An interactive learning approach on digital twin for deriving the controller logic in IEC 61499 standard

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Contents

- Introduction
- Controller logic design from event logs
- Conclusion & Future work

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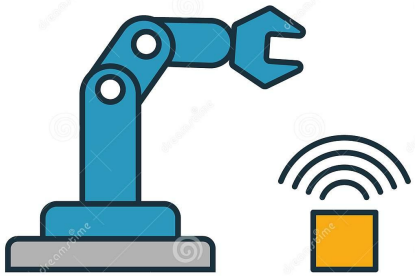
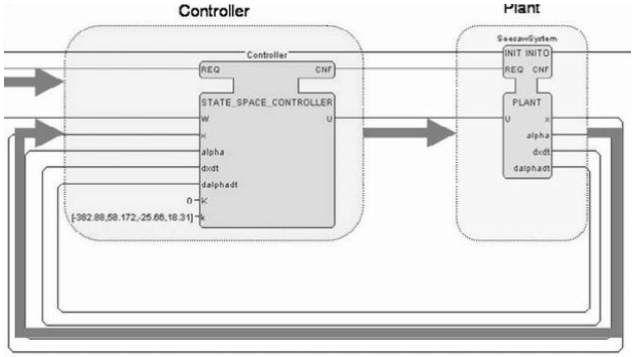
Introduction





- CPS
- IEC 61499
- Controller logic
- Simulation and Testing

Fig. 1:CPS. “https://larastock.com/”
Fig. 2:IEC 61499. “INDIN 2021 twitter post”
Fig. 3:Closed-loop system. “Auinger, Franz & Strasser, Thomas & Christensen, James. (2004). Using IEC 61499 Function Blocks (FB) for Closed Loop Control Applications. ”
Fig. 4:FV. “https://www.flaticon.com/free-icon/process_1523938”

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how to generate controller logic automatically?

Fig. 5:Thinking icon. “https://stock.adobe.com/”

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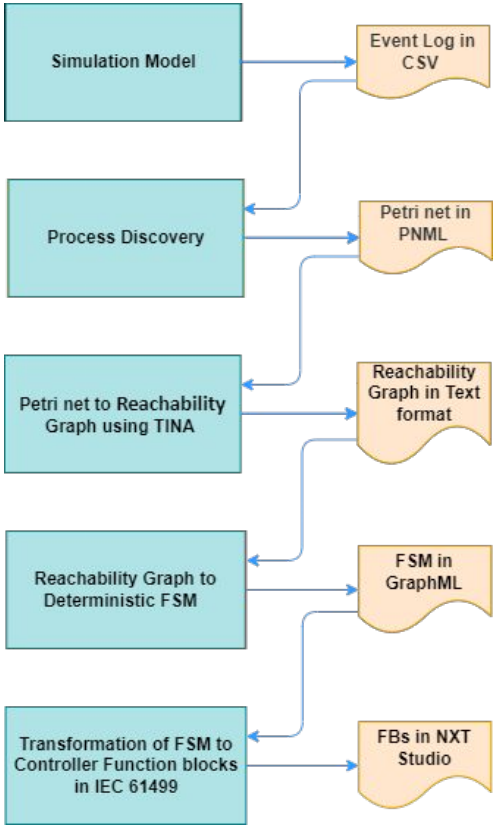
Proposed Solution



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Experiment

Conveyor-Gripper system.

Simulation model of system is developed using Visual Components.

Major components in the simulation model are conveyors, gripper and robotino.

Event log is recorded via OPC UA Communication protocol

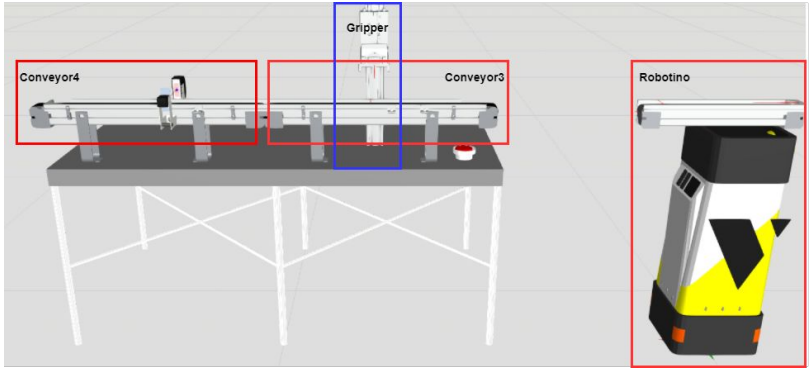

Figure. Simulation in Visual Components

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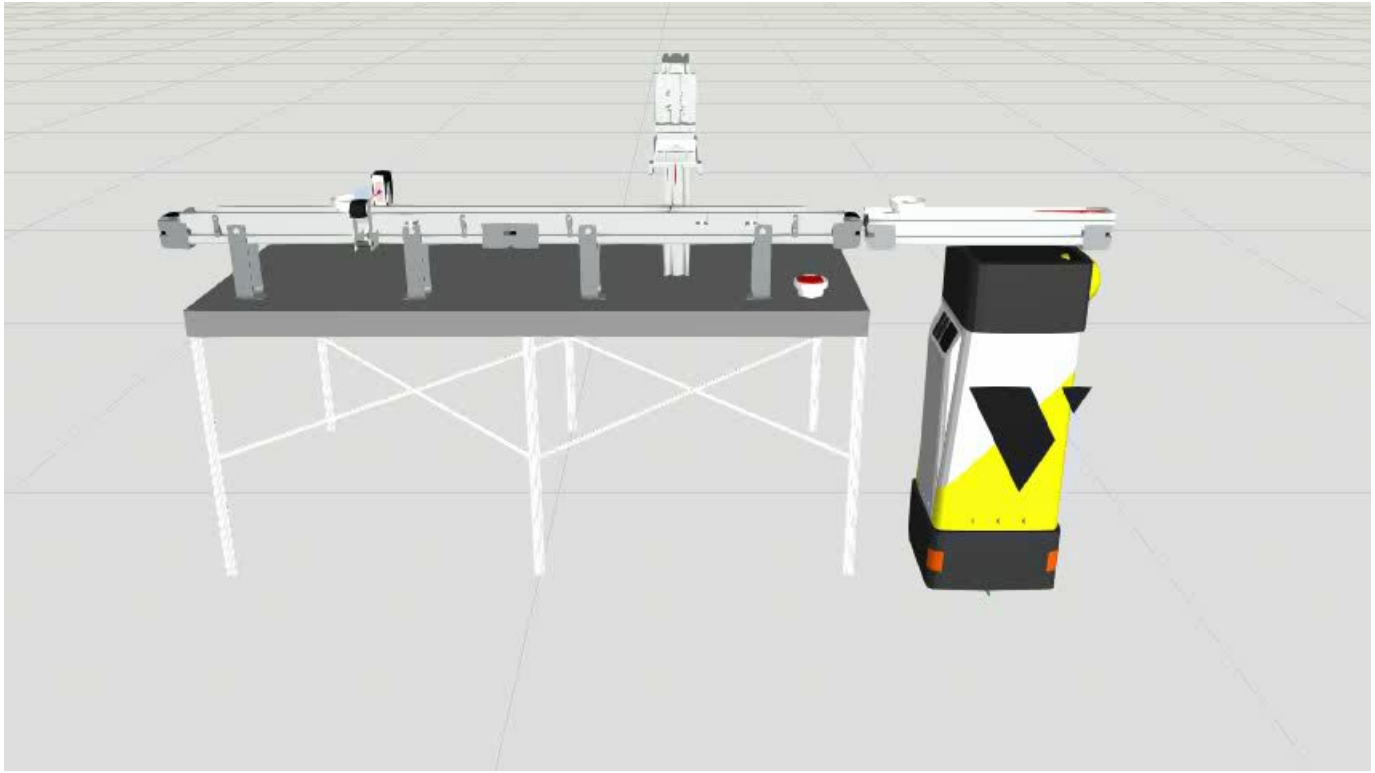
Simulation in Visual components



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Process discovery from event log

a)

```
CaseId, State, TimeStamp, Component, Signal, Value
1, 1000000000, 3.822, Conveyor_Robotino, create_new_cup_cmd, True
1, 1100000000, 3.822, Conveyor_Robotino, run_cmd, True
1, 1110000000, 3.822, Conveyour3, run_cmd, True
1, 1110001000, 8.940, Conveyour3, detected, True
1, 1100001000, 9.150, Conveyour3, run_cmd, False
1, 0100001000, 10.071, Conveyor_Robotino, create_new_cup_cmd, False
1, 0000001000, 10.071, Conveyor_Robotino, run_cmd, False
1, 0001001000, 10.071, Gripper1, extend_cmd, True
1, 0001001100, 10.571, Gripper1, extended, 30.0
1, 0001101100, 11.072, Gripper1, close_cmd, True
1, 0001101110, 11.272, Gripper1, closed, 0.0
1, 0000101110, 12.072, Gripper1, extend_cmd, False
1, 0000100110, 12.230, Conveyour3, detected, False
1, 0000100010, 12.572, Gripper1, vertical_retracted, 0.0
1, 0001100010, 13.073, Gripper1, extend_cmd, True
1, 0001101010, 13.420, Conveyour3, detected, True
1, 0001101110, 13.573, Gripper1, extended, 30.0
1, 0001001110, 14.074, Gripper1, close_cmd, False
1, 0001001100, 14.274, Gripper1, opened, 5.0
1, 0000001100, 15.071, Gripper1, extend_cmd, False
1, 0000001000, 15.571, Gripper1, vertical_retracted, 0.0
1, 0010001000, 16.072, Conveyour3, run_cmd, True
1, 0010000000, 16.250, Conveyour3, detected, False
1, 0010010000, 17.057, Conveyour4, run_cmd, True
1, 0010010001, 20.060, Camera1_sensor_c4, detected, empty
1, 0000010001, 20.276, Conveyour3, run_cmd, False
1, 0000000001, 20.667, Conveyour4, run_cmd, False
.....................................................................
```

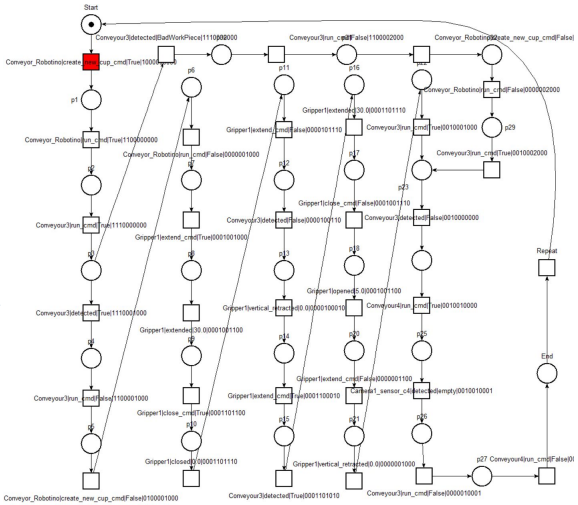
Event log – CSV

Event log – XES

Alpha algorithm

Petri net

b)



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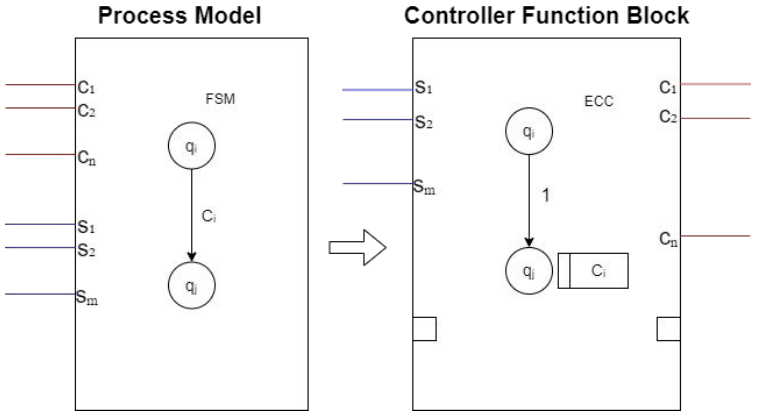
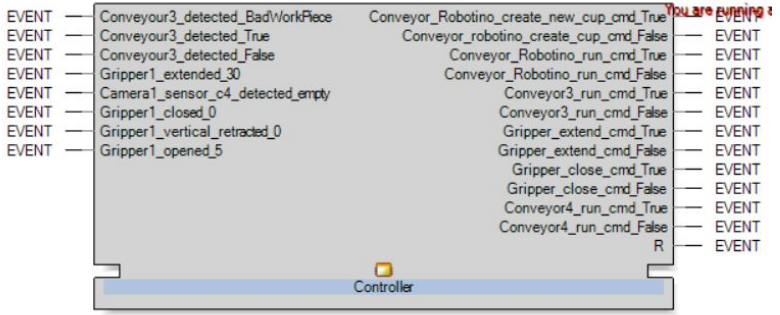
Controller FB Interface

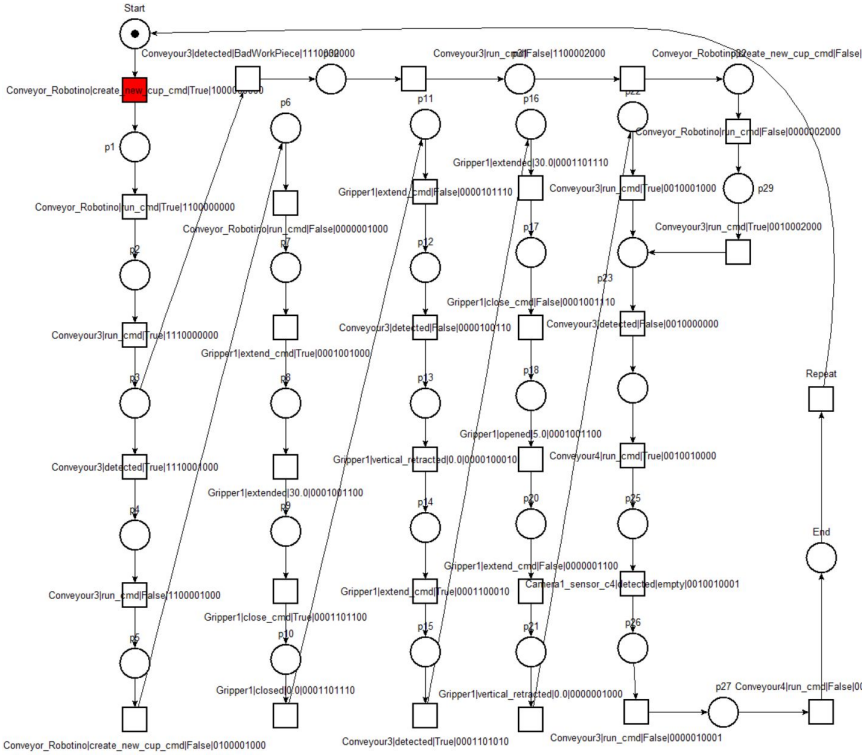
a)

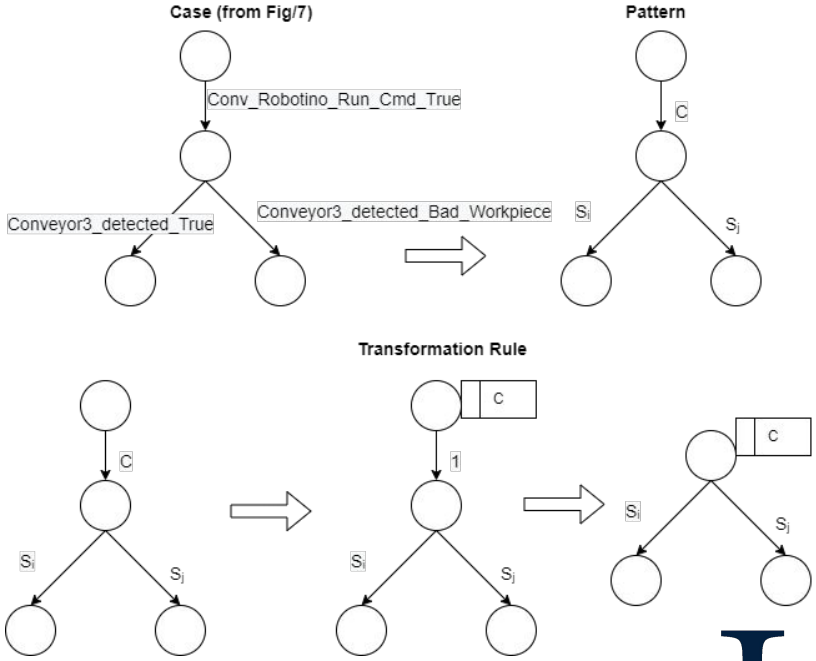


b)



ECC generation from Petri net





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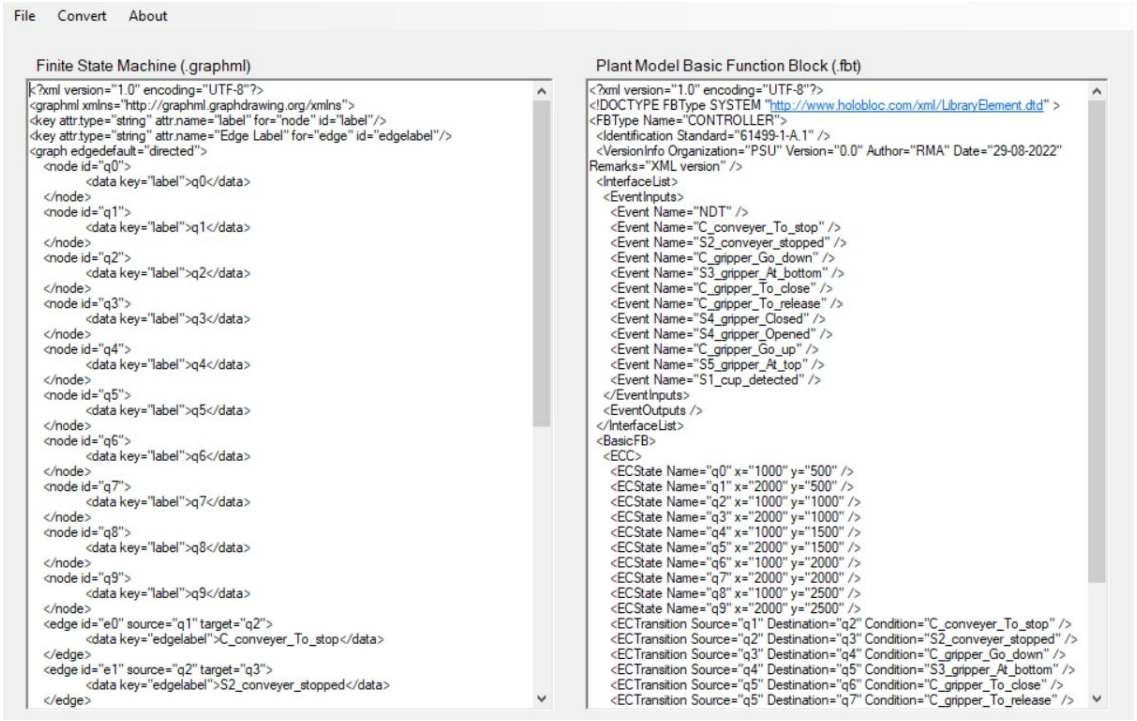
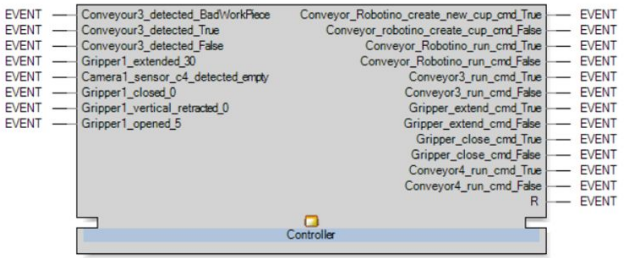
IEC 61499 Controller Generator

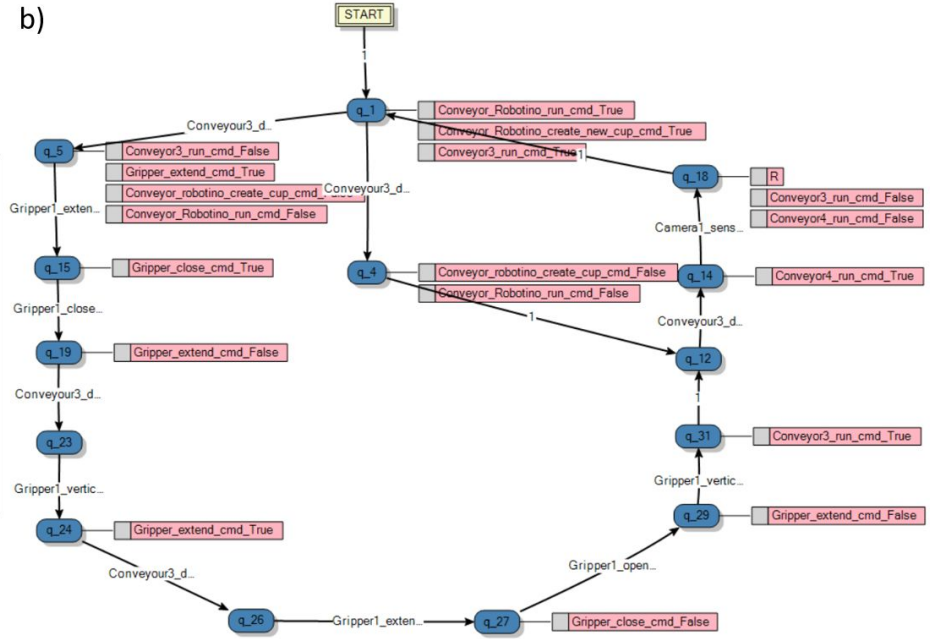


IEC 61499 Controller FB

a)



b)



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Conclusion

- Generated IEC 61499 FB of Controller
- Derived Petri net helps to understand the process logic

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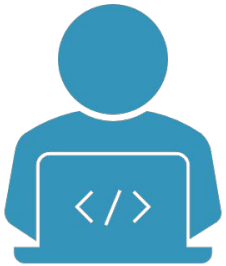
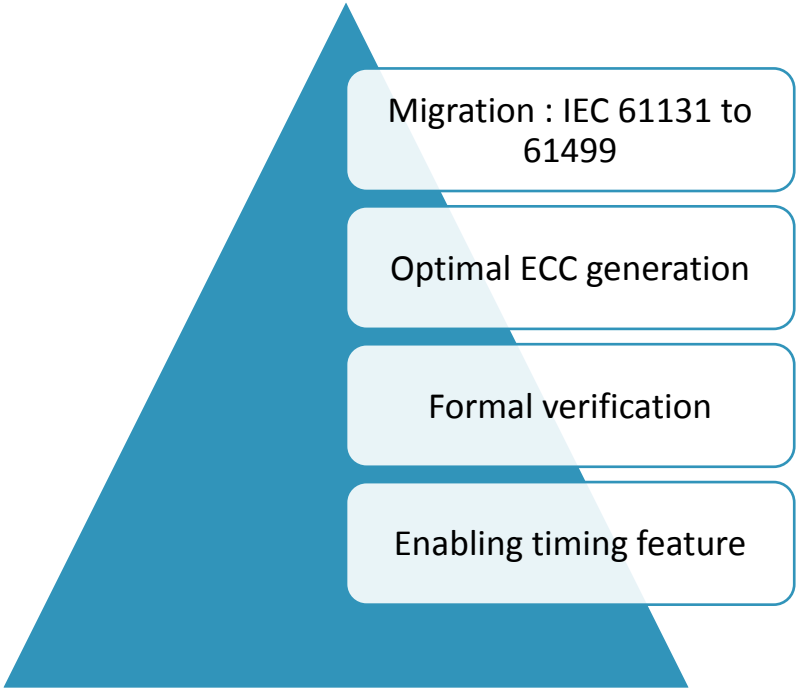
Future plan





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Thank you

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ECC generation from Petri net