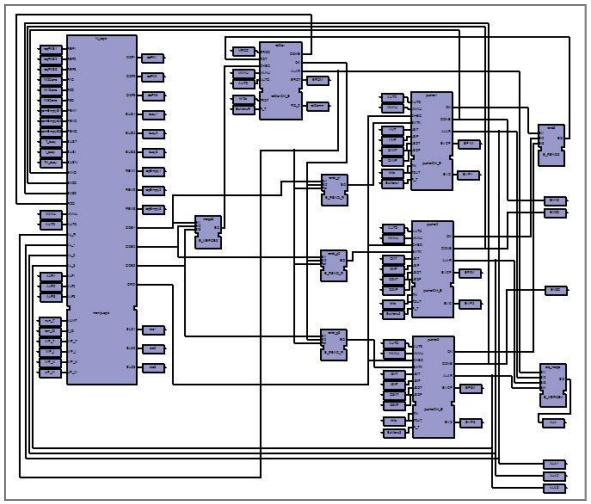
Istituto di Tecnologie Industriali e Automazione
Consiglio Nazionale delle Ricerche

SYNESIS

IEC61499 based Control development of Advanced Manufacturing and HVAC solutions

Alessandro Brusaferri



About ITIA-CNR and Synesis

Istituto di Tecnologie Industriali e Automazione
Consiglio Nazionale delle Ricerche

ITIA-CNR, as a promoter of Industrial Innovation, performs strategic activities of Scientific Research and Technological Development for the Competitiveness and Sustainability of Italian and European Manufacturing Industries.
The focus of the research activities concerns the following issues:
- Machine/System control solutions
- Intelligent robot systems
- Enterprise engineering and virtual applications

SYNESIS

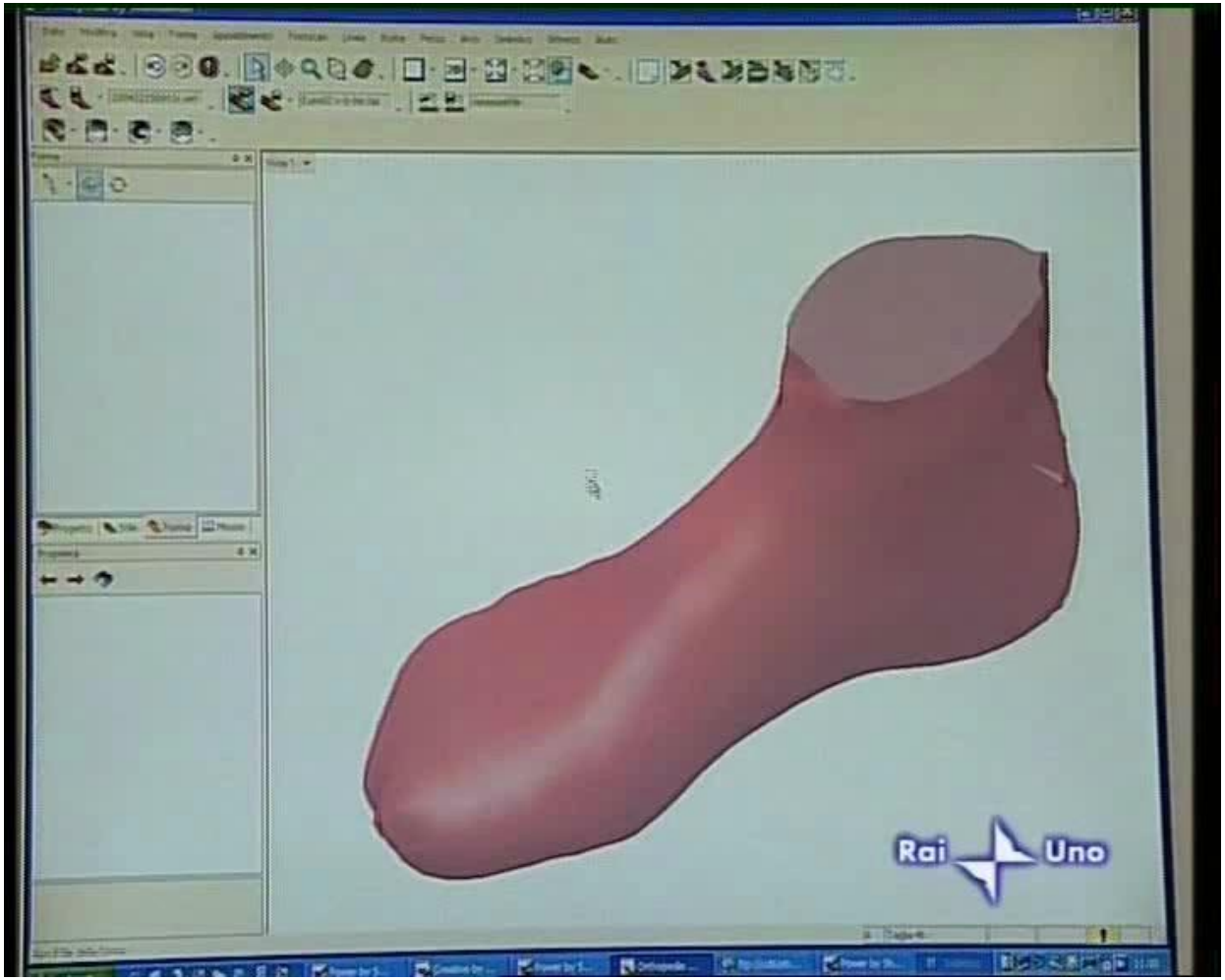
Synesis, as an European Public-Private technology development consortium, acts on a spectrum of enabling technologies for production systems:
from innovative operating machines to adaptive factories
from design and optimization of production systems to energy efficient and green manufacturing processes

Solutions

Requirements

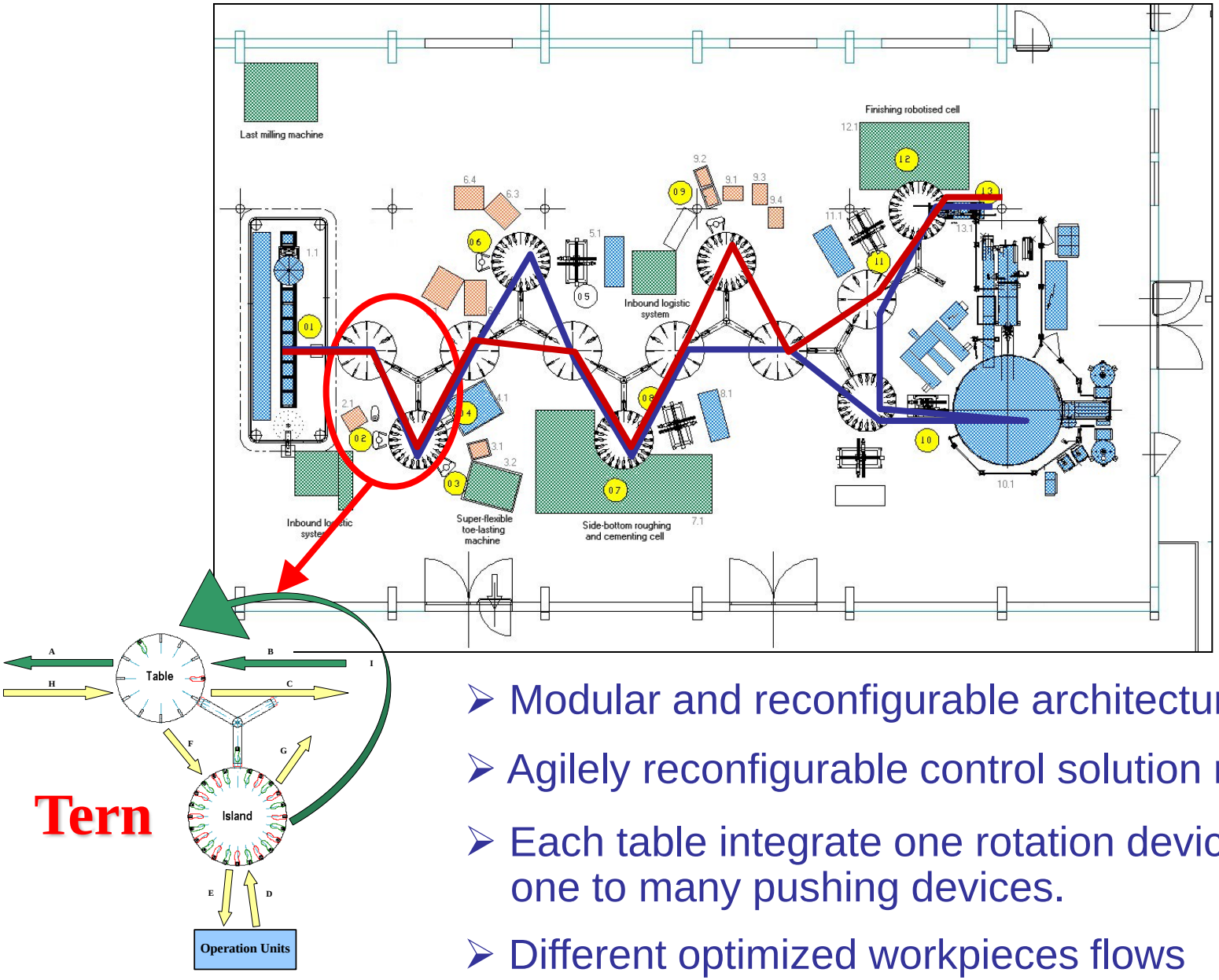
MARKET

Innovative Shoe Manufacturing Plant



Responsive Manufacturing Plant

Molecular Line Architecture



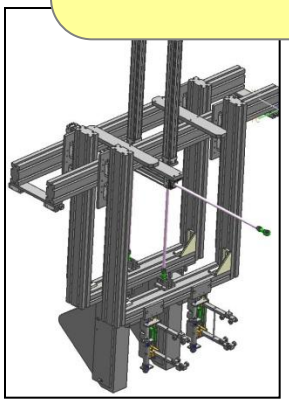
- Modular and reconfigurable architecture
- Agilely reconfigurable control solution required
- Each table integrate one rotation device and one to many pushing devices.
- Different optimized workpieces flows

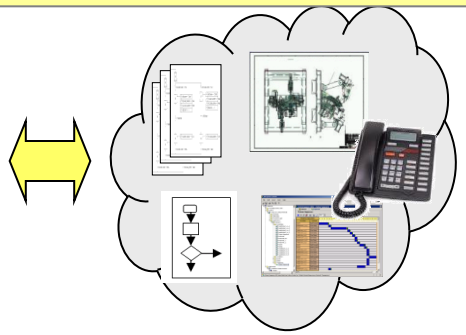
Advanced Manufacturing Systems requirements

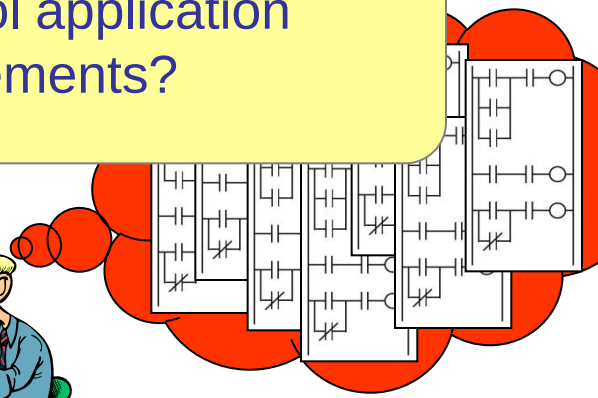
- Automation systems increasing complexity
- Growing product variety and shorter lifecycle
- Agile solutions reconfiguration required

- Not properly structured control application
- Difficult to maintain and re-adapt
- Need to formalize and reause knowledge
- Avoid star
- Reduce ti

How to properly structure the control application in order to satisfy such requirements?



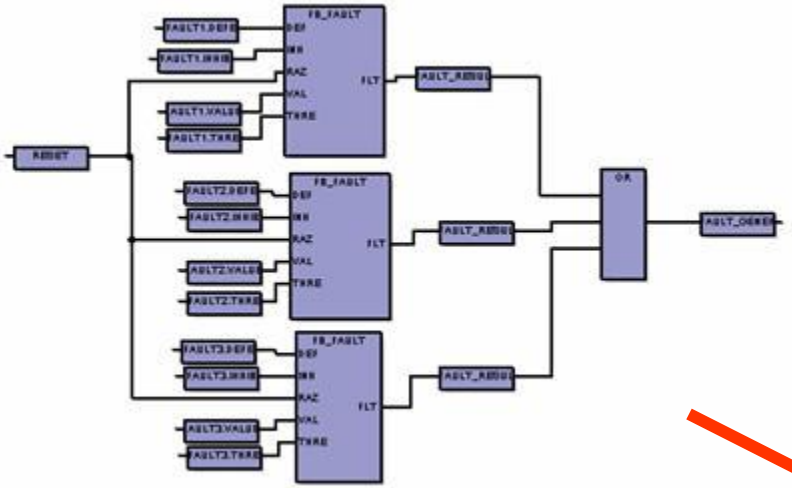




Mechanical Design

Control Development

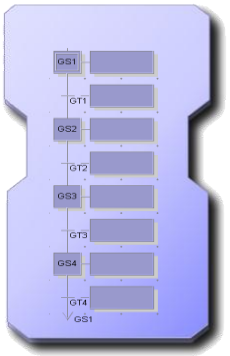
IEC 61499 – Structured design formalism

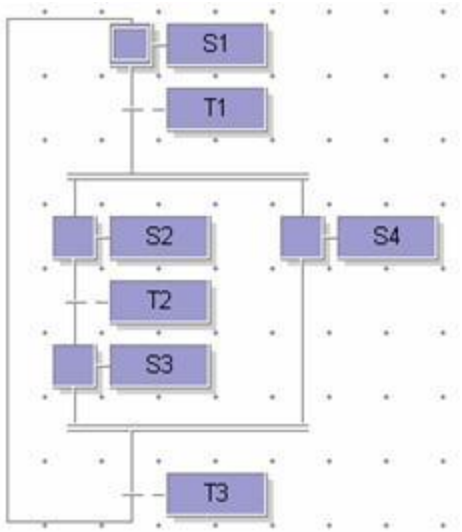


IEC 61131 FBD: Explicit modules interactions

```
(* Referencements instruction Cutting Condition On *)
(*-----------------------------------------------------*)
Instr_iRefInCutCondOn(IFCMD_ENCLENCHEMENT,
                      Instr_iCutCondOn,
                      PUB_ExeCuttingCondOn,
                      PUB_ExeMeasuringCondOn,
                      Sys_RefVide,
                      Sys_RefVide,
                      Sys_RefVide,
                      Sys_RefVide,
                      Sys_RefVide,
                      Sys_RefVide,
                      FALSE);
IF Instr_iRefInCutCondOn.CmdOut
THEN
    IF ((HWR_inWirePanelCoverOpened   (* Porte platine fil fermée   *)
      AND HWR_iBigSpoolDoorClosed) (* Porte grosse bobine fermée *)
     OR Instr_iSimul)
    THEN
        Instr_iCutCondOn.Cmd := TRUE;
    ELSE
        IF NOT HWR_inWirePanelCoverOpened (* Platine fil ouverte *)
        THEN
            Instr_iPlatineFilOuverte := TRUE;
        END_IF;
        IF NOT HWR_iBigSpoolDoorClosed    (* Grosse bobine ouverte *)
        THEN
            Instr_iGrosseBobOuverte := TRUE;
        END_IF;
        Instr_iCutCondOn.Cmd := FALSE;
        Instr_iCutCondOn.Err := TRUE;
    END_IF;
ELSE
```

IEC 61131 ST: Complex algorithm support

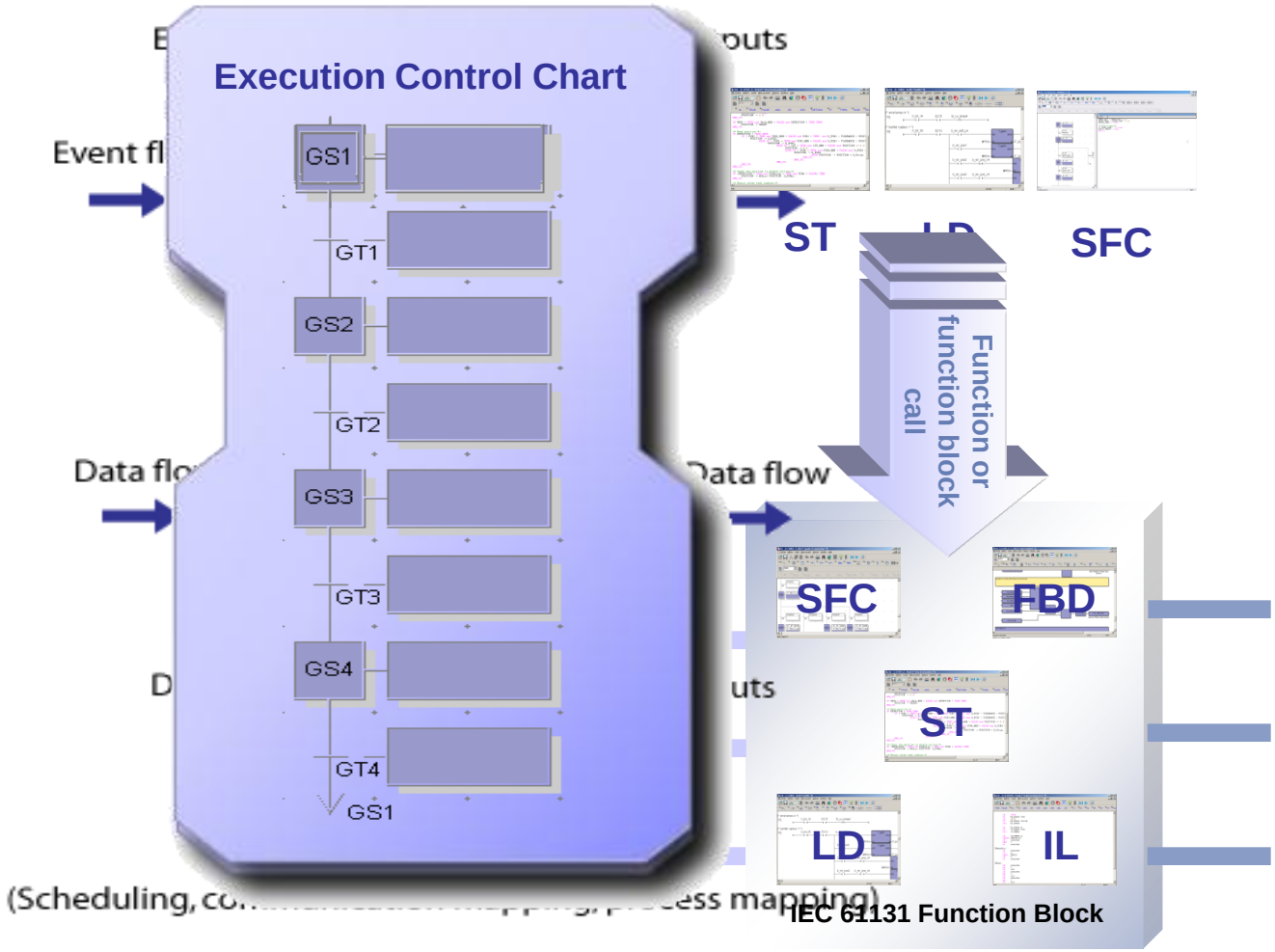




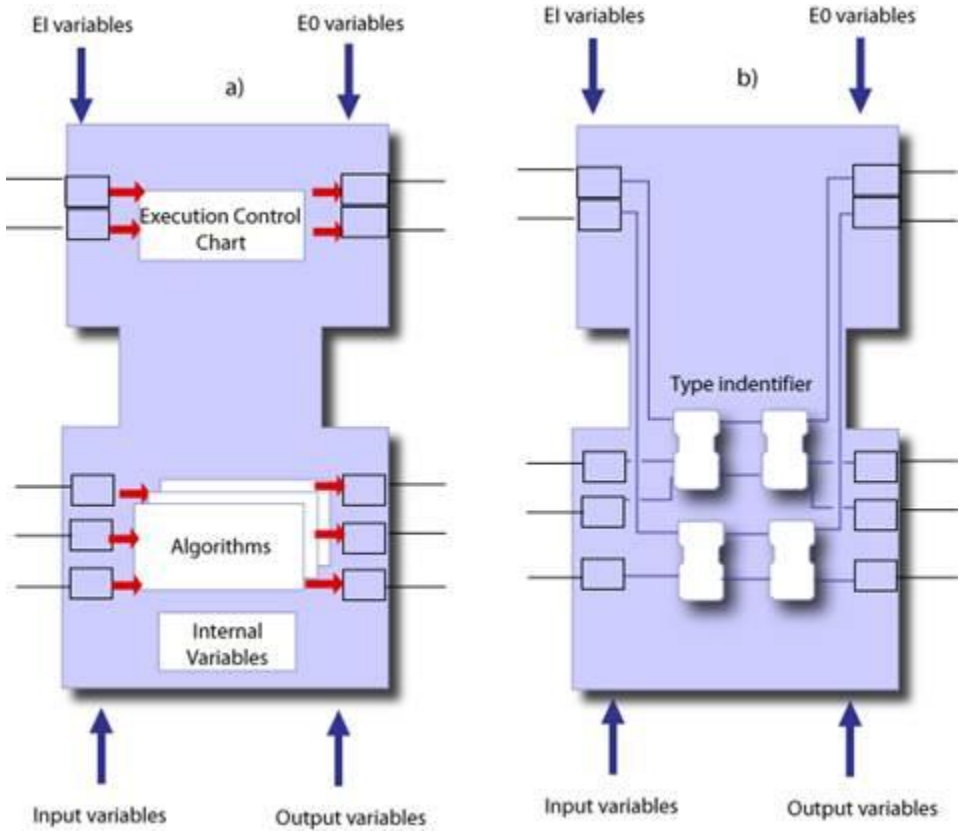
IEC 61131 SFC: Structured logic organization

IEC 61131 LD: Easy Boolean rules

IEC 61499 – Structured design formalism



IEC 61499 – Structured design formalism

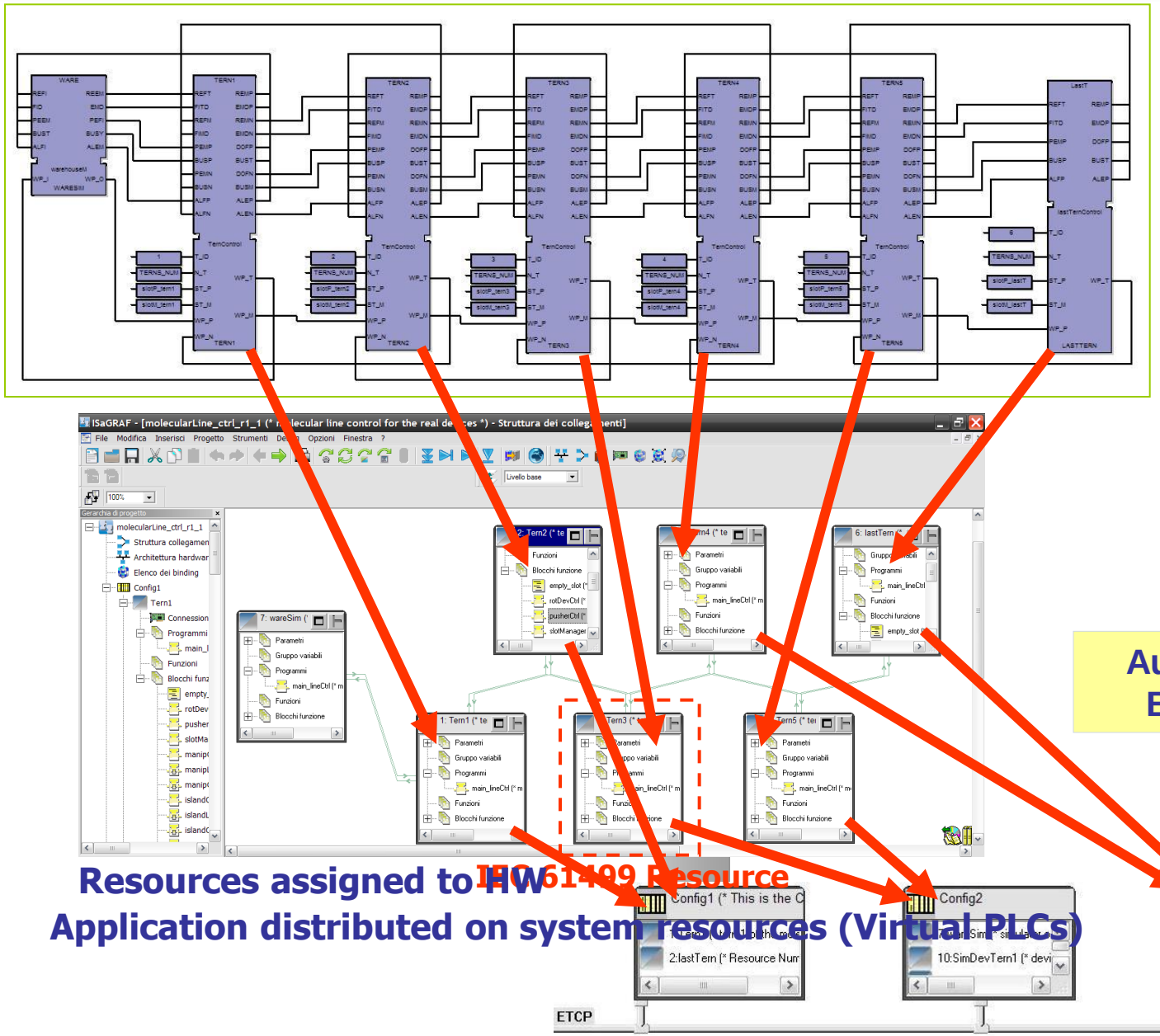


Basic FB *Composite FB*

Structured approach supported by Composite Function Blocks:

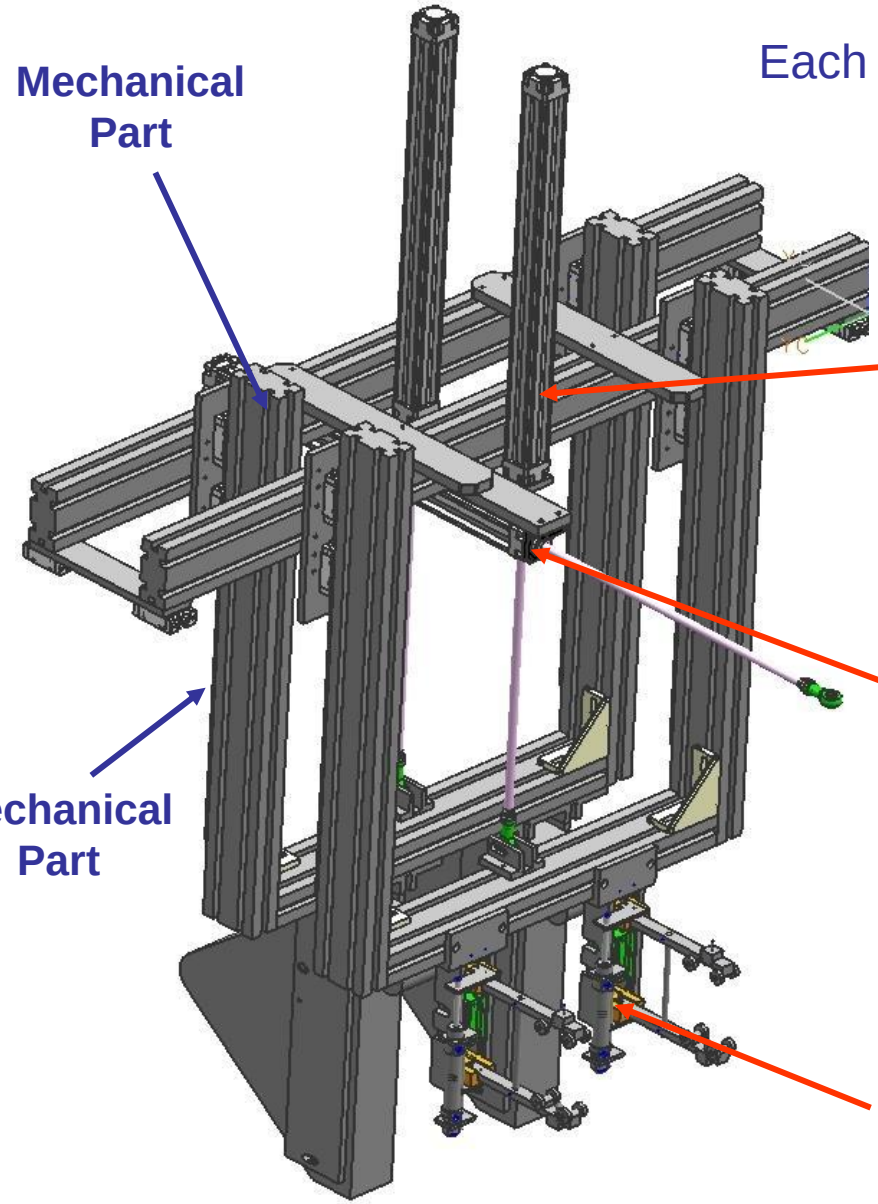
A Composite Function Block includes many Basic and/or Composite Function Blocks

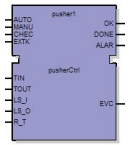
IEC 61499 – Distributed Control Solutions

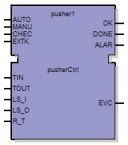


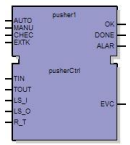
Control software modularization

Each module of the system is represented by a IEC61499 Function Block.



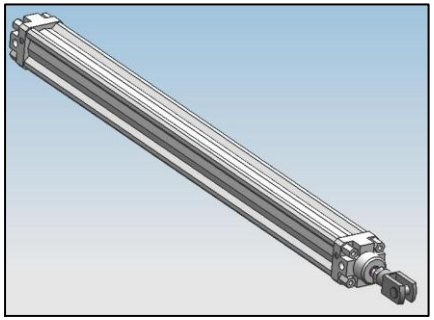


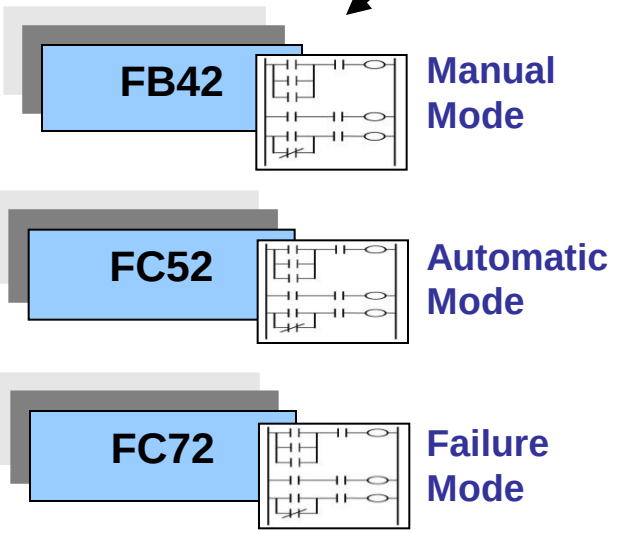


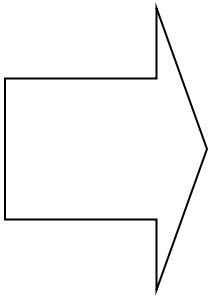


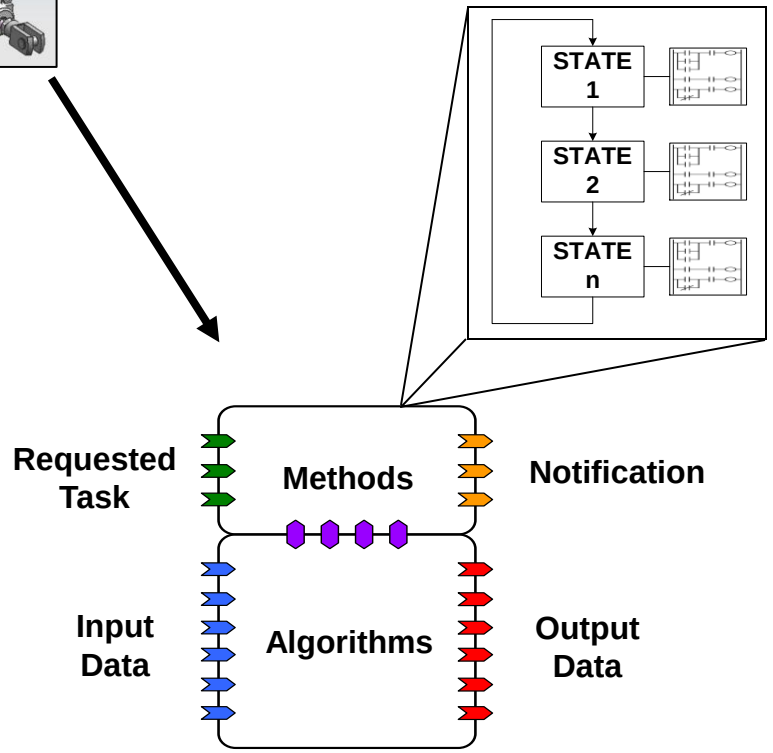
Control software modularization

Structure control logic organization in a IEC61499 Function Block.









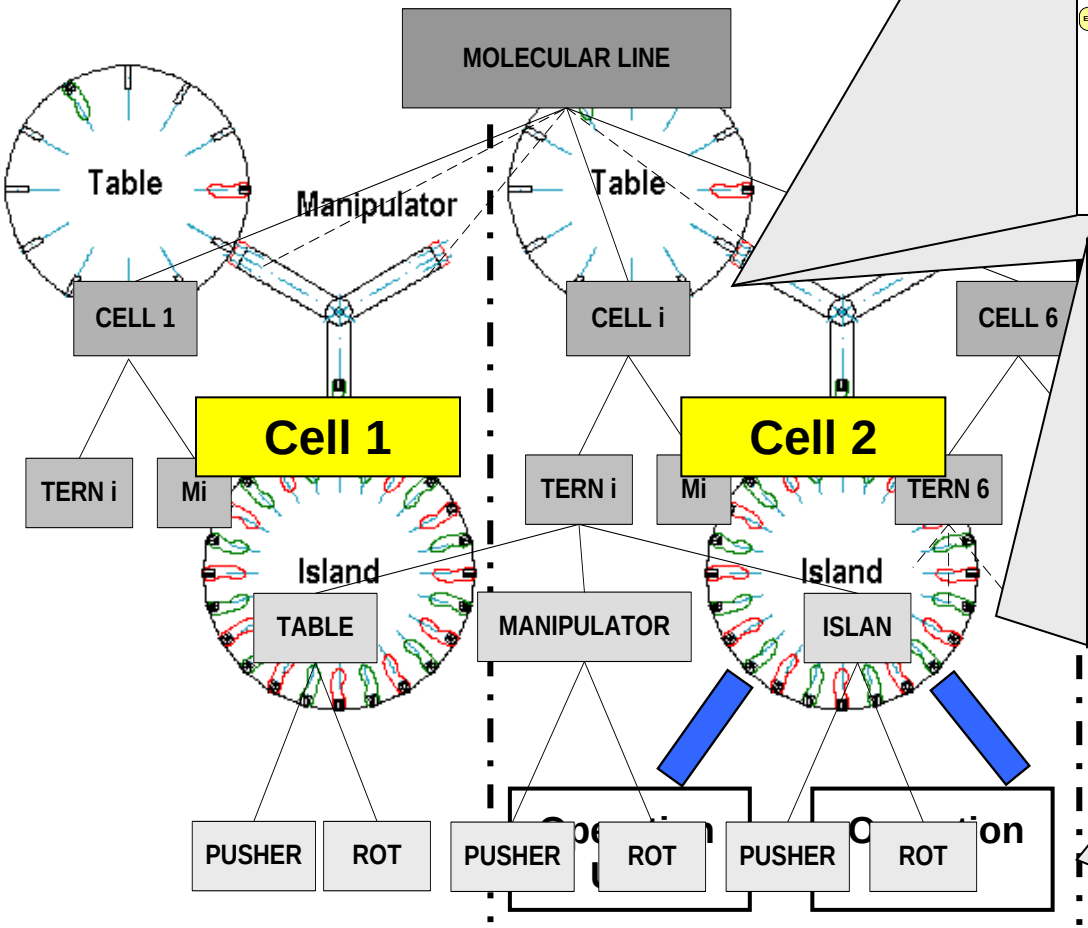
Control Solution Design

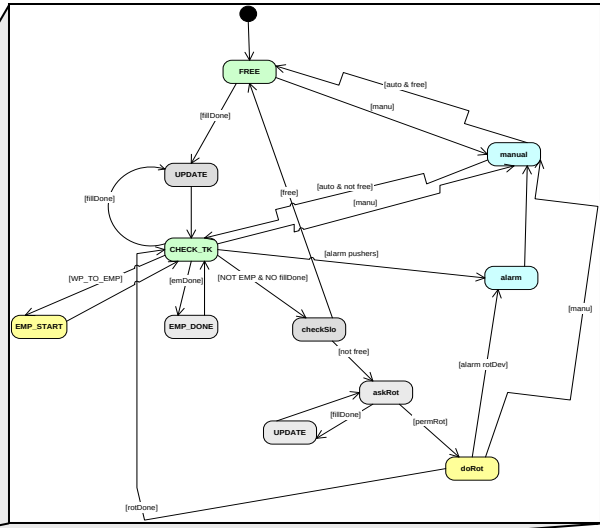
First step:

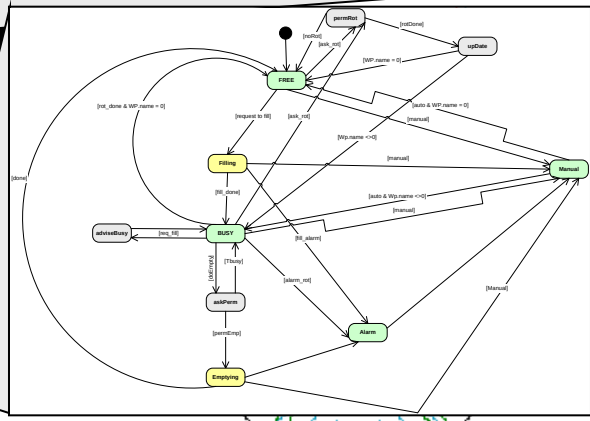
Process top down analysis:

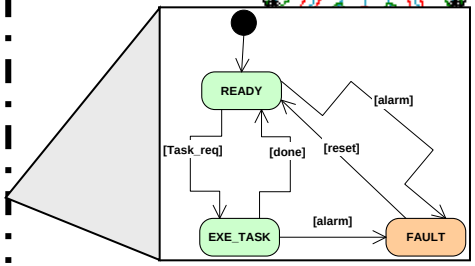
→ Modular system decomposition

→ Identification of modules functions





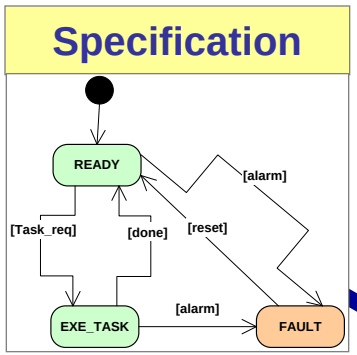




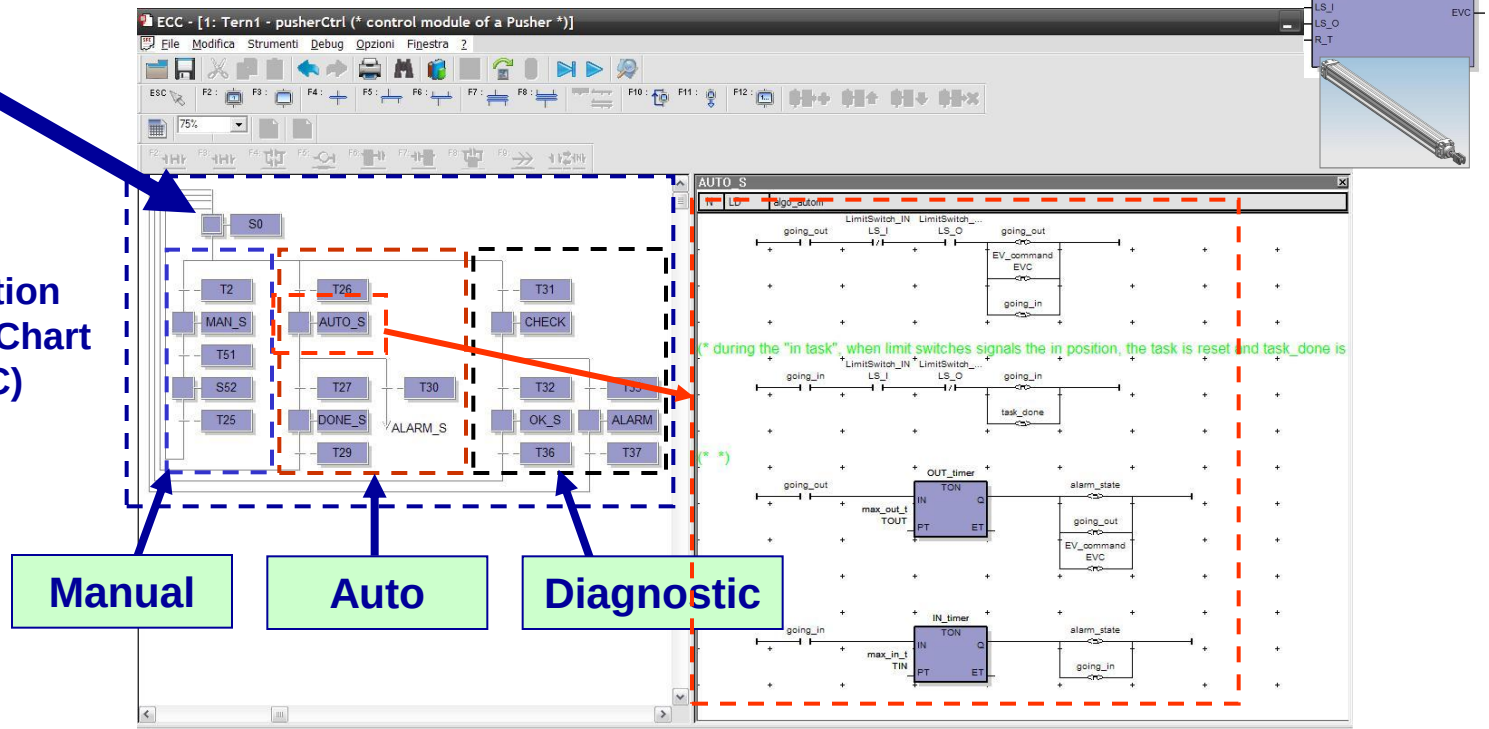
IEC 61499 based Control Development

The IEC61499 basic function block content:

- ✓ **Agile specification to control code phase**
- ✓ **Function block logics structured into a State Machine (ECC)**
- ✓ **Powerful high level formalism to design function block behavior**
- ✓ **IEC 61131 languages to implement the algorithms**

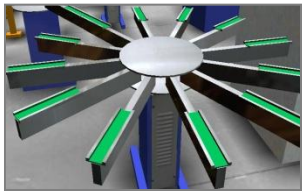


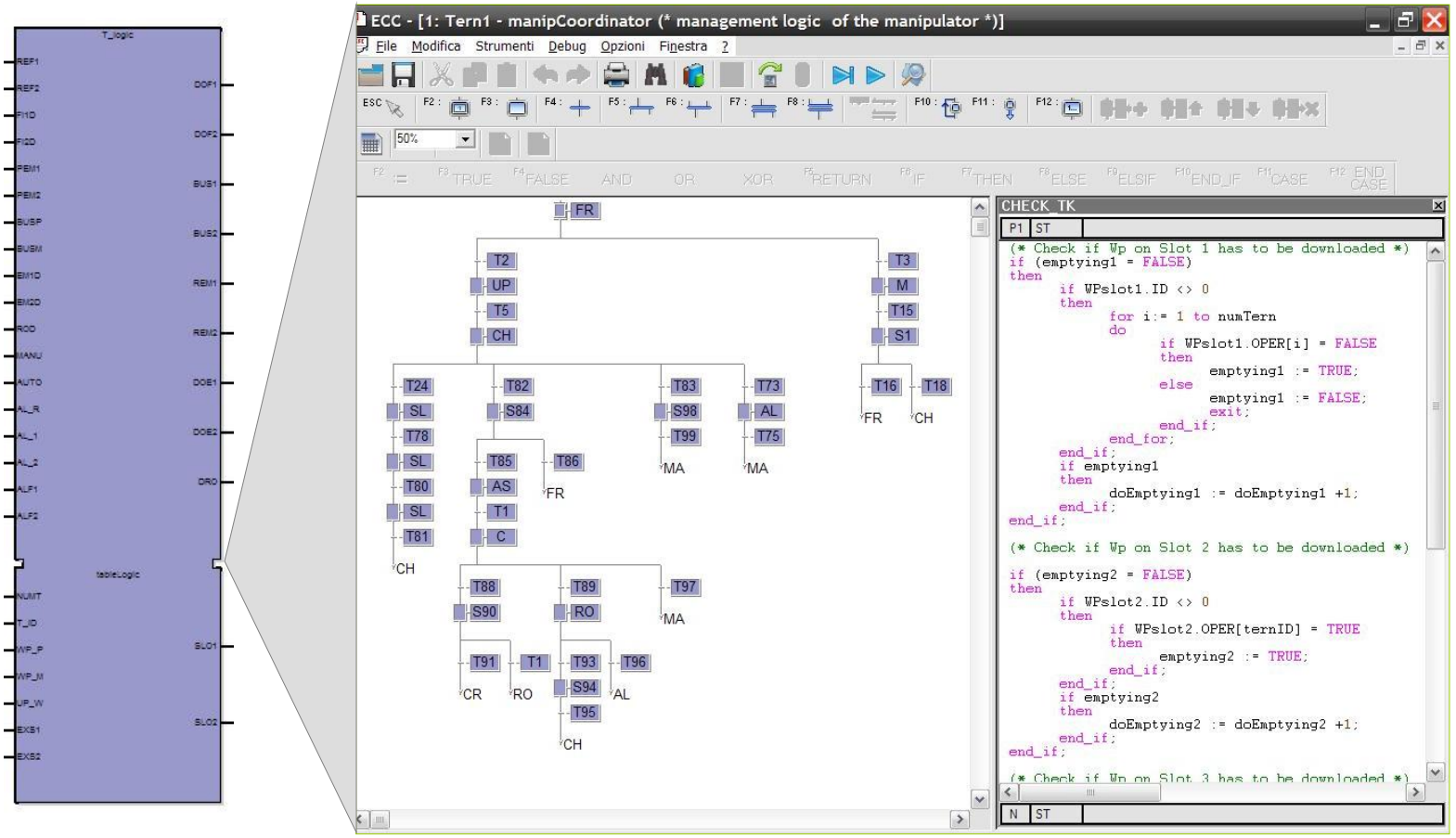
Execution Control Chart (ECC)



IEC 61499 based Control Development

- Table Manager IEC 61499 Function Block -

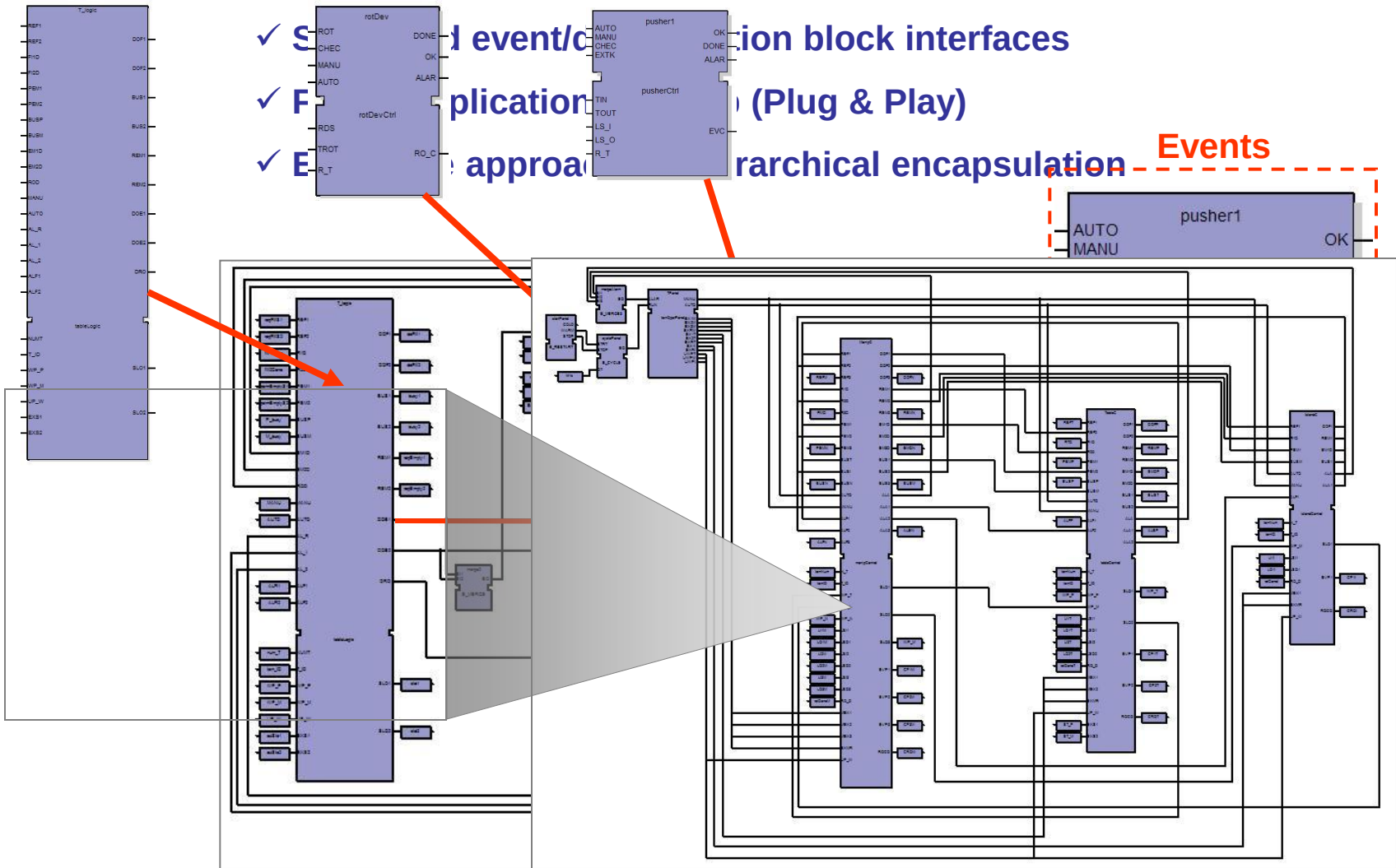




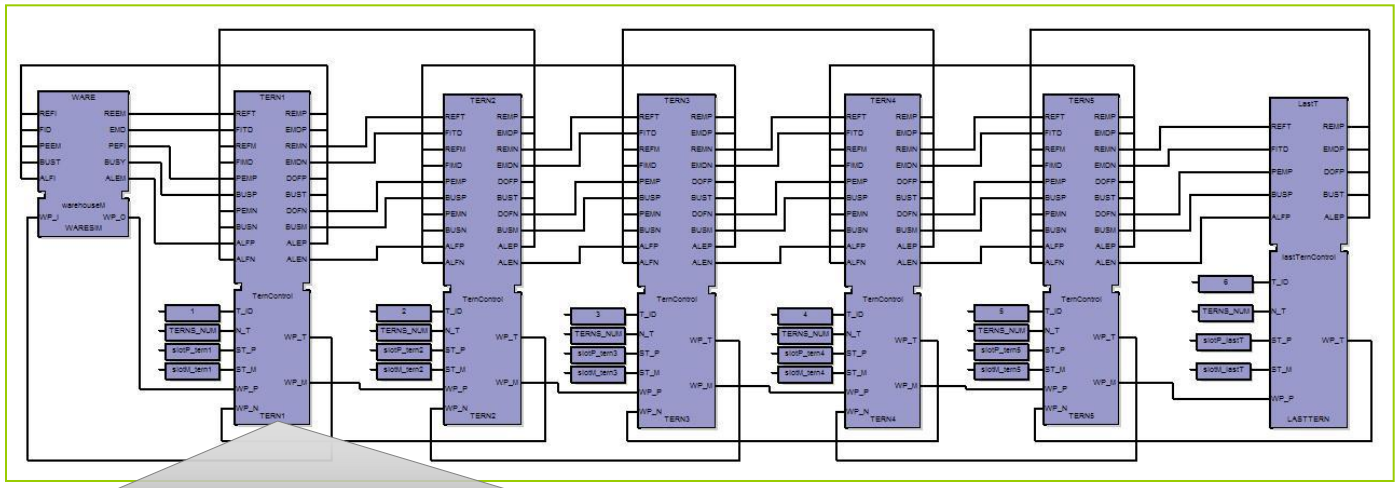
IEC 61499 based Control Development

The IEC61499 composite function block content:

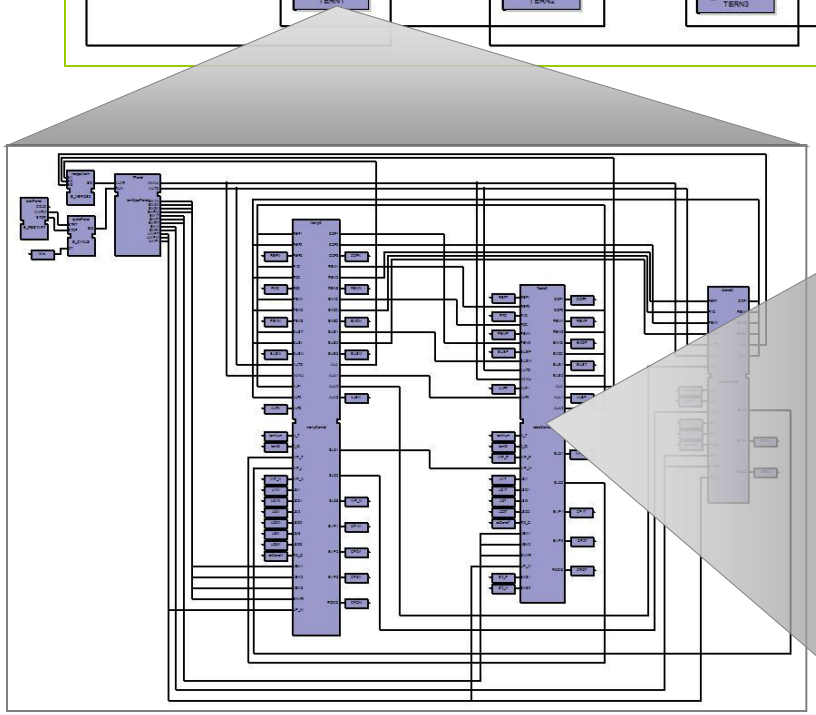
- ✓ **Network of connected function blocks**
- ✓ **Event based blocks interaction policy**
- ✓ **S… event/c…ion block interfaces**
- ✓ **F… plication… (Plug & Play)**
- ✓ **E… approa… rarchical encapsulation**



IEC 61499 based Control Development



Molecular Line Control



Tern Control

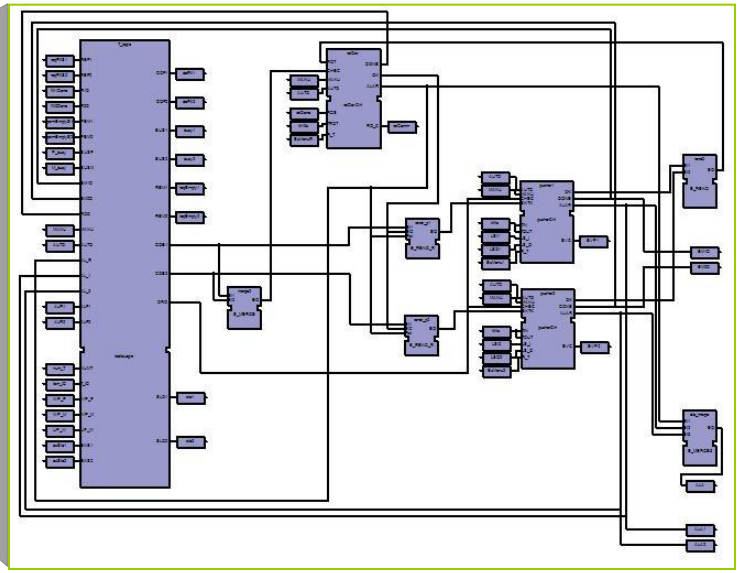
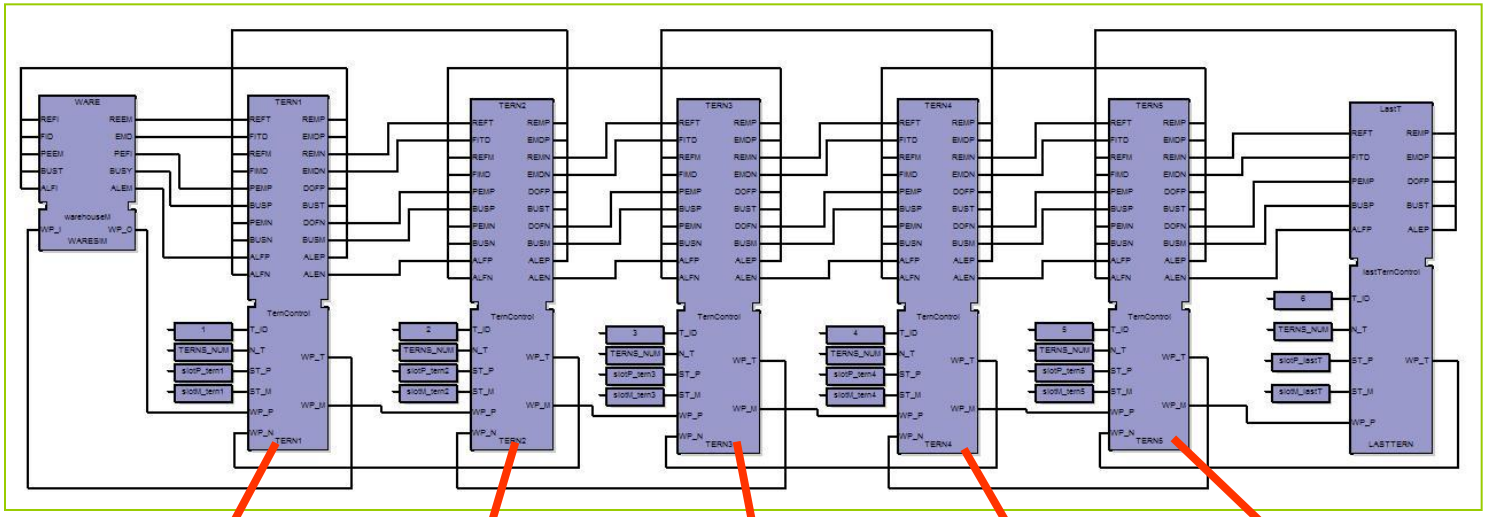


Table Control

Hardware architecture



Automatic Binding

ETCP

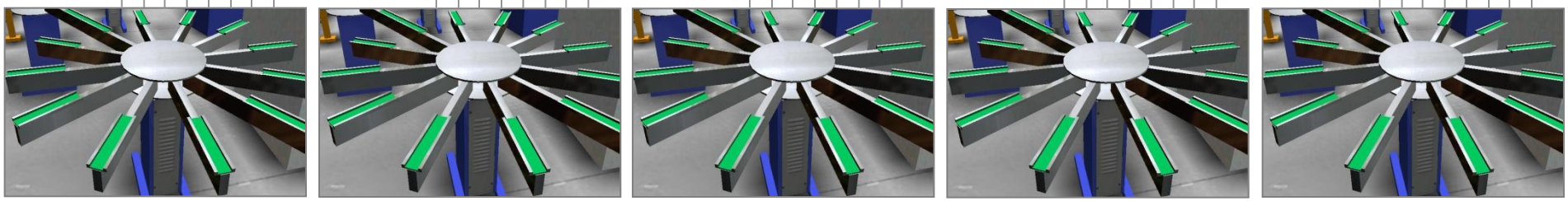
PC + Isagraf Run-time

PC + Isagraf Run-time

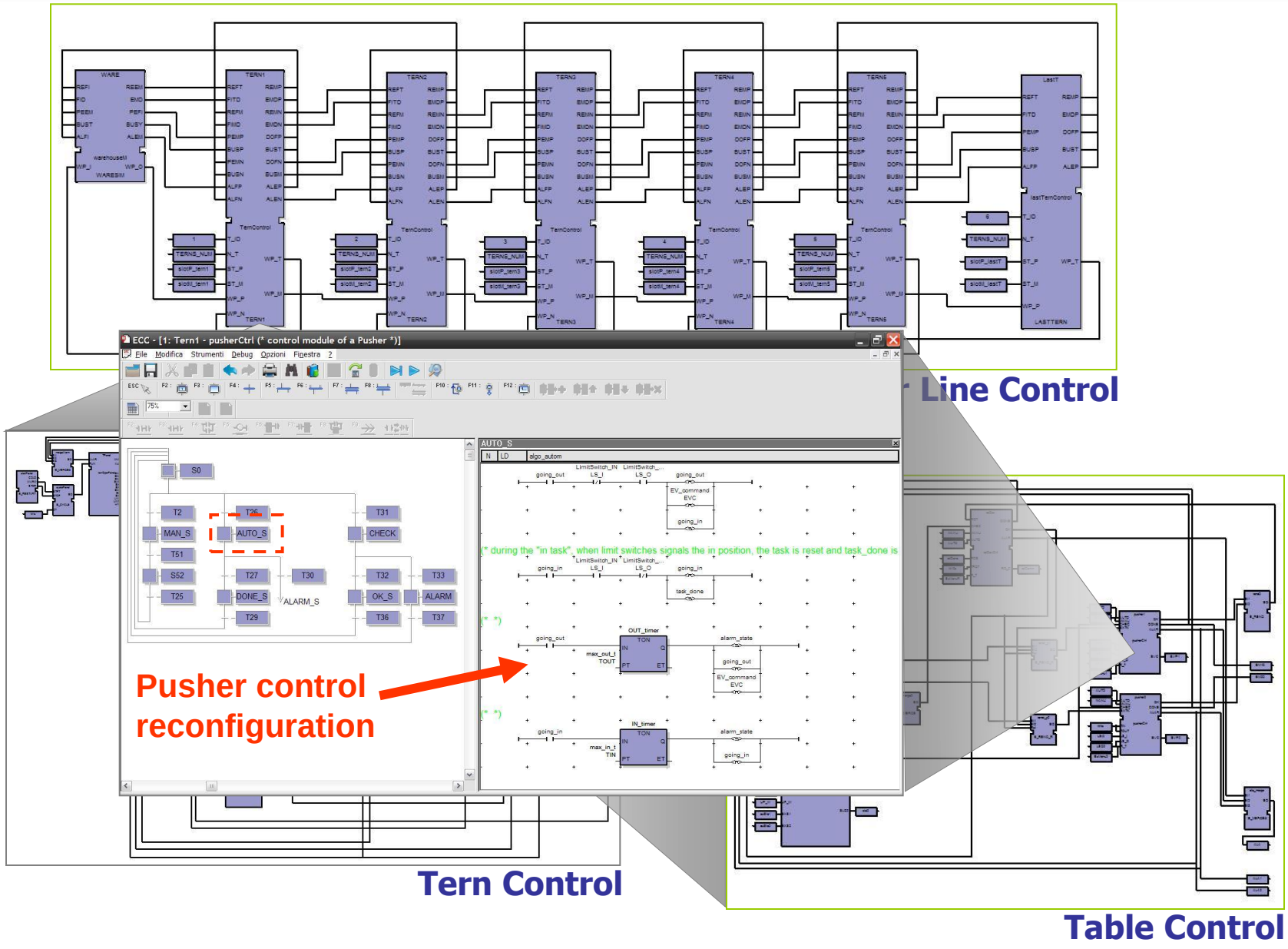
PC + Isagraf Run-time

PC + Isagraf Run-time

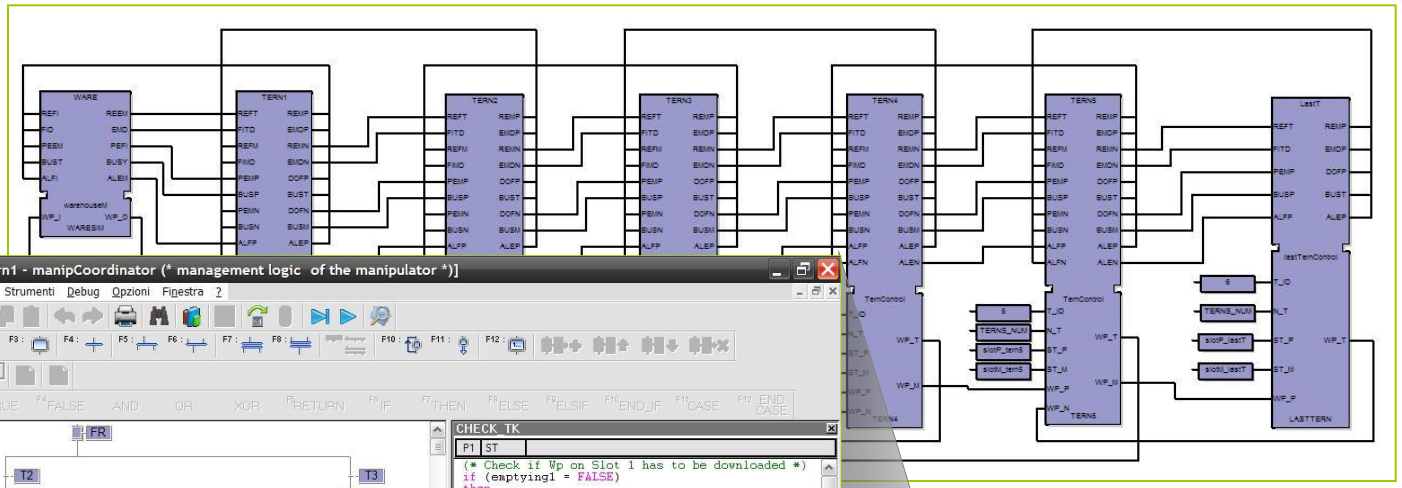
PC + Isagraf Run-time



Control solution reconfigurations



Control solution reconfigurations



Molecular Line Control

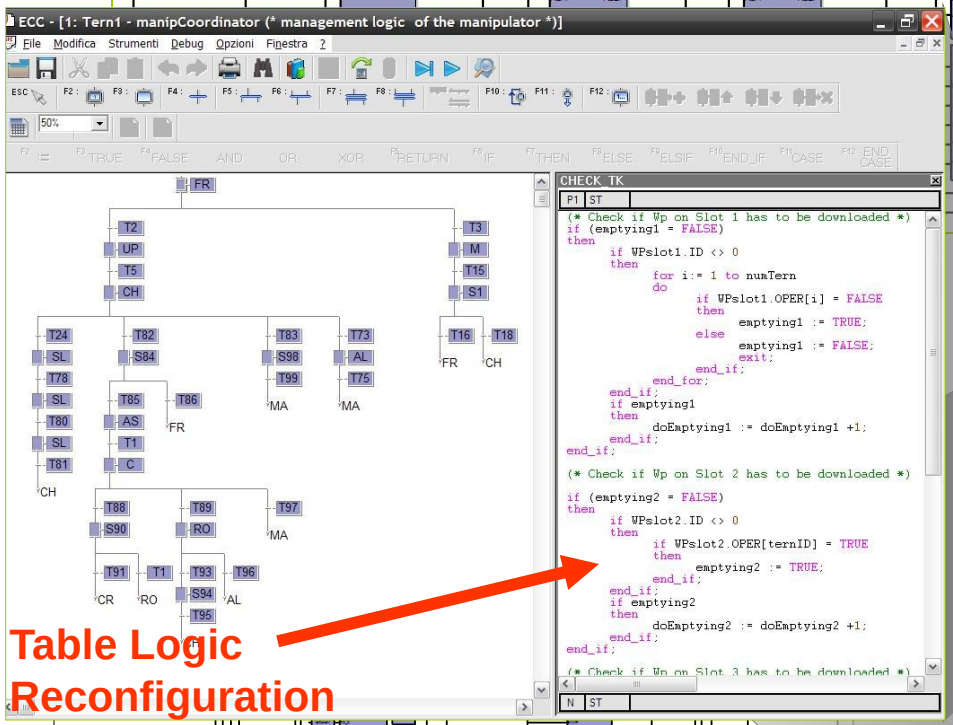


Table Logic Reconfiguration

Tern Control

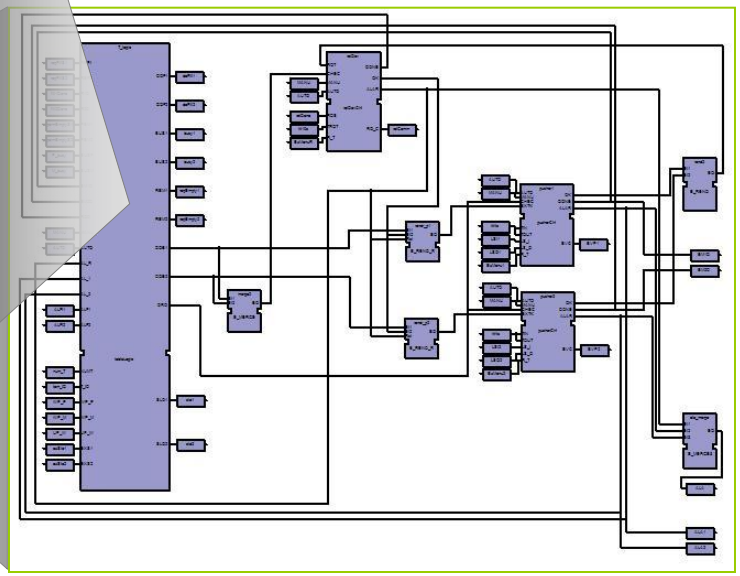
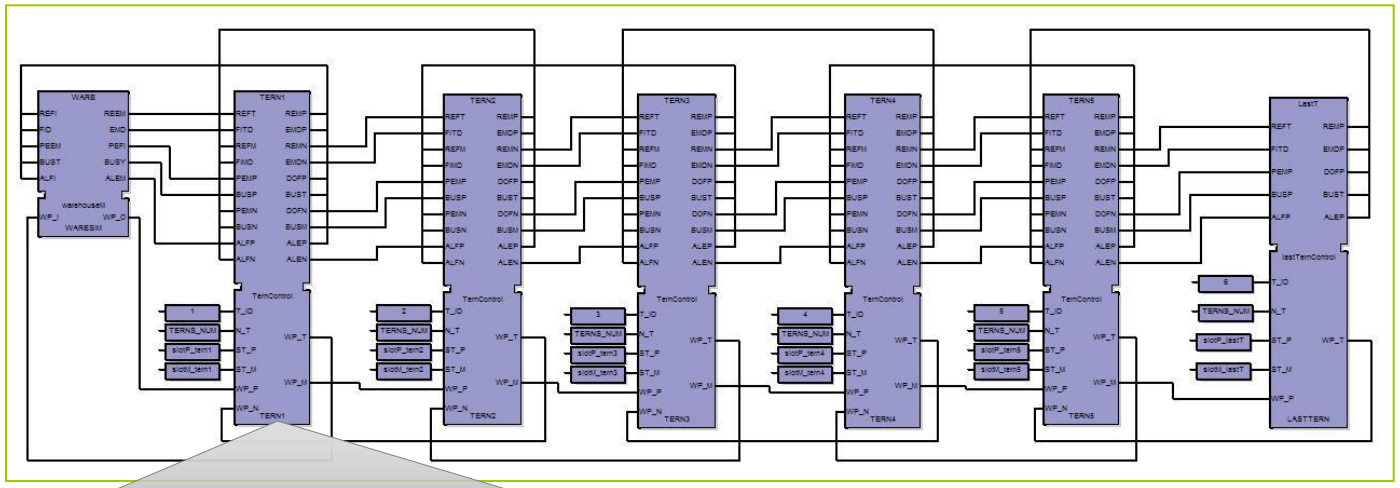
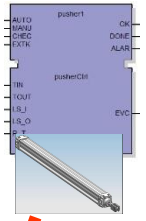


Table Control

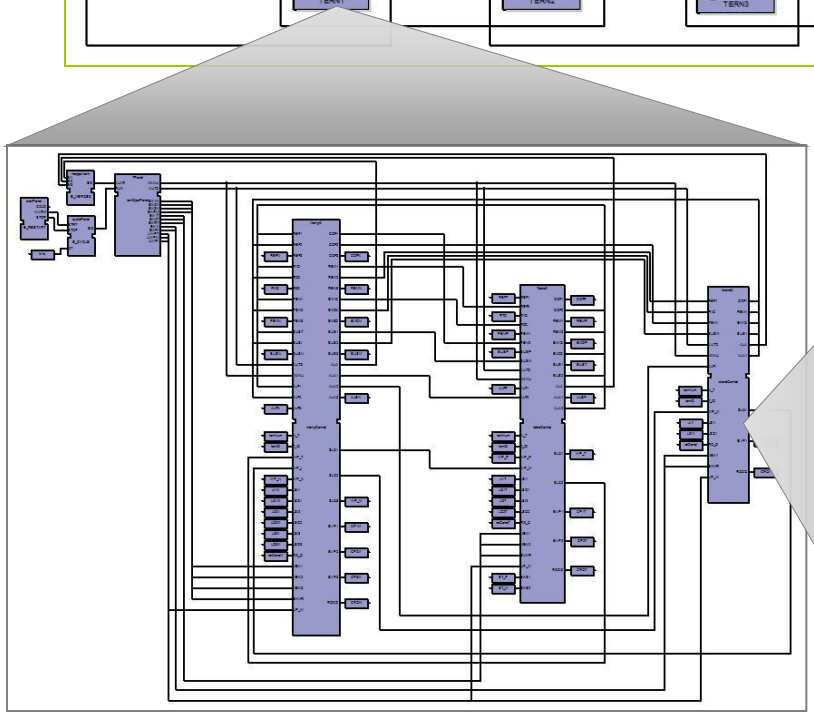
Control solution reconfigurations



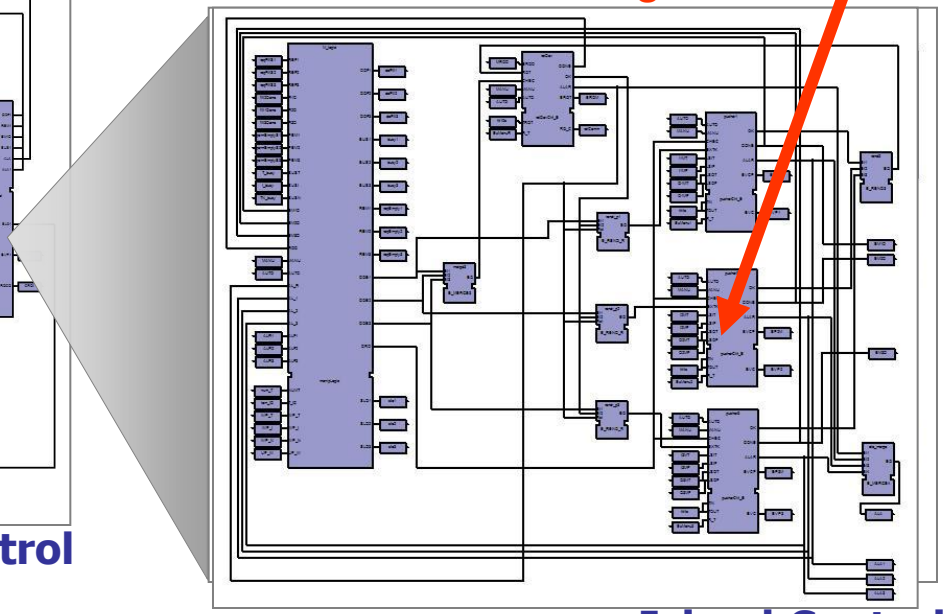
Molecular Line Control



Island Reconfiguration



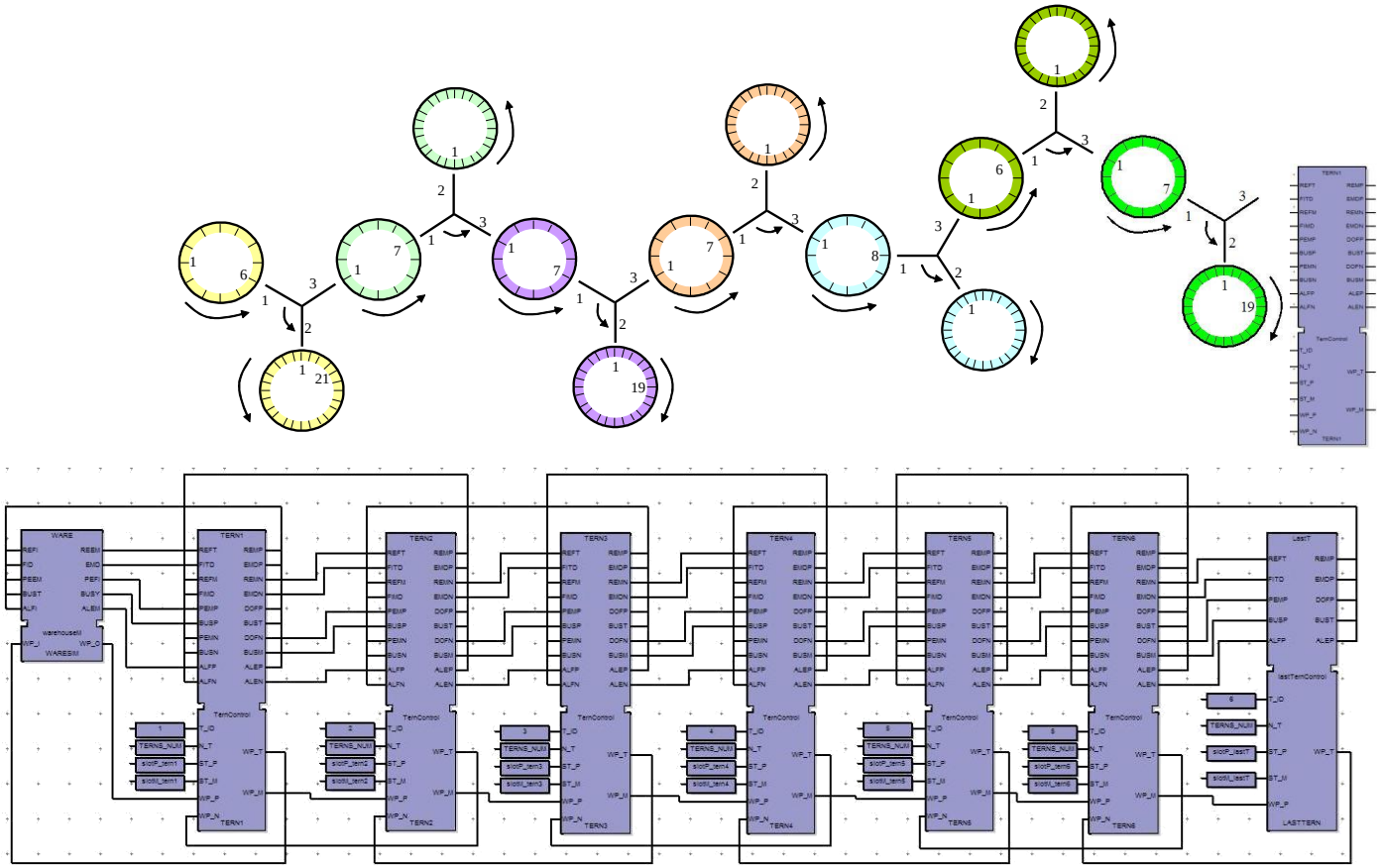
Tern Control



Island Control

Control solution reconfigurations

- New cell integration -



→ **Add FB Instance into the application, connect & play**

Main emerged benefits

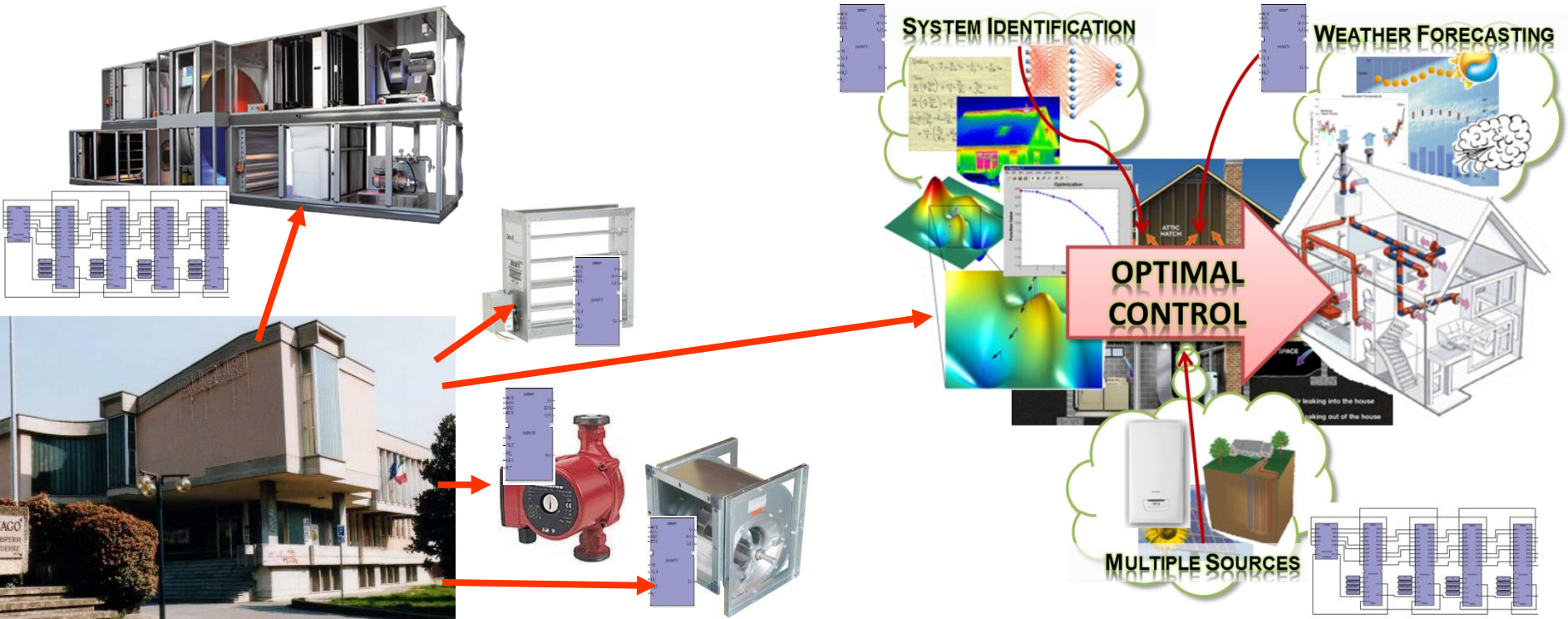
- Enhanced control code readability and maintainability
- Reduction in time and effort during control development
- Less control solutions validation effort
- Increased control solutions re-usability
- Faster application distribution
- Agile reconfiguration of control solution

NEXT: IEC61499 based control of a Pilot Remanufacturing Plant

HVAC Brain Solution

Library of Function Block for HVAC control oriented to the reduction of Building energy consumption (EN15232):

- ❑ Distributed Building HVAC Intelligence
- ❑ Demanded Predictive control and optimal sources commitment
- ❑ Peak Energy demand reduction, oriented to Smart Grids.



HVAC Brain Solution

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- ❑ Distributed Building HVAC Intelligence
- ❑ Demanded Predictive control and optimal sources commitment
- ❑ Peak Energy demand reduction, oriented to Smart Grids.

Already Installed on two Pilot Buildings in Italy. Validation ongoing!

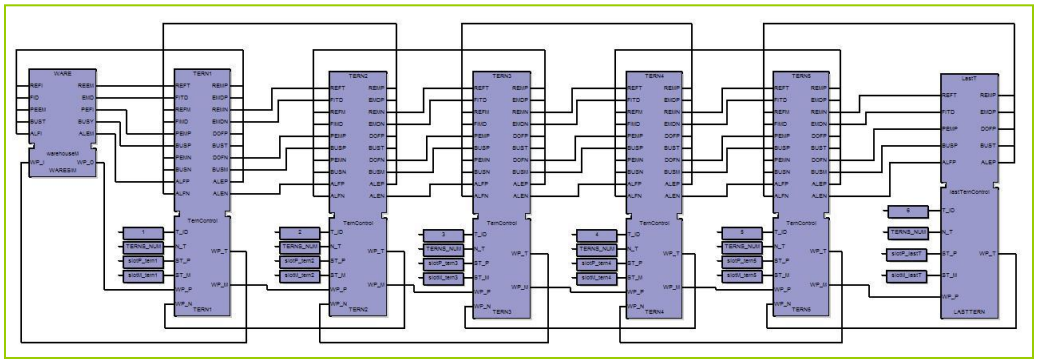
In collaboration with:

Prometeo Srl
il provider di soluzioni tecnologich

GruppoCOGESER

COSTER

ISaGRAF



Thanks

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