9th UCAAT User Conference on Advanced Automated Testing

Back-to-back testing applied to distributed PLC

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Solutions temps réel sécurisées

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Context

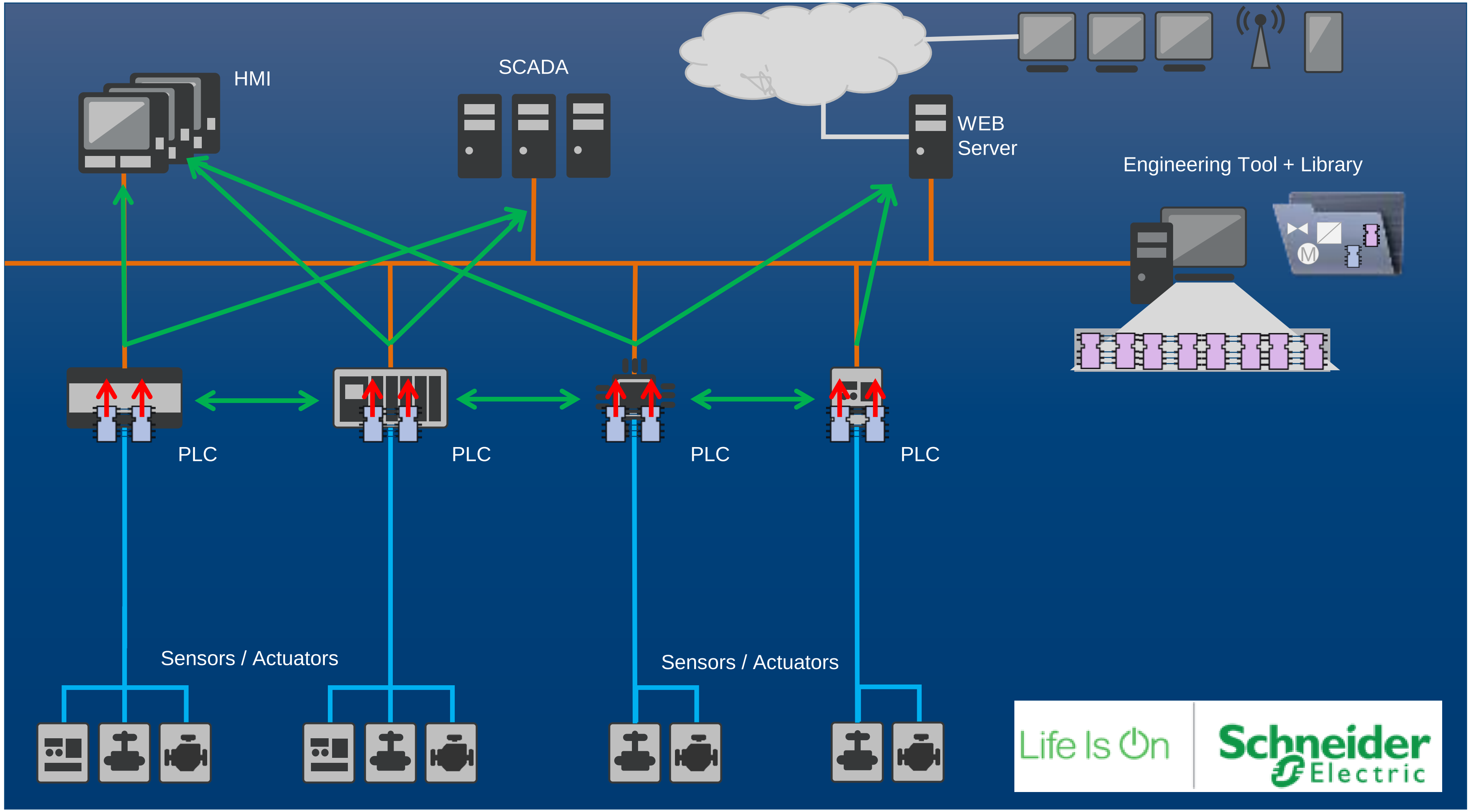
R&D Project : Back-to-Back testing

- Multiple partners
  - CEA List
  - Schneider Electric
  - Systerel
- Industrial topics
- Public funders

Back To Back Testing

This project has been supported by both the French State, through the program “Investing for the future”, and the french regions

Industrial context



Project objectives

Main considerations

- Deployment of a PLC solution based on IEC 61499
- Concerns about evaluation of the application design
  - Has the application been well designed ?
  - Does the implemented program behaves as designed ?

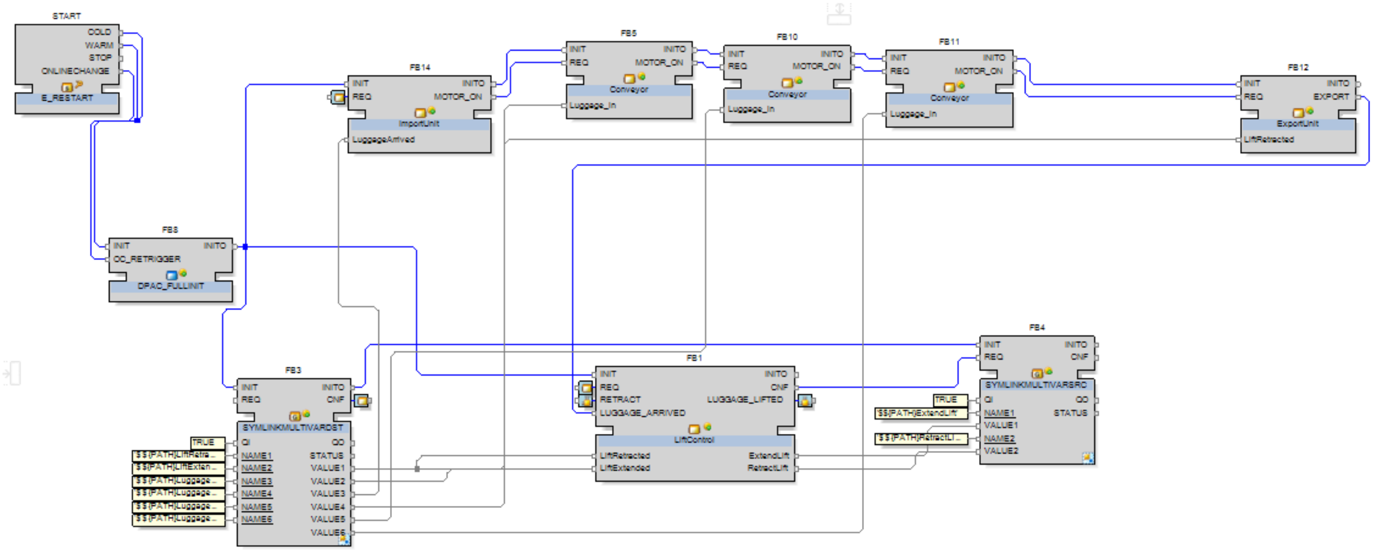
Project objectives

- Definition and measurement of relevant metrics
- Automatic allocation of the application in the candidate resources
- Automatic generation and execution of test sequences based on back-to-back principle

IEC 61499 standard principle

Based on distributed systems

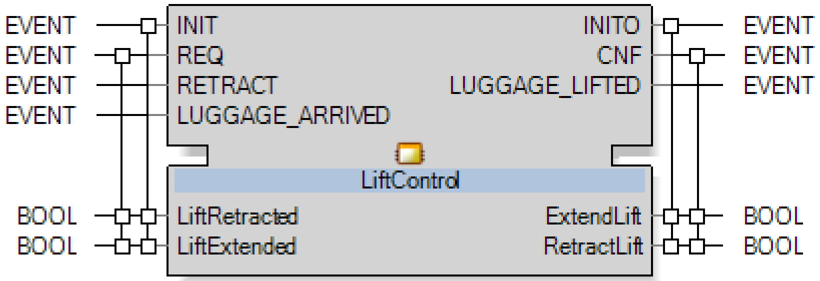
- Application written without concern of devices
- Once written, allocation of the selected parts on different devices or resources

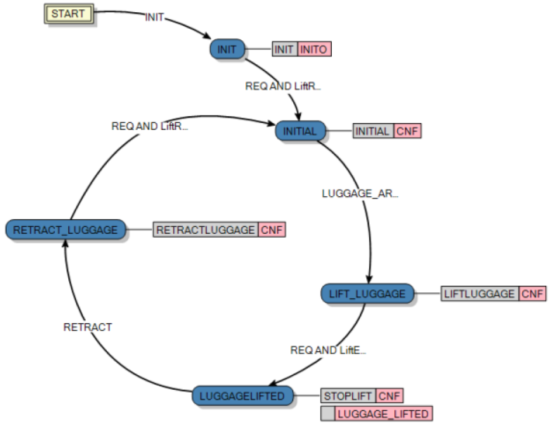


Function block

Application structure

- Network of Function Blocks that exchange both events and data
- Activation of FBs scheduled through events
- Each FB activated reads its input data, performs operation and emits output events and data
- Specific FBs allow to read external inputs and emit external outputs

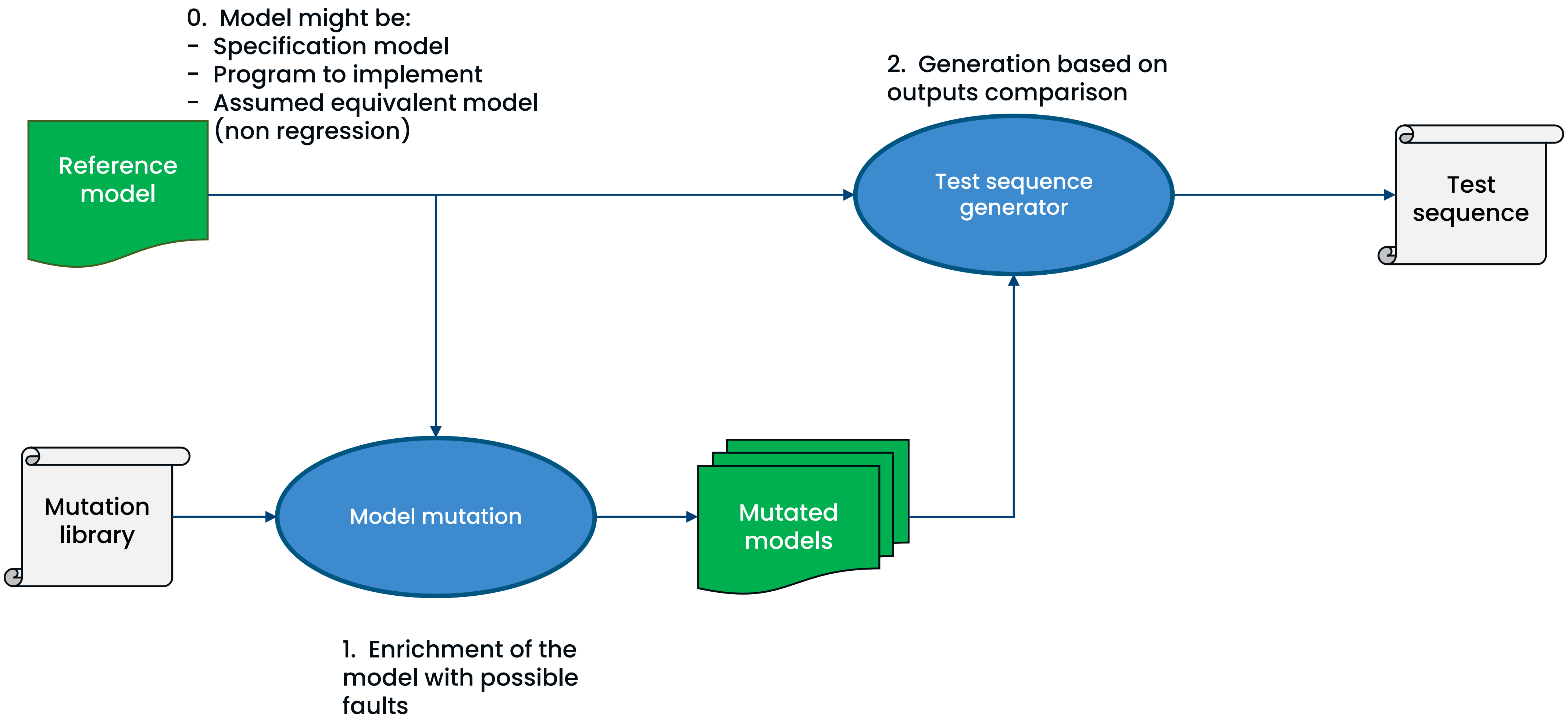




IEC 61499 distinctive features

- Diversity of variables (bool, int, float, string, date, …) and interfaces (dry contact, analogic, digital, ..)
- Event-based behavior (non-cyclic)
  - External events may occur within a processing
  - Possibly no stabilization
- Distributed architecture (non-determinist)
  - FB on different resources may evolve independently
  - No guaranty of input reading synchronism

B2BT: Test sequence generation

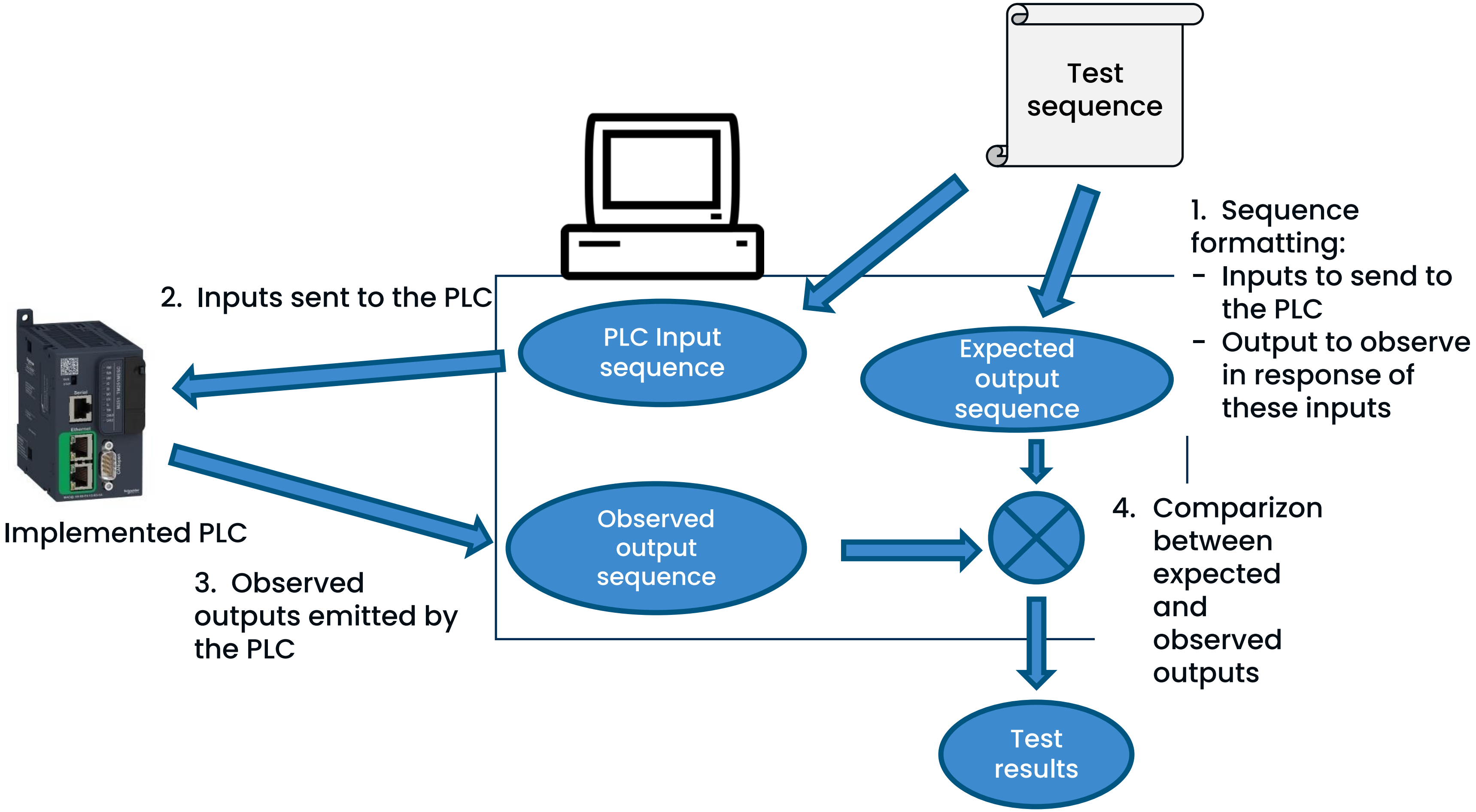


0. Model might be:
- Specification model
- Program to implement
- Assumed equivalent model (non regression)

2. Generation based on outputs comparison

1. Enrichment of the model with possible faults

B2BT: Test sequence execution



Test sequence

1. Sequence formatting:
   - Inputs to send to the PLC
   - Output to observe in response of these inputs

2. Inputs sent to the PLC

Implemented PLC

3. Observed outputs emitted by the PLC

4. Comparizon between expected and observed outputs

B2BT: Advantages and drawbacks

Coverage criterion

- Detects all possible observable fault on each variable assignation / logic operation according to the mutation library

Observability

- A fault is covered if its consequences are observable through the outputs

Precise input injection control

- As the model represents the executed code, input injection must occur precisely to fit the expected behavior

Calculation power

- Precise models require more resources to evaluate the behavior

B2BT applied to IEC 61499

Pseudo-cyclic behavior

- Send input variables
- Wait for stabilization
- Collects output variables

Temporization and Clocks control

- Considered as external inputs
- Prevents undesired events during a test cycle

Input changes limitation

- Only inputs from the same resource can change at each step
- Temporization and clocks can only be triggered alone

Test bench principle and realization

Scheduler (computer)

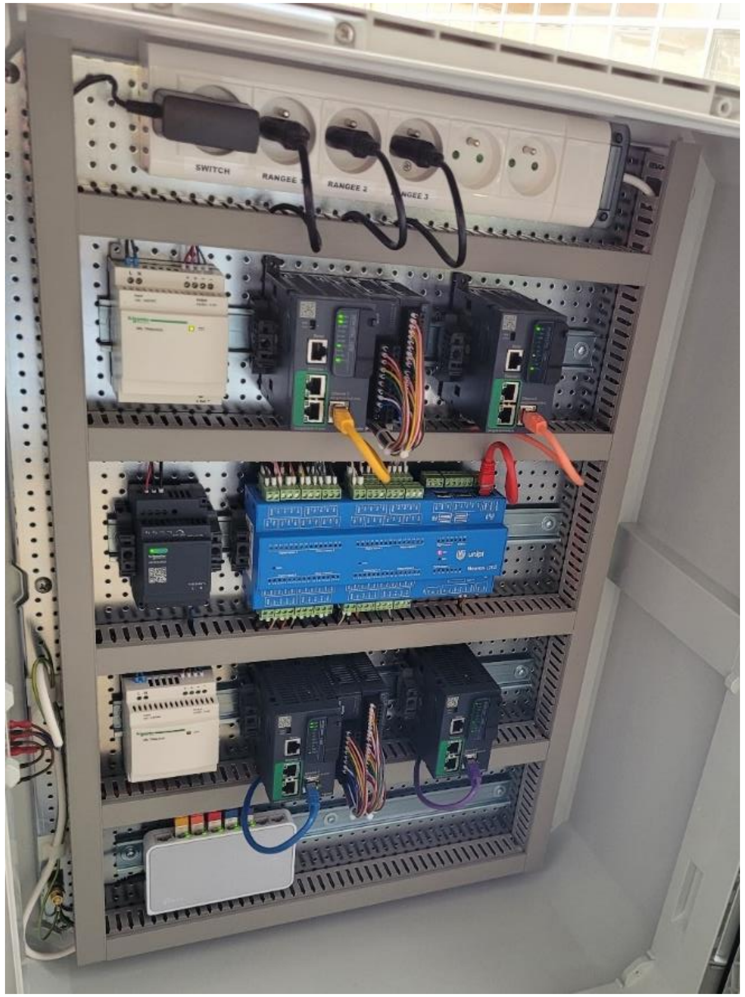
- Sends and receives I/O updates
- Compares the observed outputs with expected ones

Input / outputs

- Logic I/O directly through network connection
- Dry contact and analogic I/O through a converter device

Testing instrumentation

- Maintenance tool used to :
    - Trigger the input event after having updated all the input variables
    - Restrain and trigger temporization and cyclic FB



Results and difficulties

Results

Application	FB Activated	Exchanges between PLC	Pending internal queue	Pending external queue
Example 1 PLC	19	/	2	1
Example 2 PLC	48	2	4	1

Difficulties

- Obfuscated FB (standard and private libraries)
- Non-cyclic behavior
- Great diversity of internal variable types
- Indeterminism of distributed architectures

Conclusions

Testing IEC 61499 standard

- Highly dependent of the conception tool
- Non-cyclic behavior increases the number of possible input stimulations
- Requires a high level of instrumentation (gray box at least)

B2BT with IEC 61499 standard

- Requires restrictions or instrumentation to reach a stable state between each test step
    - Restrictions leads to a combinatory explosion for sequence calculation
    - Instrumentation (One FB activation per step) leads to an explosion of the test sequence length

Any further questions?

Contact me
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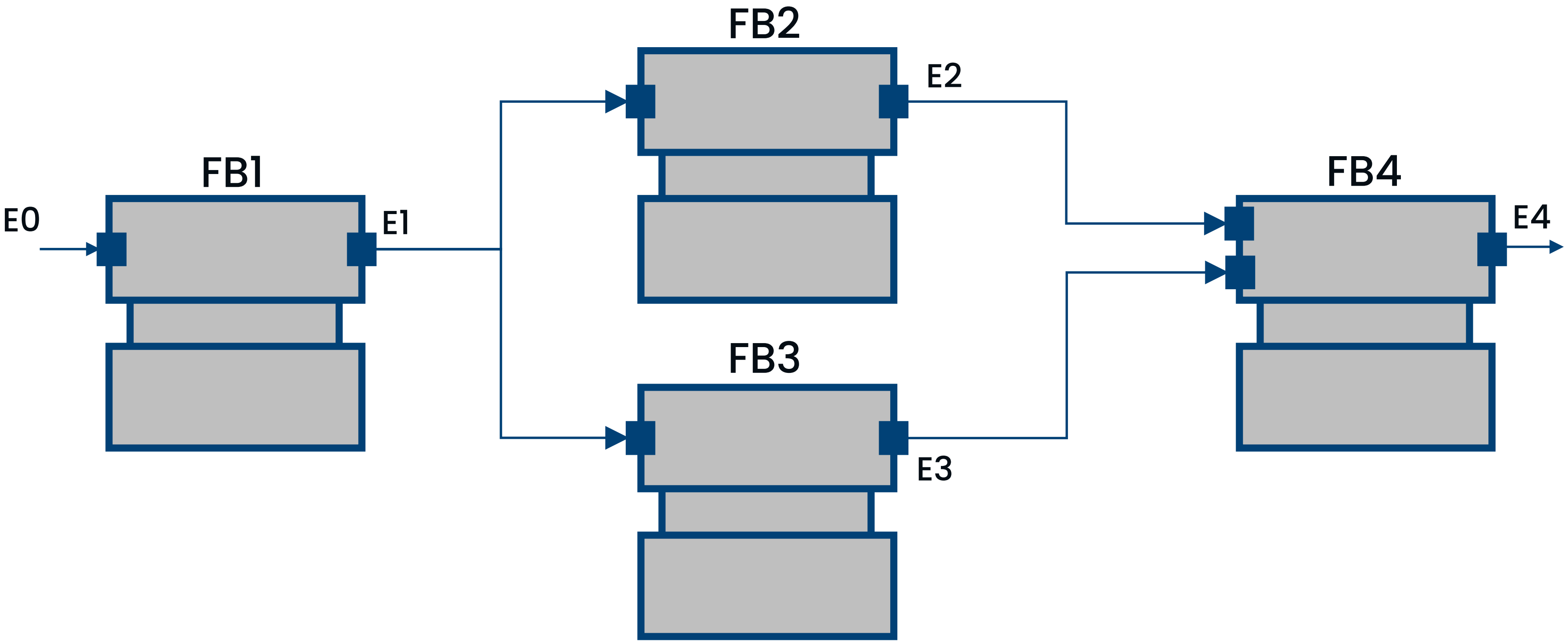
Application execution example

Event Queue : {(E0, FB0), (E1,FB2), (E1, FB3),(E2,FB4),(E3,FB4),E4, E4}
Active FB : {FB1 -> FB2 -> FB3 -> FB4 -> FB4}


FB2
E2
FB1
E0
E1
FB4
E4
FB3
E3