Test Automation in Industrial Automation

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Why test automation is required in Industrial automation

Due to problems in conventional manual testing:

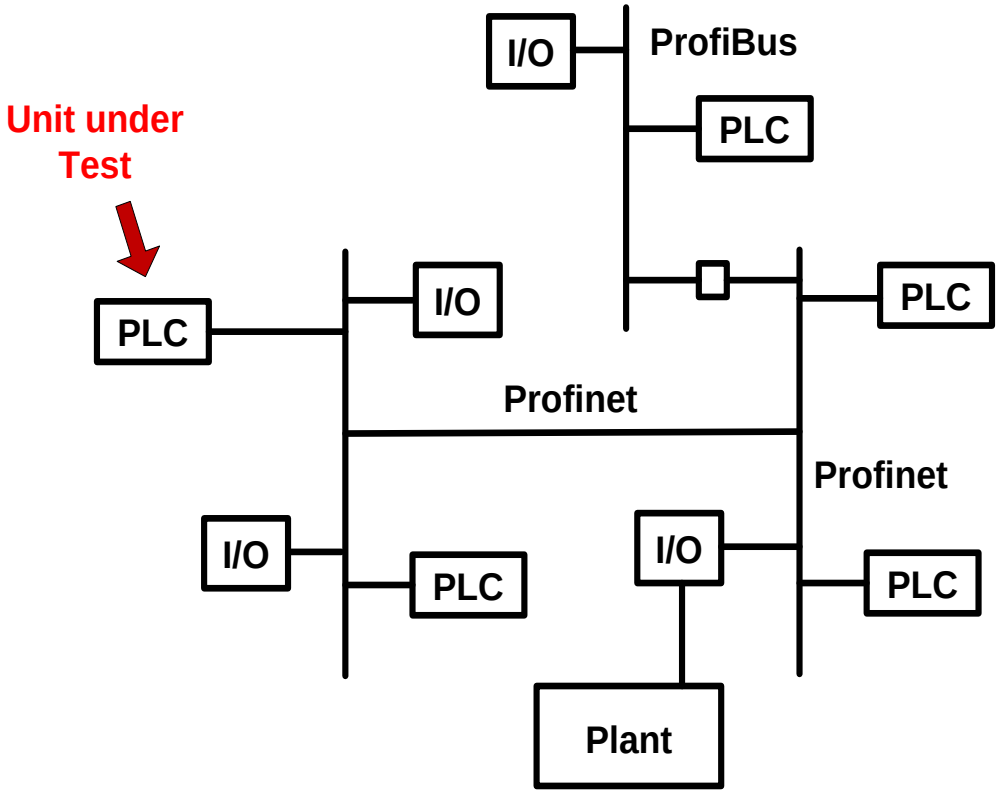
- Cost intensive
- Requires high effort
- Unproductive (time consuming)
- Often inadequate (error prone)
- Low coverage

Objective

To test :

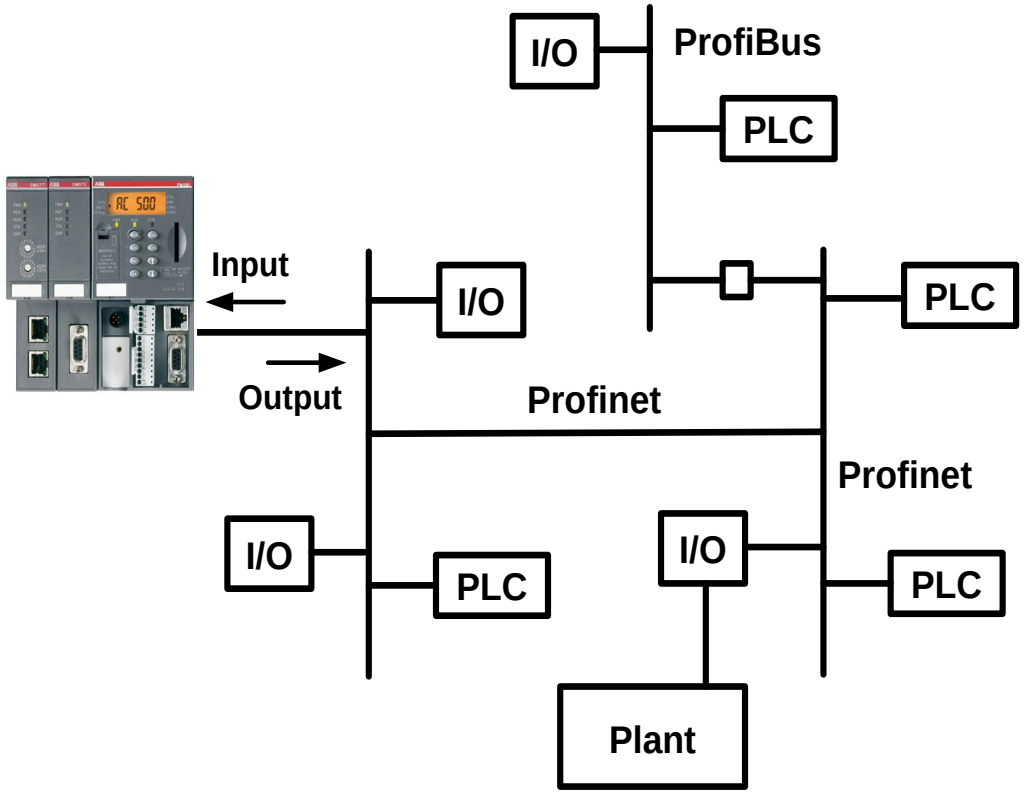
- new control software of Programmable logic controllers (PLC)s
- modified PLC logic
- migrating Systems

Test setup



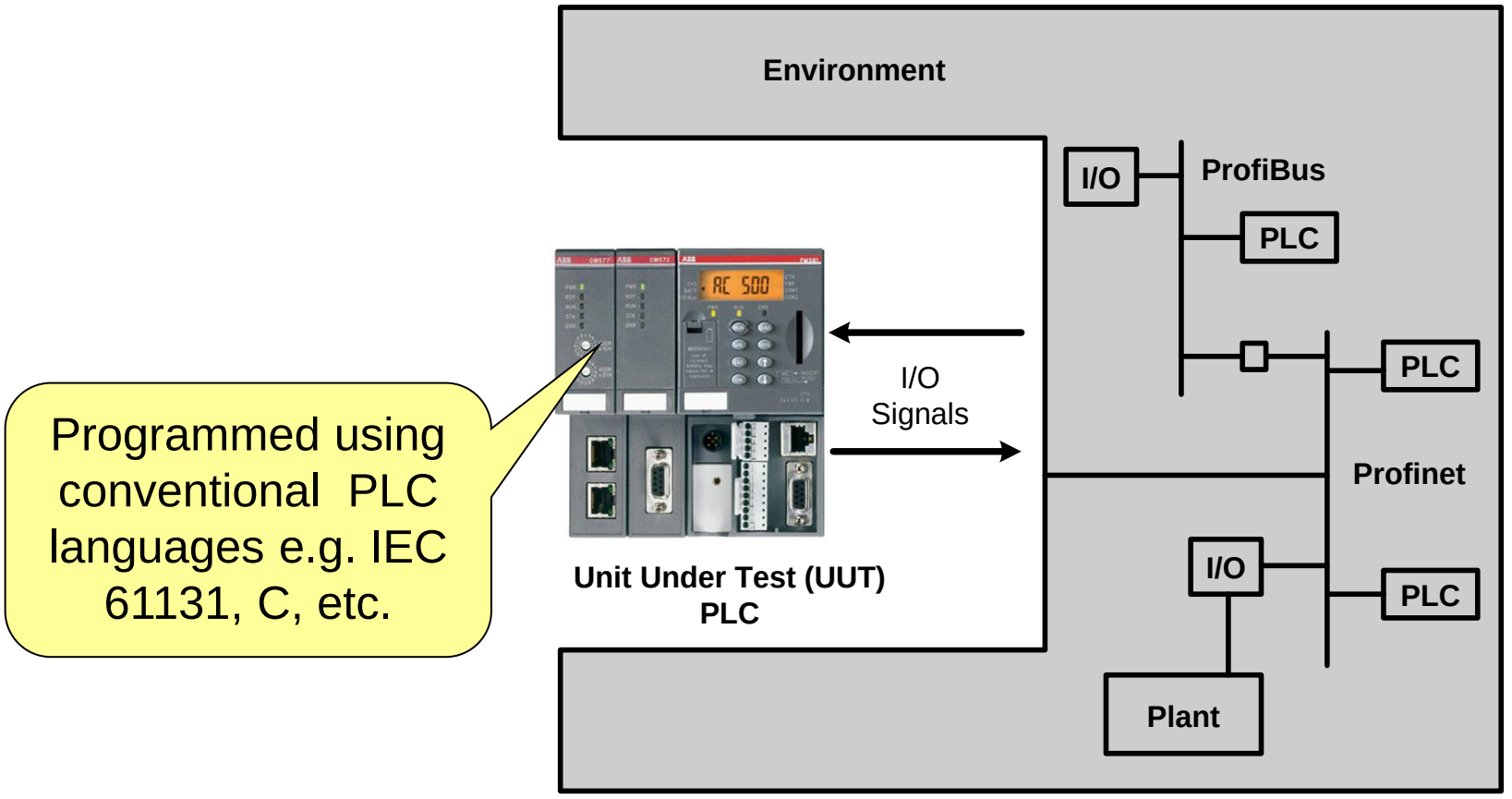
Manufactoring Automation setup

Test setup

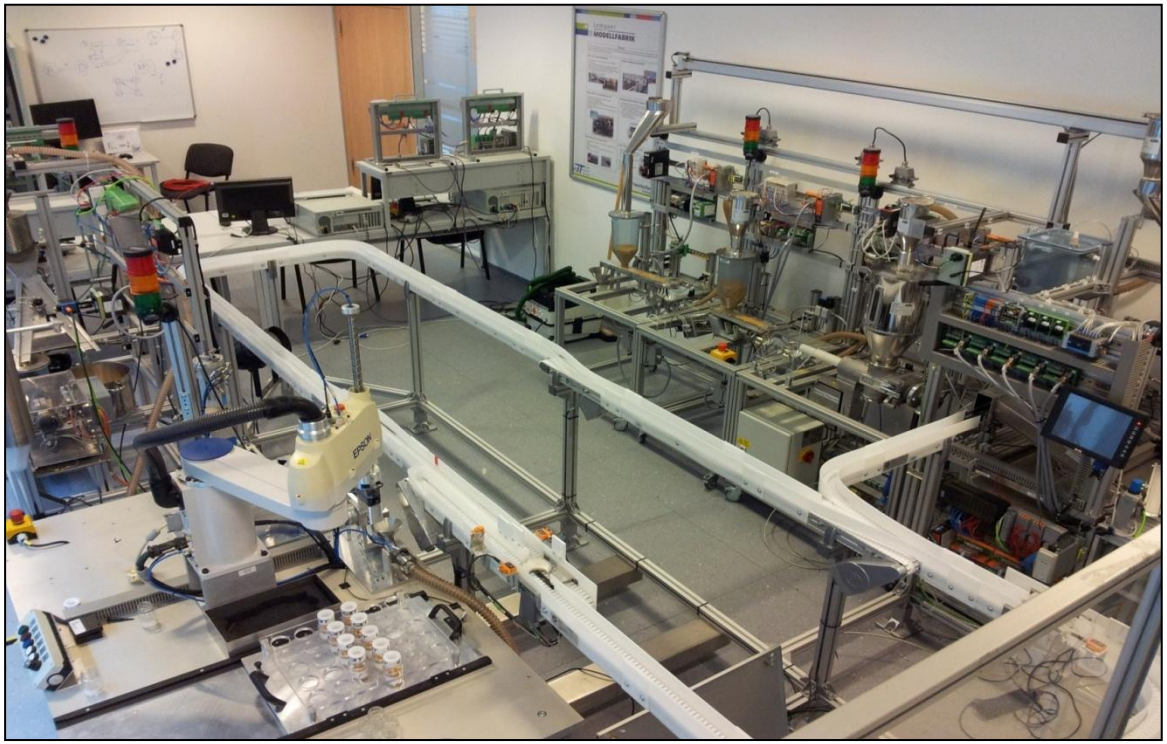


Manufactoring Automation setup

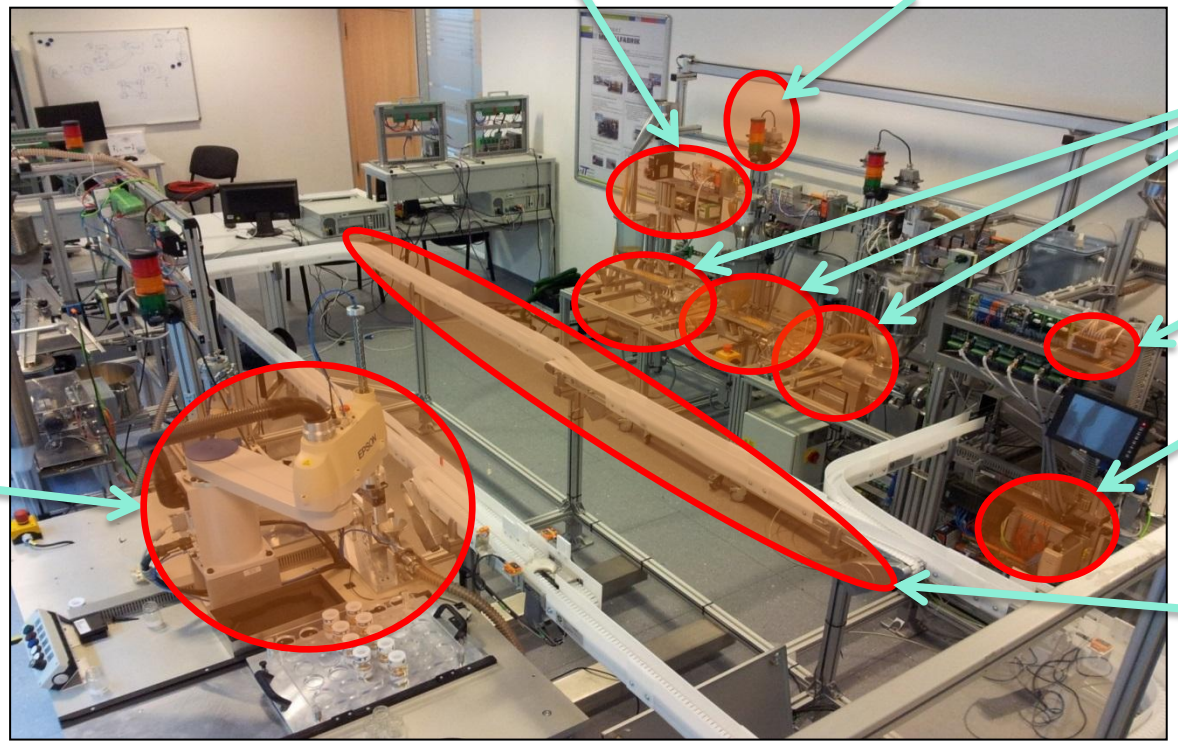
Test setup – Hardware in the the loop



Case study:
Lemgo Model Factory (LMF)



Industrial automation environment



Industrial automation environment

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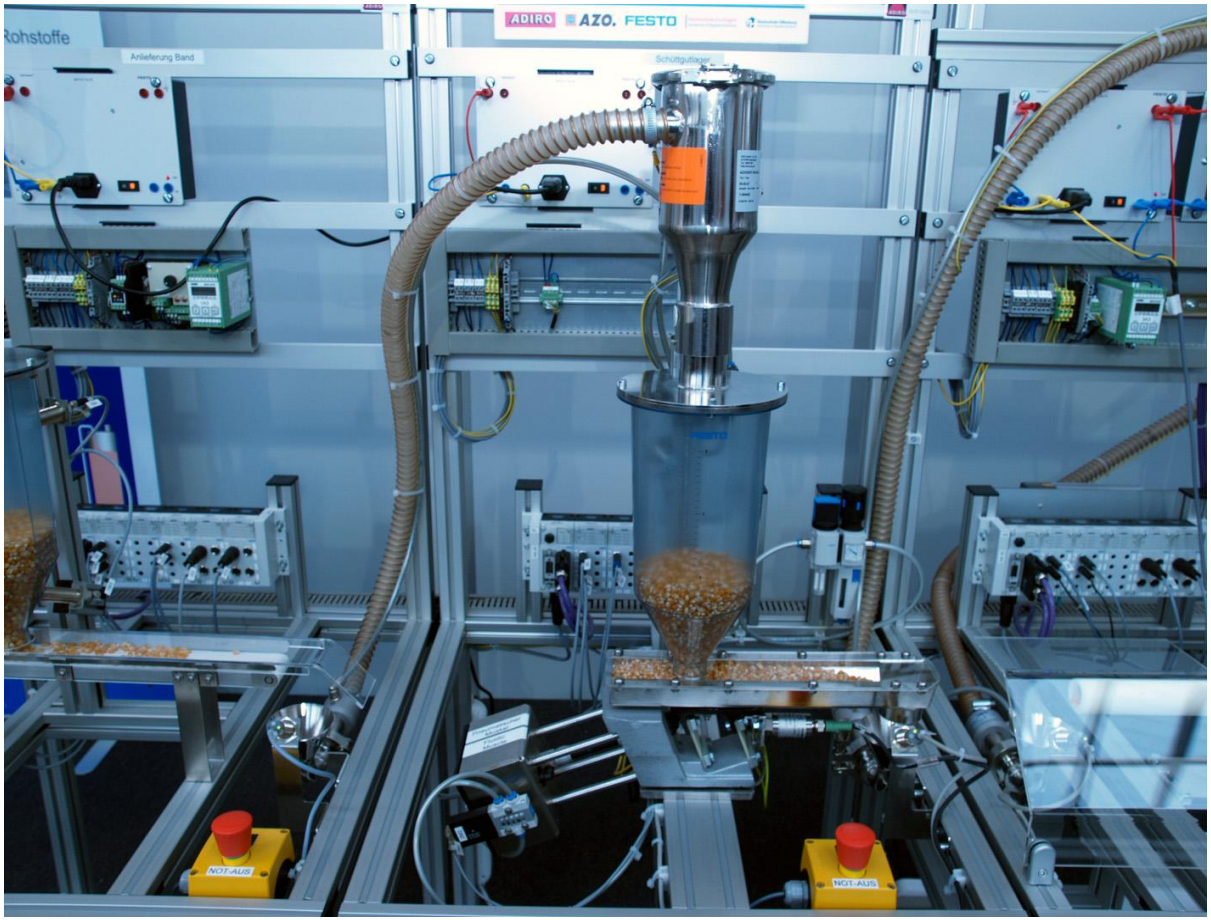


Industrial automation complexities

- Hybrid system nature
- Non-deterministic
- Timed nature (real-time systems)

Pilot project: test focus

To identify:

- Logical Errors
  - e.g. if a funnel is blocked , does the PLC stop the conveyor belt?
- Timing Errors
  - e.g. if a funnel is blocked, does the PLC stop the conveyor in the pre-defined duration?
- Plant Errors
  - e.g. if a sensor is broken can the PLC still handle the plant appropriately

Pilot project framework

Model
(Commercial tool)

Industrial
Automation
Adapter
(Our software)

Test Generation
(Commercial tool)

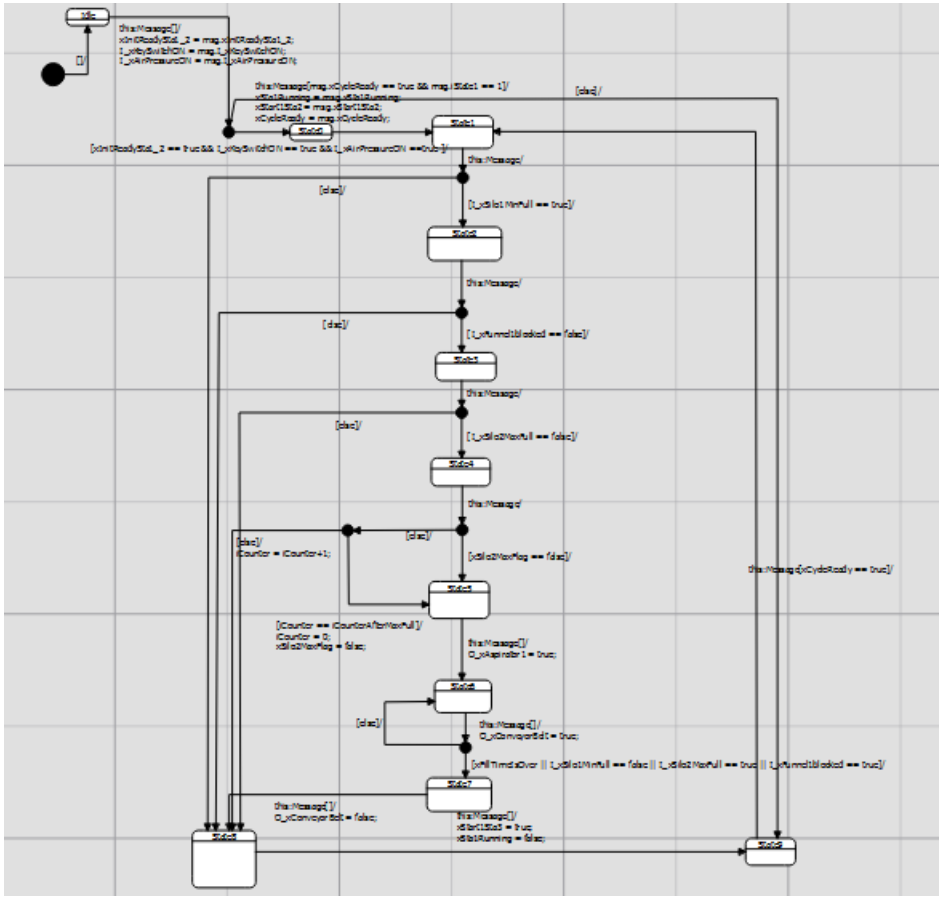
PLC

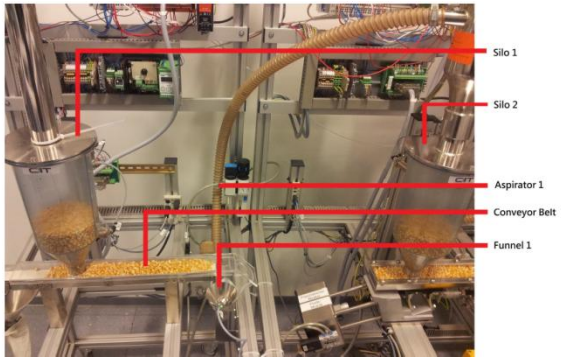
Fieldbus

Test
Execution
Engine
(Our Software)

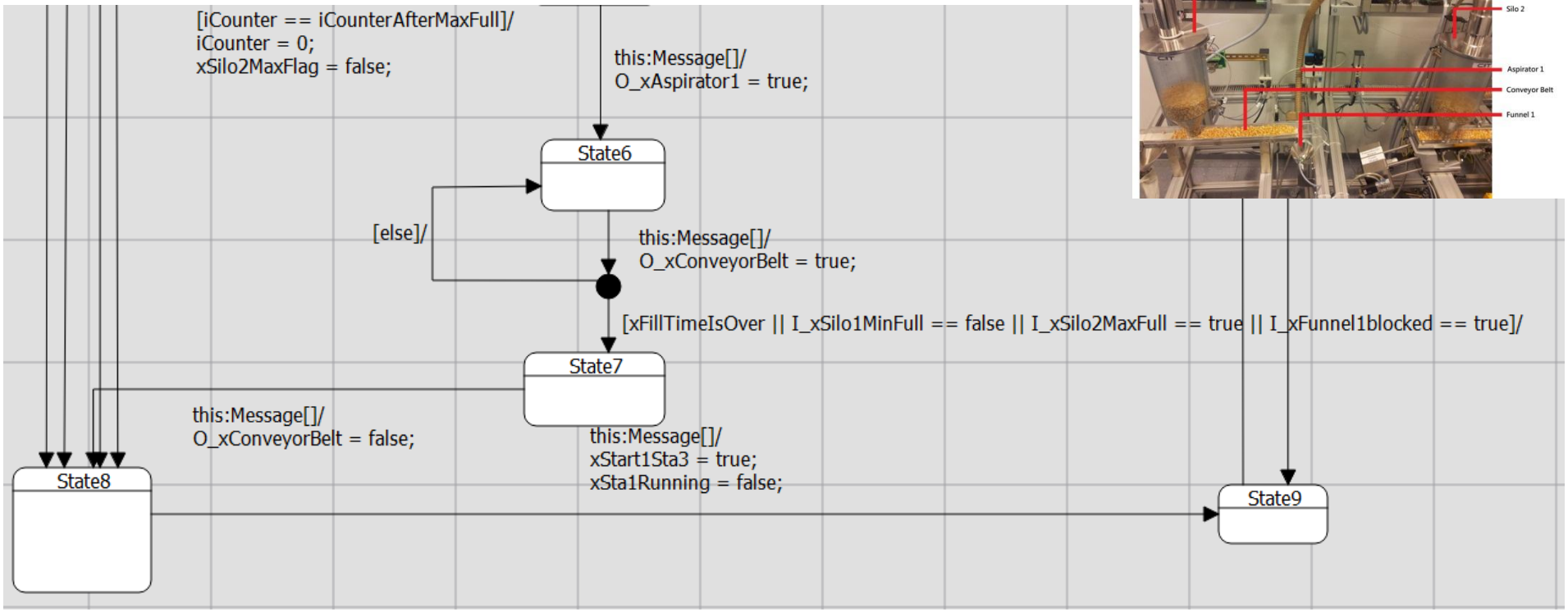
Test Suite

Model

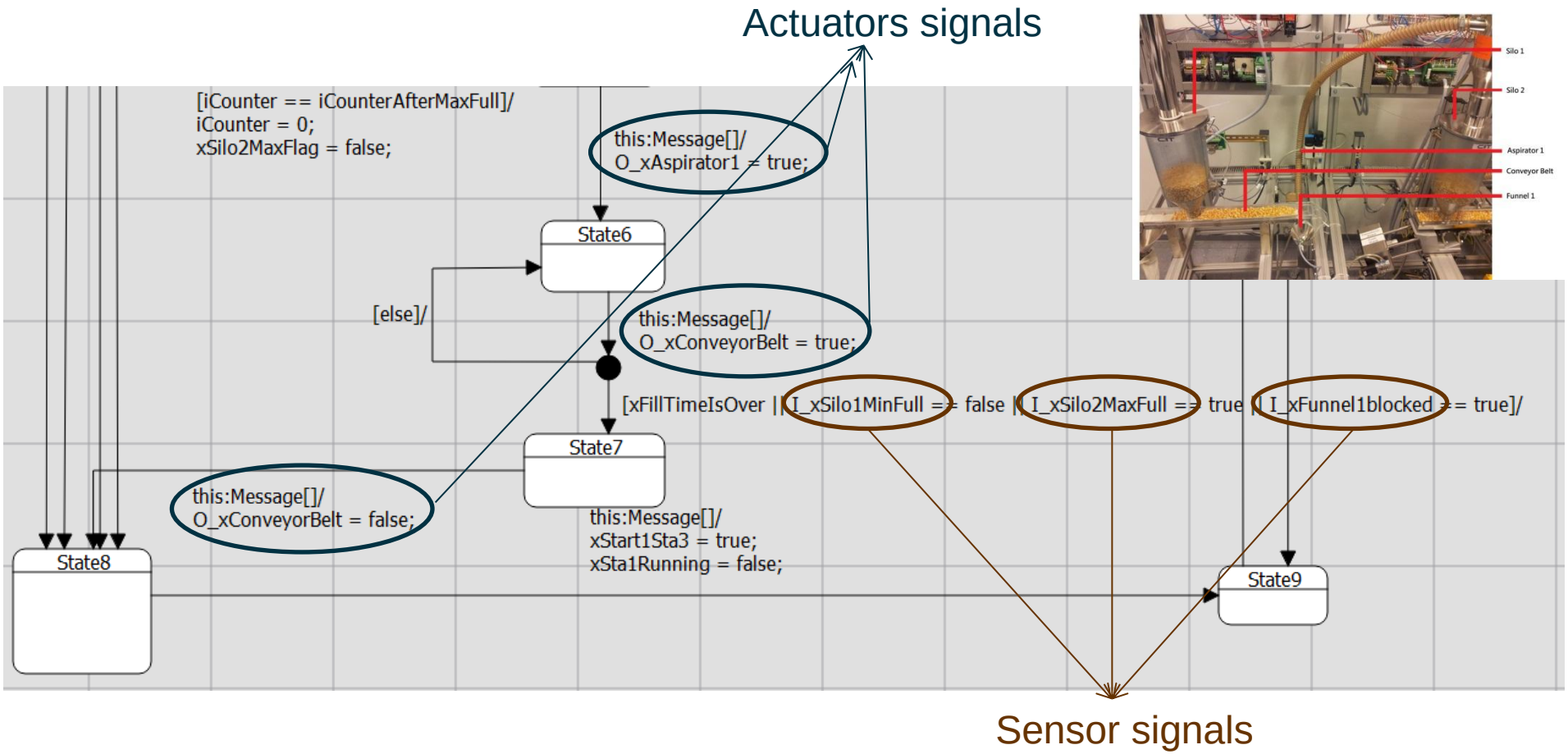




Model



Model



Commercial tool generated test cases

Institute Industrial IT

1 Message	in	0.0
O_xAspirator1	true	
O_xConveyorBelt	true	
I_xFunnel1blocked	true	
I_xSilo1MinFull	true	
I_xSilo1ToMinLevel	true	
I_xSilo2MaxFull	true	
I_xSilo2MinFull	true	
xSta1Running	true	
st	true	
xSilo2MaxFlag	true	
xFillTimeIsOver	true	
xStart1Sta3	true	
xCycleReady	true	
I_xAirPressureON	true	
I_xKeySwitchON	true	
xInitReadySta1_2	true	
xStart1Sta2	true	
iCounter	0 (0x0 0o0 0b0)	
iCounterAfterMaxFull	0 (0x0 0o0 0b0)	
iState1	0 (0x0 0o0 0b0)	

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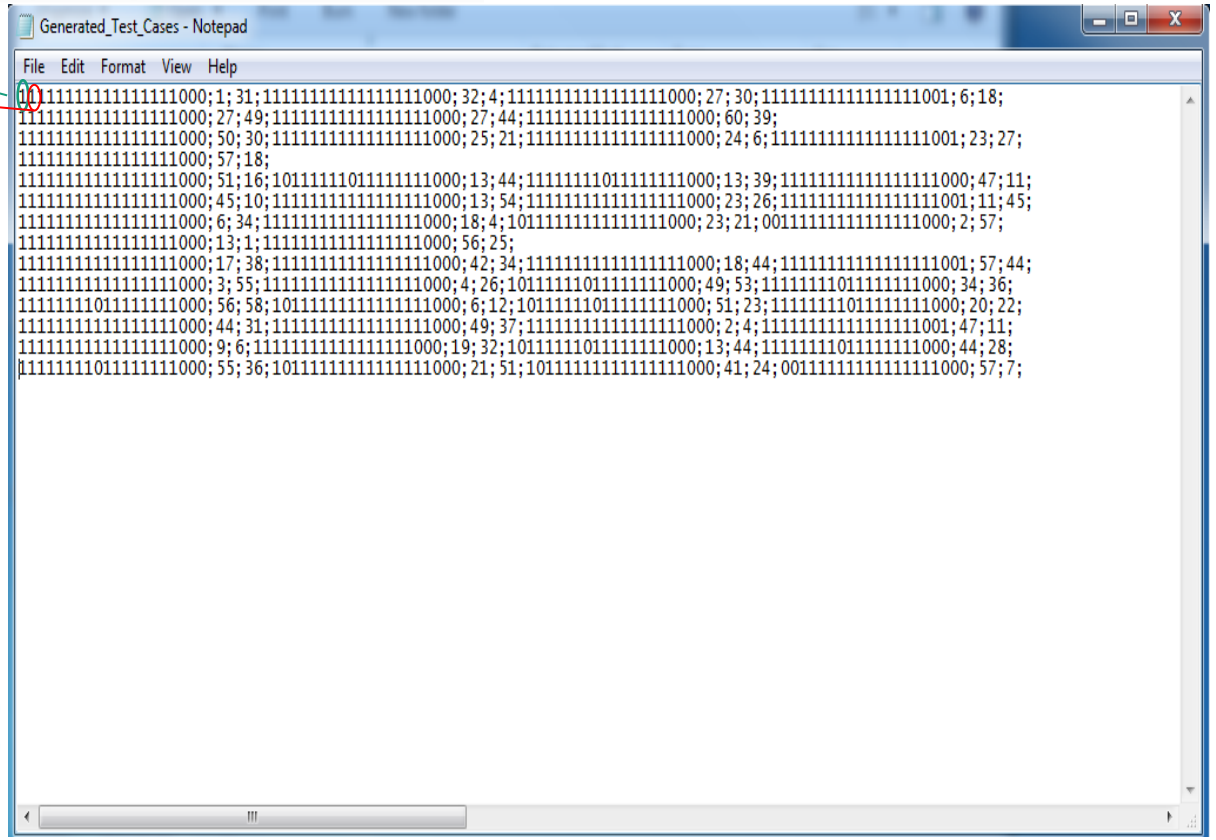
Adapted test cases

Message	in
O_xAspirator1	true
O_xConveyorBelt	true
I_xFunnel1blocked	true
I_xSilo1MinFull	true
I_xSilo1ToMinLevel	true
I_xSilo2MaxFull	true
I_xSilo2MinFull	true
xSta1Running	true
st	true
xSilo2MaxFlag	true
xFillTimeIsOver	true
xStart1Sta3	true
xCycleReady	true
I_xAirPressureON	true
I_xKeySwitchON	true
xInitReadySta1_2	true
xStart1Sta2	true
iCounter	0 (0x0 0o0 0b0)
iCounterAfterMaxFull	0 (0x0 0o0 0b0)
iState1	0 (0x0 0o0 0b0)



Test execution

```
Please Note: The following monitored values should be read as follows:

Actual Values / Expected Values [Time of Arrival in milliseconds] Y/N ; ..... ;   ---->   'Overall Verdict'

Hint: 'Y' after the 'Arrival time' indicates that the 'real-time constriant' / 'Expected Values' were satisfied and 'N' represents the contrary


0001000000000001000001100000000000000000000000000000010000/0001000000000001000001100000000000000000000000000010000 [103] Y ;
0010100000000000000011101111111100000000000000000011010000/0010100000000000000011101111111100000000000000000011010000 [197] Y ;
0010100000000100000011101111111100000000000000000011010000/0010100000000100000011101111111100000000000000000011010000 [1119] Y ;
0110100000000100000011101111111100000000000000000011010000/0110100000000100000011101111111100000000000000000011010000 [912] Y ;
0110100000000000000011101111111100000000000000000011010000/0110100000000000000011101111111100000000000000000011010000 [1200] Y ;
0110100000000000000011101111111100000000000000001111101000/0110100000000000000011101111111100000000000000001111101000 [20381] Y;
0110100000000000000011101111111100000000000000000011101000/0110100000000000000011101111111100000000000000000011101000 [200] Y ;
0010100000000000000011101111111100000000000000000011101000/0010100000000000000011101111111100000000000000000011101000 [281] Y ;
0010100000000000000011101111111100000000000000001111101000/0010100000000000000011101111111100000000000000001111101000 [27712] Y;
0000000000000001000001100000000000000000000000000000010000/0000000000000001000001100000000000000000000000000010000 [200] Y ;
0001000000000001000001100000000000000000000000000000010000/0001000000000001000001100000000000000000000000000010000 [4831] Y ;
---->  TC 1 : 'PASS'
```

Test verdict

```
PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS;      ---->     Testcase 2 : Over All Verdict = PASS;

PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS;      ---->     Testcase 3 : Over All Verdict = PASS;

PASS; PASS; PASS; PASS; PASS; PASS; PASS; FAIL; PASS; PASS; PASS;      ---->     Testcase 4 : Over All Verdict = FAIL;

PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS;      ---->     Testcase 5 : Over All Verdict = PASS;

PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS;      ---->     Testcase 6 : Over All Verdict = PASS;

PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS; PASS;      ---->     Testcase 7 : Over All Verdict = PASS;
```

Logical errors - results

Module ID	Inserted Errors	Detected Errors
1	24	16
2	24	14
3	42	27
4	88	53
5	36	22
6	122	108
7	48	34

Timing errors - results

Module ID	Error Log	
1 to 7	Correctly detected errors :	287
	Undetected errors :	36
	False detection :	51

Plant errors - results

Module ID	Inserted Errors	Detected Errors
1	10	4
2	11	4
3	14	6
4	3	0
5	10	4
6	46	17
7	11	5

I am done ! ☺