Reconfigurable and Distributed Process Control System Compliant IEC 61499 Function Blocks Model Structure

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Abstract—

Due to fast changing markets demand, frequently changing production scheduling, implementing new technology- Modern control engineering fullfull those challenges by moving from centralized to module base decentralized phenomena to serve better automation services to manufacturing, logistic and process industries . IEC 61499 standard used for developing flexible distributed application in IPMCS(industrial processes, measurement and control systems).It is component based, open architecture and even based execution mechanism to facilitate reconfiguration,interoperatibilty and portability features. Function block is abstract model of it and devices, application and resources are key elements of distributed application under IEC 61499. FBDK is most widely used software simulation tool to develop and tested IEC 61499 compliant distributed application. This paper discuss distributed and reconfigurable concept by using IEC 61499 function block basic building element and transforming rules from PLC to IEC 61499 reference model. To achieving reconfigurabililty, deriving modular representation of distributed application and develop distributed controller devices and resources for it.

Keywords— IEC,FBDK,IPMCS,FB,CFB,SIFB

I. INTRODUCTION

Nowadays Modern control engineering concept moving from traditional PLC based centralized control system to Distributed control system. The reason is globalization of market need to make manufacturing industries to rapidly change or customize their production in respond to change in custom need, market need or technology changed. As there is development of smart field instrumentation and embedded controller in process and communication domain, the concept of flexible distributed control system get popular. Modern manufacturing/ production/logistic application need to flexible ,fast changing ,reconfiguration and reused feature as to respond to fast changing market demand, production variation, technology variation.The high level demanded features need to address by modern control engineering are :

Distribution: The ability to distribute software program component among distributed hardware devices
Configurability: Any device and its software components can be configured by software tools from multiple vendors.
Reconfiguration: The ability to adapt control hardware and software during operation.
Interoperability: Embedded devices can operate together to perform the functions needed for distributed applications.
Portability: Software tools can accept and correctly interpret software components and system configurations produced by other software tools.

The new international standard IEC 61499 introduce model to implement distributed control system with reconfigurabilty, reused and interoperatibilty features.[1]Therefore this paper focus on distributed and reconfigurabililty added to process control devices using IEC 61499 function block model structure by distributed function blocks among several devices.
This paper is organized as follows. Section II: Overview the IEC 61499 standard brief function block as its basic building block. In Section III discuss FBDK a software tool used to develop the application in IEC 61499.Section IV distributed and reconfigurable concept in IEC 61499 reference model. Finally a conclusion on this work is given.

II. IEC 61499 STANDARD

International Electrotechnical Commission(IEC) given new standard IEC 61499 for implementing flexible distribution control in Industrial Process Measurement and Control Systems(IPMCS).This is a component-based, open architecture for distributed industrial - process measurement & control systems (IPMCS) which can meet both current and future requirements for intelligent automation. Basically IEC 61499 standard combine the features of PLC Function Blocks (IEC 61131-3standard) and DCS Function Blocks (IEC 61804 project standard).It can provide modular and hierarchical control system design with direct link to devices, resources, and communication systems.[1].The various components of IEC 61499 are :
System: A collection of DEVICES interconnected and communicating with each other by means of a communication network consisting of segments and links.
Device: An independent physical entity capable of performing one or more specified functions in a particular context and delimited by its interfaces.
Resource: A functional unit having independent control of its operation, and which provides various services to applications including scheduling and execution of algorithms.
Application: A software functional unit that is specific to the solution of a problem in industrial-process measurement and

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control. An application may be distributed among devices and may communicate with other applications.

Function block: A software functional unit that is the smallest element of a distributed control system. It utilizes an execution control chart (ECC) state machine to control the execution of its algorithms.

The function block is the smallest functional unit act as software module in IEC 61499 based application. It is software abstract model which contribute to given reusability, reconfigurabililty and interoperability to systems. The main part of function block are input/output even and data connection, algorithms and Electronic control chart and It support even driven control concept.

There are mainly three type of Function block.

1. Basic Function Block
2. Composite Function Block
3. Service Interface Function Block

Basic function block remain passive until an input even arrive. When input even arrived it trigger the algorithm as state into ECC(Execution Control Chart) and make available output data which send on available of output even to next connected function block.

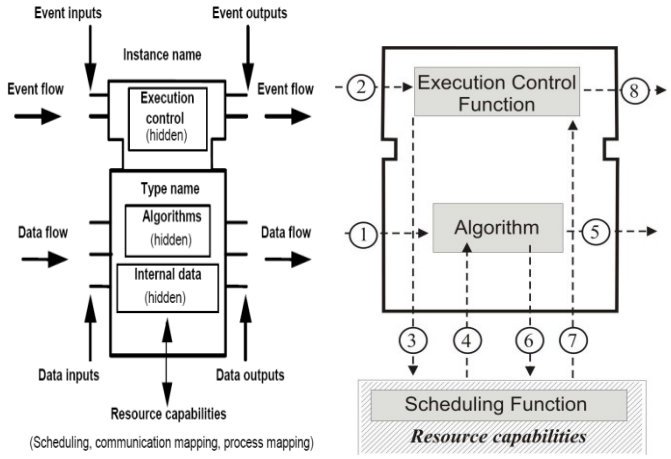

Fig 1: Basic Function Block & it's execution sequence

The input invent trigger and output even available, there is sequential execution sequence to function the function block are as shown below

1. The input variable values relevant to the input event are made available.
2. The input event occurs, the execution control of the function block is triggered
3. The execution control function evaluates the ECC and notifies the scheduling function to schedule algorithm for execution
4. Algorithm execution begins.
5. The algorithm completes the establishment of values for the output variables associated with the event output by the WITH qualifier
6. The resource scheduling function is notified that algorithm execution has ended.
7. The scheduling function invokes the execution control function.
8. The execution control function signals event at the event output.

Composite FBs (CFBs) contain a group of Function blocks as one unit else it is similar to basic function block. It act as sub resource for given device which serve the subtask of main function by combining function blocks which together to serve uniform functionality of subapplication.Let say that composite function block behave like group of resources which handles the internal data and event connections. But it passes algorithm scheduling requests from inner basic FBs out to the resource like a normal basic FB.

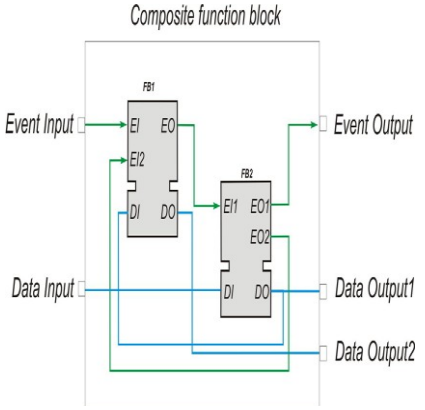

Fig 2: Composite Function Block

The service interface function block provide service the application such aw interaction between application and resources like network or HMI..It consist the interface with process devices like sensors and actuator .PUBLISHER and SUBSCRIBER are the basic service interface FBs to communication between various devices.

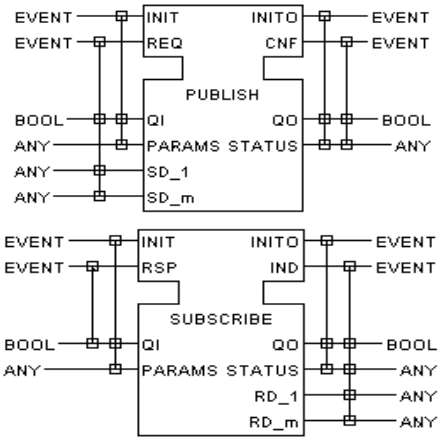

Fig 3: Service interface Function Block

III FBDK TOOL

There are various type of software tool available to design and develop distributed application in IEC 61499 are FBDK(function block development kit), 4DIAC,Fbench,ISaGRAG. FBDK is most popular research

tool developed by Rockwell automation/holobloc inc.,USA.It is currently maintained and make it free available for academic research purpose by holobloc which can update it's version to reflect and implement changes proposed by IEC 61499.

FBDK basically provides graphical platform through which IEC 61499 based application can be design, program and simulated. It create the function block using java development kit(JDK).The application can developed by creating function block network.FBDK facilitate the user to define,resused built or user define function blocks in designing the distributed control application.

Control software can supported by standard library of function blocks which can be used by user to develop the application in plug and play fasion.It can run the individual devices. standard service interface blocks available to make communication among devices.

The key abstract features of FBDK software tool are:

Views: The FBDK editor provides three different views on edited window. The 1st window is on left of editor which consist the application tree which consist of application, devices and resources. The 2nd window is workspace of FBDK editor where we define and develop the various function block network by appropriate connecting events and datas.The 3rd window is textual view at the bottom that shows either the corresponding source code or the equivalent XML source text .

Graphical and textual development: The textual view is to view and modify if need XML source text or source code. Any changes made to the text are also reflected in the graphical view

User interaction: The only one way to edit the properties of a function block is to right-click into the graphical view and choose an action from the context menu, which makes special editing windows appear.

Library mechanism: When developing a Composite FB it is necessary to create and modify its function block network. New function blocks are inserted into the network by using the context menu and selecting NEW and FB. Then, a file wizard pops up from which the user can select a file that stores another function block and give a name to it. This mechanisms not as comfortable as dragging and dropping from a palette but still fast and easy
to use.

IV DISTRIBTED AND RECONFIGURABLE CONCEPT IN IEC 61499

Distributed concept bring the change into automation into manufacturing and process industries. In distribution phenomena the control can be distributed among the several hierarchical control layer from field to top layer management. The whole application distributed among various layer to fulfil the complete functionality using various communication protocols standards.IEC 61499 enable to design and develop flexible distributed control system/applications by merging the features of PLC function blocks and DCS function blocks.It's abstract model is basic function block and support the even based execution. The application can be created by interconnection of even driven software modules with distributed application among the various resources.[1]

IEC 61499 standard define general model and methodology for describing function blocks in a format that is independent of specific application implementation. This model used by designers to develop distributed control application for industries. Basically application based on this standard allow system in term of logically connected function blocks sharing among various resources. This standard emphasized formal models and methods based on object oriented concept and unified modelling language[1].

Generalized concept based on IEC 61499 standard is illustrated below figure

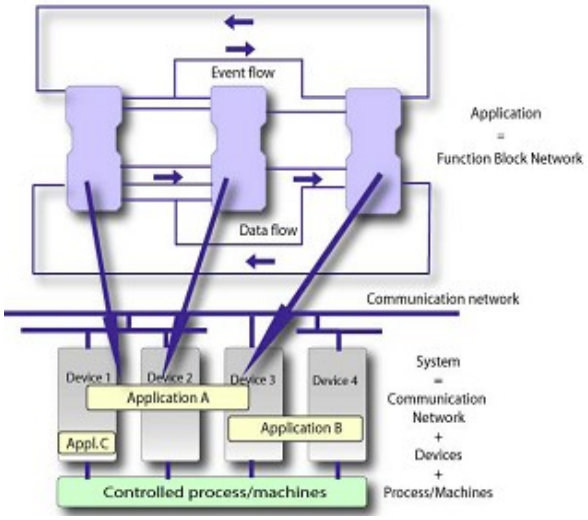

Fig 4: Distributed System in IEC 61499

Device, application and resources are the main elements of distributed process control system based on IEC 61499 model structure. The device is basic control element consist processor, I/O interfacing and communication interfaceing.The application is group of function blocks communicating to each other to complete the control tasks. The resource is consider as sub-device which can independent control of its operation and the part of distributed application run on resources[1].

The 61499 standard facilitate the world trade by removing centralized barriers drawback by providing the portability, configurability & reconfigurabililty and interoperatibilty features. The configurability of device means device can be configurable by control software. The reconfigurabililty means device can be reconfigurable by change in it's parameters or variable from multiple vendors by software tool of multiple suppliers[1].

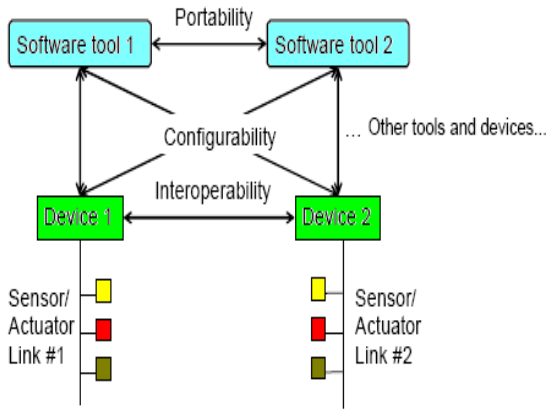

Fig 5 : IEC 61499 feature : interoperatibilty, portability and configurability & reconfigurabilty

The Algorithm of function block can support function block diagram, Ladder diagram, statement text and Java as shown in fig. In this sense It provide reconfigurabililty at abstract level of Function block of IEC 61499 standard.

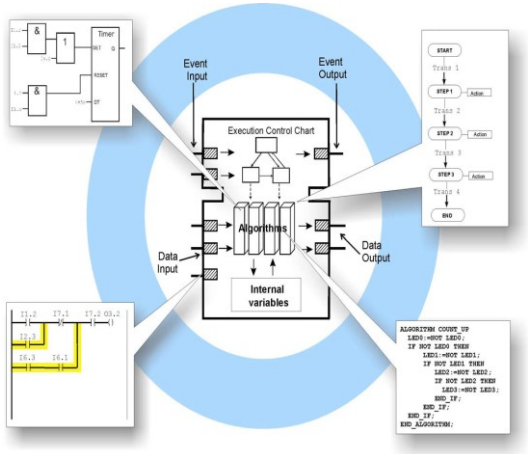

Fig 6: supported languages for the Function Block algorithm

PLC and CNC are used as lower level production line automation implementation. Reconfiguration control of these controllers can be great challenge due to different characteristics of individual control rules. Combine them both in single manufacturing environment to achieving reconfigurable control architecture in focus interest. For that initially study reconfigurable control of PLC and CNC controller. Then study the reconfigurable transform rules from PLC and CNC to IEC 61499 – describe transform rules from IEC 61131 to IEC 61499 reference structure model and describe STEP-NC reconfigurable numerical controller. Then implement reconfigurable control for single PLC and CNC based manufacturing industries[4]. This work can focus on reconfiguration need for lower level machine control enable to design IEC 61499 compliant PLC controller of machine. That can be move to transform to new structure and then integrate them into lower level manufacturing network of production line. For that first, mapping IEC 61499 and IEC 61499 elements to physical structure of production unit. second, constructing IEC 61499 complaint PLC controller design by reconfiguration concept[4]

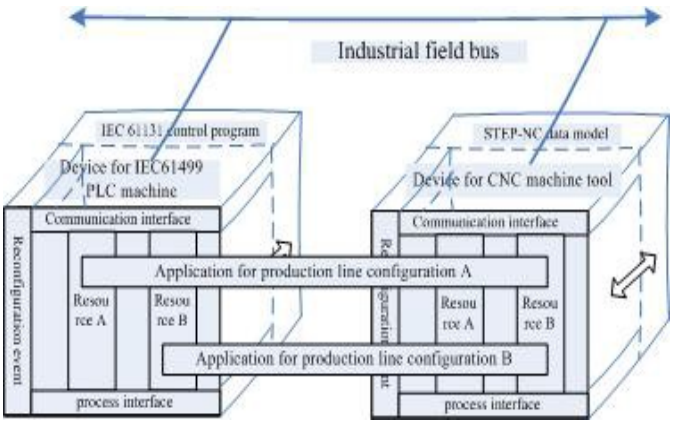

Fig 7: modify IEC 61499 compliant architecture from PLC and CNC controller

As shown in fig. PLC and CNC act as lower level manufacturing controller connected by industrial fieldbus.IEC 61499 compliant architecture proposed based on reconfigurable control software structure from lower level production environment. To do that, PLC and CNC controller are act as DEVICE model and even based control execution mechanism used as reconfiguration triggers and action.

To develop methodology to automate the design of distributed controllers of discrete manufacturing systems from a single description of the system is great challenge in automation system. Deriving modular representation of distributed application based on IEC 61499 standard and develop distributed controller for same. So if application can develop into modular form then it can be easily reused and reconfigurable. A key concept of this work is make the partition of the complete application into subsystem as workunit which allows to design modular description based on function blocks: these blocks can integrated into composite models to act as single module[5].

This work focus on using even based execution model instead of scan based execution model. It mean transform from IEC 61131 to IEC 61499 architecture model.IEC 61499 defining hardware independent distributed application using hierarchical,modular,reused and reconfigurable software components. An application generator software was developed for deployment of IEC 61499 model into industrial scan based controllers. It's application to closed loop control system using inverted pendulum as case study discuss.

V CONCLUSION

The knowledge, need of IEC 61499 reference standard for developing flexible distributed system is fully describe. FBDK is most popular academic/research oriented software tool to develop and stimulate/test distributed application based on

IEC 61499 reference model. Function block is basic element of IEC 61499 provide even based execution mechanism, reconfiguration at algorithm level, easily re-used features to develop application. The application can be distributed among several devices and resources by developing function block networks in IEC 61499 reference model. Reconfigurable phenomena study at various aspect :1.Algorithm level of function block 2. Modular structure of application and
3. Transformation from PLC,CNC controller to IEC 61499 model structure.

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