IEC 61499 in Material handling

Research in Progress with Glidepath Ltd, New Zealand

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Outline

• Challenges
  – Performance:
    • Spatially dispersed
    • Real-time requirements
  – Engineering
    • Re-use
    • Verification and Validation

• Distributed approach

• Pathway
  – Performance and class-oriented design pattern
  – Migration
    • Re-use of PLC code inside of IEC 61499 FBs
    • Semantic model
  – Testing
Machines need more Intelligence!

Now That’s Smart!

Information Infrastructure of Intelligent Machines
Based on the IEC 61499 Architecture

The requirements of flexible manufacturing and material handling systems, such as rapid integration and reconfiguration, as well as the growing information intensity of the production environments imply that manufacturing equipment is becoming more autonomous and intelligent.

A large number of intelligent machine concepts have been proposed in the last decade (see overview in [10]). Their systematic discussion and evaluation is beyond the goals of this article. A few characteristic concepts, however, need to be mentioned. The holistic manufacturing systems (HMSs) [3] emphasize the idea of self-configurability, envisioning that holistic machines will form new production configurations “on the fly,” reacting to the external and internal changes. For example, an external change could be a change in the product specification. An internal change can be a breakdown of a certain machine in the production system. The reconfigurable manufacturing systems (RMSs) [7] and the intelligent mechatronic actors introduced by Lasare in [18] rely on the “divide” (in advance) customization of the machinery driven by the changing production.
Conveyors already have a motor control unit and network connectivity, so it won’t be a big deal to equip them with the function blocks execution capability.

Future BHS parts will be smart, having embedded controllers on board.
If we have several conveyor sections interconnected like this:

Then the control program will look like this network of function blocks.

And if we add one more conveyor, then the program will be augmented with one more function block!

Modular Machines = Modular Code
Intelligent Distributed BHS

- Truly distributed logic
- Each conveyor and mechatronic object may have its own controller hardware
- Communication between components
Design Pattern: Generic Conveyor Function Block

- Encapsulates functionality of a single conveyor
  - Merge
  - Divert
  - Routing and tracking
  - Emergency/Cascade stop
Modelling the Conveyor

- IEC 61499 Composite Function Block
- MVC Design Pattern
  - Distributed Control Design
Modelling the Conveyor

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  - Behavioural Model
Modelling the Conveyor

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  - Visualization
Modelling the Conveyor
Visualization

- Gives a quick view of the system state
- Generated based on graph model of BHS
Distributed Algorithms

- Merging, Diverting, Fault tolerance handled using distributed techniques

Distributed Routing

Distributed Bellman-Ford algorithm is applied

Network of 5 conveyors with distance metrics and the routing tables for Node A at time $t=0$ and $t=1$
Scaling

Conveyor
Distributed FB Testbed with 50+ Nodes

Performance?

Network traffic and response time have been measured using PRTG Traffic Analyzer.

Event transmission delays between two control nodes

Network traffic for 3 selected control nodes
Object Oriented Design

- Connect FBs according to physical layout
Migration to Object-oriented Architecture

PLC Program Structure

- Main Program
- Conveyor Control
- Push Diverter Control
- Indicators (Beacons)
- Bags Tracking
- PLC Interfaces

FB Program Structure for BHS

CONV_D101
CONV_C101
CONV_C102
CONV_C103
CONV_C104
CONV_C105
CONV_D102
BEACON_B101
PUSHER_CD1
D101 D102 D103 D104
**Class-Oriented Design**

➢ Connect FB Class with Physical Input and output FBs

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Semantic model of automated BHS

FB Program Structure for BHS

PLC Program Structure

Main Program

Conveyor Control
Push Diverter Control
Indicators (Beacons)
Bags Tracking
PLC Interfaces