Test generation from functional 3D virtual environment models

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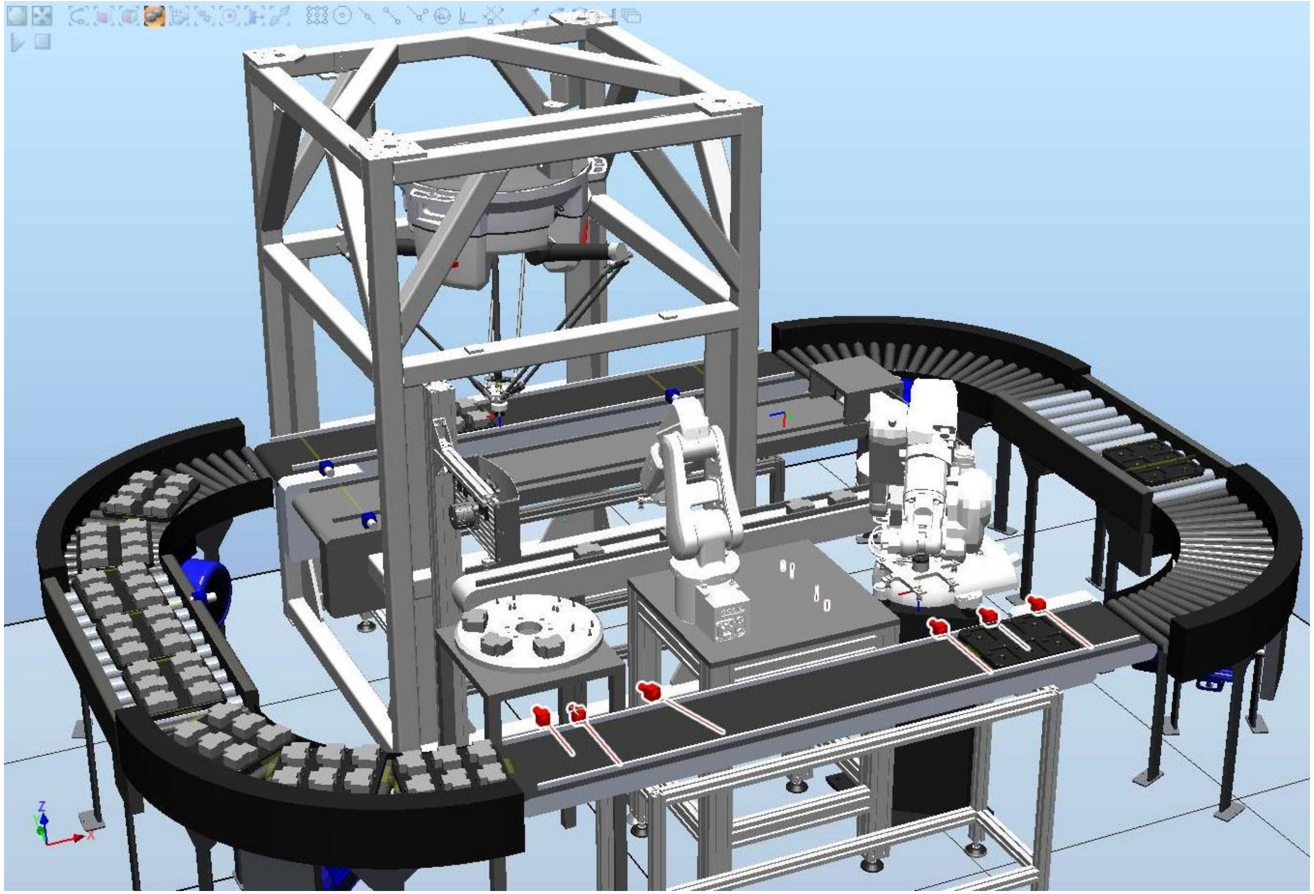
Objective of the prototype



Automated test case generation from 3D virtual production floor models (plant models) for Programmable logic Controller (PLC) testing.

To Test

Control software of:

- Migrating PLCs (i.e. PLCs with updated logic)
- Exchanged PLCs (i.e. New hardware without changes to logic)

Errors to be identified in the control logic:

- Logical Errors
  - e.g. If the tray is empty, does the PLC take an appropriate action?

- Timing Errors (Not considered in this work)
  - e.g. If the tray is empty, does the PLC take appropriate action in a pre-defined duration?

- Plant Errors
  - e.g. if a sensor is broken can the PLC still handle the plant appropriately

Haves and Challenge

Haves:

- A 3D virtual representation of a production facility (plant model). This virtual facility can mimic the workings of the real plant – when we provide the necessary stimulus

- We know how to generated test cases from formal behavior models

Our Challenge:

- To extract the necessary behavior information from the 3D virtual plant model to construct formal behavioral model of the plant

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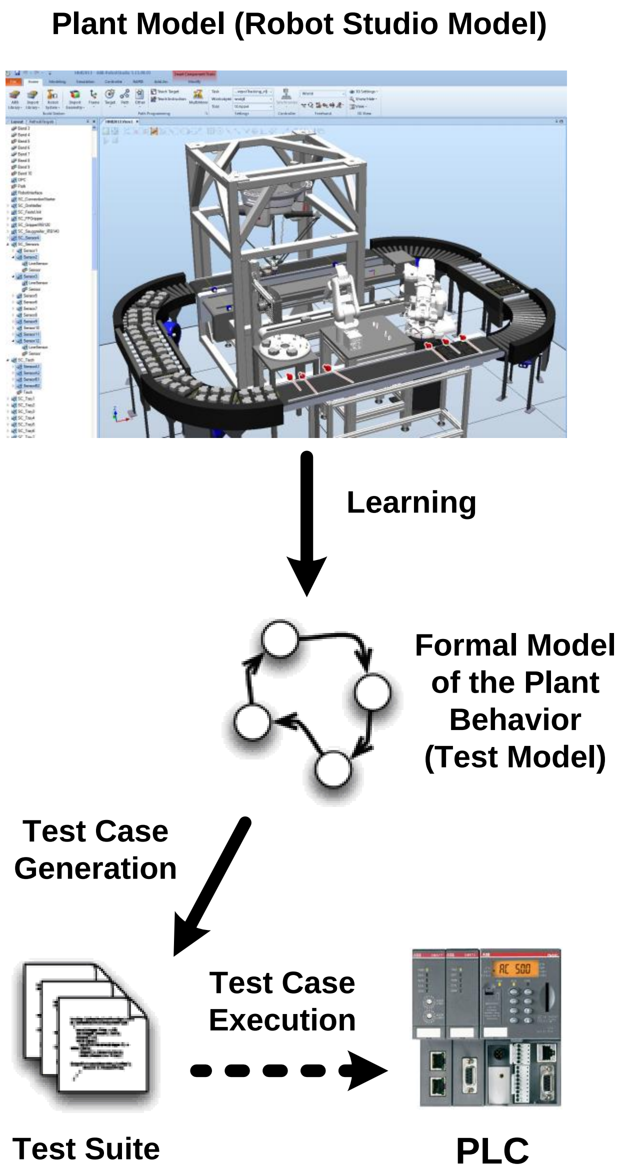
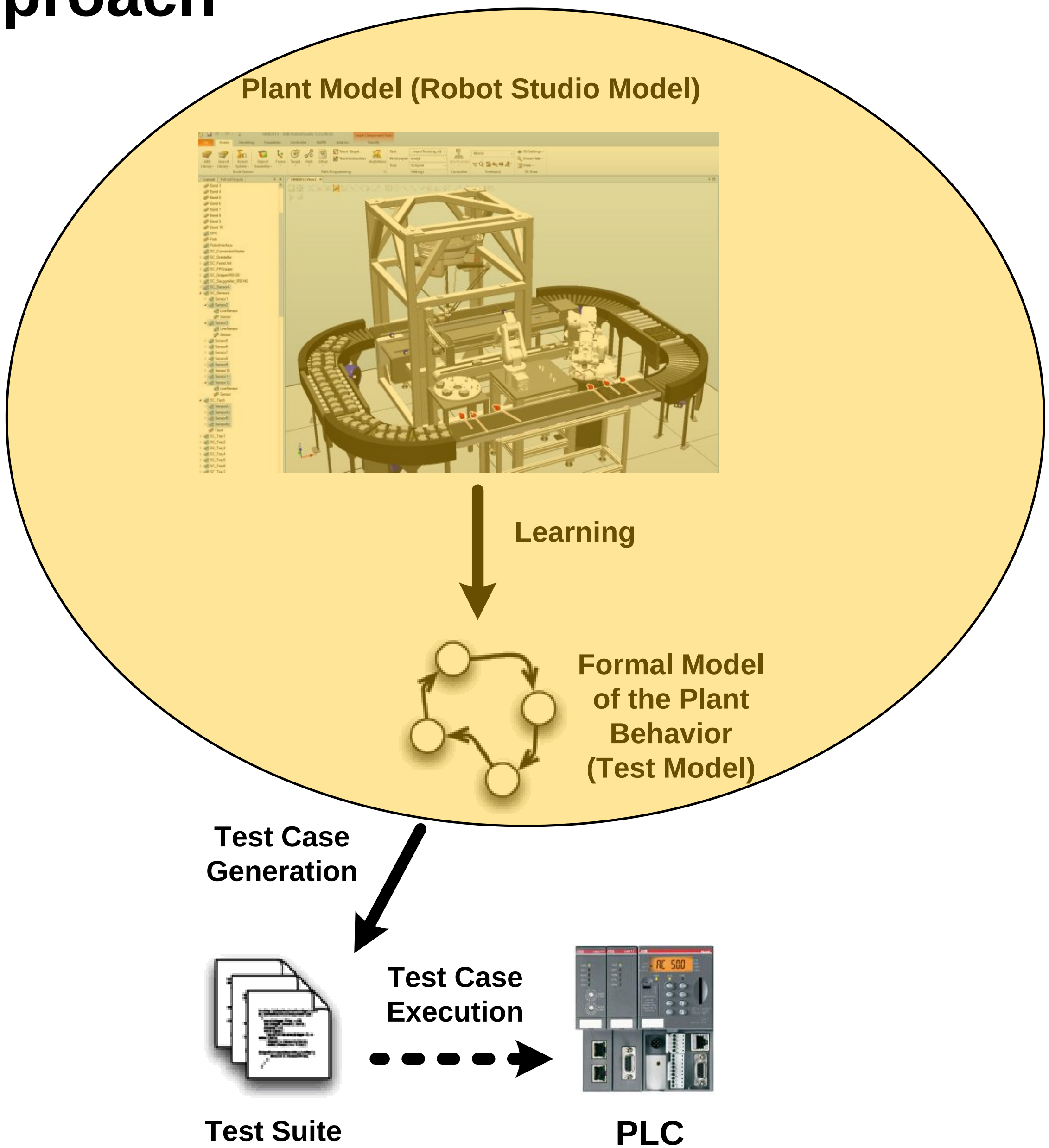
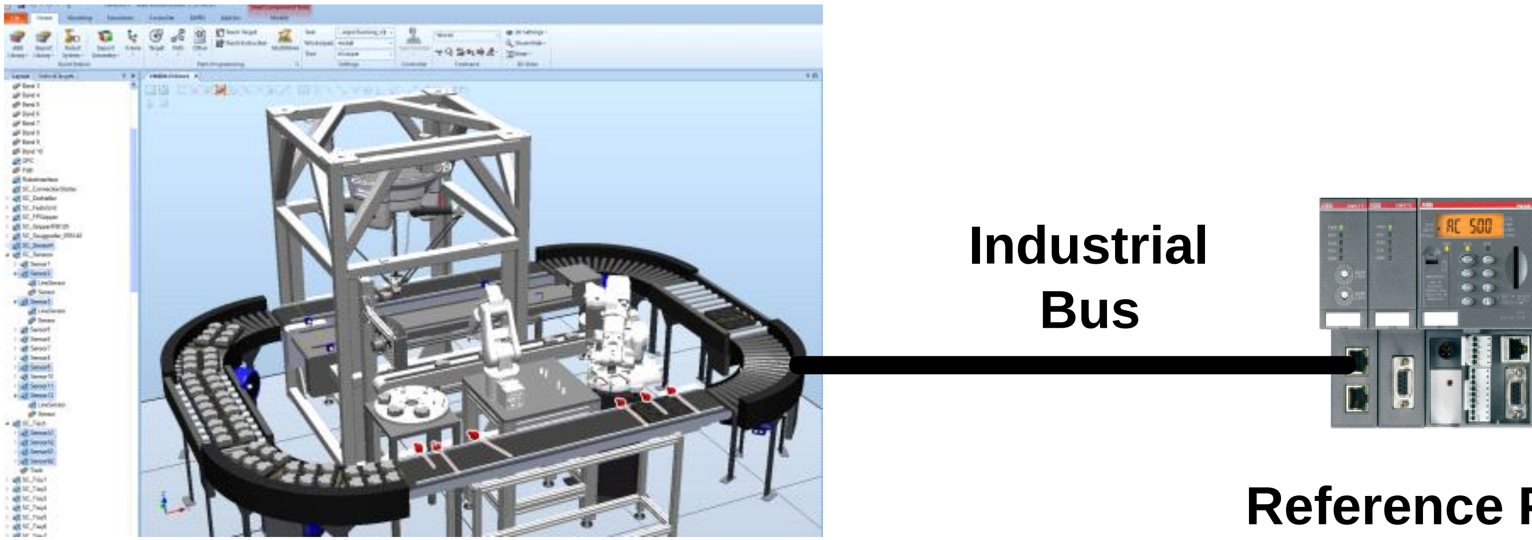
Proposed Approach



Proposed Approach



Hardware-in-the-loop (HIL) Simulation - Information Source



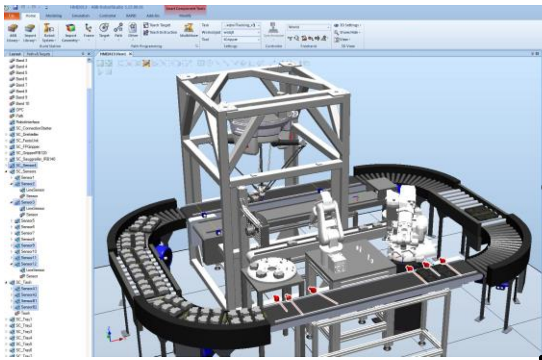
Reference PLC

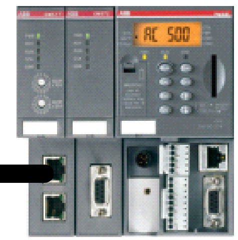
Plant Model

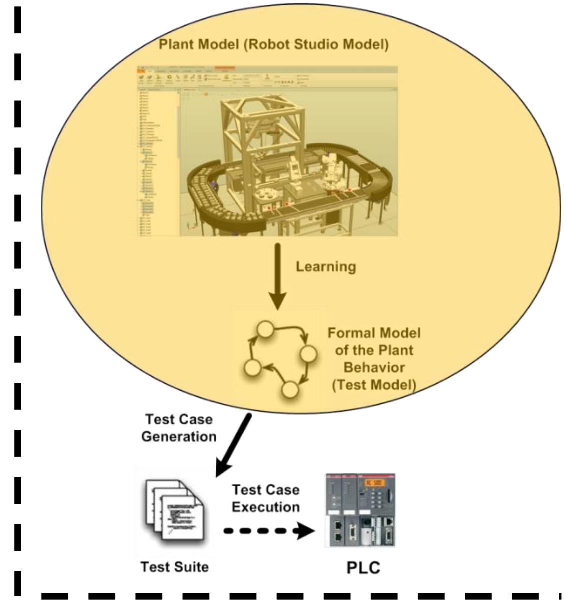
Hardware-in-the-Loop Model Learning Setup

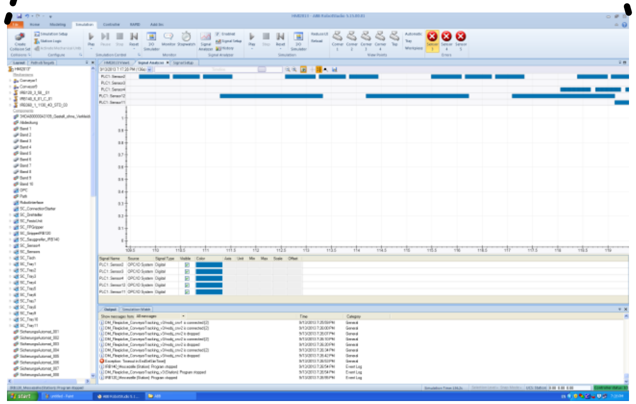
Model Learning

Plant Model (Robot Studio Model)





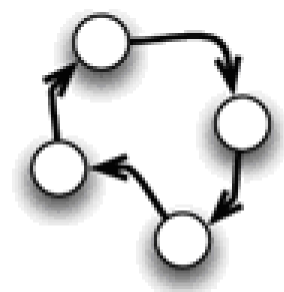




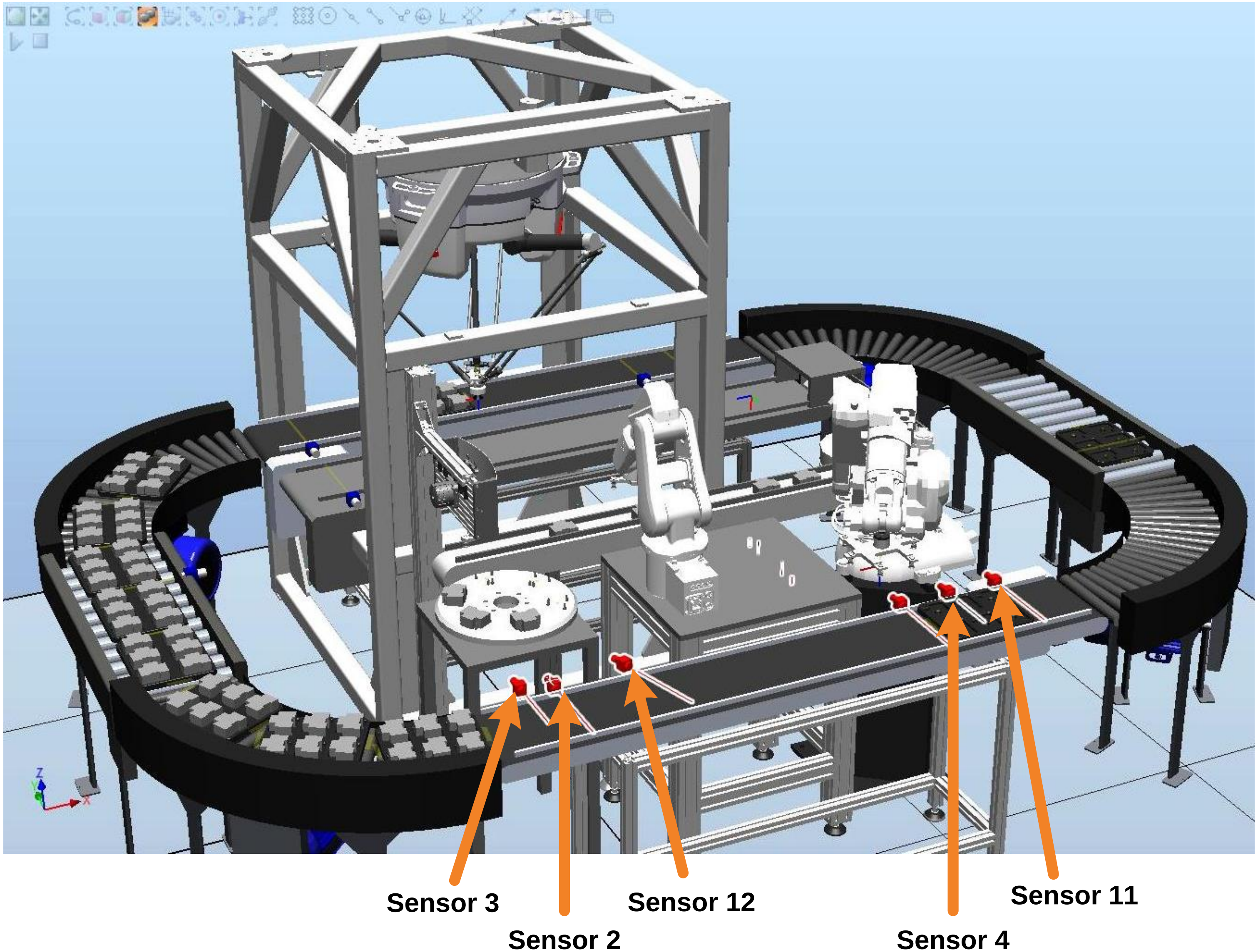
Signal Analyser

Learning

Formal Model of the Plant Behavior (Test Model)



Virtual Plant Model



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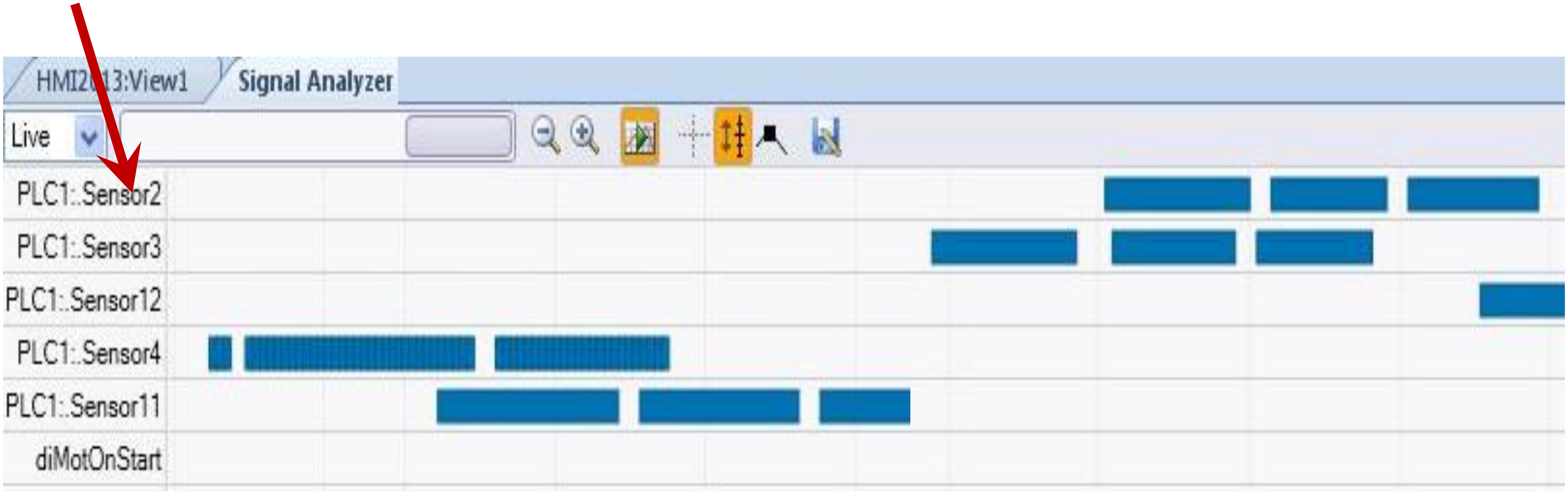
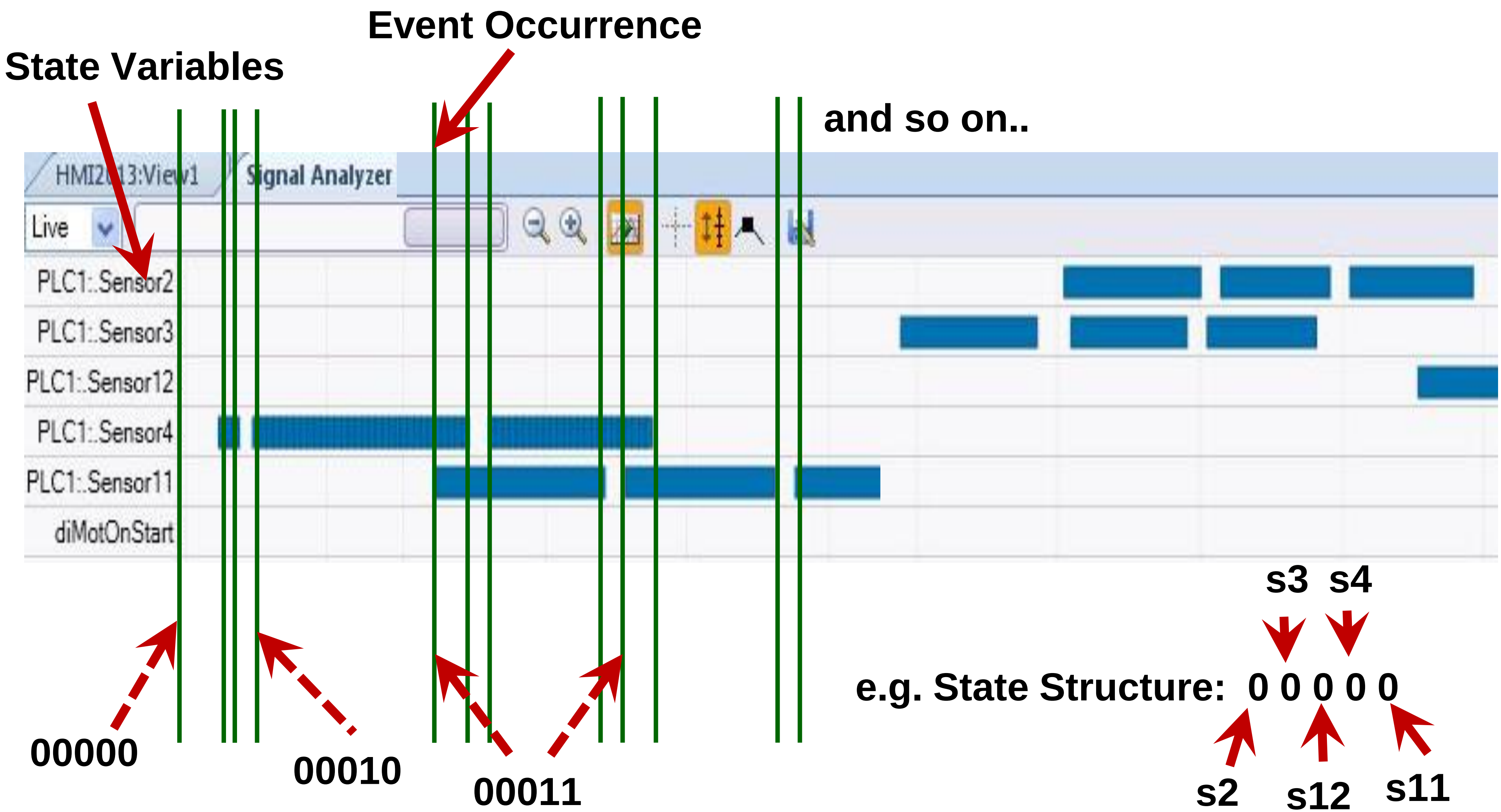
Information from Signal Analysis

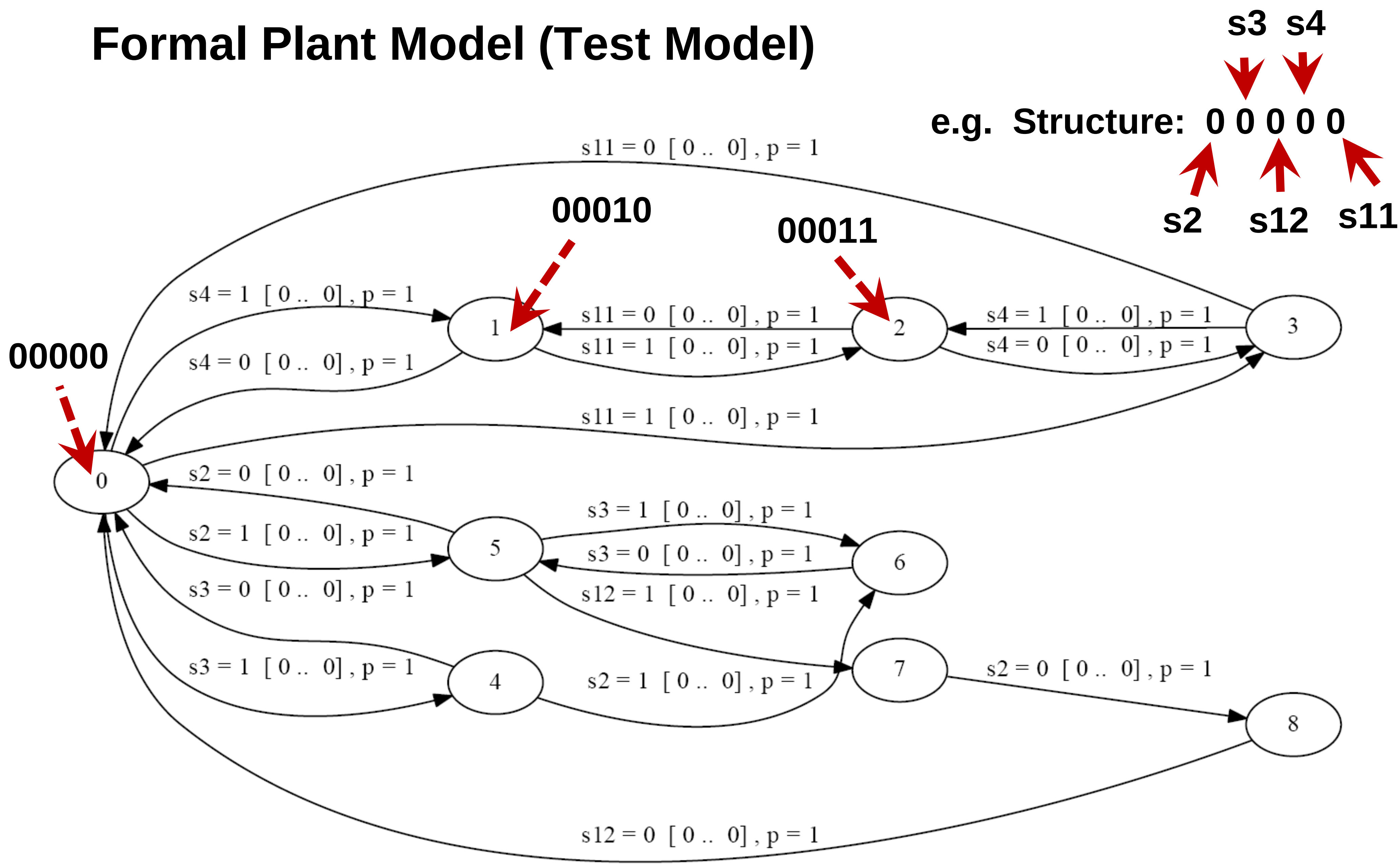
Sensors (State Variables)



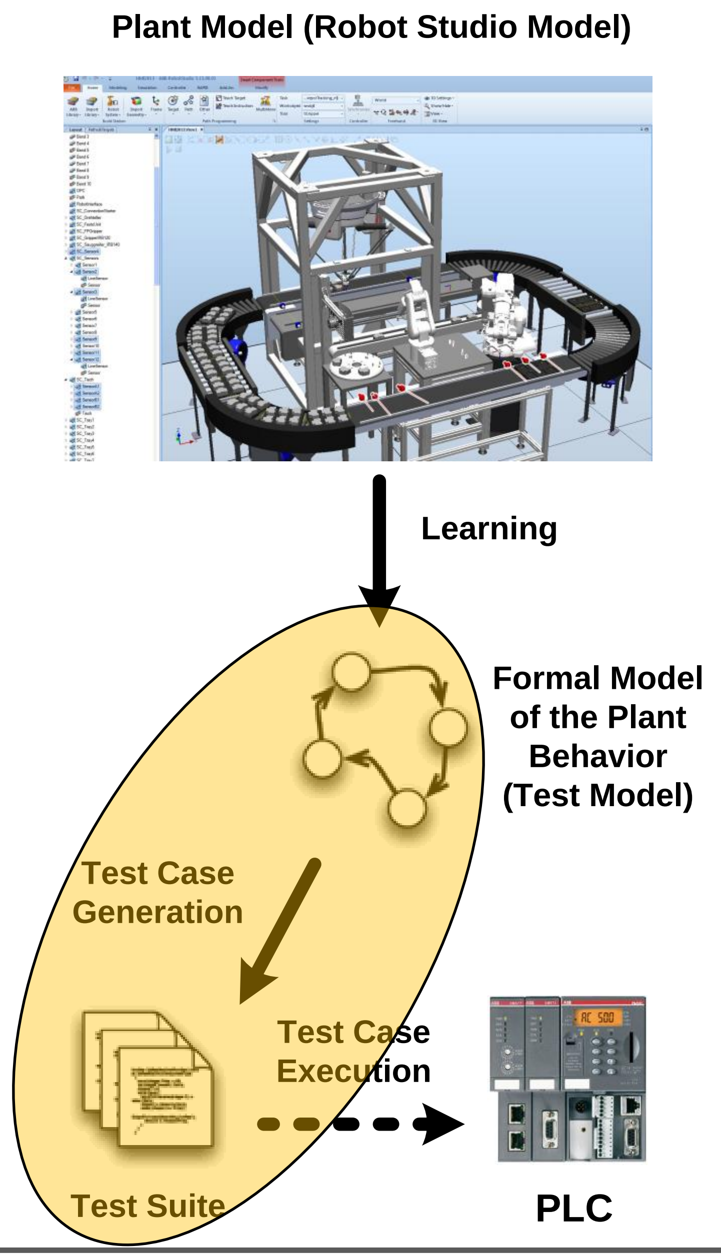
Information from Signal Analysis



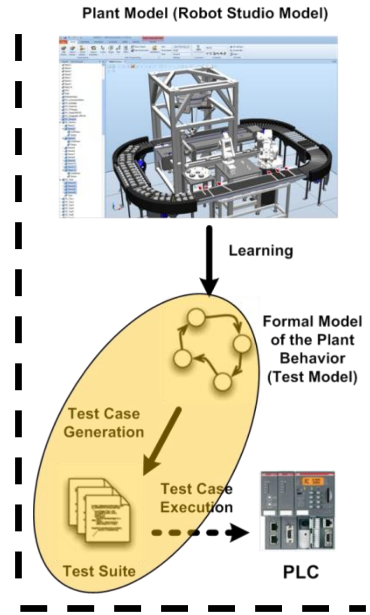
Formal Plant Model (Test Model)

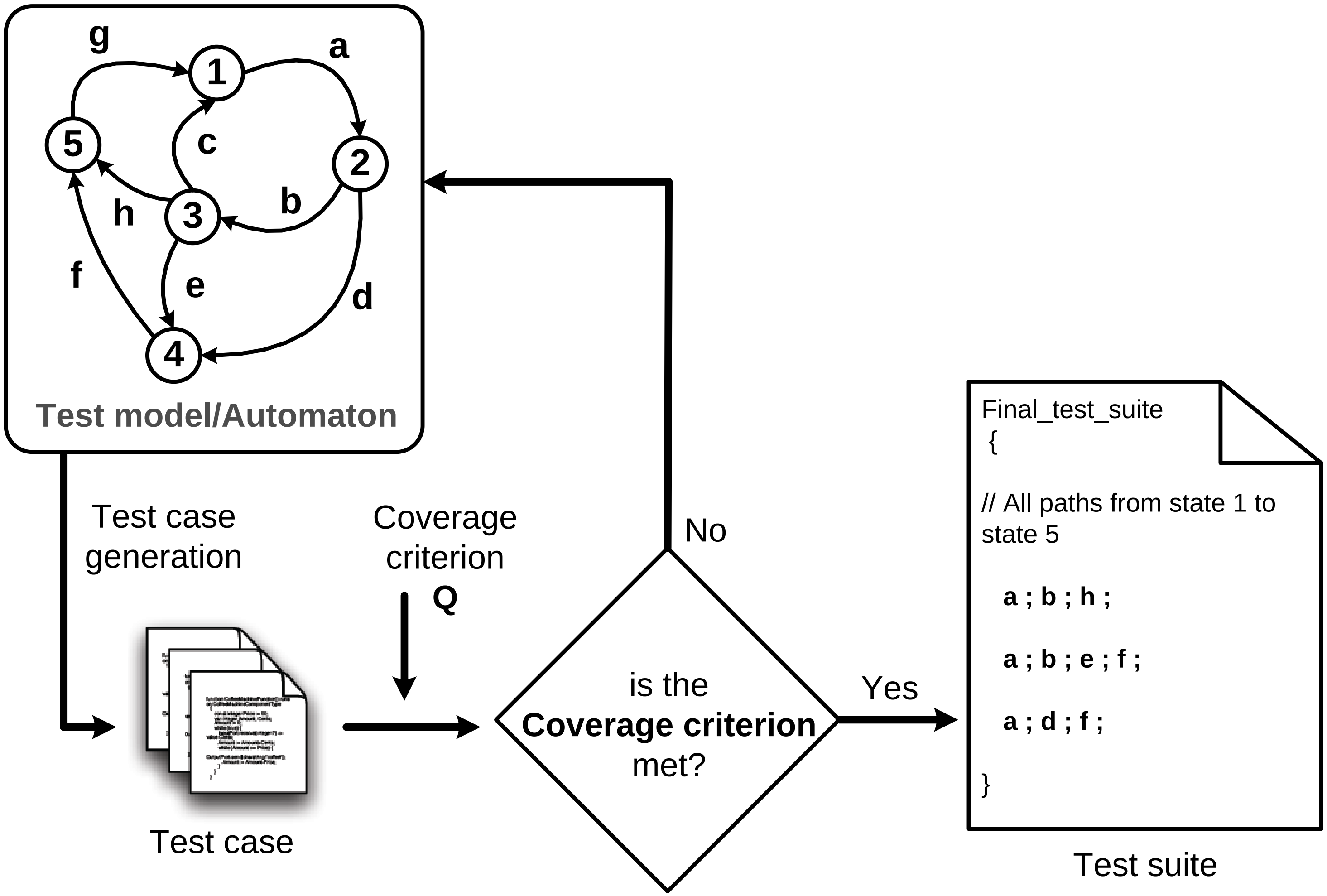


Test Case Generation



Test Case Generation (with coverage criterion)





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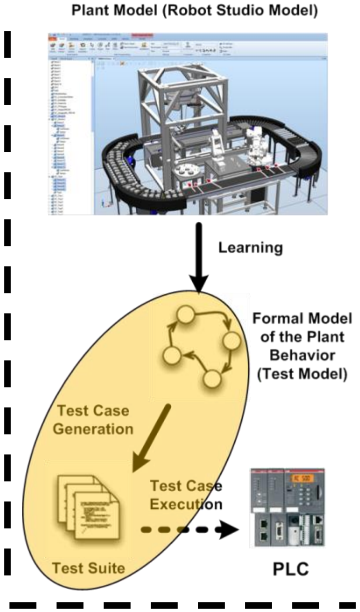
Generated Test Suite

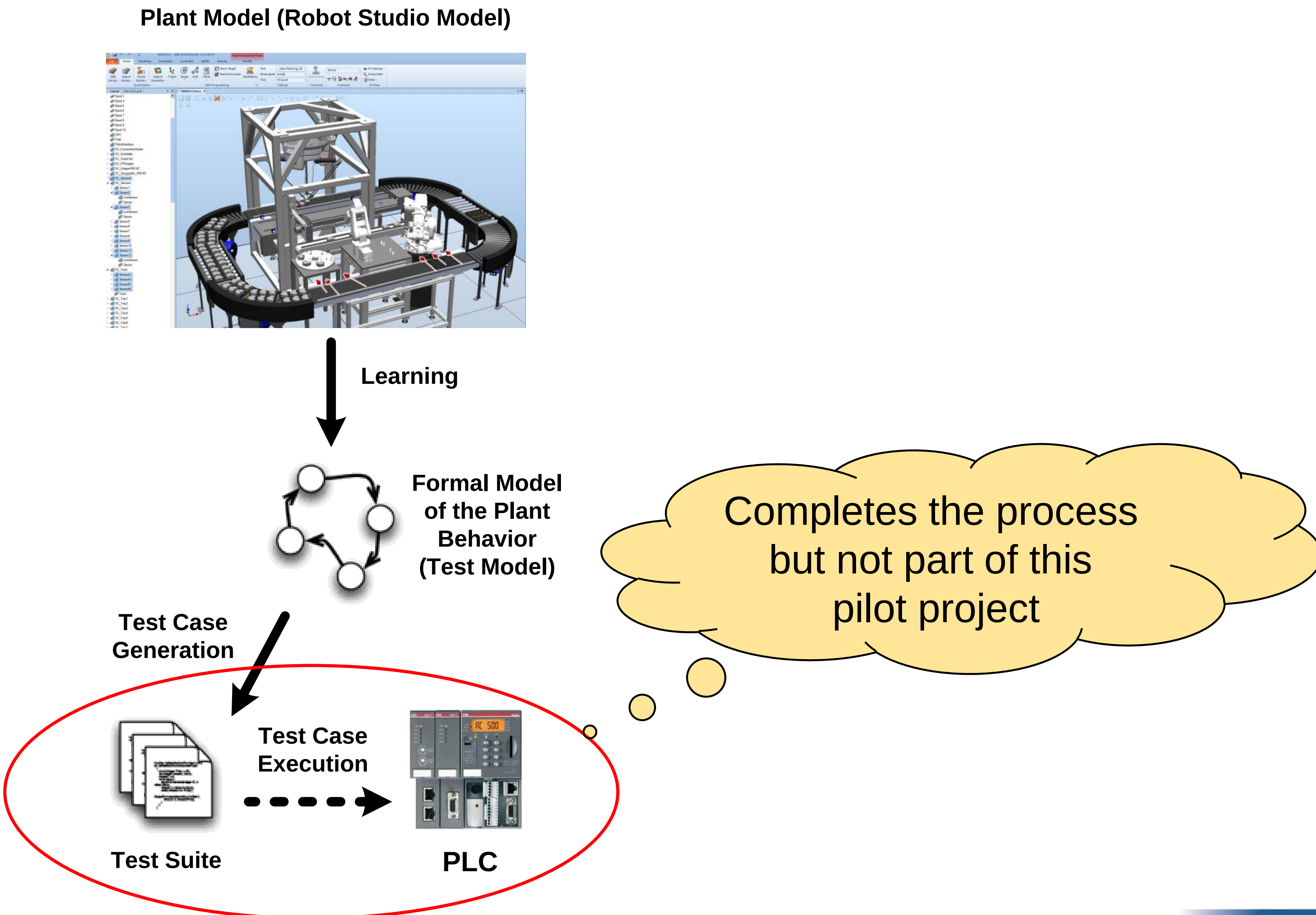


Module Test Suite

s3 = 1;s2 = 1;s3 = 0;s12 = 1;s2 = 0;s12 = 0;
s3 = 1;s2 = 1;s3 = 0;s2 = 0;
s3 = 1;s3 = 0;
s2 = 1;s12 = 1;s2 = 0;s12 = 0;
s2 = 1;s3 = 1;s3 = 0;s12 = 1;s2 = 0;s12 = 0;
s2 = 1;s3 = 1;s3 = 0;s2 = 0;
s2 = 1;s2 = 0;
s11 = 1;s11 = 0;
s11 = 1;s4 = 1;s4 = 0;s11 = 0;
s11 = 1;s4 = 1;s11 = 0;s11 = 1;s4 = 0;s11 = 0;
s11 = 1;s4 = 1;s11 = 0;s4 = 0;
s4 = 1;s11 = 1;s4 = 0;s11 = 0;
s4 = 1;s11 = 1;s4 = 0;s4 = 1;s11 = 0;s4 = 0;
s4 = 1;s11 = 1;s11 = 0;s4 = 0;
s4 = 1;s4 = 0;

Test case generation time: 00:00:45.5781250 seconds
Avoided loops : 8
Generated test cases: 15

Test Case Execution



Analysis of the Approach

- ★ Errors in 'Migrating PLCs' and on 'Exchanged PLCs' can be detected
- ★ No manual formal modeling effort is required
- ★ This approach can be adopted even for testing legacy systems that have been in existence for decades
- ★ Existence of a reference implementation ('Reference PLC') is a pre-requisite
- ★ As the reference implementation is the input for the learned model, logical errors present in the reference implementation cannot be detected

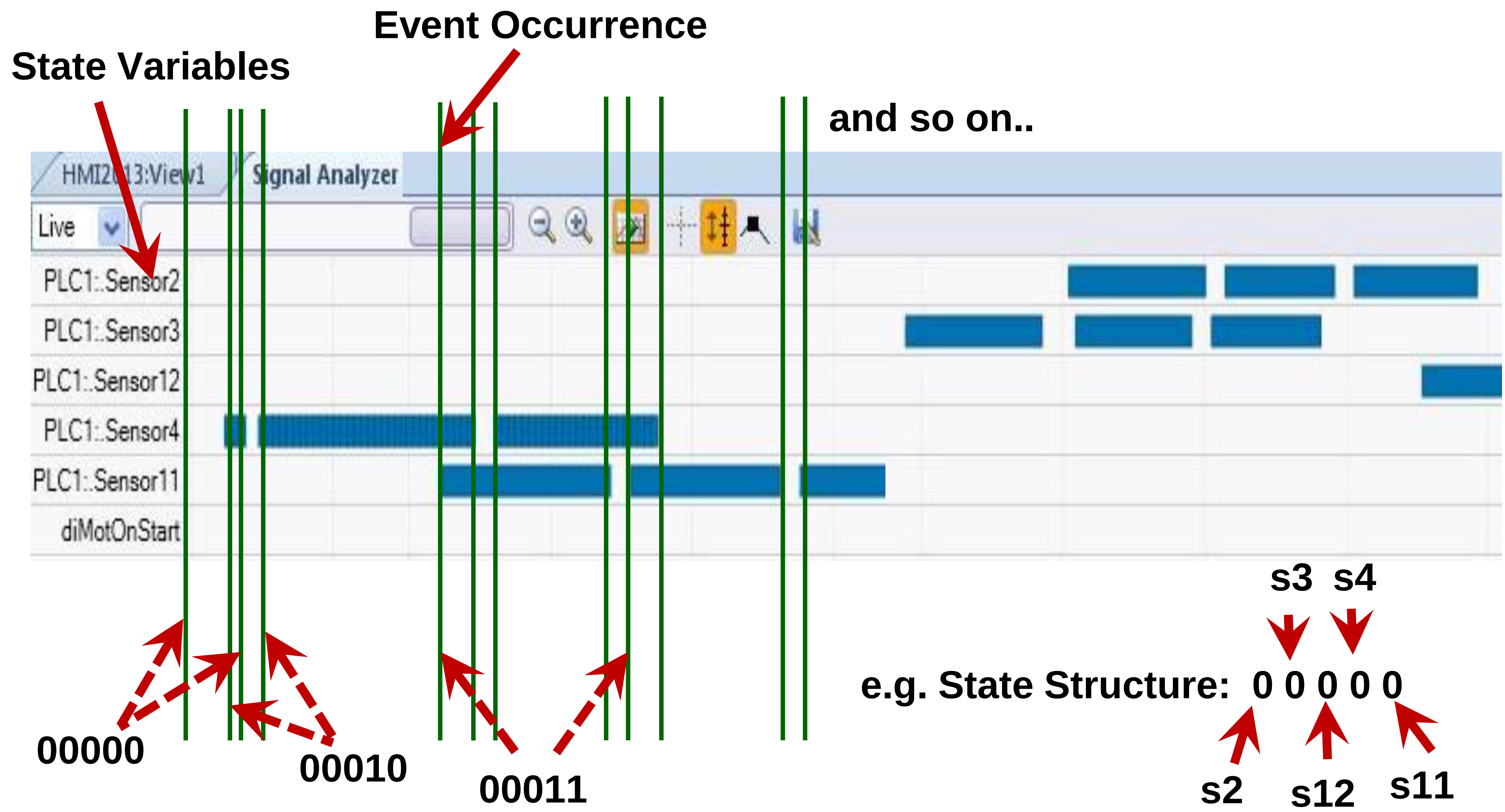
Outlook

- Learning of continous behavior
- Learning of non-deterministic behavior
- Learning of real-time behavior
- Test case generation from complex ‘non-deterministic hybrid real-time’ models
- Identification of timing errors

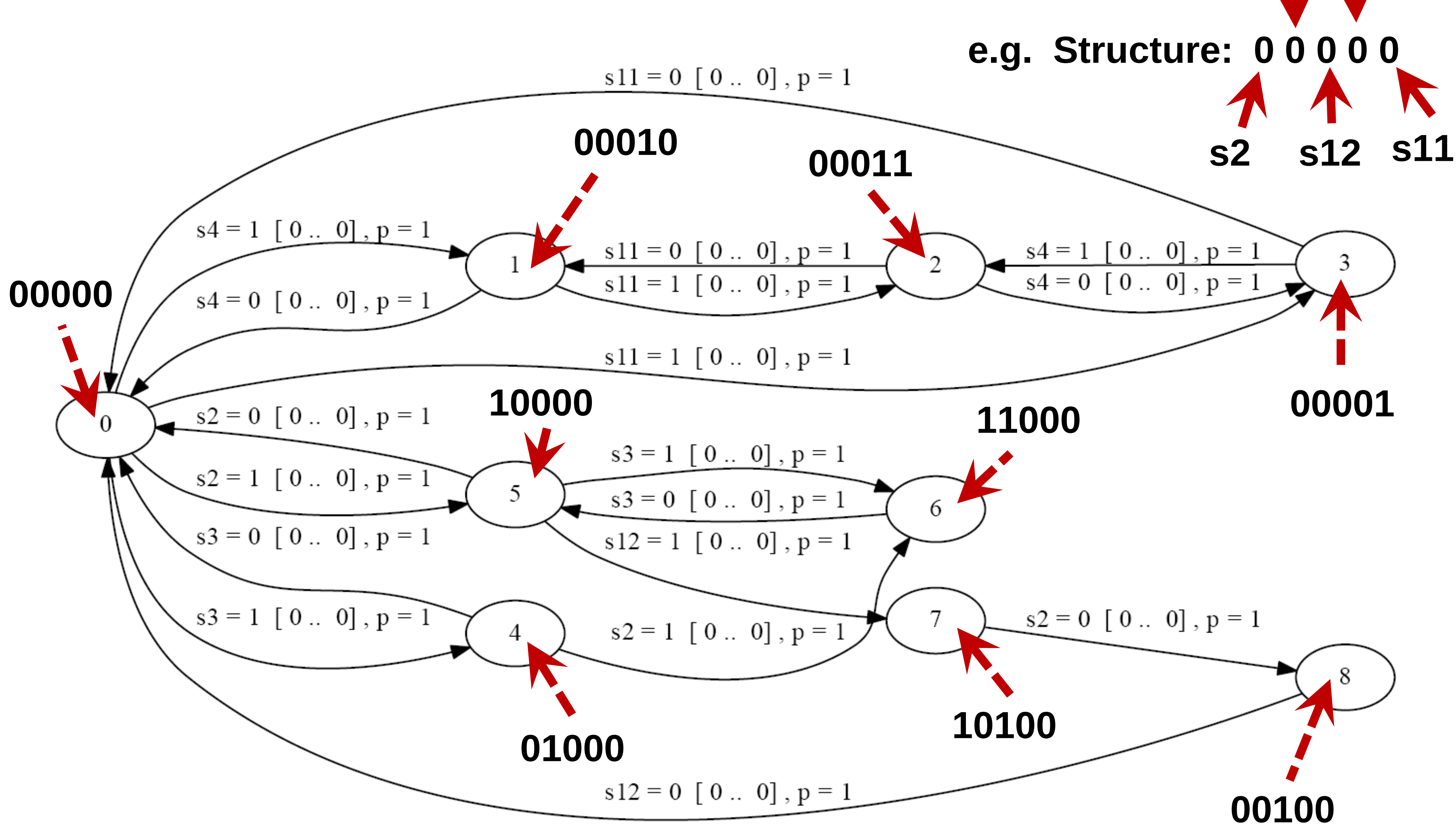
I am done ! ☺

Reserve Slides

Information from Signal Analysis



Formal Plant Model (Test Model)



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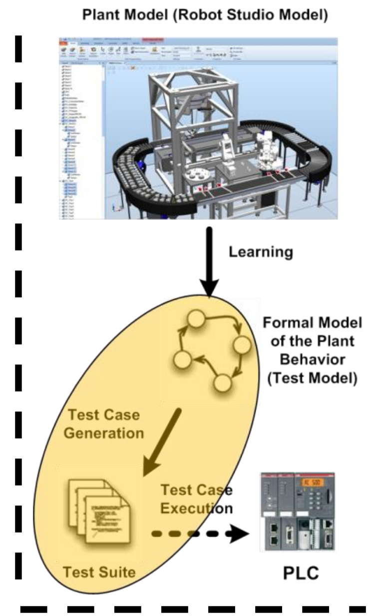
Benefits

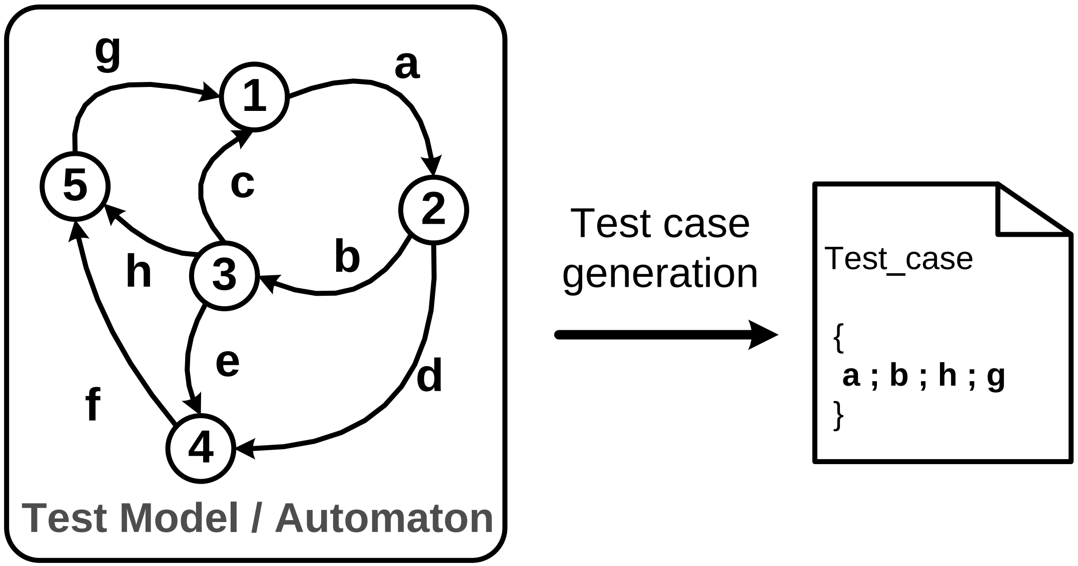
- Cost-effective
- Reduces plant down-time (planned and unplanned downtime)
- Surprises during commissioning can be minimized
- To improve testing thoroughness and maintenance of tests cases

Analysis Summary

	Logical Errors	Plant Errors
Reference PLC	No	Yes
Exchanged PLC	Yes	Yes
Migrating PLC	Yes	Yes

Test Case Generation (Basic Idea)





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