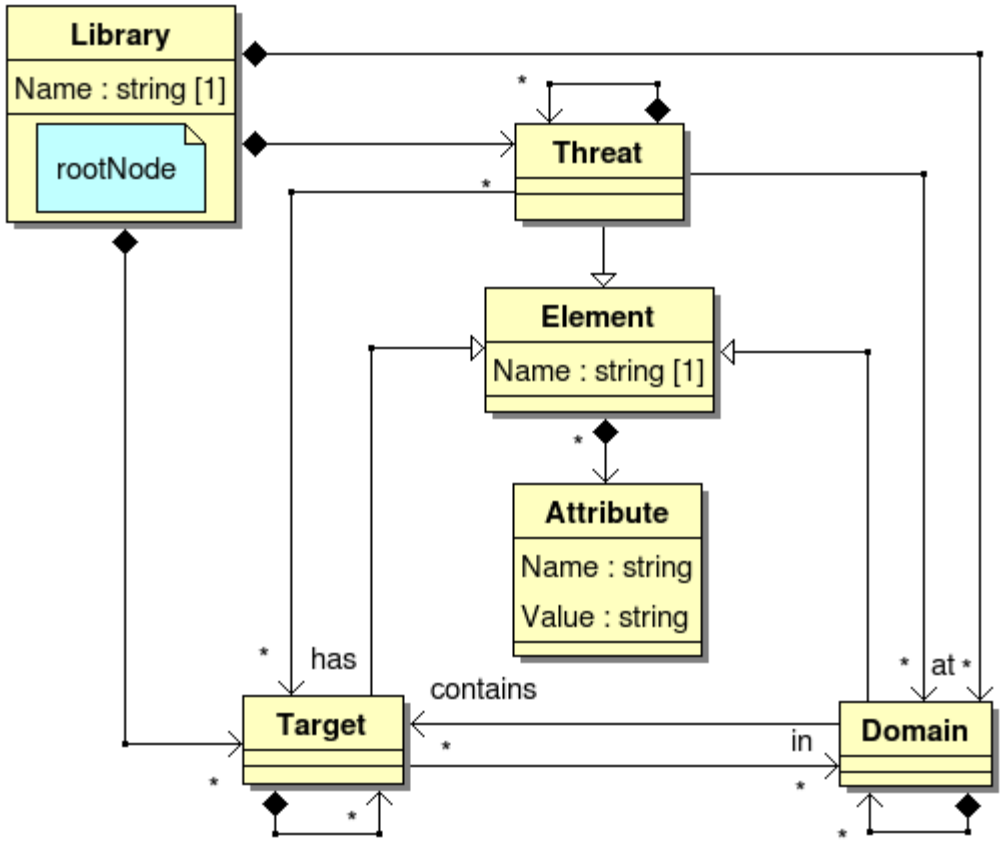


Fault models must be tailored to the requirements of the targeted domain

Concept – Meta-Model

"An explicit model of the constructs and rules needed to build specific models within a domain of interest"





Fault Library Metamodel

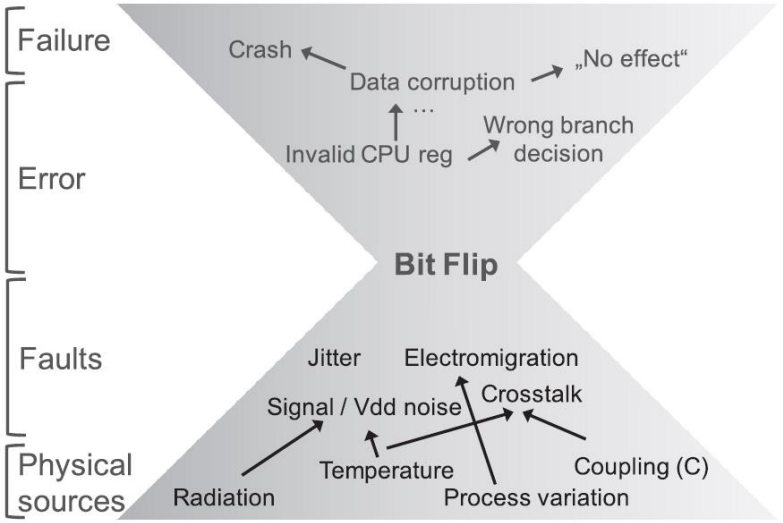
Concept – Meta-Model

Ontological meta-model [3] serves as common foundation for libraries:

- Enables automatic code generation
- Reusability

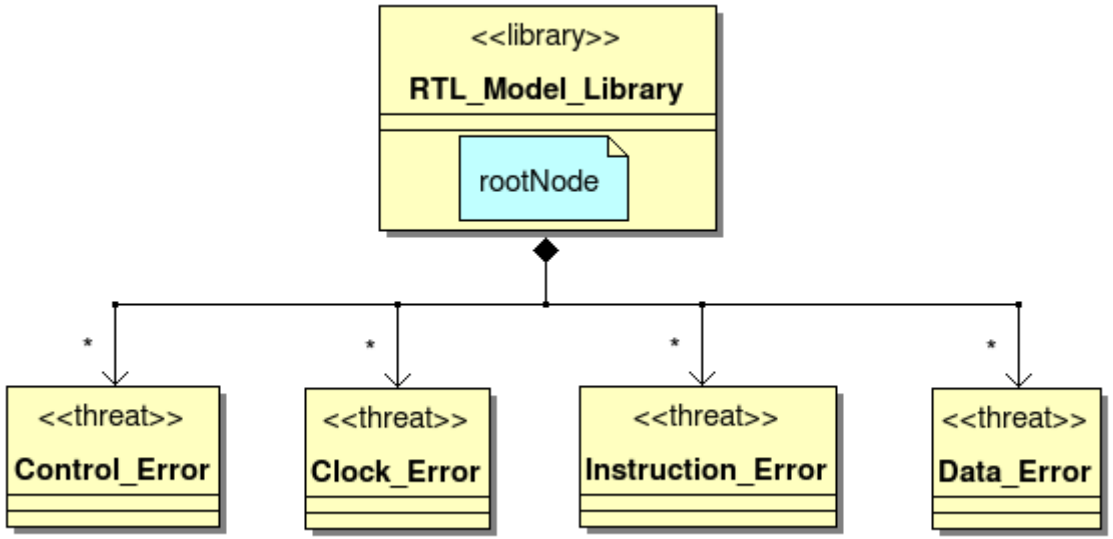
Bit-flip as smallest observable change:

- Resilience articulation point [4]
- Creation of accumulated models of higher order



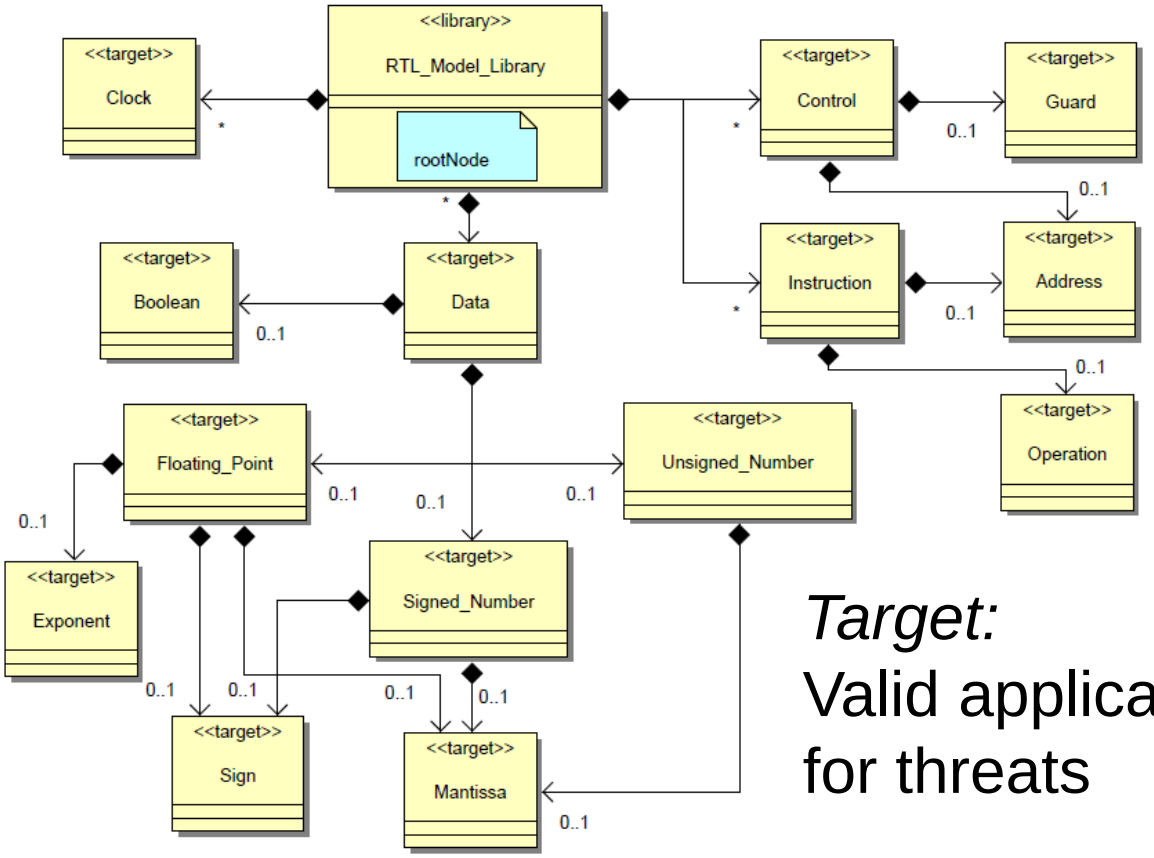
Source: Herkersdorf, A. et al.: Resilience articulation point (RAP) [4]

Concept - Threats



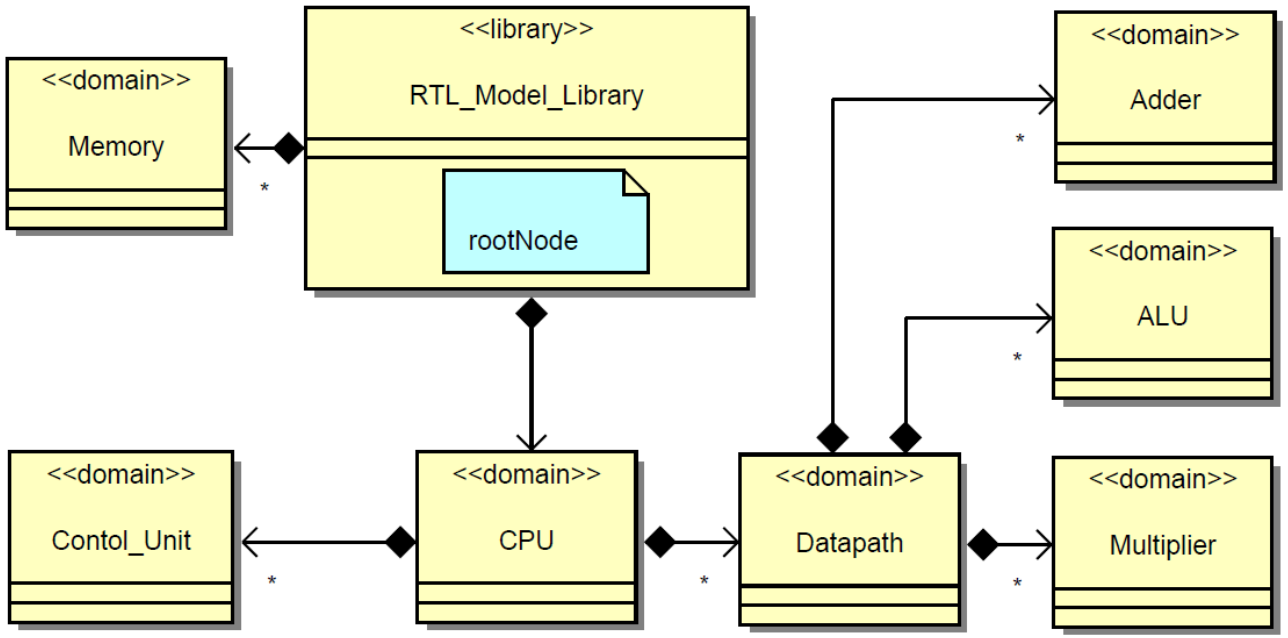
Threats: faults, errors and failures

Concept - Targets



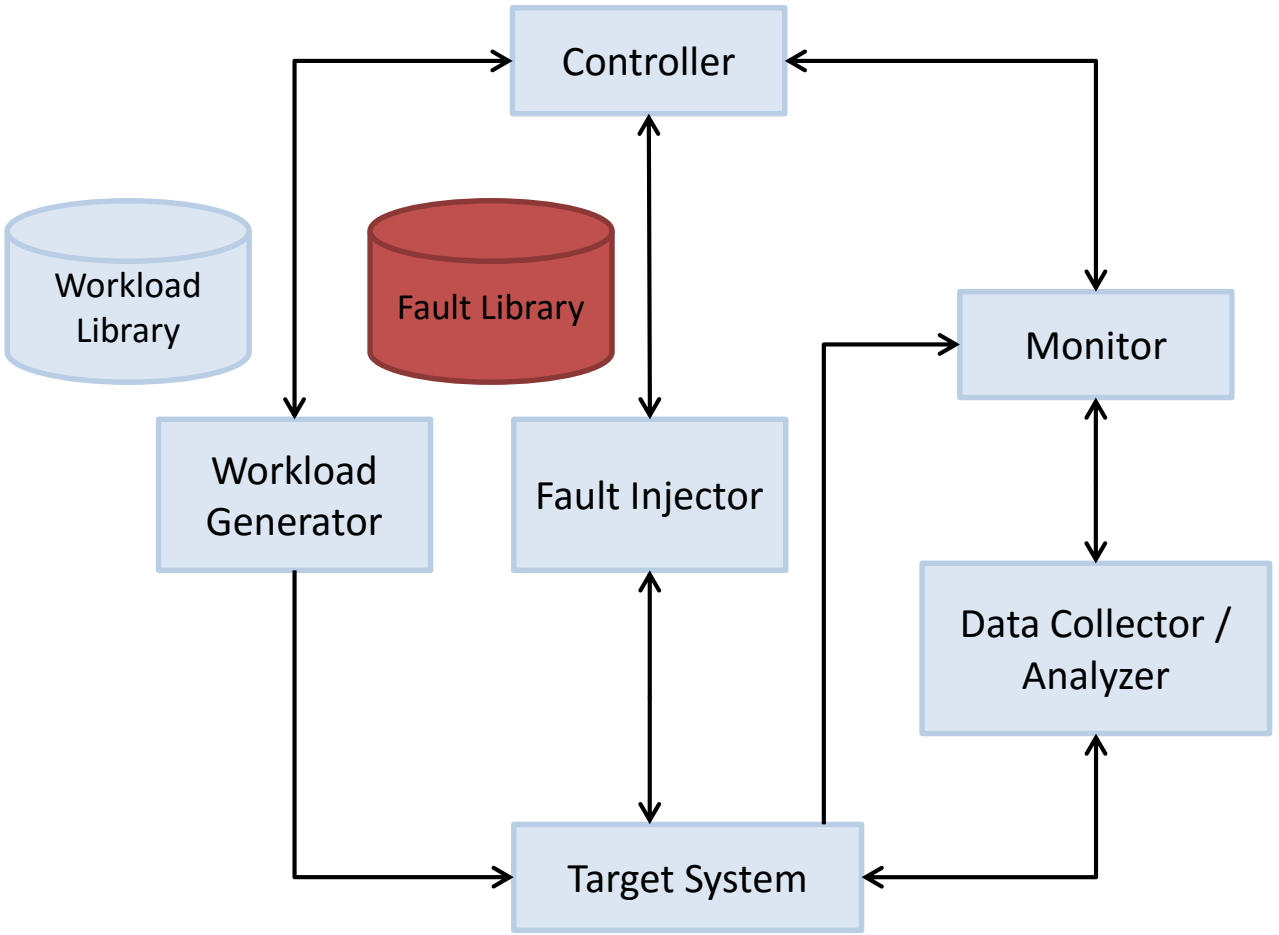
Target:
Valid application points for threats

Concept - Domain



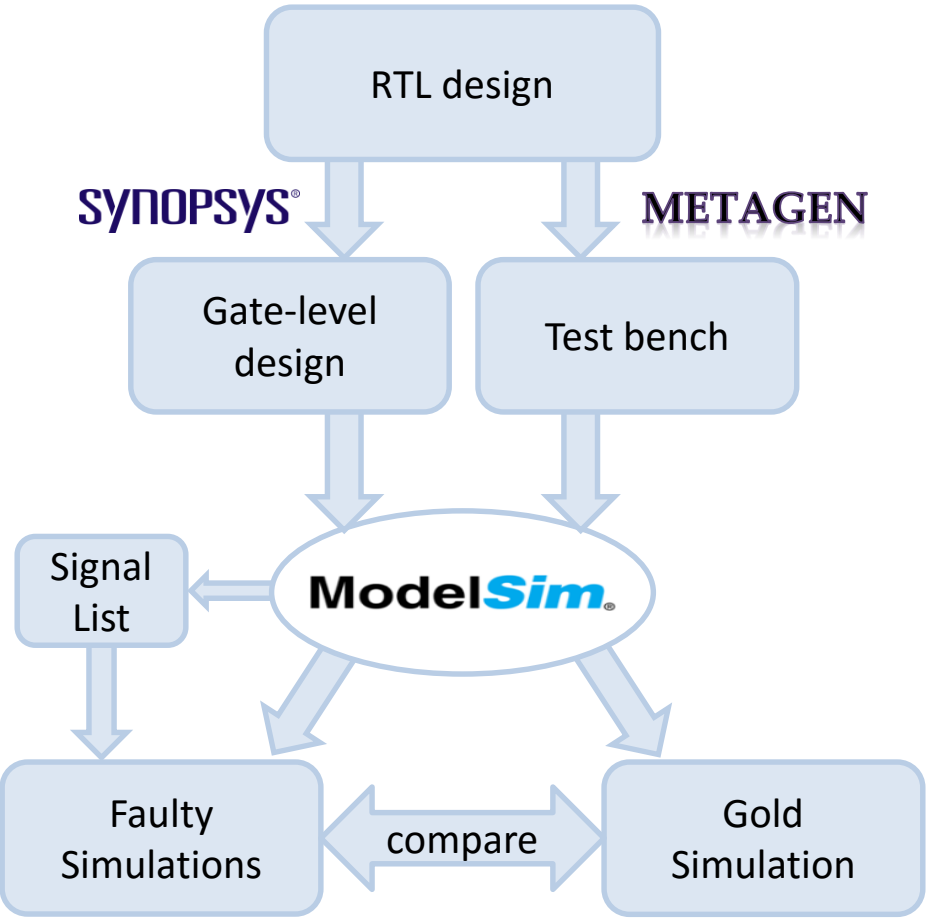
Domain: Areas of interest and/or functionality

Simulation – General Framework



Simulation - Flow

Automatic construction of the meta-model-related frameworks via the *Metagen* [5] code generation tool



Simulation - Setup

Target System

- 32-bit MIPS-architecture
- Automatic testbench generation

Simulation

- Fault injection
- Randomized workload
- One campaign per VHDL module
- 300 unique runs / campaign

Result

All observed errors were covered by the defined fault models

Conclusion

- A systematic approach
- Implicit assumptions during abstraction specialization
- Fault models can be aggregated
- New layer of semantic information
- The meta-modeling-based approach enables formalization of fault models

Questions

Finalize slide set with questions slide

References

(1) Avizienis, A.; Laprie, J.-C.; Randell, B.; Landwehr, C. (2004). Basic concepts and taxonomy of dependable and secure computing. Dependable and Secure Computing, IEEE Transactions on, 1(1):11–33.

(2) Hsueh, M.-C.; Tsai, T. K.; Iyer, R. K. (1997). Fault injection techniques and tools. Computer, 30(4):75–82.

(3) Atkinson, C.; Kühne, T. (2003). Model-driven development: a metamodeling foundation. Software, IEEE, 20(5):36–41.

(4) Herkersdorf, A. et al. (2014). Resilience articulation point (rap): Cross-layer dependability modeling for nanometer system-on-chip resilience. Microelectronics Reliability, 54(6-7):1066 – 1074

(5) Ecker, W.; Velten, M.; Zafari, L.; Goyal, A. (2014). "The metamodeling approach to system level synthesis," Design, Automation and Test in Europe Conference and Exhibition (DATE), vol., no., pp. 1(2):24-28

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