Automatic code generation based on generic description of intelligent instrument

Stéphane Perrin, Eric Benoit, Laurent Foulloy

► To cite this version:

Stéphane Perrin, Eric Benoit, Laurent Foulloy. Automatic code generation based on generic description of intelligent instrument. IEEE International Conference on Systems, Man and Cybernetics, Oct 2002, Hammamet, Tunisia. pp.WA2Q5, 10.1109/ICSMC.2002.1175651 . hal-00628052

HAL Id: hal-00628052

<https://hal.science/hal-00628052>

Submitted on 29 Mar 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Automatic Code Generation based on Generic Description of Intelligent Instrument

Stéphane Perrin, Eric Benoit, Laurent Foulloy

LAMII-ESIA Université de Savoie

B.P. 806, F-74016 Annecy cedex, France

stephane.perin@univ-savoie.fr, eric.benoit@univ-savoie.fr, laurent.foulloy@univ-savoie.fr

Abstract - *This paper presents an automatic outputs generation based on XML description of intelligent instruments. This description uses the service based approach called INOMs. The XML representation of intelligent instruments enables three different outputs: user informations output in html format, supervisor information output, and source code output for selected field bus network target. The intelligent instrument model is briefly described and the area of interest consists in the automatic code generation. A basic example is presented in order to illustrate the different steps and to show the simplicity of the operational implementation.*

Keywords: *Automatic Generation Code, XML, Intelligent Instrument, Generic Description.*

I INTRODUCTION

Intelligent instruments, i.e. intelligent sensors and intelligent actuators, are now commonly used in industry. Their design is performed both by software engineer and by physicist who not necessary understand each other. Recent studies propose instrument models based on a set of functionalities organized with a general behavioural description, i.e. automation graph or object model [1][2][3]. The idea of this paper is to propose a solution that cuts the design process into two pieces based on the same instrument modelling. The aim of this approach is to simplify the activity of the software engineer and the physicist with respect to their respective competencies.

This paper is a extension to recent works about based service approach [4] and a dedicated tool: CAPtool [5][6], that is able, to verify the model and now, to produce generic XML description of intelligent instruments. Wollschlaeger discusses about the representation of CANopen device profile in XML language[7]. He shows that specific informations for service and support can be extracted from a general XML based description. Based on XML format, the intelligent instrument representation can also be used to generate code source as well as user information can be created in html format or supervisor information i.e. Electronic Data Sheet (EDS) can be created in dedicated format. In this paper we propose to extend this approach to source code generation of the instrument into a source file that will be used for several translation in order to produce a source code.

II SERVICE BASED INTELLIGENT INSTRUMENT MODELLING

A. Principle

This section presents the chosen modelling for intelligent instrument. Recent studies propose models based on a set of functionalities organized with a general behavioural description, i.e. automation graph or object model [2][8][9]. The internal modelling of intelligent instruments is not sufficient for the design of large applications. Obviously, intelligent instruments need to inter-operate. Therefore an external model of intelligent instrument is required. Staroswiecki proposed to model a sensor by a set of services [4]. Services are organized into subsets called "User Operating Modes" (USOM). In this model, a sensor service can be requested, and so serviced, only if the current active USOM includes this service. This prevents the requirement of services when they cannot be available.

The approach discussed in [10] was proposed to model existing instruments from the external point of view. In particular, the external model of the instrument can be used to build a global model for an application involving several instruments. This kind of approach can also be used to define the internal functional model of a sensor [11].

Instruments are considered as entities that offer some more or less complex services. These services represent the instrument functionalities from the user point of view. At a lower level, each instrument service is defined as a set of internal services Fig. 1.

Fig. 1. Service based structure of an intelligent instrument.

These levels are representative of the gap between the instrument user point of view, the instrument designer point of view and the software designer activity. In order to use instrument designer capabilities for the design of intelligent

instruments, instrument functionalities are described with basic internal services. Then the designer will just have to define each external service with a set of internal services.

B. Modelling

The software designer creates basic pieces of code, i.e. internal services, using the usual C language. Then, he defines all possible sequences between internal services. Finally he creates internal modes as sets of internal services.

Fig. 2. Internal services and internal modes of the counter example.

The Fig. 2. shows an example of the graphical model produced by the software designer. In this example, the instrument handle a counter. When the counter is initialised, the counter value is set to 0, the initial value is set to 0 and the final value is set to 10. The default mode is *up*. Then counter value can be incremented while it is less than final value. When the counter value is greater or equal than final value, the counter switch to the *down* mode. Then counter value can be decremented while it is greater than final value.

Internal service *reset* sets the *counter* value to 0 and the *final_var* to 0. The *show_x* internal services, e.g. *show_counter*, send the value of the associated variable on the fieldbus connected to the instrument. *Decrement* and *increment* internal services modify the counter each time they are called. The internal data flow is included into the definition of internal services and does not appear at the model level. The designer have to indicate input and output variables: three variables are used to perform this instrument: *count_var* contains the current value of the counter (output), *start_var* contains the start value of the counter (input/output) and *final_var* contains the final value of the counter (input/output).

The instrument designer creates each external service by defining which internal service is started, and which other internal service is used by this external service. Then he creates external modes as sets of external services (Fig. 3.) and defines the authorized transitions between modes (Fig. 4.). In this example, the instrument designer defines the external service *count* that uses the *show_counter* internal service in order to make the service *count* sending the counter value over the network.

Fig. 3. Model of the external service *count*

The functional description describes the implementation of those functional requirements. Fig. 5. represents the generating of specific output descriptions for a device.

Fig. 4. External services and external modes of the counter example.

From the graphical modelling of the intelligent instrument a global generic device description file is created. A graphical user interface may be used for creating this XML description.

Fig. 5. Principle of using XML for intelligent

III XML REPRESENTATION OF THE MODEL

The produced XML file contains all information included in the graphical modelling. The XML file of the example can be seen in the annexe. The C format definition of internal services is not included into the XML file and stays in this format for convenient use. The XML representation of internal services then includes services names and the sequence between services. A small piece of the XML file of the example is presented below:

```
<!--Internal services definitions-->
```

```

<iservice id="reset">
  <starts>show_counter</starts>
  <starts>show_start_var</starts>
  <starts>show_final_var</starts>
</iservice>
<iservice id="decrement">
  <starts>show_counter</starts>
</iservice>
<iservice id="increment">
  <starts>show_counter</starts>
</iservice>
<iservice id="show_start_var" />
<iservice id="show_final_var" />
<iservice id="show_counter" />

```

An XML based representation file can easily be transformed into an other file (i.e. XML, or HTML, etc....). This can be performed by a set of rules. These rules are expressed using extensible style language for transformation (XSLT) and can be contained into XSL files. Each XSL file appears as conventional files that includes some transformation rules. Indeed an XSL file dedicated to the generation of an HTML file includes essentially HTML markers, and some transformation rules that translate XML information into HTML markers.

For example, if the XSL file includes:

```

<H1>List of services</H1>
<xsl: for-each select="instrument/iservice">
internal service: <xsl:value-of select="@id" /><BR/>
</xsl:for-each>

```

then the translation of the XML file of the counter example by this file will includes:

```

<H1>List of services</H1>
internal service: reset<BR/>
internal service: decrement<BR/>
internal service: increment<BR/>
internal service: show_start_var<BR/>
internal service: show_final_var<BR/>
internal service: show_counter<BR/>

```

This is a pure HTML file. The same approach can be used for the generation of EDS or source code. For example, an XSL file dedicated to the generation of C source code is essentially a C source code with some rules that translate XML information into C items. For example, the following XSL file translate the XML example file into a C file.

```

void initializeIServices(void){
<xsl:for-each select="instrument/iservice">
start_<xsl:value-of select="@id"> = 0;</xsl:for-each>
}

```

This translates the XML file into:

```

void initializeIServices(void){

```

```

start_reset = 0;
start_decrement = 0;
start_increment = 0;
start_show_start_var = 0;
start_show_final_var = 0;
start_show_counter = 0;
}

```

IV FROM GRAPHICAL MODEL TO FINAL SOFTWARE

This kind of approach allows the designer to be independent of a field bus technology. Therefore its developments can be directly used for a dedicated field bus. Thus, from a only one XML representation of instrument intelligent, source code files can be generated. The specific rules, in regards to field bus network specifications, is expressed into XSL files. So, to obtain source code for a dedicated field bus, it is just necessary to add corresponding transformation rules using XSLT language. No other dedicated tools are necessary. Fig. 6. illustrates the code generation procedure.

Fig. 6. Implemented approach for designing intelligent instrument based on XML representation.

Writing XSL files for the generation of source code is a solution chosen in order to reduce the complexity of the code generation. This approach simplifies the adaptation of the automatic generation mechanism to a specific fieldbus. Indeed, as the differences between field buses are very important and concern generally the highest layer of the OSI model, the differences in the source code are also very important.

V CONCLUSIONS

The design of intelligent instruments requires more and more multiple competencies. The design complexity of instruments requires several specialists such as, sensor or actuator designers, and software designer. The model approach and its global description, proposed in this paper, allows the designer to be independent of field bus technology. Source code can be automatically created for any field bus technology if a dedicated set of rules is provided. In addition, it is easy to implement these rules with XSL/XSLT format. The approach chosen is compatible with the application model based on USOMs.

ANNEXE: XML FILE

```
<?xml version="1.0" ?>
```

```
<instrument>
<!-- Software designer section -->
<!-- Variables definition -->
<variable id="start_var" type="unsigned8" acces="io"/>
<variable id="final_var" type="unsigned8" acces="io"/>
<variable id="counter_var" type="unsigned8" acces="io"/>

<!-- Internal services definitions -->
<iservice id="reset">
  <starts>show_counter</starts>
  <starts>show_start_var</starts>
  <starts>show_final_var</starts>
</iservice>
<iservice id="decrement">
  <starts>show_counter</starts>
</iservice>
<iservice id="increment">
  <starts>show_counter</starts>
</iservice>
<iservice id="show_start_var" />
<iservice id="show_final_var" />
<iservice id="show_counter" />

<!-- Internal modes definition -->
<imode id="down">
  <includes>reset</includes>
  <includes>show_counter</includes>
  <includes>show_start_var</includes>
  <includes>show_final_var</includes>
  <includes>decrement</includes>
</imode>
<imode id="up">
  <includes>reset</includes>
  <includes>show_counter</includes>
  <includes>show_start_var</includes>
  <includes>show_final_var</includes>
  <includes>increment</includes>
</imode>

<!-- Instrument designer section -->
<!-- External services definition -->
<service id="count">
```

```
  <starts>increment</starts>
  <starts>decrement</starts>
  <uses>show_counter</uses>
</service>
<service id="initialize">
  <starts>reset</starts>
  <uses>show_counter</uses>
  <uses>show_start_var</uses>
  <uses>show_final_var</uses>
</service>
<service id="set_start_var">
  <uses>show_start_var</uses>
</service>
<service id="set_final_var">
  <uses>show_final_var</uses>
</service>
<service id="show_bounds">
  <starts>show_start_var</starts>
  <starts>show_final_var</starts>
</service>
<service id="show_counter_var">
  <starts>show_counter</starts>
</service>

<!-- External modes definition -->
<mode id="run" >
  <includes>count</includes>
</mode>
<mode id="configuration" >
  <includes>initialize</includes>
  <includes>set_start_var</includes>
  <includes>set_final_var</includes>
  <includes>show_bounds</includes>
  <includes>show_counter_var</includes>
</mode>

<transition start="configuration" end="run" />
<transition start="run" end="configuration" />

</instrument>
```

REFERENCES

- [1] Bloch G., Eugene C., Robert M., Humbert C., "Measurement Evolution: from Sensors to Information Producer", Proc. of IMEKO TC1 TC7, (September 8-10, 1993) London, UK, pp 335-341.
- [2] J.M. Riviere, M. Bayart, J.M. Thiriet, A. Bouras, M. Robert, "Intelligent instruments: some modelling approaches", Measurement and Control, (July-August 1996) Vol.29, pp.179-186.
- [3] J. Rumbaugh, M. Blaha, W. Premerlani, F. Eddy, "Object Oriented Modeling and Design", Prentice Hall International, 1991.
- [4] M. Staroswiecki, M. Bayart, "Models and Languages for

the Interoperability of Smart Instruments”, *Automatica* (1996), Vol. 32, n° 6, pp. 859-873, .

- [5] Benoit E., Foulloy L., Tailland J. “Automatic Smart Sensors Generation Based on InOMs”, *Proc. of the 16th IMEKO World Congress. Vienna, Austria, Sept. 25-28 2000. Vol IX*, pp. 335-340.
- [6] Benoit E., Tailland J., Foulloy L., Mauris G., “A software tool for designing intelligent sensors”, in *Proc. of the IEEE Instrumentation & Measurement technology IMTC/2000 Conference*, Baltimore, Maryland, USA, may 1-4 2000, pp. 322-326.
- [7] Wollschlaeger M, Diedrich C., Thron M., "Generation of Role-specific information for an Enterprise integration Framework using XML description", in *ETFA 2001*, Antibes, France, Octobre 2001, pp 237-244.
- [8] Q. Yang, C. Butler, “An Object-Oriented Model of Measurement Systems”, in *Proc. of the IEEE/IMTC Instrumentation and Measurement Technology Conference*, Ottawa, Canada, May 19-21, 1997.
- [9] H.J.W. Spoelder, A.H. Ullings, F.C.A. Groen, “Virtual Instrumentation: A survey of Standards and their Interrelation”, in *Proc. of the IEEE/IMTC Instrumentation and Measurement Technology Conference*, Ottawa, Canada, May 19-21, 1997.
- [10] A. Bouras, M. Staroswiecki, “How can Intelligent Instruments Interoperate in an Application Framework ? A Mechanism for Taking into Account Operating Constraints”, *Proc. of Int. Conf. SICICA'97 (9-11 juin 1997)* Annecy, France.
- [11] Benoit E., Foulloy L., "InOMs model: a service based approach to intelligent instrument design", in *ETFA 2001*, Antibes, France, Octobre 2001.
- [12] Benoit E., Foulloy L., Tailland J., “InOMs model: a Service Based Approach to Intelligent Instruments Design”, *Proc. of the World Conf. on Systemics, Cybernetics and Informatics (SCI 2001)*, Vol. XVI, Orlando, USA, 2001, pp 160-164.