EXPERIENCE WITH STATIC PLC CODE ANALYSIS AT CERN

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THPHA160

Motivation

Improve the quality of UNICOS PLC programs

UNICOS PLC programs

- Large PLC programs based on Library of objects
  Function Blocks (FBs)
- **Programs generated** by the **UNICOS Generation** tool
- Most common PLC languages
  ST (Schneider) and SCL (Siemens)

Problems

- **Complex expressions**, specific **naming conventions**, dead code, **code repetition**, potential **concurrency problems** (PLC interrupts), unused variables, multiple assignment of output variables, etc.
- L**ack of formal and complete specification**

```
(* AUTO REQUEST / SELECT *)
IF AuMoSt THEN
  (*Avoid the starting of PCO with
  a start Interlock *)
  IF NOT (StartISt AND NOT RunOSt) THEN
    RunOSt := AuRunOrder;
    MOnRSt := AuRunOrder;
  END_IF;
  AuDepOSt := AuAuDepR;
  IF (0.0 < AuOpMoR) AND (AuOpMoR < 9.0) THEN
    IF OffSt THEN
      OpMoSt := AuOpMoR;
    ELSE
      IF POpMoTab[REAL_TO_INT(OpMoSt-1),
        REAL_TO_INT(8-AuOpMoR)] THEN
        OpMoSt := AuOpMoR;
      END_IF;
    END_IF;
  END_IF;
(* MANUAL REQUEST / SELECT *)
ELSIF MMoSt OR FoMoSt OR SoftLDSt THEN
  ...
END_IF;
```

Approach

Static analysis

What is it?

- Technique that **examines a program without executing it**
- Similar to **code review** or **code comprehension** performed by automated tools
- Leads to the early detection of bugs
- Good complement to **testing** and **formal verification**

Which method?

- Rule-based AST (Abstract Syntax Tree) analysis, control-flow analysis, data-flow analysis, call graph analysis, etc.

What can we detect?

- Naming conventions violations, bad code smells (e.g. dead or duplicated code), overcomplicated expressions, multitasking problems, etc.

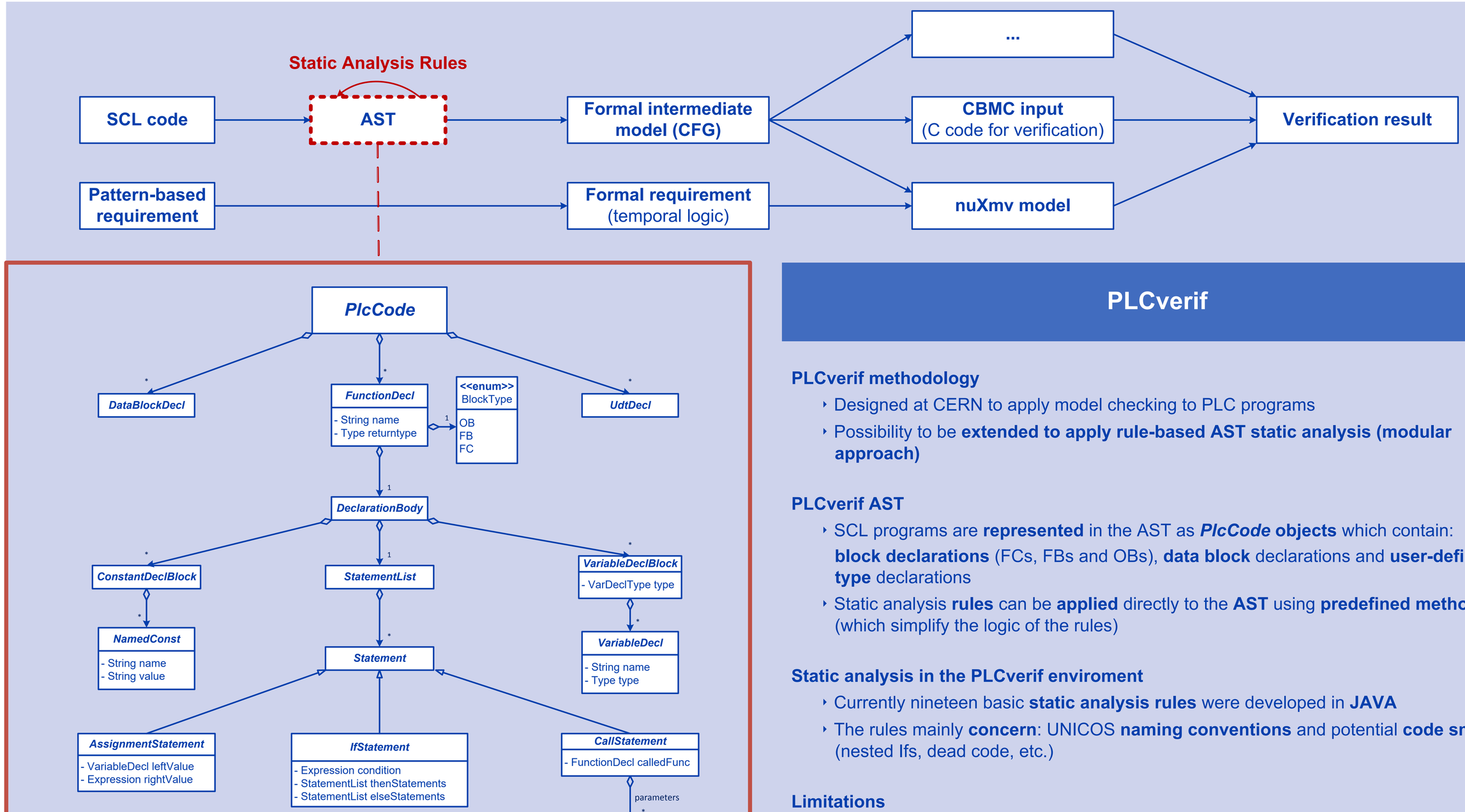
Challenges

- **Lack of Static PLC Code Analysis tools** comparing with general purpose programing languages
- Several researchers and companies are working to bring static analysis to PLC programs but **still far from being a common practice in this industry**
- UNICOS specific code guidelines implies **specific static analysis rules for our programs**

Goal

Our goal is to be one step closer to **ensure the reliability of our PLC programs by applying static analysis**, complementing the existing model checking methodology

Our solution: extending PLCverif



PLCverif

PLCverif methodology

- Designed at CERN to apply model checking to PLC programs
- Possibility to be **extended to apply rule-based AST static analysis (modular approach)**

PLCverif AST

- SCL programs are **represented** in the AST as ***PlcCode* objects** which contain: **block declarations** (FCs, FBs and OBs), **data block** declarations and **user-defined type** declarations
- Static analysis **rules** can be **applied** directly to the **AST** using **predefined methods** (which simplify the logic of the rules)

Static analysis in the PLCverif enviroment

- Currently nineteen basic **static analysis rules** were developed in **JAVA**
- The rules mainly **concern**: UNICOS **naming conventions** and potential **code smells** (nested Ifs, dead code, etc.)

Limitations

- **Not everything can be resolved with the AST method**
- Concurrency problems may require the use of different static analysis methods (e.g. call graph techniques)

Outcome

Static Analysis in PLCverif

- **First prototype** of AST-based basic static analysis rules
- Applied to **UNICOS object Function Blocks (SCL language)**
- Detection of naming convention violations in our code
- Detection of problematic structure that could lead to maintainability and readability problems

Future work

- Add new and more complex AST-based rules
- Integrate more static analysis methods in PLCverif