IEC61499 based Control development of Advanced Manufacturing and HVAC solutions

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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, 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
Innovative Shoe Manufacturing Plant

Responsive Manufacturing Plant
Molecular Line Architecture

- Modular and reconfigurable architecture
- Agilely reconfigurable control solution required
- Each table integrates 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 re-use knowledge
- Avoid starting from scratch
- Reduce time and cost of control software development

How to properly structure the control application in order to satisfy such requirements?
IEC 61499 – Structured design formalism

IEC 61131 FBD: Explicit modules interactions

IEC 61131 ST: Complex algorithm support

IEC 61131 SFC: Structured logic organization

IEC 61131 LD: Easy Boolean rules
IEC 61499 – Structured design formalism

Execution Control Chart

IEC 61131 Function Block

IEC 613131 Function Block

Event flow

Data flow

Function or function block call

LD

SFC

ST

IL

FBD

(Scheduling, communication, addressing, process mapping)
IEC 61499 – Structured design formalism

Structured approach supported by Composite Function Blocks:

A Composite Function Block includes many Basic and/or Composite Function Blocks
IEC 61499 – Distributed Control Solutions

- Resources assigned to HW
- Application distributed on system resources (Virtual PLCs)
- Automatic Binding
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.

Manual Mode

Automatic Mode

Failure Mode

Requested Task

Methods

Input Data

Algorithms

Notification

Output Data
Control Solution Design

First step:

Process top down analysis:
→ Modular system decomposition
→ Identification of modules functions
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

### Specification

![Specification Diagram]

- **READY**
- **EXE_TASK**
- **FAULT**

### Execution Control Chart (ECC)

- **Manual**
- **Auto**
- **Diagnostic**

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**IEC 61499 based Control Development**
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
- Separated event/data function block interfaces
- Faster application build (Plug & Play)
- Extensive approach by hierarchical encapsulation
IEC 61499 based Control Development

Molecular Line Control

Tern Control

Table Control
Hardware architecture
Control solution reconfigurations

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

In collaboration with:

- Prometeo Srl
- COSTER
- ISaGRAF
Thanks

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