



### Automatic Generation of IEC 61499 Applications based on Workflow Models

M. Plasch, G. Ebenhofer, M. Hofmann ETFA 2012 – 4DIAC User's Workshop

# LEADING INNOVATIONS

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- Motivation and Aim of the Work
- Overall Concept
- Workflow Modeling
- Generation of the Supervisory Control Application (IEC 61499)
- Communication Concepts
- Resulting System Architecture
- オ Example Application



## Motivation and Aim of the Work

- Rising need for flexible, modular robotic systems in production industry
- Fast (re)-configuration; preferably user-friendly programming methods and tools
- Example: Bin-Picking application



- Aim: Simplified programming of a supervisory control application (according to IEC 61499)
   Graphical Workflow Modeling
  - **7** Generation of the control application through a code generator



# **Overall Concept**



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# **Background: Workflow Modeling**

#### Workflow Definition

- Activities in order to describe a process
- Workflow Management System coordinates execution
- Hardware/Software Resources

### Workflow Modeling Languages

- Business Process Execution Language BPEL textual language
- Petri-Net based languages graphical language
- Inified Modeling Language UML Activity Diagrams

### Workflow Patterns

- Design guidelines for Workflow Modeling Languages
- Benchmark criteria



# **Development of a Workflow Modeling Language**

- Language elements
  Service Activities
  - Activity Connections
  - Control-Flow Activities







- Language Characteristics
  - Combined control- and data-flow modeled by Activity Connections
  - Parameter Mapping-Tables to model data passing
  - Embedded Exception Handling



# **Implementation of a Graphical Workflow Editor**

### 4DIAC Integrated Development Environment (www.fordiac.org)

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# **Generation of the Supervisory Control Application (1)**

- **Step 1**: Generation of a Function Block (FB) type library
  - Represent Control-Flow- and Service-Activities
  - オ Activity Interfaces ←→ FB WITH-Constructs
  - Behavior according to FB base types



# **Generation of the Supervisory Control Application (2)**

- Step 2: Creation of FB instances
  Required instances according to Workflow Model
- **Step 3**: Creation of Event- and Data connections
  - Modeled Activity Connections and Parameter-Mappings
  - Data connection start- and end-points through WITH-Construct
- Execution of the control application
  - ↗ IEC 61499 compliant runtime environment
  - Alternatively combined with 3D-Simulation Environment



## **Interaction of Control Application and Service-Component**





## **Resulting System Architecture**





# **Example Application (Video)**

- 5 Degrees-of-Freedom robotic arm
  IEC 61499 Service Component
- Iltrasonic sensor, touch sensor from Mindstorms NXT
- Robot arm follows predefined path continuously
- Adaption of speed with ultrasonic sensor
- Interruption of movement with touch sensor
- Link: <u>http://www.locobot.eu/2012/09/12/model-based-application-programming/</u>



## **Results and Future Work**

Results

- Implemented graphical Workflow Editor
- **7** Code Generator for IEC 61499 compliant control applications
- Appliance of the approach within the European funded research projects LOCOBOT (<u>www.locobot.eu</u>)

Future Steps

Hierarchical Workflow Structures

- low cost robot co-workers
- Improved exception handling concepts
- Improved integration of Service-Components into the simulation model



#### Thanks for your attention!

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