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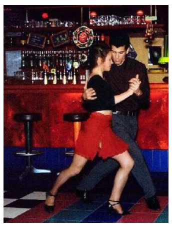


Introduction

Introduction to device server

Device servers were first developed at the European Synchrotron radiation Facility (ESRF) for controlling the 6 Gev synchrotron radiation source. This document is a Programmer's Manual on how to write TANGO device servers. It will not go into the details of the ESRF, nor its Control System nor any of the specific device servers in the Control System. The role of this document is to help programmers faced with the task of writing TANGO device servers.

Device servers have been developed at the ESRF in order to solve the main task of Control Systems viz provide read and write access to all devices in a distributed system. The problem of distributed device access is only part of the problem however. The other part of the problem is providing a programming framework for a large number of devices programmed by a large number of programmers each having different levels of experience and style.

Device servers have been written at the ESRF for a large variety of different devices. Devices vary from serial line devices to devices interfaced by field-bus to memory mapped VME cards or PC cards to entire data acquisition systems. The definition of a device depends very much on the user's requirements. In the simple case a device server can be used to hide the serial line protocol required to communicate with a device. For more complicated devices the device server can be used to hide the entire complexity of the device timing, configuration and acquisition cycle behind a set of high level commands.

In this manual the process of how to write TANGO client (applications) and device servers will be treated. The manual has been organized as follows :

- A getting started chapter.
- The TANGO device server model is treated in chapter 3
- Generalities on the Tango Application Programmer Interfaces are given in chapter 4
- Chapter 5 is an a programmer's guide for the Tango Application ToolKit (TangoATK). This is a Java toolkit to help Tango Java application developers.
- How to write a TANGO device server is explained in chapter 6
- Chapter 7 describes advanced Tango features

Throughout this manual examples of source code will be given in order to illustrate what is meant. Most examples have been taken from the StepperMotor class - a simulation of a stepper motor which illustrates how a typical device server for a stepper motor at the ESRF functions.

Device server history

The concept of using device servers to access devices was first proposed at the ESRF in 1989. It has been successfully used as the heart of the ESRF Control System for the institute accelerator complex. This Control System has been named TACO[1]. Then, it has been decided to also used TACO to control devices in the beam-lines. Today, more than 30 instances of TACO are running at the ESRF. The main technologies used within

TACO are the leading technologies of the 80's. The Sun Remote Procedure Call (RPC) is used to communicate over the network between device server and applications, OS-9 is used on the front-end computers, C is the reference language to write device servers and clients and the device server framework follows the MIT Widget model. In 1999, a renewal of the control system was started. In June 2002, Soleil and ESRF offically decide to collaborate to develop this renewal of the old TACO control system. Soleil is a French synchrotron radiation facility currently under construction in the Paris suburbs. See [**?**] to get all information about Soleil. In December 2003, Elettra joins the club. Elettra is an Italian synchrotron radiation facility located in Trieste. See [**?**] to get all information about Elettra. Then, beginning of 2005, ALBA also decided to join. ALBA is a Spanish synchrotron radiation facility located in Barcelona. See [**?**] to get all information about ALBA. The new version of the Alba/Elettra/ESRF/Soleil control system is named TANGO[2] and is based on the 21 century technologies :

- CORBA[3] and ZMQ:raw-latex:*cite{ZMQ}* to communicate between device server and clients
- C++, Python and Java as reference programming languages
- Linux and Windows as operating systems
- Modern object oriented design patterns

Getting Started

A C++ TANGO client

The quickest way of getting started is by studying this example :

```
/*
 * example of a client using the TANGO C++ api.
 */
#include <tango.h>
using namespace Tango;
int main(unsigned int argc, char **argv)
{
    try
    {

//
// create a connection to a TANGO device
//

        DeviceProxy *device = new DeviceProxy("sys/database/2");

//
// Ping the device
//

        device->ping();

//
// Execute a command on the device and extract the reply as a string
//

        string db_info;
        DeviceData cmd_reply;
        cmd_reply = device->command_inout("DbInfo");
        cmd_reply >> db_info;
        cout << "Command reply " << db_info << endl;

//
// Read a device attribute (string data type)
//

        string spr;
        DeviceAttribute att_reply;
        att_reply = device->read_attribute("StoredProcedureRelease");
        att_reply >> spr;
        cout << "Database device stored procedure release: " << spr <<
    }
    catch (DevFailed &e)
    {
        Except::print_exception(e);
        exit(-1);
    }
}
```

Modify this example to fit your device server or client's needs, compile it and link with the library -ltango. Forget about those painful early TANGO days when you had to learn CORBA and manipulate Any's. Life's going to easy and fun from now on !

A TANGO device server

The code given in this chapter as example has been generated using POGO. Pogo is a code generator for Tango device server. See [**?**] for more information about POGO. The following examples briefly describe how to write device class with commands which receives and return different kind of Tango data types and also how to write device attributes The device class implements 5 commands and 3 attributes. The commands are :

- The command **DevSimple** deals with simple Tango data type
- The command **DevString** deals with Tango strings
- **DevArray** receive and return an array of simple Tango data type
- **DevStrArray** which does not receive any data but which returns an array of strings
- **DevStruct** which also does not receive data but which returns one of the two Tango composed types (DevVarDoubleStringArray)

For all these commands, the default behavior of the state machine (command always allowed) is acceptable. The attributes are :

- A spectrum type attribute of the Tango string type called **StrAttr**
- A readable attribute of the Tango::DevLong type called **LongRdAttr**. This attribute is linked with the following writable attribute
- A writable attribute also of the Tango::DevLong type called **LongWrAttr**.

Since release 9, a Tango device also supports pipe. This is an advanced feature reserved for some specific cases. Therefore, there is no device pipe example in this Getting started chapter.

The commands and attributes code

For each command called DevXxxx, pogo generates in the device class a method named dev_xxx which will be executed when the command is requested by a client. In this chapter, the name of the device class is *DocDs*

The DevSimple command This method receives a Tango::DevFloat type and also returns a data of the Tango::DevFloat type which is simply the double of the input value. The code for the method executed by this command is the following:

```
 1   Tango::DevFloat DocDs::dev_simple(Tango::DevFloat argin)
 2   {
 3           Tango::DevFloat argout ;
 4           DEBUG_STREAM << "DocDs::dev_simple(): entering... !" << endl;
 5
 6           //      Add your own code to control device here
 7
 8           argout = argin * 2;
 9           return argout;
10   }
```

This method is fairly simple. The received data is passed to the method as its argument. It is
doubled at line 8 and the method simply returns the result.

The DevArray command This method receives a data of the Tango::DevVarLongArray type and also returns a data of the Tango::DevVarLongArray type. Each element of the array is doubled. The code for the method executed by the command is the following :

```
 1   Tango::DevVarLongArray *DocDs::dev_array(const Tango::DevVarLongArray *
 2   {
 3           //      POGO has generated a method core with argout allocatio
 4           //      If you would like to use a static reference without co
 5           //      See "TANGO Device Server Programmer's Manual"
 6           //              (chapter x.x)
 7           //------------------------------------------------------------
 8          Tango::DevVarLongArray  *argout  = new Tango::DevVarLongArray
 9
10          DEBUG_STREAM << "DocDs::dev_array(): entering... !" << endl;
11
12          //      Add your own code to control device here
13
14          long argin_length = argin->length();
15          argout->length(argin_length);
16          for (int i = 0;i < argin_length;i++)
17                  (*argout)[i] = (*argin)[i] * 2;
18
19          return argout;
20  }
```

The argout data array is created at line 8. Its length is set at line 15 from the input argument length. The array is populated at line 16,17 and returned. This method allocates memory for the argout array. This memory is freed by the Tango core classes after the data have been sent to the caller (no delete is needed). It is also possible to return data from a statically allocated array without copying. Look at chapter [Data exchange] for all the details.

The DevString command This method receives a data of the Tango::DevString type and also returns a data of the Tango::DevString type. The command simply displays the content of the input string and returns a hard-coded string. The code for the method executed by the command is the following :

```
 1  Tango::DevString DocDs::dev_string(Tango::DevString argin)
 2  {
 3          //      POGO has generated a method core with argout allocatio
 4          //      If you would like to use a static reference without co
 5          //      See "TANGO Device Server Programmer's Manual"
 6          //              (chapter x.x)
 7          //------------------------------------------------------------
 8          Tango::DevString        argout;
 9          DEBUG_STREAM << "DocDs::dev_string(): entering... !" << endl;
10
11          //      Add your own code to control device here
12
13          cout << "the received string is " << argin << endl;
14
15          string str("Am I a good Tango dancer ?");
16          argout = new char[str.size() + 1];
17          strcpy(argout,str.c_str());
18
19          return argout;
20  }
```

The argout string is created at line 8. Internally, this method is using a standard C++ string. Memory for the returned data is allocated at line 16 and is initialized at line 17. This method allocates memory for the argout string. This memory is freed by the Tango core classes after the data have been sent to the caller (no delete is needed). It is also possible to return data from a statically allocated string without copying. Look at chapter [Data exchange] for all the details.

The DevStrArray command This method does not receive input data but returns an array of strings (Tango::DevVarStringArray type). The code for the method executed by this command is the following:

```
1   Tango::DevVarStringArray *DocDs::dev_str_array()
2    {
3           //      POGO has generated a method core with argout allocatio
4           //      If you would like to use a static reference without co
5           //      See "TANGO Device Server Programmer's Manual"
6           //              (chapter x.x)
7           //------------------------------------------------------------
8           Tango::DevVarStringArray        *argout  = new Tango::DevVarSt
9
10          DEBUG_STREAM << "DocDs::dev_str_array(): entering... !" << enc
11
12          //      Add your own code to control device here
13
14          argout->length(3);
15          (*argout)[0] = CORBA::string_dup("Rumba");
16          (*argout)[1] = CORBA::string_dup("Waltz");
17          string str("Jerck");
18          (*argout)[2] = CORBA::string_dup(str.c_str());
19          return argout;
20   }
```

The argout data array is created at line 8. Its length is set at line 14. The array is populated at line 15,16 and 18. The last array element is initialized from a standard C++ string created at line 17. Note the usage of the *string_dup* function of the CORBA namespace. This is necessary for strings array due to the CORBA memory allocation schema.

The DevStruct command This method does not receive input data but returns a structure of the Tango::DevVarDoubleStringArray type. This type is a composed type with an array of double and an array of strings. The code for the method executed by this command is the following:

```
1   Tango::DevVarDoubleStringArray *DocDs::dev_struct()
2    {
3           //      POGO has generated a method core with argout allocatio
4           //      If you would like to use a static reference without co
5           //      See "TANGO Device Server Programmer's Manual"
6           //              (chapter x.x)
7           //------------------------------------------------------------
8           Tango::DevVarDoubleStringArray  *argout  = new Tango::DevVarDo
```

```
 9
10            DEBUG_STREAM << "DocDs::dev_struct(): entering... !" << endl;
11
12            //      Add your own code to control device here
13
14            argout->dvalue.length(3);
15            argout->dvalue[0] = 0.0;
16            argout->dvalue[1] = 11.11;
17            argout->dvalue[2] = 22.22;
18
19            argout->svalue.length(2);
20            argout->svalue[0] = CORBA::string_dup("Be Bop");
21            string str("Smurf");
22            argout->svalue[1] = CORBA::string_dup(str.c_str());
23
24            return argout;
25    }
```

The argout data structure is created at line 8. The length of the double array in the output structure is set at line 14. The array is populated between lines 15 and 17. The length of the string array in the output structure is set at line 19. This string array is populated between lines 20 an 22 from a hard-coded string and from a standard C++ string. This method allocates memory for the argout data. This memory is freed by the Tango core classes after the data have been sent to the caller (no delete is needed). Note the usage of the *string_dup* function of the CORBA namespace. This is necessary for strings array due to the CORBA memory allocation schema.

The three attributes Some data have been added to the definition of the device class in order to store attributes value. These data are (part of the class definition) :

```
protected :
        //      Add your own data members here
        //-----------------------------------------
        Tango::DevString        attr_str_array[5];
        Tango::DevLong          attr_rd;
        Tango::DevLong          attr_wr;
```

One data has been created for each attribute. As the StrAttr attribute is of type spectrum with a maximum X dimension of 5, an array of length 5 has been reserved.

Several methods are necessary to implement these attributes. One method to read the hardware which is common to all readable attributes plus one read method for each readable attribute and one write method for each writable attribute. The code for these methods is the following :

```
void DocDs::read_attr_hardware(vector<long> &attr_list)
{
     DEBUG_STREAM << "DocDs::read_attr_hardware(vector<long> &attr_list)
// Add your own code here

     string att_name;
```

```
 7      for (long i = 0;i < attr_list.size();i++)
 8      {
 9          att_name = dev_attr->get_attr_by_ind(attr_list[i]).get_name();
10
11         if (att_name == "LongRdAttr")
12         {
13             attr_rd = 5;
14         }
15     }
16 }
17
18 void DocDs::read_LongRdAttr(Tango::Attribute &attr)
19 {
20     DEBUG_STREAM << "DocDs::read_LongRdAttr(Tango::Attribute &attr) ent
21
22     attr.set_value(&attr_rd);
23 }
24
25 void DocDs::read_LongWrAttr(Tango::Attribute &attr)
26 {
27     DEBUG_STREAM << "DocDs::read_LongWrAttr(Tango::Attribute &attr) ent
28
29     attr.set_value(&attr_wr);
30 }
31
32 void DocDs::write_LongWrAttr(Tango::WAttribute &attr)
33 {
34     DEBUG_STREAM << "DocDs::write_LongWrAttr(Tango::WAttribute &attr) e
35
36     attr.get_write_value(attr_wr);
37     DEBUG_STREAM << "Value to be written = " << attr_wr << endl;
38 }
39
40 void DocDs::read_StrAttr(Tango::Attribute &attr)
41 {
42     DEBUG_STREAM << "DocDs::read_StrAttr(Tango::Attribute &attr) enter
43
44     attr_str_array[0] = const_cast<char *>("Rock");
45     attr_str_array[1] = const_cast<char *>("Samba");
46
47     attr_set_value(attr_str_array, 2);
48 }
```

The *read_attr_hardware()* method is executed once when a client execute the read_attributes CORBA request whatever the number of attribute to be read is. The rule of this method is to read the hardware and to store the read values somewhere in the device object. In our example, only the LongRdAttr attribute internal value is set by this method at line 13. The method *read_LongRdAttr()* is executed by the read_attributes CORBA call when the LongRdAttr attribute is read but after the read_attr_hardware() method has been executed. Its rule is to set the attribute value in the TANGO core classes object representing the attribute. This is done at line 22. The method *read_LongWrAttr()* will be executed when the LongWrAttr attribute is read (after the *read_attr_hardware()* method). The attribute value is set at line 29. In the same manner, the method called *read_StrAttr()* will be executed when the attribute StrAttr is read. Its value is initialized in this method at line 44 and 45 with the *string_dup* Tango function. There are several ways to code spectrum or image attribute of the DevString data type. A HowTo related to this topic is available on the Tango control system Web site. The *write_LongWrAttr()* method is executed when the LongWrAttr attribute value is set by a client. The new attribute value coming from the client is stored in the object data at line 36.

Pogo also generates a file called DocDsStateMachine.cpp (for a Tango device server class called DocDs). This file is used to store methods coding the device state machine. By default a allways allowed state machine is provided. For more information about coding the state machine, refer to the chapter Writing a device server.

[APicture]|image|

The TANGO device server model

This chapter will present the TANGO device server object model hereafter referred as TDSOM. First, it will introduce CORBA. Then, it will describe each of the basic features of the TDSOM and their function. The TDSOM can be divided into the following basic elements - the *device*, the *server*, the *database* and the *application programmers interface*. This chapter will treat each of the above elements separately.

Introduction to CORBA

CORBA is a definition of how to write object request brokers (ORB). The definition is managed by the Object Management Group (OMG [**?**]). Various commercial and non-commercial implementations exist for CORBA for all the mainstream operating systems. CORBA uses a programming language independent definition language (called IDL) to defined network object interfaces. Language mappings are defined from IDL to the main programming languages e.g. C++, Java, C, COBOL, Smalltalk and ADA. Within an interface, CORBA defines two kinds of actions available to the outside world. These actions are called **attributes** and **operations**.

Operations are all the actions offered by an interface. For instance, within an interface for a Thermostat class, operations could be the action to read the temperature or to set the nominal temperature. An attribute defines a pair of operations a client can call to send or receive a value. For instance, the position of a motor can be defined as an attribute because it is a data that you only set or get. A read only attribute defines a single operation the client can call to receives a value. In case of error, an operation is able to throw an exception to the client, attributes cannot raises exception except system exception (du to network fault for instance).

Intuitively, IDL interface correspond to C++ classes and IDL operations correspond to C++ member functions and attributes as a way to read/write public member variable. Nevertheless, IDL defines only the interface to an object and say nothing about the object implementation. IDL is only a descriptive language. Once the interface is fully described in the IDL language, a compiler (from IDL to C++, from IDL to Java...) generates code to implement this interface. Obviously, you still have to write how operations are implemented.

The act of invoking an operation on an interface causes the ORB to send a message to the corresponding object implementation. If the target object is in another address space, the ORB run time sends a remote procedure call to the implementation. If the target object is in the same address space as the caller, the invocation is accomplished as an ordinary function call to avoid the overhead of using a networking protocol.

For an excellent reference on CORBA with C++ refer to [**?**]. The complete TANGO IDL file can be found in the TANGO web page:raw-latex:*cite{Tango web}* or at the end of this document in the appendix 2 chapter.

The model

The basic idea of the TDSOM is to treat each device as an **object**. Each device is a separate entity which has its own data and behavior. Each device has a unique name which identifies it in network name space. Devices are organized according to **classes**, each device belonging to a class. All classes are derived from one root class thus allowing some common behavior for all devices. Four kind of requests can be sent to a device (locally i.e. in the same process, or remotely i.e. across the network) :

- Execute actions via **commands**
- Read/Set data specific to each device belonging to a class via TANGO **attributes**
- Read/Set data specific to each device belonging to a class via TANGO **pipes**
- Read some basic device data available for all devices via CORBA attributes.
- Execute a predefined set of actions available for every devices via CORBA operations

Each device is stored in a process called a **device server**. Devices are configured at runtime via **properties** which are stored in a **database**.

The device

The device is the heart of the TDSOM. A device is an abstract concept defined by the TDSOM. In reality, it can be a piece of hardware (an interlock bit) a collection of hardware (a screen attached to a stepper motor) a logical device (a taper) or a combination of all these (an accelerator). Each device has a unique name in the control system and eventually one alias. Within Tango, a four field name space has been adopted consisting of

[//FACILITY/]DOMAIN/CLASS/MEMBER

Facility refers to the control system instance, domain refers to the sub-system, class the class and member the instance of the device. Device name alias(es) must also be unique within a control system. There is no predefined syntax for device name alias.

Each device belongs to a class. The device class contains a complete description and implementation of the behavior of all members of that class. New device classes can be constructed out of existing device classes. This way a new hierarchy of classes can be built up in a short time. Device classes can use existing devices as sub-classes or as sub-objects. The practice of reusing existing classes is classical for Object Oriented Programming and is one of its main advantages.

All device classes are derived from the same class (the device root class) and implement **the same CORBA interface**. All devices implementing the same CORBA interface ensures all control object support the same set of CORBA operations and attributes. The device root class contains part of the common device code. By inheriting from this class, all devices shared a common behavior. This also makes maintenance and improvements to the TDSOM easy to carry out.

All devices also support a **black box** where client requests for attributes or operations are recorded. This feature allows easier debugging session for device already installed in a running control system.

The commands

Each device class implements a list of commands. Commands are very important because they are the client's major dials and knobs for controlling a device. Commands have a fixed calling syntax - consisting of one input argument and one output argument. Arguments type must be chosen in a fixed set of data types: All simple types (boolean, short, long (32 bits), long (64 bits), float, double, unsigned short, unsigned long (32 bits), unsigned long (64 bits) and string) and arrays of simple types plus array of strings and longs and array of strings and doubles). Commands can execute any sequence of actions. Commands can be executed synchronously (the requester is blocked until the command ended) or asynchronously (the requester send the request and is called back when the command ended).

Commands are executed using two CORBA operations named **command_inout** for synchronous commands and **command_inout_async** for asynchronous commands. These two operations called a special method implemented in the device root class - the *command_handler* method. The *command_handler* calls an *is_allowed* method implemented in the device class before calling the command itself. The *is_allowed* method is specific to each command[4]. It checks to see whether the command to be executed is compatible with the present device state. The command function is executed only if the *is_allowed* method allows it. Otherwise, an exception is sent to the client.

The TANGO attributes

In addition to commands, TANGO devices also support normalized data types called attributes[5]. Commands are device specific and the data they transport are not normalized i.e. they can be any one of the TANGO data types with no restriction on what each byte means. This means that it is difficult to interpret the output of a command in terms of what kind of value(s) it represents. Generic display programs need to know what the data returned represents, in what units it is, plus additional information like minimum, maximum, quality etc. Tango attributes solve this problem.

TANGO attributes are zero, one or two dimensional data which have a fix set of properties e.g. quality, minimum and maximum, alarm low and high. They are transferred in a specialized TANGO type and can be read, write or read-write. A device can support a list of attributes. Clients can read one or more attributes from one or more devices. To read TANGO attributes, the client uses the **read_attributes** operation. To write TANGO attributes, a client uses the **write_attributes** operation. To write then read TANGO attributes within the same network request, the client uses the **write_read_attributes** operation. To query a device for all the attributes it supports, a client uses the **get_attribute_config** operation. A client is also able to modify some of parameters defining an attribute with the **set_attribute_config** operation. These five operations are defined in the device CORBA interface.

TANGO support thirteen data types for attributes (and arrays of for one or two dimensional data) which are: boolean, short, long (32 bits), long (64 bits), float, double, unsigned char, unsigned short, unsigned long (32 bits), unsigned long (64 bits), string, a specific data type for Tango device state and finally another specific data type to transfer data as an array of unsigned char with a string describing the coding of these data.

The TANGO pipes

Since release 9, in addition to commands and attributes, TANGO devices also support pipes.

In some cases, it is required to exchange data between client and device of varrying data type. This is for instance the case of data gathered during a scan on one experiment. Because the number of actuators and sensors involved in the scan may change from one scan to another, it is not possible to use a well defined data type. TANGO pipes have been designed for such cases. A TANGO pipe is basically a pipe dedicated to transfer data between client and device. A pipe has a set of two properties which are the pipe label and its description. A pipe can be read or read-write. A device can support a list of pipes. Clients can read one or more pipes from one or more devices. To read a TANGO pipe, the client uses the **read_pipe** operation. To write a TANGO pipe, a client uses the **write_pipe** operation. To write then read a TANGO pipe within the same network request, the client uses the **write_read_pipe** operation. To query a device for all the pipes it supports, a client uses the **get_pipe_config** operation. A client is also able to modify some of parameters defining a pipe with the **set_pipe_config** operation. These five operations are defined in the device CORBA interface.

In contrary of commands or attributes, a TANGO pipe does not have a pre-defined data type. Data transferred through pipes may be of any basic Tango data type (or array of) and this may change every time a pipe is read or written.

Command, attributes or pipes ?

There are no strict rules concerning what should be returned as command result and what should be implemented as an attribute or as a pipe. Nevertheless, attributes are more adapted to return physical value which have a kind of time consistency. Attribute also have more properties which help the client to precisely know what it represents. For instance, the state and the status of a power supply are not physical values and are returned as command result. The current generated by the power supply is a physical value and is implemented as an attribute. The attribute properties allow a client to know its unit, its label and some other informations which are related to a physical value. Command are well adapted to send order to a device like switching from one mode of operation to another mode of operation. For a power supply, the switch from a STANDBY mode to a ON mode is typically done via a command. Finally pipe is well adapted when the kind and number of data exchanged between the client and the device change with time.

The CORBA attributes

Some key data implemented for each device can be read without the need to call a command or read an attribute. These data are :

- The device state

- The device status
- The device name
- The administration device name called adm_name
- The device description

The device state is a number representing its state. A set of predefined states are defined in the TDSOM. The device status is a string describing in plain text the device state and any additional useful information of the device as a formatted ascii string. The device name is its name as defined in [sec:dev]. For each set of devices grouped within the same server, an administration device is automatically added. This adm_name is the name of the administration device. The device description is also an ascii string describing the device rule.

These five CORBA attributes are implemented in the device root class and therefore do not need any coding from the device class programmer. As explained in [sec:corba], the CORBA attributes are not allowed to raise exceptions whereas command (which are implemented using CORBA operations) can.

The remaining CORBA operations

The TDSOM also supports a list of actions defined as CORBA operations in the device interface and implemented in the device root class. Therefore, these actions are implemented automatically for every TANGO device. These operations are :

MMMMMMMMMMMM

to ping a device to check if the device is alive. Obviously, it checks only the connection from a client to the device and not all the device functionalities

request a list of all the commands supported by a device with their input and output types and description

request information about a specific command which are its input and output type and description

request general information on the device like its name, the host where the device server hosting the device is running...

read the device black-box as an array of strings

The special case of the device state and status

Device state and status are the most important key device informations. Nearly all client software dealing with Tango device needs device(s) state and/or status. In order to simplify client software developper work, it is possible to get these two piece of information in three different manners :

1. Using the appropriate CORBA attribute (state or status)
2. Using command on the device. The command are called State or Status
3. Using attribute. Even if the state and status are not real attribute, it is possible to get their value using the read_attributes operation. Nevertheless, it is not possible to set the attribute configuration for state and status. An error is reported by the server if a client try to do so.

The device polling

Within the Tango framework, it is also possible to force executing command(s) or reading attribute(s) at a fixed frequency. It is called *device polling*. This is automatically handled by Tango core software with a polling threads pool. The command result or attribute value are stored in circular buffers. When a client want to read attribute value (or command result) for a polled attribute (or a polled command), he has the choice to get the attribute value (or command result) with a real access to the device of from the last value stored in the device ring buffer. This is a great advantage for "slow" devices. Getting data from the buffer is much faster than accessing the device itself. The technical disadvantage is the time shift between the data returned from the polling buffer and the time of the request. Polling a command is only possible for command without input arguments. It is not possible to poll a device pipe.

Two other CORBA operations called *command_inout_history_X* and *read_attribute_history_X* allow a client to retrieve the history of polled command or attribute stored in the polling buffers. Obviously, this history is limited to the depth of the polling buffer.

The whole polling system is available only since Tango release 2.x and above in CPP and since TangORB release 3.7.x and above in Java.

The server

Another integral part of the TDSOM is the server concept. The server (also referred as device server) is a process whose main task is to offer one or more services to one or more clients. To do this, the server has to spend most of its time in a wait loop waiting for clients to connect to it. The devices are hosted in the server process. A server is able to host several classes of devices. In the TDSOM, a device of the **DServer** class is automatically hosted by each device server. This class of device supports commands which enable remote device server process administration.

TANGO supports device server process on two families of operating system : Linux and Windows.

The Tango Logging Service

During software life, it is always convenient to print miscellaneous informations which help to:

- Debug the software
- Report on error
- Give regular information to user

This is classically done using cout (or C printf) in C++ or println method in Java language. In a highly distributed control system, it is difficult to get all these informations coming from a high number of different processes running on a large number of computers. Since its release 3, Tango has incorporated a Logging Service called the Tango Logging Service (TLS) which allows print messages to be:

- Displayed on a console (the classical way)
- Sent to a file

- Sent to specific Tango device called log consumer. Tango package has an implementation of log consumer where every consumer device is associated to a graphical interface. This graphical interface display messages but could also be used to sort messages, to filter messages... Using this feature, it is possible to centralise display of these messages coming from different devices embedded within different processes. These log consumers can be:
  - Statically configured meaning that it memorizes the list of Tango devices for which it will get and display messages.
  - Dynamically configured. The user, with the help of the graphical interface, chooses devices from which he want to see messages.

The database

To achieve complete device independence, it is necessary however to supplement device classes with a possibility for configuring device dependencies at runtime. The utility which does this in the TDSOM is the **property database**. Properties[6] are identified by an ascii string and the device name. TANGO attributes are also configured using properties. This database is also used to store device network addresses (CORBA IOR's), list of classes hosted by a device server process and list of devices for each class in a device server process. The database ensure the uniqueness of device name and of alias. It also links device name and it list of aliases.

TANGO uses MySQL:raw-latex:*cite{mysql}* as its database. MySQL is a relational database which implements the SQL language. However, this is largely enough to implement all the functionalities needed by the TDSOM. The database is accessed via a classical TANGO device hosted in a device server. Therefore, client access the database via TANGO commands requested on the database device. For a good reference on MySQL refer to [**?**]

The controlled access

Tango also provides a controlled access system. It's a simple controlled access system. It does not provide encrypted communication or sophisticated authentification. It simply defines which user (based on computer loggin authentification) is allowed to do which command (or write attribute) on which device and from which host. The information used to configure this controlled access feature are stored in the Tango database and accessed by a specific Tango device server which is not the classsical Tango database device server described in the previous section. Two access levels are defined:

- Everything is allowed for this user from this host
- The write-like calls on the device are forbidden and according to configuration, a command subset is also forbidden for this user from this host

This feature is precisely described in the chapter Advanced features

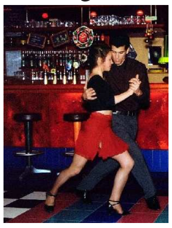
The Application Programmers Interfaces

Rules of the API

While it is true TANGO clients can be programmed using only the CORBA API, CORBA knows nothing about TANGO. This means client have to know all the details of retrieving IORs from the TANGO database, additional information to send on the wire, TANGO version control etc. These details can and should be wrapped in TANGO Application Programmer Interface (API). The API is implemented as a library in C++ and as a package in Java. The API is what makes TANGO clients easy to write. The API's consists the following basic classes :

- DeviceProxy which is a *proxy* to the real device
- DeviceData to encapsulate data send/receive from/to device via commands
- DeviceAttribute to encapsulate data send/receive from/to device via attributes
- Group which is a *proxy* to a group of devices

In addition to these main classes, many other classes allows a full interface to TANGO features. The following figure is a drawing of a typical client/server application using TANGO.



The database is used during server and client startup phase to establish connection between client and server.

Communication between client and server using the API

With the API, it is possible to request command to be executed on a device or to read/write device attribute(s) using one of the two communication models implemented. These two models are:

1. The synchronous model where client waits (and is blocked) for the server to send the answer or until the timeout is reached
2. The asynchronous model. In this model, the clients send the request and immediately returns. It is not blocked. It is free to do whatever it has to do like updating a graphical user interface. The client has the choice to retrieve the server answer by checking if the reply is arrived by calling an API specific call or by requesting that a call-back method is executed when the client receives the server answer.

The asynchronous model is available with Tango release 3 and above.

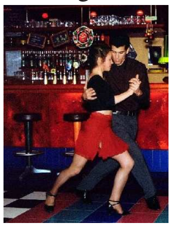
Tango events

On top of the two communication model previously described, TANGO offers an event system. The standard TANGO communication paradigm is a synchronou/asynchronous two-way call. In this paradigm the call is initiated by the client who contacts the server. The server handles the client's request and sends the answer to the client or throws an exception which the client catches. This paradigm involves two calls to receive a single answer and requires the client to be active in initiating the request. If the client has a permanent interest in a value he is obliged to poll the server for an update in a value every time. This is not efficient in terms of network bandwidth nor in terms of client programming.

For clients who are permanently interested in values the event-driven communication paradigm is a more efficient and natural way of programming. In this paradigm the client registers his interest once in an event (value). After that the server informs the client every time the event has occurred. This paradigm avoids the client polling, frees it for doing other things, is fast and makes efficient use of the network.

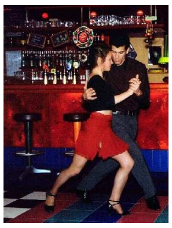
Before TANGO release 8, TANGO used the CORBA OMG COS Notification Service to generates events. TANGO uses the omniNotify implementation of the Notification service. omniNotify was developed in conjunction with the omniORB CORBA implementation also used by TANGO. The heart of the Notification Service is the notification daemon. The omniNotify daemons are the processes which receive events from device servers and distribute them to all clients which are subscribed. In order to distribute the load of the events there is one notification daemon per host. Servers send their events to the daemon on the local host. Clients and servers get the IOR for the host from the TANGO database.

The following figure is a schematic of the Tango event system for Tango releases before Tango 8.



Starting with Tango 8, a new design of the event system has been implemented. This new design is based on the ZMQ library. ZMQ is a library allowing users to create communicating system. It implements several well known communication pattern including the Publish/Subscribe pattern which is the basic of the new Tango event system. Using this library, a separate notification service is not needed anymore and event communiction is available with only client and server processes which simplifies the overall design. Starting with Tango 8.1, the event propagation between devices and clients could be done using a multicasting protocol. The aim of this is to reduce both the network bandwidth use and the CPU consumption on the device server side. See chapter on Advanced Features to get all the details on this feature.

The following figure is a schematic of the Tango event system for Tango releases starting with Tango release 8.



[OneRicardo]|image|

Writing a TANGO client using TANGO APIs

Introduction

TANGO devices and database are implemented using the TANGO device server model. To access them the user has the CORBA interface e.g. command_inout(), write_attributes() etc. defined by the idl file. These methods are very low-level and assume a good working knowledge of CORBA. In order to simplify this access, high-level api has been implemented which hides all CORBA aspects of TANGO. In addition the api hides details like how to connect to a device via the database, how to reconnect after a device has been restarted, how to correctly pack and unpack attributes and so on by implementing these in a manner transparent to the user. The api provides a unified error handling for all TANGO and CORBA errors. Unlike the CORBA C++ bindings the TANGO api supports native C++ data types e.g. strings and vectors.

This chapter describes how to use these API's. It is not a reference guide. Reference documentation is available as Web pages in the Tango Web site

Getting Started

Refer to the chapter Getting Started for an example on getting start with the C++ or Java api.

Basic Philosophy

The basic philosophy is to have high level classes to deal with Tango devices. To communicate with Tango device, uses the **DeviceProxy** class. To send/receive data to/from Tango device, uses the **DeviceData, DeviceAttribute** or **DevicePipe** classes. To communicate with a group of devices, use the **Group** class. If you are interested only in some attributes provided by a Tango device, uses the **AttributeProxy** class. Even if the Tango database is implemented as any other devices (and therefore accessible with one instance of a DeviceProxy class), specific high level classes have been developped to query it. Uses the **Database**, **DbDevice**, **DbClass**, **DbServer** or **DbData** classes when interfacing the Tango database. Callback for asynchronous requests or events are implemented via a **CallBack** class. An utility class called **ApiUtil** is also available.

Data types

The definition of the basic data type you can transfert using Tango is:

|c|c| **Tango type name & C++ equivalent type** DevBoolean & boolean DevShort & short DevEnum & enumeration (only for attribute / See chapter on advanced

features) DevLong & int (always 32 bits data) DevLong64 & long long on 32 bits chip or long on 64 bits chip & always 64 bits data DevFloat & float DevDouble & double DevString & char * DevEncoded & structure with 2 fields: a string and an array of unsigned

char DevUChar & unsigned char DevUShort & unsigned short DevULong & unsigned int (always 32 bits data) DevULong64 & unsigned long long on 32 bits chip or unsigned long on 64

bits chip & always 64 bits data DevState & Tango specific data type

Using commands, you are able to transfert all these data types, array of these basic types and two other Tango specific data types called DevVarLongStringArray and DevVarDoubleStringArray. See chapter [Data exchange] to get details about them. You are also able to create attributes using any of these basic data types to transfer data between clients and servers.

Request model

For the most important API remote calls (command_inout, read_attribute(s) and write_attribute(s)), Tango supports two kind of requests which are the synchronous model and the asynchronous model. Synchronous model means that the client wait (and is blocked) for the server to send an answer. Asynchronous model means that the client does not wait for the server to send an answer. The client sends the request and immediately returns allowing the CPU to do anything else (like updating a graphical user interface). Device pipe supports only the synchronous model. Within Tango, there are two ways to retrieve the server answer when using asynchronous model. They are:

1. The polling mode
2. The callback mode

In polling mode, the client executes a specific call to check if the answer is arrived. If this is not the case, an exception is thrown. If the reply is there, it is returned to the caller and if the reply was an exception, it is re-thrown. There are two calls to check if the reply is arrived:

- Call which does not wait before the server answer is returned to the caller.
- Call which wait with timeout before returning the server answer to the caller (or throw the exception) if the answer is not arrived.

In callback model, the caller must supply a callback method which will be executed when the command returns. They are two sub-modes:

1. The pull callback mode
2. The push callback mode

In the pull callback mode, the callback is triggered if the server answer is arrived when the client decide it by calling a *synchronization* method (The client pull-out the answer). In push mode, the callback is executed as soon as the reply arrives in a separate thread (The server pushes the answer to the client).

Synchronous model

Synchronous access to Tango device are provided using the *DeviceProxy* or *AttributeProxy* class. For the *DeviceProxy* class, the main synchronous call methods are :

- *command_inout()* to execute a Tango device command
- *read_attribute()* or *read_attributes()* to read a Tango device attribute(s)
- *write_attribute()* or *write_attributes()* to write a Tango device attribute(s)
- *write_read_attribute()* or *write_read_attributes()* to write then read Tango device attribute(s)
- *read_pipe()* to read a Tango device pipe
- *write_pipe()* to write a Tango device pipe
- *write_read_pipe()* to write then read Tango device pipe

For commands, data are send/received to/from device using the *DeviceData* class. For attributes, data are send/received to/from device attribute using the *DeviceAttribute* class. For pipes, data are send/receive to/from device pipe using the *DevicePipe* and *DevicePipeBlob* classes.

In some cases, only attributes provided by a Tango device are interesting for the application. You can use the *AttributeProxy* class. Its main synchronous methods are :

- *read()* to read the attribute value
- *write()* to write the attribute value
- *write_read()* to write then read the attribute value

Data are transmitted using the *DeviceAttribute* class.

Asynchronous model

Asynchronous access to Tango device are provided using *DeviceProxy* or *AttributeProxy, CallBack* and *ApiUtil* classes methods. The main asynchronous call methods and used classes are :

- To execute a command on a device
  - *DeviceProxy::command_inout_asynch()* and *DeviceProxy::command_inout_reply()* in polling model.
  - *DeviceProxy::command_inout_asynch()*, *DeviceProxy::get_asynch_replies()* and *CallBack* class in callback pull model
  - *DeviceProxy::command_inout_asynch()*, *ApiUtil::set_asynch_cb_sub_model()* and *CallBack* class in callback push model
- To read a device attribute
  - *DeviceProxy::read_attribute_asynch()* and *DeviceProxy::read_attribute_reply()* in polling model
  - *DeviceProxy::read_attribute_asynch()*, *DeviceProxy::get_asynch_replies()* and *CallBack* class in callback pull model.

  - *DeviceProxy::read_attribute_asynch()*, *ApiUtil::set_asynch_cb_sub_model()* and *CallBack* class in callback push model

- To write a device attribute
  - *DeviceProxy::write_attribute_asynch()* in polling model
  - *DeviceProxy::write_attribute_asynch()* and *CallBack* class in callback pull model
  - *DeviceProxy::write_attribute_asynch()*, *ApiUtil::set_asynch_cb_sub_model()* and *CallBack* class in callback push model

For commands, data are send/received to/from device using the *DeviceData* class. For attributes, data are send/received to/from device attribute using the *DeviceAttribute* class. It is also possible to generate asynchronous request(s) using the *AttributeProxy* class following the same schema than above. Methods to use are :

- *read_asynch*() and *read_reply()* to asynchronously read the attribute value
- *write_asynch()* and *write_reply()* to asynchronously write the attribute value

Events

Introduction

Events are a critical part of any distributed control system. Their aim is to provide a communication mechanism which is fast and efficient.

The standard CORBA communication paradigm is a synchronous or asynchronous two-way call. In this paradigm the call is initiated by the client who contacts the server. The server handles the client's request and sends the answer to the client or throws an exception which the client catches. This paradigm involves two calls to receive a single answer and requires the client to be active in initiating the request. If the client has a permanent interest in a value he is obliged to poll the server for an update in a value every time. This is not efficient in terms of network bandwidth nor in terms of client programming.

For clients who are permanently interested in values the event-driven communication paradigm is a more efficient and natural way of programming. In this paradigm the client registers her interest once in an event (value). After that the server informs the client every time the event has occurred. This paradigm avoids the client polling, frees it for doing other things, is fast and makes efficient use of the network.

The rest of this chapter explains how the TANGO events are implemented and the application programmer's interface.

Event definition

TANGO events represent an alternative channel for reading TANGO device attributes. Device attributes values are sent to all subscribed clients when an event occurs. Events can be an attribute value change, a change in the data quality or a periodically send event. The clients continue receiving events as long as they stay subscribed. Most of the time, the device server polling thread detects the event and then pushes the device attribute value to all clients. Nevertheless, in some cases, the delay introduced by the polling thread in the event propagation is detrimental. For such cases, some API calls directly push the event. Until TANGO release 8, the omniNotify implementation of the CORBA Notification service was used to dispatch events. Starting with TANGO 8, this CORBA Notification service has been replaced by the ZMQ library which implements a Publish/Subscribe communication model well adapted to TANGO events communication.

Event types

The following eight event types have been implemented in TANGO :

1. **change** - an event is triggered and the attribute value is sent when the attribute value changes significantly. The exact meaning of significant is device attribute dependent. For analog and digital values this is a delta fixed per attribute, for string values this is any non-zero change i.e. if the new attribute value is not equal to the previous attribute value. The delta can either be specified as a relative or absolute change. The delta is the same for all clients unless a filter is specified (see below). To easily write applications using the change event, it is also triggered in the following case :

   1. When a spectrum or image attribute size changes.
   2. At event subscription time
   3. When the polling thread receives an exception during attribute reading
   4. When the polling thread detects that the attribute quality factor has changed.
   5. The first good reading of the attribute after the polling thread has received exception when trying to read the attribute
   6. The first time the polling thread detects that the attribute quality factor has changed from INVALID to something else
   7. When a change event is pushed manually from the device server code. (*DeviceImpl::push_change_event()*).
   8. By the methods Attribute::set_quality() and Attribute::set_value_date_quality() if a client has subscribed to the change event on the attribute. This has been implemented for cases where the delay introduced by the polling thread in the event propagation is not authorized.

2. **periodic** - an event is sent at a fixed periodic interval. The frequency of this event is determined by the *event_period* property of the attribute and the polling frequency. The polling frequency determines the highest frequency at which the attribute is read. The event_period determines the highest frequency at which the periodic event is sent. Note if the event_period is not an integral number of the polling period there will be a beating of the two frequencies[7]. Clients can reduce the frequency at which they receive periodic events by specifying a filter on the periodic event counter.

3. **archive** - an event is sent if one of the archiving conditions is satisfied. Archiving conditions are defined via properties in the database. These can be a mixture of delta_change and periodic. Archive events can be send

from the polling thread or can be manually pushed from the device server code (*DeviceImpl::push_archive_event()*).

4. **attribute configuration** - an event is sent if the attribute configuration is changed.

5. **data ready** - This event is sent when coded by the device server programmer who uses a specific method of one of the Tango device server class to fire the event (*DeviceImpl::push_data_ready_event()*). The rule of this event is to inform a client that it is now possible to read an attribute. This could be useful in case of attribute with many data.

6. **user** - The criteria and configuration of these user events are managed by the device server programmer who uses a specific method of one of the Tango device server class to fire the event (*DeviceImpl::push_event()*).

7. **device interface change** - This event is sent when the device interface changes. Using Tango, it is possible to dynamically add/remove attribute/command to a device. This event is the way to inform client(s) that attribute/command has been added/removed from a device. Note that this type of event is attached to a device and not to one attribute (like all other event types). This event is triggered in the following case :

    1. A dynamic attribute or command is added or removed. The event is sent after a small delay (50 mS) in order to eliminate the risk of events storm in case several attributes/commands are added/removed in a loop
    2. At the end of admin device RestartServer or DevRestart command
    3. After a re-connection due to a device server restart. Because the device interface is not memorized, the event is sent even if it is highly possible that the device interface has not changed. A flag in the data propagated with the event inform listening applications that the device interface change is not guaranteed.
    4. At event re-connection time. This case is similar to the previous one (device interface change not guaranteed)

8. **pipe** - This is the kind of event which has to be used when the user want to push data through a pipe. This kind of event is only sent by the user code by using a specific method (*DeviceImpl::push_pipe_event()*). There is no way to ask the Tango kernel to automatically push this kind of event.

The first three above events are automatically generated by the TANGO library or fired by the user code. Events number 4 and 7 are only automatically sent by the library and events 5, 6 and 8 are fired only by the user code.

Event filtering (Removed in Tango release 8 and above)

Please, note that this feature is available only for Tango releases older than Tango 8. The CORBA Notification Service allows event filtering. This means that a client can ask the Notification Service to send the event only if some filter is evaluated to true.

Within the Tango control system, some pre-defined fields can be used as filter. These fields depend on the event type.

|c|c|c|c| Event type & Filterable field name & Filterable field value & type

> **system-message**
> ERROR/3 in `tango.rst`, line 1460
> Unexpected indentation. backrefs:

& delta_change_rel & Relative change (in %) since last event & double & delta_change_abs & Absolute change since last event & double & quality & Is set to 1 when the attribute quality factor has & double & & changed, otherwise it is 0 & & forced_event & Is set to 1 when the event was fired on exception &

> **system-message**
> WARNING/2 in `tango.rst`, line 1465
> Block quote ends without a blank line; unexpected unindent. backrefs:

double & & or a quality factor set to invalid & periodic & counter & Incremented each time the event is sent & long & delta_change_rel & Relative change (in %) since last event & double & delta_change_abs & Absolute change since last event & double & quality & Is set to 1 when the attribute quality factor has & double & & changed, otherwise it is 0 & & & Incremented each time the event is sent & & counter & for periodic reason. Set to -1 if event & long & & sent for change reason & & forced_event & Is set to 1 when the event was fired on exception &

double & & or a quality factor set to invalid & & delta_event & Number of milli-seconds since previous event & double

Filter are defined as a string following a grammar defined by CORBA. It is defined in [**?**]. The following example shows you the most common use of these filters in the Tango world :

- To receive periodic event one out of every three, the filter must be

  $counter % 3 == 0

- To receive change event only if the relative change is greater than % (positive and negative), the filter must be

  $delta_change_rel >= 20 or $delta_change_rel <= -20

- To receive a change event only on quality change, the filter must be

  $quality == 1

For user events, the filter field name(s) and their value are defined by the device server programmer.

Application Programmer's Interface

How to setup and use the TANGO events ? The interfaces described here are intended as user friendly interfaces to the underlying CORBA calls. The interface is modeled after the asynchronous *command_inout()* interface so as to maintain coherency. The event system supports **push callback model** as well as the **pull callback model.**

The two event reception modes are:

- **Push callback model** : On event reception a callbacks method gets immediately executed.
- **Pull callback model** : The event will be buffered the client until the client is ready to receive the event data. The client triggers the execution of the callback method.

The event reception buffer in the **pull callback model**, is implemented as a round robin buffer. The client can choose the size when subscribing for the event. This way the client can set-up different ways to receive events.

- Event reception buffer size = 1 : The client is interested only in the value of the last event received. All other events that have been received since the last reading are discarded.
- Event reception buffer size > 1 : The client has chosen to keep an event history of a given size. When more events arrive since the last reading, older events will be discarded.
- Event reception buffer size = ALL_EVENTS : The client buffers all received events. The buffer size is unlimited and only restricted by the available memory for the client.

Configuring events The attribute configuration set is used to configure under what conditions events are generated. A set of standard attribute properties (part of the standard attribute configuration) are read from the database at device startup time and used to configure the event engine. If there are no properties defined then default values specified in the code are used.

change The attribute properties and their default values for the change event are :

1. **rel_change** - a property of maximum 2 values. It specifies the positive and negative relative change of the attribute value w.r.t. the value of the previous change event which will trigger the event. If the attribute is a spectrum or an image then a change event is generated if any one of the attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no property is specified, no events are generated.
2. **abs_change** - a property of maximum 2 values.It specifies the positive and negative absolute change of the attribute value w.r.t the value of the previous change event which will trigger the event. If the attribute is a spectrum or an image then a change event is generated if any one of the

attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no properties are specified then the relative change is used.

periodic The attribute properties and their default values for the periodic event are :

1. **event_period** - the minimum time between events (in milliseconds). If no property is specified then a default value of 1 second is used.

archive The attribute properties and their default values for the archive event are :

1. **archive_rel_change** - a property of maximum 2 values which specifies the positive and negative relative change w.r.t. the previous attribute value which will trigger the event. If the attribute is a spectrum or an image then an archive event is generated if any one of the attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no properties are specified then no events are generate.
2. **archive_abs_change** - a property of maximum 2 values which specifies the positive and negative absolute change w.r.t the previous attribute value which will trigger the event. If the attribute is a spectrum or an image then an archive event is generated if any one of the attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no properties are specified then the relative change is used.
3. **archive_period** - the minimum time between archive events (in milliseconds). If no property is specified, no periodic archiving events are send.

C++ Clients This is the interface for clients who want to receive events. The main action of the client is to subscribe and unsubscribe to events. Once the client has subscribed to one or more events the events are received in a separate thread by the client.

Two reception modes are possible:

- On event reception a callbacks method gets immediately executed.
- The event will be buffered until the client until the client is ready to receive the event data.

The mode to be used has to be chosen when subscribing for the event.

Subscribing to events The client call to subscribe to an event is named *DeviceProxy::subscribe_event()* . During the event subscription the client has to choose the event reception mode to use.

Push model:

```
int DeviceProxy::subscribe_event(
                const string &attribute,
                Tango::EventType event,
                Tango::CallBack *callback,
                bool stateless = false);
```

The client implements a callback method which is triggered when the event is received. Note that this callback method will be executed by a thread started by the underlying ORB. This thread is not the application main thread. For Tango releases before 8, a similar call with one extra parameter for event filtering is also available.

Pull model:

```
int DeviceProxy::subscribe_event(
                const string &attribute,
                Tango::EventType event,
                int event_queue_size,
                bool stateless = false);
```

The client chooses the size of the round robin event reception buffer. Arriving events will be buffered until the client uses *DeviceProxy::get_events()* to extract the event data. For Tango releases before 8, a similar call with one extra parameter for event filtering is also available.

On top of the user filter defined by the *filters* parameter, basic filtering is done based on the reason specified and the event type. For example when reading the state and the reason specified is change the event will be fired only when the state changes. Events consist of an attribute name and the event reason. A standard set of reasons are implemented by the system, additional device specific reasons can be implemented by device servers programmers.

The stateless flag = false indicates that the event subscription will only succeed when the given attribute is known and available in the Tango system. Setting stateless = true will make the subscription succeed, even if an attribute of this name was never known. The real event subscription will happen when the given attribute will be available in the Tango system.

Note that in this model, the callback method will be executed by the thread doing the *DeviceProxy::get_events()* call.

The CallBack class In C++, the client has to implement a class inheriting from the Tango CallBack class and pass this to the *DeviceProxy::subscribe_event()* method. The CallBack class is the same class as the one proposed for the TANGO asynchronous call. This is as follows for events :

```
class MyCallback : public Tango::CallBack
{
   .
   .
   .
   virtual push_event(Tango::EventData *);
   virtual push_event(Tango::AttrConfEventData *);
   virtual push_event(Tango::DataReadyEventData *);
   virtual push_event(Tango::DevIntrChangeEventData *);
   virtual push_event(Tango::PipeEventData *);
}
```

where EventData is defined as follows :

```
class EventData
{
   DeviceProxy       *device;
   string            attr_name;
   string            event;
   DeviceAttribute   *attr_value;
   bool              err;
   DevErrorList      errors;
}
```

AttrConfEventData is defined as follows :

```
class AttrConfEventData
{
   DeviceProxy       *device;
   string            attr_name;
   string            event;
   AttributeInfoEx   *attr_conf;
   bool              err;
   DevErrorList      errors;
}
```

DataReadyEventData is defined as follows :

```
class DataReadyEventData
{
   DeviceProxy       *device;
   string            attr_name;
   string            event;
   int               attr_data_type;
   int               ctr;
   bool              err;
   DevErrorList      errors;
}
```

DevIntrChangeEventData is defined as follows :

```
class DevIntrChangeEventData
{
   DeviceProxy            device;
   string                 event;
   string                 device_name;
   CommandInfoList        cmd_list;
   AttributeInfoListEx    att_list;
   bool                   dev_started;
   bool                   err;
   DevErrorList           errors;
}
```

and PipeEventData is defined as follows :

```
class PipeEventData
{
   DeviceProxy       *device;
   string            pipe_name;
   string            event;
   DevicePipe        *pipe_value;
   bool              err;
   DevErrorList      errors;
}
```

In push model, there are some cases (same callback used for events coming from different devices hosted in device server process running on different hosts) where the callback method could be executed concurently by different threads started by the ORB. The user has to code his callback method in a **thread safe** manner.

Unsubscribing from an event Unsubscribe a client from receiving the event specified by *event_id* is done by calling the *DeviceProxy::unsubscribe_event()* method :

```
void DeviceProxy::unsubscribe_event(int event_id);
```

Extract buffered event data When the pull model was chosen during the event subscription, the received event data can be extracted with *DeviceProxy::get_events()*. Two possibilities are available for data extraction. Either a callback method can be executed for every event in the buffer when using

```
int DeviceProxy::get_events(
             int event_id,
             CallBack *cb);
```

Or all the event data can be directly extracted as EventDataList, AttrConfEventDataList , DataReadyEventDataList, DevIntrChangeEventDataList or PipeEventDataList when using

```
int DeviceProxy::get_events(
             int event_id,
             EventDataList &event_list);

int DeviceProxy::get_events(
             int event_id,
             AttrConfEventDataList &event_list);

int DeviceProxy::get_events(
             int event_id,
             DataReadyEventDataList &event_list);

int DeviceProxy::get_events(
             int event_id,
             DevIntrChangeEventDataList &event_list);

int DeviceProxy::get_events(
             int event_id,
             PipeEventDataList &event_list);
```

The event data lists are vectors of EventData, AttrConfEventData, DataReadyEventData or PipeEventData pointers with special destructor and clean-up methods to ease the memory handling.

```
class EventDataList:public vector<EventData *>
class AttrConfEventDataList:public vector<AttrConfEventData *>
class DataReadyEventDataList:public vector<DataReadyEventData *>
class DevIntrChangeEventDataList:public vector<DevIntrChangeEventData *
class PipeEventDataList:public vector<PipeEventData *>
```

Example Here is a typical code example of a client to register and receive events. First, you have to define a callback method as follows:

```
class DoubleEventCallBack : public Tango::CallBack
 {
    void push_event(Tango::EventData*);
 };


 void DoubleEventCallBack::push_event(Tango::EventData *myevent)
 {
     Tango::DevVarDoubleArray *double_value;
     try
     {
         cout << "DoubleEventCallBack::push_event(): called attribute "
              << myevent->attr_name
              << " event "
              << myevent->event
              << " (err="
              << myevent->err
              << ")" << endl;


          if (!myevent->err)
          {
              *(myevent->attr_value) >> double_value;
              cout << "double value "
                   << (*double_value)[0]
                   << endl;
              delete double_value;
          }
     }
     catch (...)
     {
          cout << "DoubleEventCallBack::push_event(): could not extract
     }
}
```

Then the main code must subscribe to the event and choose the push or the pull model for event reception.

Push model:

```
DoubleEventCallBack *double_callback = new DoubleEventCallBack;

Tango::DeviceProxy *mydevice = new Tango::DeviceProxy("my/device/1");

int event_id;
const string attr_name("current");
event_id = mydevice->subscribe_event(attr_name,
                         Tango::CHANGE_EVENT,
                         double_callback);
cout << "event_client() id = " << event_id << endl;

// The callback methods are executed by the Tango event reception thre
// The main thread is not concerned of event reception.
// Whatch out with synchronisation and data access in a multi threade

sleep(1000); // wait for events

mydevice->unsubscribe_event(event_id);
```

Pull model:

```
DoubleEventCallBack *double_callback = new DoubleEventCallBack;
int event_queue_size = 100; // keep the last 100 events

Tango::DeviceProxy *mydevice = new Tango::DeviceProxy("my/device/1");

int event_id;
const string attr_name("current");
event_id = mydevice->subscribe_event(attr_name,
                         Tango::CHANGE_EVENT,
                         event_queue_size);
cout << "event_client() id = " << event_id << endl;

// Check every 3 seconds whether new events have arrived and trigger t
// for the new events.

for (int i=0; i < 100; i++)
{
    sleep (3);

    // Read the stored event data from the queue and call the callbac
    mydevice->get_events(event_id, double_callback);
}
```

```

event_test->unsubscribe_event(event_id);
```

Group

A Tango Group provides the user with a single point of control for a collection of devices. By analogy, one could see a Tango Group as a proxy for a collection of devices. For instance, the Tango Group API supplies a *command_inout()* method to execute the same command on all the elements of a group.

A Tango Group is also a hierarchical object. In other words, it is possible to build a group of both groups and individual devices. This feature allows creating logical views of the control system - each view representing a hierarchical family of devices or a sub-system.

In this chapter, we will use the term *hierarchy* to refer to a group and its sub-groups. The term *Group* designates to the local set of devices attached to a specific Group.

Getting started with Tango group

The quickest way of getting started is to study an example. . .

Imagine we are vacuum engineers who need to monitor and control hundreds of gauges distributed over the 16 cells of a large-scale instrument. Each cell contains several penning and pirani gauges. It also contains one strange gauge. Our main requirement is to be able to control the whole set of gauges, a family of gauges located into a particular cell (e.g. all the penning gauges of the 6th cell) or a single gauge (e.g. the strange gauge of the 7th cell). Using a Tango Group, such features are quite straightforward to obtain.

Reading the description of the problem, the device hierarchy becomes obvious. Our gauges group will have the following structure:

```
-> gauges
  |  -> cell-01
  |      |-> inst-c01/vac-gauge/strange
  |      |-> penning
  |      |    |-> inst-c01/vac-gauge/penning-01
  |      |    |-> inst-c01/vac-gauge/penning-02
  |      |    |- ...
  |      |    |-> inst-c01/vac-gauge/penning-xx
  |      |-> pirani
  |           |-> inst-c01/vac-gauge/pirani-01
  |           |-> ...
  |           |-> inst-c01/vac-gauge/pirani-xx
  |  -> cell-02
  |      |-> inst-c02/vac-gauge/strange
  |      |-> penning
  |      |    |-> inst-c02/vac-gauge/penning-01
  |      |    |-> ...
  |      |
  |      |-> pirani
  |      |    |-> ...
  |  -> cell-03
```

```
    |       |-> ...
    |           | -> ...
```

In the C++, such a hierarchy can be build as follows (basic version):

```
//- step0: create the root group
Tango::Group *gauges = new Tango::Group("gauges");


//- step1: create a group for the n-th cell
Tango::Group *cell = new Tango::Group("cell-01");


//- step2: make the cell a sub-group of the root group
gauges->add(cell);


//- step3: create a "penning" group
Tango::Group *gauge_family = new Tango::Group("penning");


//- step4: add all penning gauges located into the cell (note the wilc
gauge_family->add("inst-c01/vac-gauge/penning*");


//- step5: add the penning gauges to the cell
cell->add(gauge_family);


//- step6: create a "pirani" group
gauge_family = new Tango::Group("pirani");


//- step7: add all pirani gauges located into the cell (note the wildc
gauge_family->add("inst-c01/vac-gauge/pirani*");


//- step8: add the pirani gauges to the cell
cell->add(gauge_family);


//- step9: add the "strange" gauge to the cell
cell->add("inst-c01/vac-gauge/strange");


//- repeat step 1 to 9 for the remaining cells
cell = new Tango::Group("cell-02");
...
```

Important note: There is no particular order to create the hierarchy. However, the insertion order of the devices is conserved throughout the lifecycle of the Group and cannot be changed. That way, the Group implementation can guarantee the order in which results are returned (see below).

Keeping a reference to the root group is enough to manage the whole hierarchy (i.e. there no need to keep trace of the sub-groups or individual devices). The Group interface provides methods to retrieve a sub-group or an individual device.

Be aware that a C++ group allways gets the ownership of its children and deletes them when it is itself deleted. Therefore, never try to delete a Group (respectively a DeviceProxy) returned by a call to *Tango::Group::get_group()* (respectively to *Tango::Group::get_device()*). Use the *Tango::Group::remove()* method instead (see the Tango Group class API documentation for details).

We can now perform any action on any element of our gauges group. For instance, let's ping the whole hierarchy to be sure that all devices are alive.

```
//- ping the whole hierarchy
if (gauges->ping() == true)
{
    std::cout << "all devices alive" << std::endl;
}
else
{
    std::cout << "at least one dead/busy/locked/... device" << std::er
}
```

Forward or not forward?

Since a Tango Group is a hierarchical object, any action performed on a group can be forwarded to its sub-groups. Most of the methods in the Group interface have a so-called *forward* option controlling this propagation. When set to *false*, the action is only performed on the local set of devices. Otherwise, the action is also forwarded to the sub-groups, in other words, propagated along the hierarchy. In C++ , the forward option defaults to true (thanks to the C++ default argument value). There is no such mechanism in Java and the forward option must be systematically specified.

Executing a command

As a proxy for a collection of devices, the Tango Group provides an interface similar to the DeviceProxy's. For the execution of a command, the Group interface contains several implementations of the *command_inout* method. Both synchronous and asynchronous forms are supported.

Obtaining command results Command results are returned using a Tango::GroupCmdReplyList. This is nothing but a vector containing a Tango::GroupCmdReply for each device in the group. The Tango::GroupCmdReply contains the actual data (i.e. the Tango::DeviceData). By inheritance, it may also contain any error occurred during the execution of the command (in which case the data is invalid).

We previously indicated that the Tango Group implementation guarantees that the command results are returned in the order in which its elements were attached to the group. For instance, if g1 is a group containing three devices attached in the following order:

```
g1->add("my/device/01");
g1->add("my/device/03");
g1->add("my/device/02");
```

the results of

```
Tango::GroupCmdReplyList crl = g1->command_inout("Status");
```

will be organized as follows:

crl[0] contains the status of my/device/01
crl[1] contains the status of my/device/03
crl[2] contains the status of my/device/02

Things get more complicated if sub-groups are added between devices.

```
g2->add("my/device/04");
g2->add("my/device/05");


g4->add("my/device/08");
g4->add("my/device/09");


g3->add("my/device/06");
g3->add(g4);
g3->add("my/device/07");


g1->add("my/device/01");
g1->add(g2);
g1->add("my/device/03");
g1->add(g3);
g1->add("my/device/02");
```

The result order in the Tango::GroupCmdReplyList depends on the value of the forward option. If set to *true*, the results will be organized as follows:

```
Tango::GroupCmdReplyList crl = g1->command_inout("Status", true);
```

crl[0] contains the status of my/device/01 which belongs to g1
crl[1] contains the status of my/device/04 which belongs to g1.g2
crl[2] contains the status of my/device/05 which belongs to g1.g2
crl[3] contains the status of my/device/03 which belongs to g1
crl[4] contains the status of my/device/06 which belongs to g1.g3
crl[5] contains the status of my/device/08 which belongs to g1.g3.g4
crl[6] contains the status of my/device/09 which belongs to g1.g3.g
crl[7] contains the status of my/device/07 which belongs to g1.g3
crl[8] contains the status of my/device/02 which belongs to g1

If the forward option is set to *false*, the results are:

```
Tango::GroupCmdReplyList crl = g1->command_inout("Status", false);
```

crl[0] contains the status of my/device/01 which belongs to g
crl[1] contains the status of my/device/03 which belongs to g1
crl[2] contains the status of my/device/02 which belongs to g1

The Tango::GroupCmdReply contains some public members allowing the identification of both the device (Tango::GroupCmdReply::dev_name) and the command (Tango::GroupCmdReply::obj_name). It means that, depending of your application, you can associate a response with its source using its position in the response list or using the Tango::GroupCmdReply::dev_name member.

Case 1: a command, no argument As an example, we execute the Status command on the whole hierarchy synchronously.

```
Tango::GroupCmdReplyList crl = gauges->command_inout("Status");
```

As a first step in the results processing, it could be interesting to check value returned by the *has_failed()* method of the GroupCmdReplyList. If it is set to true, it means that at least one error occurred during the execution of the command (i.e. at least one device gave error).

```
if (crl.has_failed())
{
    cout << "at least one error occurred" << endl;
}
else
{
    cout << "no error " << endl;
}
```

Now, we have to process each individual response in the list.

A few words on error handling and data extraction Depending of the application and/or the developer's programming habits, each individual error can be handle by the C++ (or Java) exception mechanism or using the dedicated *has_failed()* method. The GroupReply class - which is the mother class of both GroupCmdReply and GroupAttrReply - contains a static method to enable (or disable) exceptions called *enable_exception()*. By default, exceptions are disabled. The following example is proposed with both exceptions enable and disable.

In C++, data can be extracted directly from an individual reply. The GroupCmdReply interface contains a template operator » allowing the extraction of any supported Tango type (in fact the actual data extraction is delegated to DeviceData::operator »). One dedicated extract method is also provided in order to extract DevVarLongStringArray and DevVarDoubleStringArray types to std::vectors.

Error and data handling C++ example:

```
//-----------------------------------------------------
 //- synch. group command example with exception enabled
 //-----------------------------------------------------
```

```
//- enable exceptions and save current mode
bool last_mode = GroupReply::enable_exception(true);
//- process each response in the list ...
for (int r = 0; r < crl.size(); r++)
{
//- enter a try/catch block
   try
   {
//- try to extract the data from the r-th reply
//- suppose data contains a double
       double ans;
       crl[r] >> ans;
       cout << crl[r].dev_name()
            << "::"
            << crl[r].obj_name()
            << " returned "
            << ans
            << endl;
    }
    catch (const DevFailed& df)
    {
//- DevFailed caught while trying to extract the data from reply
      for (int err = 0; err < df.errors.length(); err++)
      {
           cout << "error: " << df.errors[err].desc.in() << endl;
      }
//- alternatively, one can use crl[r].get_err_stack() see below
    }
    catch (...)
    {
       cout << "unknown exception caught";
    }
}
//- restore last exception mode (if needed)
GroupReply::enable_exception(last_mode);
//- Clear the response list (if reused later in the code)
crl.reset();


//-----------------------------------------------------------
//- synch. group command example with exception disabled
//-----------------------------------------------------------
//- disable exceptions and save current mode bool
last_mode = GroupReply::enable_exception(false);
//- process each response in the list ...
for (int r = 0; r < crl.size(); r++)
{
//- did the r-th device give error?
    if (crl[r].has_failed() == true)
    {
```

```
//- printout error description
        cout << "an error occurred while executing "
             << crl[r].obj_name()
             << " on "
             << crl[r].dev_name() << endl;
//- dump error stack
        const DevErrorList& el = crl[r].get_err_stack();
        for (int err = 0; err < el.size(); err++)
        {
            cout << el[err].desc.in();
        }
    }
    else
    {
//- no error (suppose data contains a double)
        double ans;
        bool result = crl[r] >> ans;
        if (result == false)
        {
            cout << "could not extract double from "
                 << crl[r].dev_name()
                 << " reply"
                 << endl;
        }
        else
        {
            cout << crl[r].dev_name()
                 << "::"
                 << crl[r].obj_name()
                 << " returned "
                 << ans
                 << endl;
        }
    }
}
//- restore last exception mode (if needed)
GroupReply::enable_exception(last_mode);
//- Clear the response list (if reused later in the code)
crl.reset();
```

Now execute the same command asynchronously. C++ example:

```
//-----------------------------------------------------
//- asynch. group command example (C++ example)
//-----------------------------------------------------
long request_id = gauges->command_inout_asynch("Status");
//- do some work
do_some_work();


```

```
//- get results
crl = gauges->command_inout_reply(request_id);
//- process responses as previously describe in the synch. implementat
for (int r = 0; r < crl.size(); r++)
{
//- data processing and error handling goes here
//- copy/paste code from previous example
. . .
}
//- clear the response list (if reused later in the code)
crl.reset();
```

Case 2: a command, one argument[sub:Case-2] Here, we give an example in which the same input argument is applied to all devices in the group (or its sub-groups).

In C++:

```
//- the argument value
double d = 0.1;
//- insert it into the TANGO generic container for command: DeviceData
Tango::DeviceData dd;
dd << d;
//- execute the command: Dev_Void SetDummyFactor (Dev_Double)
Tango::GroupCmdReplyList crl = gauges->command_inout("SetDummyFactor",
```

Since the SetDummyFactor command does not return any value, the individual replies (i.e. the GroupCmdReply) do not contain any data. However, we have to check their *has_failed()* method returned value to be sure that the command completed successfully on each device (acknowledgement). Note that in such a case, exceptions are useless since we never try to extract data from the replies.

In C++ we should have something like:

```
//- no need to process the results if no error occurred (Dev_Void comma
 if (crl.has_failed())
 {
 //- at least one error occurred
     for (int r = 0; r < crl.size(); r++)
     {
 //- handle errors here (see previous C++ examples)
     }
 }
 //- clear the response list (if reused later in the code)
 crl.reset();
```

See case 1 for an example of asynchronous command.

Case 3: a command, several arguments Here, we give an example in which a **specific** input argument is applied to each device in the hierarchy. In order to use this form of command_inout, the user must have an a priori and perfect knowledge of the devices order in the hierarchy. In such a case, command arguments are passed in an array (with one entry for each device in the hierarchy).

The C++ implementation provides a template method which accepts a std::vector of C++ type for command argument. This allows passing any kind of data using a single method.

The size of this vector must equal the number of device in the hierarchy (respectively the number of device in the group) if the forward option is set to true (respectively set to false). Otherwise, an exception is thrown.

The first item in the vector is applied to the first device in the hierarchy, the second to the second device in the hierarchy, and so on... That's why the user must have a perfect knowledge of the devices order in the hierarchy.

Assuming that gauges are ordered by name, the SetDummyFactor command can be executed on group cell-01 (and its sub-groups) as follows:

Remember, cell-01 has the following internal structure:

```
-> gauges
   | -> cell-01
   |     |-> inst-c01/vac-gauge/strange
   |     |-> penning
   |     |    |-> inst-c01/vac-gauge/penning-01
   |     |    |-> inst-c01/vac-gauge/penning-02
   |     |    |-> ...
   |     |    |-> inst-c01/vac-gauge/penning-xx
   |     |-> pirani
   |          |-> inst-c01/vac-gauge/pirani-01
   |          |-> ...
   |          |-> inst-c01/vac-gauge/pirani-xx
```

Passing a specific argument to each device in C++:

```
//- get a reference to the target group
Tango::Group *g = gauges->get_group("cell-01");
//- get number of device in the hierarchy (starting at cell-01)
long n_dev = g->get_size(true);
//- Build argin list
std::vector<double> argins(n_dev);
//- argument for inst-c01/vac-gauge/strange
argins[0] = 0.0;
//- argument for inst-c01/vac-gauge/penning-01
argins[1] = 0.1;
//- argument for inst-c01/vac-gauge/penning-02
argins[2] = 0.2;
//- argument for remaining devices in cell-01.penning
. . .
//- argument for devices in cell-01.pirani
. . .
//- the reply list
Tango::GroupCmdReplyList crl;
//- enter a try/catch block (see below)
try
{
//- execute the command
    crl = g->command_inout("SetDummyFactor", argins, true);
    if (crl.has_failed())
    {
//- error handling goes here (see case 1)
    }
}
catch (const DevFailed& df)
{
//- see below
}
crl.reset();
```

If we want to execute the command locally on cell-01 (i.e. not on its sub-groups), we should write the following C++ code:

```
//- get a reference to the target group
Tango::Group *g = gauges->get_group("cell-01");
//- get number of device in the group (starting at cell-01)
long n_dev = g->get_size(false);
//- Build argin list
std::vector<double> argins(n_dev);
//- argins for inst-c01/vac-gauge/penning-01
argins[0] = 0.1;
//- argins for inst-c01/vac-gauge/penning-02
argins[1] = 0.2;
//- argins for remaining devices in cell-01.penning
. . .
//- the reply list
Tango::GroupCmdReplyList crl;
//- enter a try/catch block (see below)
try
{
//- execute the command
    crl = g->command_inout("SetDummyFactor", argins, false);
    if (crl.has_failed())
    {
//- error handling goes here (see case 1)
    }
}
catch (const DevFailed& df)
{
//- see below
}
crl.reset();
```

Note: if we want to execute the command locally on cell-01 (i.e. not on its sub-groups), we should write the following code:

```
//- get a reference to the target group
Group g = gauges.get_group("cell-01");
//- get pre-build arguments list for the group (starting@cell-01)
DeviceData[] argins = g.get_command_specific_argument_list(false);
```

```
//- argins for inst-c01/vac-gauge/penning-01
argins[0].insert(0.1);
//- argins for inst-c01/vac-gauge/penning-02
argins[1].insert(0.2);
//- argins for remaining devices in cell-01.penning
. . .
//- the reply list
GroupCmdReplyList crl;
//- enter a try/catch block (see below)
try
{
//- execute the command
    crl = g.command_inout("SetDummyFactor", argins, false, false);
    if (crl.has_failed())
    {
//- error handling goes here (see case 1)
    }
}
catch (DevFailed d)
{
//- see below
}
```

This form of *command_inout* (the one that accepts an array of value as its input argument), may throw an exception **before** executing the command if the number of elements in the input array does not match the number of individual devices in the group or in the hierarchy (depending on the forward option).

An asynchronous version of this method is also available. See case 1 for an example of asynchronous command.

Reading attribute(s)[sub:Read-attr]

In order to read attribute(s), the Group interface contains several implementations of the *read_attribute()* and *read_attributes()* methods. Both synchronous and asynchronous forms are supported. Reading several attributes is very similar to reading a single attribute. Simply replace the std::string used for attribute name by a vector of std::string with one element for each attribute name. In case of read_attributes() call, the order of attribute value returned in the GroupAttrReplyList is all attributes for first element in the group followed by all attributes for the second group element and so on.

Obtaining attribute values Attribute values are returned using a GroupAttrReplyList. This is nothing but an array containing a GroupAttrReply for each device in the group. The GroupAttrReply contains the actual data (i.e. the DeviceAttribute). By inheritance, it may also contain any error occurred during the execution of the command (in which case the data is invalid).

Here again, the Tango Group implementation guarantees that the attribute values are returned in the order in which its elements were attached to the group. See Obtaining command results for details.

The GroupAttrReply contains some public methods allowing the identification of both the device (GroupAttrReply::dev_name) and the attribute (GroupAttrReply::obj_name).

It means that, depending of your application, you can associate a response with its source using its position in the response list or using the Tango::GroupAttrReply::dev_name member.

A few words on error handling and data extraction Here again, depending of the application and/or the developer's programming habits, each individual error can be handle by the C++ exception mechanism or using the dedicated *has_failed()* method. The GroupReply class - which is the mother class of both GroupCmdReply and GroupAttrReply - contains a static method to enable (or disable) exceptions called *enable_exception()*. By default, exceptions are disabled. The following example is proposed with both exceptions enable and disable.

In C++, data can be extracted directly from an individual reply. The GroupAttrReply interface contains a template operator» allowing the extraction of any supported Tango type (in fact the actual data extraction is delegated to DeviceAttribute::operator»).

Reading an attribute is very similar to executing a command.

Reading an attribute in C++:

```
//-----------------------------------------------------------------
//- synch. read "vacuum" attribute on each device in the hierarchy
//- with exceptions enabled - C++ example
//-----------------------------------------------------------------
//- enable exceptions and save current mode
bool last_mode = GroupReply::enable_exception(true);
//- read attribute
Tango::GroupAttrReplyList arl = gauges->read_attribute("vacuum");
//- for each response in the list ...
for (int r = 0; r < arl.size(); r++)
{
//- enter a try/catch block
   try
   {
//- try to extract the data from the r-th reply
//- suppose data contains a double
      double ans;
      arl[r] >> ans;
      cout << arl[r].dev_name()
           << "::"
           << arl[r].obj_name()
           << " value is "
           << ans << endl;
   }
   catch (const DevFailed& df)
   {
//- DevFailed caught while trying to extract the data from reply
      for (int err = 0; err < df.errors.length(); err++)
      {
         cout << "error: " << df.errors[err].desc.in() << endl;
      }
//- alternatively, one can use arl[r].get_err_stack() see below
```

```
   }
   catch (...)
   {
      cout << "unknown exception caught";
   }
}
//- restore last exception mode (if needed)
GroupReply::enable_exception(last_mode);
//- clear the reply list (if reused later in the code)
arl.reset();
```

In C++, an asynchronous version of the previous example could be:

```
//- read the attribute asynchronously
long request_id = gauges->read_attribute_asynch("vacuum");
//- do some work
do_some_work();


//- get results
Tango::GroupAttrReplyList arl = gauges->read_attribute_reply(request_i
//- process replies as previously described in the synch. implementati
for (int r = 0; r < arl.size(); r++)
{
//- data processing and/or error handling goes here
...
}
//- clear the reply list (if reused later in the code)
arl.reset();
```

Writing an attribute

The Group interface contains several implementations of the *write_attribute()* method. Both synchronous and asynchronous forms are supported. However, writing more than one attribute at a time is not supported.

Obtaining acknowledgement Acknowledgements are returned using a GroupReplyList. This is nothing but an array containing a GroupReply for each device in the group. The GroupReply may contain any error occurred during the execution of the command. The return value of the *has_failed()* method indicates whether an error occurred or not. If this flag is set to true, the *GroupReply::get_err_stack()* method gives error details.

Here again, the Tango Group implementation guarantees that the attribute values are returned in the order in which its elements were attached to the group. See Obtaining command results for details.

The GroupReply contains some public members allowing the identification of both the device (GroupReply::dev_name) and the attribute (GroupReply::obj_name). It means that, depending of your application, you can associate a response with its source using its position in the response list or using the GroupReply::dev_name member.

Case 1: one value for all devices[sub:Case-1-writing] Here, we give an example in which the same attribute value is written on all devices in the group (or its sub-groups). Exceptions are supposed to be disabled.

Writing an attribute in C++:

```cpp
//-----------------------------------------------------------------
//- synch. write "dummy" attribute on each device in the hierarchy
//-----------------------------------------------------------------
//- assume each device support a "dummy" writable attribute
//- insert the value to be written into a generic container
Tango::DeviceAttribute value(std::string("dummy"), 3.14159);
//- write the attribute
Tango::GroupReplyList rl = gauges->write_attribute(value);
//- any error?
if (rl.has_failed() == false)
{
    cout << "no error" << endl;
}
else
{
    cout << "at least one error occurred" << endl;
//- for each response in the list ...
    for (int r = 0; r < rl.size(); r++)
    {
//- did the r-th device give error?
        if (rl[r].has_failed() == true)
        {
//- printout error description
            cout << "an error occurred while reading "
                 << rl[r].obj_name()
                 << " on "
                 << rl[r].dev_name()
                 << endl;
//- dump error stack
            const DevErrorList& el = rl[r].get_err_stack();
            for (int err = 0; err < el.size(); err++)
            {
               cout << el[err].desc.in();
            }
        }
     }
}
//- clear the reply list (if reused later in the code)
rl.reset();
```

Here is a C++ asynchronous version:

```cpp
//- insert the value to be written into a generic container
Tango::DeviceAttribute value(std::string("dummy"), 3.14159);
```

```
//- write the attribute asynchronously
long request_id = gauges.write_attribute_asynch(value);
//- do some work
do_some_work();


//- get results
Tango::GroupReplyList rl = gauges->write_attribute_reply(request_id);
//- process replies as previously describe in the synch. implementatio
```

Case 2: a specific value per device Here, we give an example in which a **specific** attribute value is applied to each device in the hierarchy. In order to use this form of *write_attribute()*, the user must have an a priori and perfect knowledge of the devices order in the hierarchy.

The C++ implementation provides a template method which accepts a std::vector of C++ type for command argument. This allows passing any kind of data using a single method.

The size of this vector must equal the number of device in the hierarchy (respectively the number of device in the group) if the forward option is set to true (respectively set to false). Otherwise, an exception is thrown.

The first item in the vector is applied to the first device in the group, the second to the second device in the group, and so on... That's why the user must have a perfect knowledge of the devices order in the group.

Assuming that gauges are ordered by name, the dummy attribute can be written as follows on group cell-01 (and its sub-groups) as follows:

Remember, cell-01 has the following internal structure:

```
-> gauges
    | -> cell-01
    |      |-> inst-c01/vac-gauge/strange
    |      |-> penning
    |      |     |-> inst-c01/vac-gauge/penning-01
    |      |     |-> inst-c01/vac-gauge/penning-02
    |      |     |-> ...
    |      |     |-> inst-c01/vac-gauge/penning-xx
    |      |-> pirani
    |            |-> inst-c01/vac-gauge/pirani-01
    |            |-> ...
    |            |-> inst-c01/vac-gauge/pirani-xx
```

C++ version:

```
//- get a reference to the target group
Tango::Group *g = gauges->get_group("cell-01");
//- get number of device in the hierarchy (starting at cell-01)
long n_dev = g->get_size(true);
//- Build value list
std::vector<double> values(n_dev);
//- value for inst-c01/vac-gauge/strange
values[0] = 3.14159;
//- value for inst-c01/vac-gauge/penning-01
```

```
values[1] = 2 * 3.14159;
//- value for inst-c01/vac-gauge/penning-02
values[2] = 3 * 3.14159;
//- value for remaining devices in cell-01.penning
. . .
//- value for devices in cell-01.pirani
. . .
//- the reply list
Tango::GroupReplyList rl;
//- enter a try/catch block (see below)
try
{
//- write the "dummy" attribute
    rl = g->write_attribute("dummy", values, true);
    if (rl.has_failed())
    {
//- error handling (see previous cases)
    }
}
catch (const DevFailed& df)
{
//- see below
}
rl.reset();
```

Note: if we want to execute the command locally on cell-01 (i.e. not on its sub-groups), we should write the following code

```
//- get a reference to the target group
Tango::Group *g = gauges->get_group("cell-01");
//- get number of device in the group
long n_dev = g->get_size(false);
//- Build value list
std::vector<double> values(n_dev);
//- value for inst-c01/vac-gauge/penning-01
values[0] = 2 * 3.14159;
//- value for inst-c01/vac-gauge/penning-02
values[1] = 3 * 3.14159;
//- value for remaining devices in cell-01.penning
. . .
//- the reply list
Tango::GroupReplyList rl;
//- enter a try/catch block (see below)
try
{
//- write the "dummy" attribute
   rl = g->write_attribute("dummy", values, false);
   if (rl.has_failed())
   {
//- error handling (see previous cases)
   }
}
catch (const DevFailed& df)
{
//- see below
}
rl.reset();
```

This form of *write_attribute()* (the one that accepts an array of value as its input argument), may throw an exception before executing the command if the number of elements in the input array does not match the number of individual devices in the group or in the hierarchy (depending on the forward option).

An asynchronous version of this method is also available.

Reading/Writing device pipe

Reading or writing device pipe is made possible using DeviceProxy class methods. To read a pipe, you have to use the method **read_pipe()**. To write a pipe, use the **write_pipe()** method. A method **write_read_pipe()** is also provided in case you need to write then read a pipe in a non-interuptible way. All these calls generate synchronous request and support only reading or writing a single pipe at a time. Those pipe related DeviceProxy class methods (read_pipe, write_pipe,...) use DevicePipe class instances. A DevicePipe instance is nothing more than a string for the pipe name and a *DevicePipeBlob* instance called the root blob. In a DevicePipeBlob instance, you have:

- The blob name
- One array of *DataElement*. Each instance of this DataElement class has:
  - A name
  - A value which can be either
    - Scalar or array of any basic Tango type
    - Another DevicePipeBlob

Therefore, this is a recursive data structure and you may have DevicePipeBlob in DevicePipeBlob. There is no limit on the depth of this recursivity even if it is not recommended to have a too large depth. The following figure summarizes DevicePipe data structure

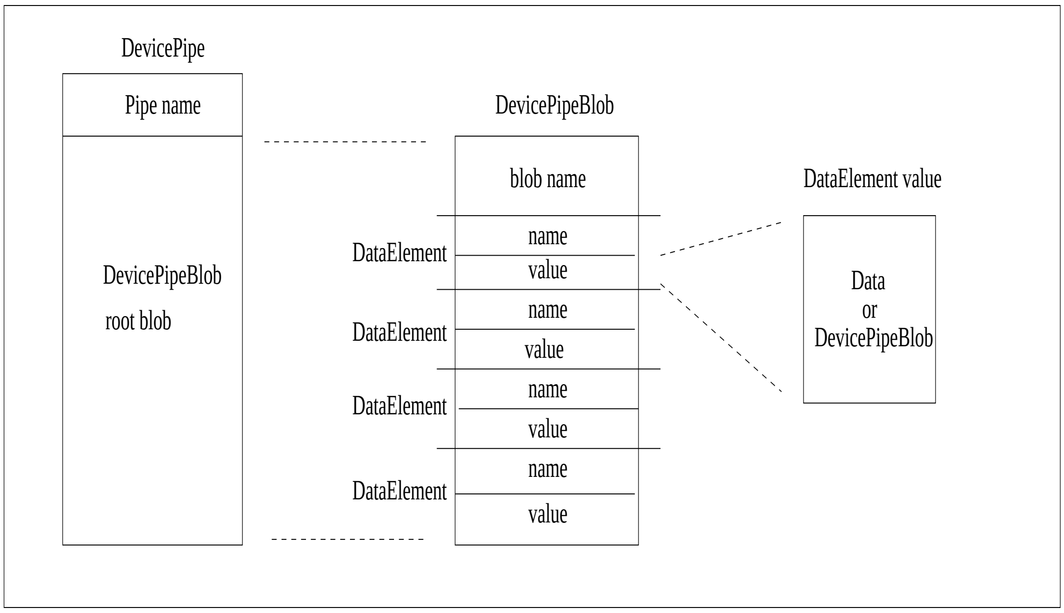


Figure 1: DevicePipe data structure

Many methods to insert/extract data into/from a DevicePipe are available. In the DevicePipe class, these methods simply forward their action to the DevicePipe root blob. The same methods are available in the DevicePipeBlob in case you need to use the recursivity provided by this data structure.

Reading a pipe

When you read a pipe, you have to extract data received from the pipe. Because data transferred through a pipe can change at any moment, two differents cases are possible:

1. The client has a prior knowledge of what should be transferred through the pipe
2. The client does not know at all what has been received through the pipe

Those two cases are detailed in the following sub-chapters.

Extracting data with pipe content prior knowledge To extract data from a DevicePipe object (or from a DevicePipeBlob object), you have to use its extraction operator ». Let's suppose that we already know (prior knowledge) that the pipe contains 3 data elements with a Tango long, an array of double and finally an array of unsigned short. The code you need to extract these data is (Without error case treatment detailed in a next sub-chapter)

```
DevicePipe dp = mydev.read_pipe("MyPipe");

DevLong dl;
vector<double> v_db;
```

```
5  DevVarUShortArray *dvush = new DevVarUShortArray();
6
7  dp >> dl >> v_db >> dvush;
8
9  delete dvush;
```

The pipe is read at line 1. Pipe (or root blob) data extracttion is at line 7. As you can see, it is just a matter of chaining extraction operator (») into local data (declared line 3 to 5). In this example, the transported array of double is extracted into a C++ vector while the unsigned short array is extracted in a Tango sequence data type. When you extract data into a vector, there is a unavoidable memory copy between the DevicePipe object and the vector. When you extract data in a Tango sequence data type, there is no memory copy but the extraction method consumes the memory and it is therefore caller responsability to delete the memory. This is the rule of line 9. If there is a DevicePipeBlob inside the DevicePipe, simply extract it into one instance of the DevicePipeBlob class.

You may notice that the pipe root blob data elements name are lost in the previous example. The Tango API also has a DataElement class which allows you to retrieve/set data element name. The following code is how you can extract pipe data and retrieve data element name (same pipe then previously)

```
1  DevicePipe dp = mydev.read_pipe("MyPipe");
2
3  DataElement<DevLong> de_dl;
4  DataElement<vector<double> > de_v_db;
5  DataElement<DevVarUShortArray *> de_dvush(new DevVarUShortArray());
6
7  dp >> de_dl >> de_v_db >> de_dvush;
8
9  delete de_dvush.value;
```

The extraction line (number 7) is similar to the previous case but local data are instances of DataElement class. This is template class and instances are created at lines 4 to 6. Each DataElement instance has only two elements which are:

1. The data element name (a C++ string): *name*
2. The data element value (One instance of the template parameter): *value*

Extracting data in a generic way (without prior knowledge) Due to the dynamicity of the data transferred through a pipe, the API alows to extract data from a pipe without any prior knowledge of its content. This is achived with methods *get_data_elt_nb()*, *get_data_elt_type()*, *get_data_elt_name()* and the extraction operator ». These methods belong to the DevicePipeBlob class but they also exist on the DevicePipe class for its root blob. Here is one example of how you use them:

```
1   DevicePipe dp = mydev.read_pipe("MyPipe");
2
3   size_t nb_de = dp.get_data_elt_nb();
4   for (size_t loop = 0;loop < nb;loop++)
5   {
6      int data_type = dp.get_data_elt_type(loop);
```

```
 7      string de_name = dp.get_data_elt_name(loop);
 8      switch(data_type)
 9      {
10         case DEV_LONG:
11         {
12             DevLong lg;
13             dp >> lg;
14         }
15         break;
16
17         case DEVVAR_DOUBLEARRAY:
18         {
19             vector<double> v_db;
20             dp >> v_db;
21         }
22         break;
23         ....
24     }
25     ...
26  }
```

The number of data element in the pipe root blob is retrieve at line 3. Then a loop for each data element is coded. For each data element, its value data type and its name are retrieved at lines 6 and 7. Then, according to the data element value data type, the data are extracted using the classical extraction operator (lines 13 or 20)

Error management By default, in case of error, the DevicePipe object throws different kind of exceptions according to the error kind. It is possible to disable exception throwing. If you do so, the code has to test the DevicePipe state after extraction. The possible error cases are:

- DevicePipe object is empty
- Wrong data type for extraction (For instance extraction into a double data while the DataElement contains a string)
- Wrong number of DataElement (Extraction code extract 5 data element while the pipe contains only four)
- Mix of extraction (or insertion) method kind (classical operators « or ») and [] operator.

Methods *exceptions()* and *reset_exceptions()* of the DevicePipe and DevicePipeBlob classes allow the user to select which kind of error he is interested in. For error treatment without exceptions, methods *has_failed()* and *state()* has to be used. See reference documentation for details about these methods.

Writing a pipe

Writing data into a DevicePipe or a DevicePipeBlob is similar to reading data from a pipe. The main method is the insertion operator «. Let's have a look at a first example if you want to write a pipe with a Tango long, a vector of double and finally an array of unsigned short.

```
 1   DevicePipe dp("MyPipe");
 2
 3   vector<string> de_names {"FirstDE","SecondDE","ThirdDE"};
 4   db.set_data_elt_names(de_names);
 5
 6   DevLong dl = 666;
 7   vector<double> v_db {1.11,2.22};
 8   unsigned short *array = new unsigned short [100];
 9   DevVarUShortArray *dvush = create_DevVarUShortArray(array,100);
10
11  try
12  {
13     dp << dl << v_db << dvush;
14     mydev.write_pipe(dp);
15  }
16  catch (DevFailed &e)
17  {
18     cout << "DevicePipeBlob insertion failed" << endl;
19     ....
20  }
```

Insertion into the DevicePipe is done at line 12 with the insert operators. The main difference with extracting data from the pipe is at line 3 and 4. When inserting data into a pipe, you need to FIRST define its number od name of data elements. In our example, the device pipe is initialized to carry three data element and the names of these data elements is defined at line 4. This is a mandatory requirement. If you don't define data element number, exception will be thrown during the use of insertion methods. The population of the array used for the third pipe data element is not represented here.

It's also possible to use DataElement class instances to set the pipe data element. Here is the previous example modified to use DataElement class.

```
 1   DevicePipe dp("MyPipe");
 2
 3   DataElement<DevLong> de_dl("FirstElt",666);
 4   vector<double>  v_db {1.11,2.22};
 5   DataElement<vector<double> > de_v_db("SecondElt,v_db);
 6
 7   unsigned short *array = new unsigned short [100];
 8   DevVarUShortArray *dvush = create_DevVarUShortArray(array,100);
 9   DataElement<DevVarUShortArray *> de_dvush("ThirdDE",array);
10
11  try
12  {
13     dp << de_dl << de_v_db << de_dvush;
14     mydev.write_pipe(dp);
15  }
16  catch (DevFailed &e)
17  {
18     cout << "DevicePipeBlob insertion failed" << endl;
19     ....
20  }
```

The population of the array used for the third pipe data element is not represented here. Finally, there is a third way to insert data into a device pipe. You have to defined number and names of the data element within the pipe (similar to first insertion method) but you are able to insert data into the data element in any order using the operator overwritten for the DevicePipe and DevicePipeBlob classes. Look at the following example:

```
 1   DevicePipe dp("MyPipe");
 2
 3   vector<string> de_names {"FirstDE","SecondDE","ThirdDE"};
 4   db.set_data_elt_names(de_names);
 5
 6   DevLong dl = 666;
 7   vector<double> v_db = {1.11,2.22};
 8   unsigned short *array = new unsigned short [100];
 9   DevVarUShortArray *dvush = create_DevVarUShortArray(array,100);
10
11  dp["SecondDE"] << v_db;
12  dp["FirstDE"] << dl;
13  dp["ThirdDE"] << dvush;
```

Insertion into the device pipe is now done at lines 11 to 13. The population of the array used for the third pipe data element is not represented here. Note that the data element name is case insensitive.

Error management When inserting data into a DevicePipe or a DevicePipeBlob, error management is very similar to reading data from from a DevicePipe or a DevicePipeBlob. The difference is that there is one moer case which could trigger one exception during the insertion. This case is

- Insertion into the DevicePipe (or DevicePipeBlob) if its data element number have not been set.

Device locking

Starting with Tango release 7 (and device inheriting from Device_4Impl), device locking is supported. For instance, this feature could be used by an application doing a scan on a synchrotron beam line. In such a case, you want to move an actuator then read a sensor, move the actuator again, read the sensor...You don't want the actuator to be moved by another client while the application is doing the scan. If the application doing the scan locks the actuator device, it will be sure that this device is reserved for the application doing the scan and other client will not be able to move it until the scan application un-locks this actuator.

A locked device is protected against:

- *command_inout* call except for device state and status requested via command and for the set of commands defined as allowed following the definition of allowed command in the Tango control access schema.
- *write_attribute* and *write_pipe* call
- *write_read_attribute, write_read_attributes* and *write_read_pipe* call

- *set_attribute_config* and *set_pipe_config* call
- polling and logging commands related to the locked device

Other clients trying to do one of these calls on a locked device will get a DevFailed exception. In case of application with locked device crashed, the lock will be automatically release after a defined interval. The API provides a set of methods for application code to lock/unlock device. These methods are:

- *DeviceProxy::lock()* and *DeviceProxy::unlock()* to lock/unlock device
- *DeviceProxy::locking_status()*, *DeviceProxy::is_locked()*, *DeviceProxy::is_locked_by_me()* and *DeviceProxy::get_locker()* to get locking information

These methods are precisely described in the API reference chapters.

Reconnection and exception

The Tango API automatically manages re-connection between client and server in case of communication error during a network access between a client and a server. By default, when a communication error occurs, an exception is returned to the caller and the connection is internally marked as bad. On the next try to contact the device, the API will try to re-build the network connection. With the *set_transparency_reconnection()* method of the DeviceProxy class, it is even possible not to have any exception thrown in case of communication error. The API will try to re-build the network connection as soon as it is detected as bad. This is the default mode. See [sec:Reconnection-and-exception] for more details on this subject.

Thread safety

Starting with Tango 7.2, some classes of the C++ API has been made thread safe. These classes are:

- DeviceProxy
- Database
- Group
- ApiUtil
- AttributeProxy

This means that it is possible to share between threads a pointer to a DeviceProxy instance. It is safe to execute a call on this DeviceProxy instance while another thread is also doing a call to the same DeviceProxy instance. Obviously, this also means that it is possible to create thread local DeviceProxy instances and to execute method calls on these instances. Nevertheless, data local to a DeviceProxy instance like its timeout are not managed on a per thread basis. For a DeviceProxy instance shared between two threads, if thread 1 changes the instance timeout, thread 2 will also see this change.

Compiling and linking a Tango client

Compiling and linking a Tango client is similar to compiling and linking a Tango device server. Please, refer to chapter Compiling, Linking and executing a Tango device server process ([sec:Compiling,-linking-and]) to get all the details.

[ThreeRicardo]|image|

TangoATK Programmer's Guide

This chapter is only a brief Tango ATK (Application ToolKit) programmer's guide. You can find a reference guide with a full description of TangoATK classes and methods in the ATK JavaDoc [?].

A tutorial document [?] is also provided and includes the detailed description of the ATK architecture and the ATK components. In the ATK Tutorial [?] you can find some code examples and also Flash Demos which explain how to start using Tango ATK.

Introduction

This document describes how to develop applications using the Tango Application Toolkit, TangoATK for short. It will start with a brief description of the main concepts behind the toolkit, and then continue with more practical, real-life examples to explain key parts.

Assumptions

The author assumes that the reader has a good knowledge of the Java programming language, and a thorough understanding of object-oriented programming. Also, it is expected that the reader is fluent in all aspects regarding Tango devices, attributes, and commands.

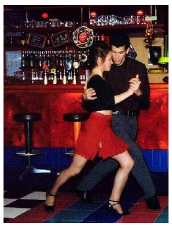
The key concepts of TangoATK

TangoATK was developed with these goals in mind

- TangoATK should help minimize development time
- TangoATK should help minimize bugs in applications
- TangoATK should support applications that contain attributes and commands from several different devices.
- TangoATK should help avoid code duplication.

Since most Tango-applications were foreseen to be displayed on some sort of graphic terminal, TangoATK needed to provide support for some sort of graphic building blocks. To enable this, and since the toolkit was to be written in Java, we looked to Swing to figure out how to do this.

Swing is developed using a variant over a design-pattern the Model-View-Controller (MVC) pattern called *model-delegate*, where the view and the controller of the MVC-pattern are merged into one object.



This pattern made the choice of labor division quite easy: all non-graphic parts of TangoATK reside in the packages beneath `fr.esrf.tangoatk.core`, and anything remotely graphic are located beneath `fr.esrf.tangoatk.widget`. More on the content and organization of this will follow.

The communication between the non-graphic and graphic objects are done by having the graphic object registering itself as a listener to the non-graphic object, and the non-graphic object emmiting events telling the listeners that its state has changed.

Minimize development time

For TangoATK to help minimize the development time of graphic applications, the toolkit has been developed along two lines of thought

- Things that are needed in most applications are included, eg `Splash`, a splash window which gives a graphical way for the application to show the progress of a long operation. The splash window is moslty used in the startup phase of the application.
- Building blocks provided by TangoATK should be easy to use and follow certain patterns, eg every graphic widget has a `setModel` method which is used to connect the widget with its non-graphic model.

In addition to this, TangoATK provides a framework for error handling, something that is often a time consuming task.

Minimize bugs in applications

Together with the Tango API, TangoATK takes care of most of the hard things related to programming with Tango. Using TangoATK the developer can focus on developing her application, not on understanding Tango.

Attributes and commands from different devices

To be able to create applications with attributes and commands from different devices, it was decided that the central objects of TangoATK were not to be the device, but rather the *attributes and the commands*. This will certainly feel a bit awkward at first, but trust me, the design holds.

For this design to be feasible, a structure was needed to keep track of the commands and attributes, so the *command-list and the attribute-list* was introduced. These two objects can hold commands and attributes from any number of devices.

Avoid code duplication

When writing applications for a control-system without a framework much code is duplicated. Anything from simple widgets for showing numeric values to error handling has to be implemented each time. TangoATK supplies a number of frequently used widgets along with a framework for connecting these widgets with their non-graphic counterparts. Because of this, the developer only needs to write the *glue* - the code which connects these objects in a manner that suits the specified application.

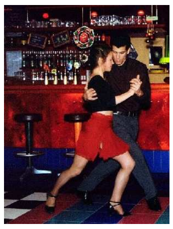
The real getting started

Generally there are two kinds of end-user applications: Applications that only know how to treat one device, and applications that treat many devices.

Single device applications

Single device applications are quite easy to write, even with a gui. The following steps are required

1. Instantiate an AttributeList and fill it with the attributes you want.
2. Instantiate a CommandList and fill it with the commands you want.
3. Connect the whole *AttributeList* with a *list viewer* and / or each *individual attribute* with an *attribute viewer*.
4. Connect the whole *CommandList* to a *command list viewer* and / or connect each *individual command* in the command list with a *command viewer*.



The following program (FirstApplication) shows an implementation of the list mentioned above. It should be rather self-explanatory with the comments.

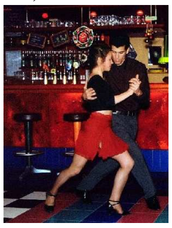
```
package examples;


import javax.swing.JFrame;
import javax.swing.JMenuItem;
import javax.swing.JMenuBar;
import javax.swing.JMenu;


import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.BorderLayout;


import fr.esrf.tangoatk.core.AttributeList;
import fr.esrf.tangoatk.core.ConnectionException;


import fr.esrf.tangoatk.core.CommandList;
import fr.esrf.tangoatk.widget.util.ErrorHistory;
import fr.esrf.tangoatk.widget.util.ATKGraphicsUtils;
import fr.esrf.tangoatk.widget.attribute.ScalarListViewer;
import fr.esrf.tangoatk.widget.command.CommandComboViewer;


public class FirstApplication extends JFrame
{
JMenuBar menu;                    // So that our application looks
                                  // halfway decent.
AttributeList attributes;         // The list that will contain our
                                  // attributes
CommandList commands;             // The list that will contain our
                                  // commands
ErrorHistory errorHistory;        // A window that displays errors
ScalarListViewer sListViewer;     // A viewer which knows how to
                                  // display a list of scalar attribu
                                  // If you want to display other typ
                                  // than scalars, you'll have to wai
                                  // for the next example.
CommandComboViewer commandViewer; // A viewer which knows how to disp
                                  // a combobox of commands and execu
                                  // them.
String device;                    // The name of our device.


public FirstApplication()
{
   // The swing stuff to create the menu bar and its pulldown menus
   menu = new JMenuBar();
   JMenu fileMenu = new JMenu();
   fileMenu.setText("File");
   JMenu viewMenu = new JMenu();
   viewMenu.setText("View");

   JMenuItem quitItem = new JMenuItem();
   quitItem.setText("Quit");
   quitItem.addActionListener(new
      java.awt.event.ActionListener()
      {
       public void
       actionPerformed(ActionEvent evt)
       {quitItemActionPerformed(evt);}
      });
   fileMenu.add(quitItem);
```

```

    JMenuItem errorHistItem = new JMenuItem();
    errorHistItem.setText("Error History");
    errorHistItem.addActionListener(new
            java.awt.event.ActionListener()
            {
             public void
             actionPerformed(ActionEvent evt)
             {errHistItemActionPerformed(evt);}
            });
    viewMenu.add(errorHistItem);
    menu.add(fileMenu);
    menu.add(viewMenu);

    //
    // Here we create ATK objects to handle attributes, commands and e
    //
    attributes = new AttributeList();
    commands = new CommandList();
    errorHistory = new ErrorHistory();
    device = "id14/eh3_mirror/1";
    sListViewer = new ScalarListViewer();
    commandViewer = new CommandComboViewer();


 //
 // A feature of the command and attribute list is that if you
 // supply an errorlistener to these lists, they'll add that
 // errorlistener to all subsequently created attributes or
 // commands. So it is important to do this _before_ you
 // start adding attributes or commands.
 //

    attributes.addErrorListener(errorHistory);
    commands.addErrorListener(errorHistory);

 //
 // Sometimes we're out of luck and the device or the attributes
 // are not available. In that case a ConnectionException is thrown.
 // This is why we add the attributes in a try/catch
 //

    try
    {

 //
 // Another feature of the attribute and command list is that they
 // can add wildcard names, currently only '*' is supported.
 // When using a wildcard, the lists will add all commands or
 // attributes available on the device.
```

```
//
   attributes.add(device + "/*");
   }
   catch (ConnectionException ce)
   {
      System.out.println("Error fetching " +
                         "attributes from " +
                         device + " " + ce);
   }


//
// See the comments for attributelist
//


   try
   {
      commands.add(device + "/*");
   }
   catch (ConnectionException ce)
   {
      System.out.println("Error fetching " +
                         "commands from " +
                         device + " " + ce);
   }


//
// Here we tell the scalarViewer what it's to show. The
// ScalarListViewer loops through the attribute-list and picks out
// the ones which are scalars and show them.
//

   sListViewer.setModel(attributes);


//
// This is where the CommandComboViewer is told what it's to
// show. It knows how to show and execute most commands.
//


   commandViewer.setModel(commands);


//
// add the menubar to the frame
//

```

```

      setJMenuBar(menu);


   //
   // Make the layout nice.
   //


      getContentPane().setLayout(new BorderLayout());
      getContentPane().add(commandViewer, BorderLayout.NORTH);
      getContentPane().add(sListViewer, BorderLayout.SOUTH);


   //
   // A third feature of the attributelist is that it knows how
   // to refresh its attributes.
   //


      attributes.startRefresher();


   //
   // JFrame stuff to make the thing show.
   //


      pack();
      ATKGraphicsUtils.centerFrameOnScreen(this); //ATK utility to cente

      setVisible(true);
      }


      public static void main(String [] args)
      {
         new FirstApplication();
      }

      public void quitItemActionPerformed(ActionEvent evt)
      {
         System.exit(0);
      }

      public void errHistItemActionPerformed(ActionEvent evt)
      {
         errorHistory.setVisible(true);
      }
   }
```

The program should look something like this (depending on your platform and your device)



Multi device applications

Multi device applications are quite similar to the single device applications, the only difference is that it does not suffice to add the attributes by wildcard, you need to add them explicitly, like this:

```java
try
{
    // a StringScalar attribute from the device one
   attributes.add("jlp/test/1/att_cinq");
   // a NumberSpectrum attribute from the device one
   attributes.add("jlp/test/1/att_spectrum");
   // a NumberImage attribute from the device two
   attributes.add("sr/d-ipc/id25-1n/Image");
}
catch (ConnectionException ce)
{
   System.out.println("Error fetching " +
       "attributes" + ce);
}
```

The same goes for commands.

More on displaying attributes

So far, we've only considered scalar attributes, and not only that, we've also cheated quite a bit since we just passed the attribute list to the `fr.esrf.tangoatk.widget.attribute.ScalarList` and let it do all the magic. The attribute list viewers are only available for scalar attributes (NumberScalarListViewer and ScalarListViewer). If you have one or several spectrum or image attributes you must connect each spectrum or image attribute to it's corresponding attribute viewer individually. So let's take a look at how you can connect individual attributes (and not a whole attribute list) to an individual attribute viewer (and not to an attribute list viewer).

Connecting an attribute to a viewer Generally it is done in the following way:

1. You retrieve the attribute from the attribute list
2. You instantiate the viewer
3. Your call the `setModel` method on the viewer with the attribute as argument.

4. You add your viewer to some panel

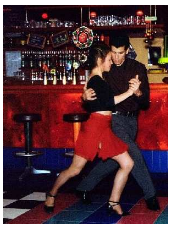
The following example (SecondApplication), is a Multi-device application. Since this application uses individual attribute viewers and not an attribute list viewer, it shows an implementation of the list mentioned above.

```java
package examples;


import javax.swing.JFrame;
import javax.swing.JMenuItem;
import javax.swing.JMenuBar;
import javax.swing.JMenu;


import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.BorderLayout;
import java.awt.Color;


import fr.esrf.tangoatk.core.AttributeList;
import fr.esrf.tangoatk.core.ConnectionException;

import fr.esrf.tangoatk.core.IStringScalar;
import fr.esrf.tangoatk.core.INumberSpectrum;
import fr.esrf.tangoatk.core.INumberImage;
import fr.esrf.tangoatk.widget.util.ErrorHistory;
import fr.esrf.tangoatk.widget.util.Gradient;
import fr.esrf.tangoatk.widget.util.ATKGraphicsUtils;
import fr.esrf.tangoatk.widget.attribute.NumberImageViewer;
import fr.esrf.tangoatk.widget.attribute.NumberSpectrumViewer;
import fr.esrf.tangoatk.widget.attribute.SimpleScalarViewer;

public class SecondApplication extends JFrame
{
     JMenuBar            menu;
     AttributeList       attributes;   // The list that will contain
     ErrorHistory        errorHistory; // A window that displays erro
     IStringScalar        ssAtt;
     INumberSpectrum      nsAtt;
     INumberImage         niAtt;
     public SecondApplication()
     {
        // Swing stuff to create the menu bar and its pulldown menus
        menu = new JMenuBar();
        JMenu fileMenu = new JMenu();
        fileMenu.setText("File");
        JMenu viewMenu = new JMenu();
        viewMenu.setText("View");
        JMenuItem quitItem = new JMenuItem();
```

```
   quitItem.setText("Quit");
   quitItem.addActionListener(new java.awt.event.ActionListener
                                 {
                                  public void actionPerformed(Ac
                                  {quitItemActionPerformed(evt);
                                 });

   fileMenu.add(quitItem);
   JMenuItem errorHistItem = new JMenuItem();
   errorHistItem.setText("Error History");
   errorHistItem.addActionListener(new java.awt.event.ActionList
           {
            public void actionPerformed(ActionEvent evt)
            {errHistItemActionPerformed(evt);}
           });
   viewMenu.add(errorHistItem);
   menu.add(fileMenu);
   menu.add(viewMenu);
 //
 // Here we create TangoATK objects to view attributes and error
 //
   attributes = new AttributeList();
   errorHistory = new ErrorHistory();
 //
 // We create a SimpleScalarViewer, a NumberSpectrumViewer and
 // a NumberImageViewer, since we already knew that we were
 // playing with a scalar attribute, a number spectrum attribute
 // and a number image attribute this time.
 //
 SimpleScalarViewer     ssViewer = new SimpleScalarViewer();
   NumberSpectrumViewer   nSpectViewer = new NumberSpectrumViewe
   NumberImageViewer      nImageViewer = new NumberImageViewer()
   attributes.addErrorListener(errorHistory);
//
// The attribute (and command) list has the feature of returning
// attribute that was added to it. Just remember that it is retu
// IEntity object, so you need to cast it into a more specific o
// IStringScalar, which is the interface which defines a string
//
  try
   {

      ssAtt = (IStringScalar) attributes.add("jlp/test/1/att_cin
      nsAtt = (INumberSpectrum) attributes.add("jlp/test/1/att_s
      niAtt = (INumberImage) attributes.add("sr/d-ipc/id25-1n/In
   }
   catch (ConnectionException ce)
   {
      System.out.println("Error fetching one of the attributes
      System.out.println("Application Aborted.");
      System.exit(0);
   }
   //
   // Pay close attention to the following three lines!! This is
   // This is how it's always done! The setModelsetModel method
  // of connecting the viewer to the attribute (model) it's in c
  // This is the way to tell each viewer what (which attribute)
  // Note that we use a viewer adapted to each type of attribute
  //
   ssViewer.setModel(ssAtt);
   nSpectViewer.setModel(nsAtt);
   nImageViewer.setModel(niAtt);
//
   nSpectViewer.setPreferredSize(new java.awt.Dimension(400, 300
   nImageViewer.setPreferredSize(new java.awt.Dimension(500, 300
   Gradient  g = new Gradient();
   g.buidColorGradient();
   g.setColorAt(0,Color.black);
   nImageViewer.setGradient(g);
   nImageViewer.setBestFit(true);

   //
   // Add the viewers into the frame to show them
   //
   getContentPane().setLayout(new BorderLayout());
   getContentPane().add(ssViewer, BorderLayout.SOUTH);
   getContentPane().add(nSpectViewer, BorderLayout.CENTER);
   getContentPane().add(nImageViewer, BorderLayout.EAST);
   //
   // To have the attributes values refreshed we should start th
   // attribute list's refresher.
   //
   attributes.startRefresher();
   //
   // add the menubar to the frame
   //
   setJMenuBar(menu);
   //
   // JFrame stuff to make the thing show.
   //
   pack();
   ATKGraphicsUtils.centerFrameOnScreen(this); //ATK utility to
   setVisible(true);
}
public static void main(String [] args)
{
   new SecondApplication();
}
public void quitItemActionPerformed(ActionEvent evt)
{
```

```
            System.exit(0);
        }
        public void errHistItemActionPerformed(ActionEvent evt)
        {
            errorHistory.setVisible(true);
        }
    }
```

This program (SeondApplication) should look something like this (depending on your platform and your device attributes)



system-message

ERROR/3 in `tango.rst`, line 3939

Content block expected for the "code" directive; none found.

```
.. code:: cpp
  :number-lines:
```

backrefs:

Synoptic viewer TangoATK provides a generic class to view and to animate the synoptics. The name of this class is fr.esrf.tangoatk.widget.jdraw.SynopticFileViewer. This class is based on a “home-made” graphical layer called jdraw. The jdraw package is also included inside TangoATK distribution.

SynopticFileViewer is a sub-class of the class TangoSynopticHandler. All the work for connection to tango devices and run time animation is done inside the TangoSynopticHandler.

The recipe for using the TangoATK synoptic viewer is the following

1. You use Jdraw graphical editor to draw your synoptic
2. During drawing phase don’t forget to associate parts of the drawing to tango attributes or commands. Use the “name” in the property window to do this
3. During drawing phase you can also aasociate a class (frequently a “specific panel” class) which will be displayed when the user clicks on some part of the drawing. Use the “extension” tab in the property window to do this.
4. Test the run-time behaviour of your synoptic. Use “Tango Synoptic view” command in the “views” pulldown menu to do this.
5. Save the drawing file.

6. There is a simple synoptic application (SynopticAppli) which is provided ready to use. If this generic application is enough for you, you can forget about the step 7.

7. You can now develop a specific TangoATK based application which instantiates the SynopticFileViewer. To load the synoptic file in the SynopticFileViewer you have the choice : either you load it by giving the absolute path name of the synoptic file or you load the synoptic file using Java input streams. The second solution is used when the synoptic file is included inside the application jarfile.

The SynopticFilerViewer will browse the objects in the synoptic file at run time. It discovers if some parts of the drawing is associated with an attribute or a command. In this case it will automatically connect to the corresponding attribute or command. Once the connection is successfull SynopticFileViewer will animate the synoptic according to the default behaviour described below :

- For *tango state attributes* : the colour of the drawing object reflects the value of the state. A mouse click on the drawing object associated with the tango state attribute will instantiate and display the class specified during the drawing phase. If no class is specified the atkpanel generic device panel is displayed.
- For *tango attributes* : the current value of the attribute is displayed through the drawing object
- For *tango commands* : the mouse click on the drawing object associated with the command will launch the device command.
- If the tooltip property is set to “name” when the mouse enters *any tango object* (attribute or command), inside the synoptic drawing the name of the tango object is displayed in a tooltip.

The following example (ThirdApplication), is a Synoptic application. We assume that the synoptic has already been drawn using Jdraw graphical editor.

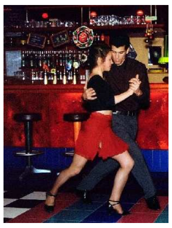
```
package examples;
import java.io.*;
import java.util.*;
import javax.swing.JFrame;
import javax.swing.JMenuItem;
import javax.swing.JMenuBar;
import javax.swing.JMenu;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
import java.awt.BorderLayout;
import fr.esrf.tangoatk.widget.util.ErrorHistory;
import fr.esrf.tangoatk.widget.util.ATKGraphicsUtils;
import fr.esrf.tangoatk.widget.jdraw.SynopticFileViewer;
import fr.esrf.tangoatk.widget.jdraw.TangoSynopticHandler;
public class ThirdApplication extends JFrame
{
     JMenuBar              menu;
     ErrorHistory          errorHistory;  // A window that displays e
```

```
    SynopticFileViewer    sfv;           // TangoATK generic synopti


    public ThirdApplication()
    {
       // Swing stuff to create the menu bar and its pulldown menus
       menu = new JMenuBar();
       JMenu fileMenu = new JMenu();
       fileMenu.setText("File");
       JMenu viewMenu = new JMenu();
       viewMenu.setText("View");
       JMenuItem quitItem = new JMenuItem();
       quitItem.setText("Quit");
       quitItem.addActionListener(new java.awt.event.ActionListener
                                    {
                                     public void actionPerformed(Ac
                                     {quitItemActionPerformed(evt);
                                    });
       fileMenu.add(quitItem);
       JMenuItem errorHistItem = new JMenuItem();
       errorHistItem.setText("Error History");
       errorHistItem.addActionListener(new java.awt.event.ActionList
                {
                 public void actionPerformed(ActionEvent evt)
                 {errHistItemActionPerformed(evt);}
                });
       viewMenu.add(errorHistItem);
       menu.add(fileMenu);
       menu.add(viewMenu);
       //
       // Here we create TangoATK synoptic viewer and error window.
       //
       errorHistory = new ErrorHistory();
       sfv = new SynopticFileViewer();
       try
       {
           sfv.setErrorWindow(errorHistory);
       }
       catch (Exception setErrwExcept)
       {
           System.out.println("Cannot set Error History Window");
       }

       //
       // Here we define the name of the synoptic file to show and t
       //
       try
       {
         sfv.setJdrawFileName("/users/poncet/ATK_OLD/jdraw_files/id
         sfv.setToolTipMode (TangoSynopticHandler.TOOL_TIP_NAME);
```

```
        }
        catch (FileNotFoundException  fnfEx)
        {
           javax.swing.JOptionPane.showMessageDialog(
              null, "Cannot find the synoptic file : id14.jdw.\n"
                   + "Check the file name you entered;"
                   + " Application will abort ...\n"
                   + fnfEx,
                   "No such file",
                   javax.swing.JOptionPane.ERROR_MESSAGE);
           System.exit(-1);
        }
        catch (IllegalArgumentException  illEx)
        {
           javax.swing.JOptionPane.showMessageDialog(
              null, "Cannot parse the synoptic file : id14.jdw.\n"
                   + "Check if the file is a Jdraw file."
                   + " Application will abort ...\n"
                   + illEx,
                   "Cannot parse the file",
                   javax.swing.JOptionPane.ERROR_MESSAGE);
           System.exit(-1);
        }
        catch (MissingResourceException  mrEx)
        {
           javax.swing.JOptionPane.showMessageDialog(
              null, "Cannot parse the synoptic file : id14.jdw.\n"
                   + " Application will abort ...\n"
                   + mrEx,
                   "Cannot parse the file",
                   javax.swing.JOptionPane.ERROR_MESSAGE);
           System.exit(-1);
        }
        //
        // Add the viewers into the frame to show them
        //
        getContentPane().setLayout(new BorderLayout());
        getContentPane().add(sfv, BorderLayout.CENTER);
        //
        // add the menubar to the frame
        //
        setJMenuBar(menu);
        //
        // JFrame stuff to make the thing show.
        //
        pack();
        ATKGraphicsUtils.centerFrameOnScreen(this); //TangoATK utilit
        setVisible(true);
     }
     public static void main(String [] args)
```

```
          {
             new ThirdApplication();
          }
          public void quitItemActionPerformed(ActionEvent evt)
          {
             System.exit(0);
          }
          public void errHistItemActionPerformed(ActionEvent evt)
          {
             errorHistory.setVisible(true);
          }
    }
    [Input: line.tex]
```

The synoptic application (ThirdApplication) should look something like this (depending on your synoptic drawing file)



A short note on the relationship between models and viewers

As seen in the examples above, the connection between a model and its viewer is generally done by calling `setModel(model)` on the viewer, it is never explained what happens behind the scenes when this is done.

Listeners Most of the viewers implement some sort of *listener* interface, eg INumberScalarListener. An object implementing such a listener interface has the capability of receiving and treating *events* from a model which emits events.

```
// this is the setModel of a SimpleScalarViewer
   public void setModelsetModel(INumberScalar scalar) {

     clearModel();

     if (scalar != null) {
       format = scalar.getProperty("format").getPresentation();
       numberModel = scalar;

    // this is where the viewer connects itself to the
    // model. After this the viewer will (hopefully) receive
    // events through its numberScalarChange() method

    numberModel.addNumberScalarListener(this);

```

```

          numberModel.getProperty("format").addPresentationListener(this
        numberModel.getProperty("unit").addPresentationListener(this);
      }

    }



// Each time the model of this viewer (the numberscalar attribute) dec
// calls the numberScalarChange method of all its registered listeners
// with a NumberScalarEvent object which contains the
// the new value of the numberscalar attribute.
//

    public void numberScalarChange(NumberScalarEvent evt) {
      String val;
      val = getDisplayString(evt);
      if (unitVisible) {
        setText(val + " " + numberModel.getUnit());
      } else {
        setText(val);
      }
    }
```

All listeners in TangoATK implement the `IErrorListener` interface which specifies the `errorChange(ErrorEvent e)` method. This means that all listeners are forced to handle errors in some way or another.

The key objects of TangoATK

As seen from the examples above, the key objects of TangoATK are the `CommandList` and the `AttributeList`. These two classes inherit from the abstract class `AEntityList` which implements all of the common functionality between the two lists. These lists use the functionality of the `CommandFactory`, the `AttributeFactory`, which both derive from `AEntityFactory`, and the `DeviceFactory`.

In addition to these factories and lists there is one (for the time being) other important functionality lurking around, the refreshers.

The Refreshers

The refreshers, represented in TangoATK by the `Refresher` object, is simply a subclass of `java.lang.Thread` which will sleep for a given amount of time and then call a method refresh on whatever kind of `IRefreshee` it has been given as parameter, as shown below

```
// This is an example from DeviceFactory.
// We create a new Refresher with the name "device"
// We add ourself to it, and start the thread


```

```
Refresher refresher = new Refresher("device");
refresher.addRefreshee(this).start();
```

Both the `AttributeList` and the `DeviceFactory` implement the `IRefreshee` interface which specify only one method, `refresh()`, and can thus be refreshed by the `Refresher`. Even if the new release of TangoATK is based on the Tango Events, the refresher mecanisme will not be removed. As a matter of fact, the method refresh() implemented in AttributeList skips all attributes (members of the list) for which the subscribe to the tango event has succeeded and calls the old refresh() method for the others (for which subscribe to tango events has failed).

In a first stage this will allow the TangoATK applications to mix the use of the old tango device servers (which do not implement tango events) and the new ones in the same code. In other words, TangoATK subscribes for tango events if possible otherwise TangoATK will refresh the attributes through the old refresher mecanisme.

Another reason for keeping the refresher is that the subscribe event can fail even for the attributes of the new Tango device servers. As soon as the specified attribute is not polled the Tango events cannot be generated for that attribute. Therefore the event subscription will fail. In this case the attribute will be refreshed thanks to the ATK attribute list refresher.

The `AttributePolledList` class allows the application programmer to force explicitly the use of the refresher method for all attributes added in an AttributePolledList even if the corresponding device servers implement tango events. Some viewers (fr.esrf.tangoatk.widget.attribute.Trend need an AttributePolledList in order to force the refresh of the attribute without using tango events.

What happens on a refresh When `refresh` is called on the `AttributeList` and the `DeviceFactory`, they loop through their objects, `IAttributes` and `IDevices`, respectively, and ask them to refresh themselves if they are not event driven.

When AttributeFactory, creates an `IAttribute`, TangoATK tries to subscribe for Tango Change event for that attribute. If the subscription succeeds then the attribute is marked as event driven. If the subscription for Tango Change event fails, TangoATK tries to subscribe for Tango Periodic event. If the subscription succeeds then the attribute is marked as event driven. If the subscription fails then the attribute is marked as to be " without events".

In the refresh() method of the AttributeList during the loop through the objects if the object is marked event driven then the object is simply skipped. But if the object (attribute) is not marked as event driven, the refresh() method of the AttributeList, asks the object to refresh itself by calling the "refresh()" method of that object (attribute or device). The refresh() method of an attribute will in turn call the "readAttribute" on the Tango device.

The result of this is that the `IAttributes` fire off events to their registered listeners containing snapshots of their state. The events are fired either because the IAttribute has received a Tango Change event, respectively a Tango Periodic event (event driven objects), or because the refresh() method of the object has issued a readAttribute on the Tango device.

The DeviceFactory

The device factory is responsible for two things

1. Creating new devices (Tango device proxies) when needed

2. Refreshing the state and status of these devices

Regarding the first point, new devices are created when they are asked for and only if they have not already been created. If a programmer asks for the same device twice, she is returned a reference to the same device-object.

The `DeviceFactory` contains a Refresher as described above, which makes sure that the all in the updates their state and status and fire events to its listeners.

The AttributeFactory and the CommandFactory

These factories are responsible for taking a name of an attribute or command and returning an object representing the attribute or command. It is also responsible for making sure that the appropriate `IDevice` is already available. Normally the programmer does not want to use these factory classes directly. They are used by TangoATK classes indirectly when the application programmer calls the AttributeList's (or CommandList's) add() method.

The AttributeList and the CommandList

These lists are containers for attributes and commands. They delegate the construction-work to the factories mentioned above, and generally do not do much more, apart from containing refreshers, and thus being able to make the objects they contain refresh their listeners.

The Attributes

The attributes come in several flavors. Tango supports the following types:

- Short
- Long
- Double
- String
- Unsigned Char
- Boolean
- Unsigned Short
- Float
- Unsigned Long

According to Tango specifications, all these types can be of the following formats:

- Scalar, a single value
- Spectrum, a single array
- Image, a two dimensional array

For the sake of simplicity, TangoATK has combined all the numeric types into one, presenting all of them as doubles. So the TangoATK classes which handle the numeric attributes are : NumberScalar, NumberSpectrum and NumberImage (Number can be short, long, double, float, ...).

The hierarchy The numeric attribute hierarchy is expressed in the following interfaces:

INumberScalar extends **INumber**

INumberSpectrum extends **INumber**

INumberImage extends **INumber**

INumber in turn extends **IAttribute**

Each of these types emit their proper events and have their proper listeners. Please consult the javadoc for further information.

The Commands

The commands in Tango are rather ugly beasts. There exists the following kinds of commands

- Those which take input
- Those which do not take input
- Those which do output
- Those which do not do output

Now, for both input and output we have the following types:

- Double
- Float
- Unsigned Long
- Long
- Unsigned Short
- Short
- String

These types can appear in scalar or array formats. In addition to this, there are also four other types of parameters:

1. Boolean
2. Unsigned Char Array
3. The StringLongArray
4. The StringDoubleArray

The last two types mentioned above are two-dimensional arrays containing a string array in the first dimension and a long or double array in the second dimension, respectively.

As for the attributes, all numeric types have been converted into doubles, but there has been made little or no effort to create an hierarchy of types for the commands.

Events and listeners The commands publish results to their `IResultListeners`, by the means of a `ResultEvent`. The `IResultListener` extends `IErrorListener`, any viewer of command-results should also know how to handle errors. So a viewer of command-results implements IResultListener interface and registers itself as a resultListener for the command it has to show the results.

system-message

ERROR/3 in `tango.rst`, line 4458

Content block expected for the "code" directive; none found.

```
.. code:: cpp
  :number-lines:
```

backrefs:

[TwoRicardo]|image|

Writing a TANGO device server

The device server framework

This chapter will present the TANGO device server framework. It will introduce what is the device server pattern and then it will describe a complete device server framework. A definition of classes used by the device server framework is given in this chapter. This manual is not intended to give the complete and detailed description of classes data member or methods, refer to [**?**] to get this full description. But first, the naming convention used in this project is detailed.

The aim of the class definition given in this chapter is only to help the reader to understand how a TANGO device server works. For a detailed description of these classes (and their methods), refer to chapter [Writing_chapter] or to [**?**].

Naming convention and programming language

TANGO fully supports three different programming languages which are **C++, Java** and **Python**. This documentation focuses on C++ Tango class. For Java and Python Tango class, have a look at the Tango web pages where similar chapter for Java and Python are available.

Every software project needs a naming convention. The naming convention adopted for the TDSOM is very simple and only defines two guidelines which are:

- Class names start with uppercase and use capitalization for compound words (For instance MyClassName).
- Method names are in lowercase and use underscores for compound words (For instance my_method_name).

The device pattern

Device server are written using the Device pattern. The aim of this pattern is to provide the control programmer with a framework in which s/he can develop new control objects. The device pattern uses other design patterns like the Singleton and Command patterns. These patterns are fully described in [**?**]. The device pattern class diagram for stepper motor device is drawn in figure [Dvice pattern figure]

. In this figure, only classes surrounded with a dash line square are device specific. All the other classes are part of the TDSOM core and are developed by the Tango system team. Different kind of classes are used by the device pattern.

- Three of them are root classes and it is only necessary to inherit from them. These classes are the **DeviceImpl**, **DeviceClass** and **Command** classes.
- Classes necessary to implement commands. The TDSOM supports two ways to create command : Using inheritance or using the template command model. It is possible to mix model within the same device pattern
  1. Using **inheritance**. This model of creating command heavily used the polymorphism offered by each modern object oriented programming language. In this schema, each command supported by a device via the command_inout or command_inout_async operation is implemented by a separate class. The Command class is the root class for each of these classes. It is an abstract class. A *execute* method must be defined in each sub-class. A *is_allowed* method may also be re-defined in each class if the default one does not fulfill all the needs[8]. In our stepper motor device server example, the DevReadPosition command follows this model.
  2. Using the **template command** model. Using this model, it is not necessary to write one class for each command. You create one instance of classes already defined in the TDSOM for each command. The link between command name and method which need to be executed is done through pointers to method. To support different kind of command, four classes are part of the TDSOM. These classes are :
     1. The **TemplCommand** class for command without input or output parameter
     2. The **TemplCommandIn** class for command with input parameter but without output parameter
     3. The **TemplCommandOu**t class for command with output parameter but without input parameter
     4. The **TemplCommandInOut** class for all the remaining commands
- Classes necessary to implement TANGO device attributes. All these classes are part of the TANGO core classes. These classes are the **MultiAttribute**, **Attribute**, **WAttribute**, **Attr**, **SpectrumAttr** and **ImageAttr** classes. The last three are used to create user attribute. Each attribute supported by a device is implemented by a separate class. The Attr class is the root class for each of these classes. According to the attribute data format, the user class implementing the

attribute must inherit from the Attr, SpectrumAttr or ImageAtttr class. SpectrumAttr class inherits from Attr class and Image Attr class inherits from the SpectrumAttr class. The Attr base class defined three methods called *is_allowed*, *read* and *write*. These methods may be redefined in sub-classes in order to implement the attribute specific behaviour.

- The other are device specific. For stepper motor device, they are named StepperMotor, StepperMotorClass and DevReadPosition.

The Tango base class (DeviceImpl class)

Description This class is the device root class and is the link between the Device pattern and CORBA. It inherits from CORBA classes and implements all the methods needed to execute CORBA operations and attributes. For instance, its method *command_inout* is executed when a client requests a command_inout operation. The method *name* of the DeviceImpl class is executed when a client requests the name CORBA attribute. This class also encapsulates some key device data like its name, its state, its status, its black box.... This class is an abstract class and cannot be instantiated as is.

Contents The contents of this class can be summarized as :

- Different constructors and one destructor
- Methods to access instance data members outside the class or its derivate classes. These methods are necessary because data members are declared as protected.
- Methods triggered by CORBA attribute request
- Methods triggered by CORBA operation request
- The *init_device()* method. This method makes the class abstract. It should be implemented by a sub-class. It is used by the inherited classes constructors.
- Methods triggered by the automatically added State and Status commands. These methods are declared virtual and therefore can be redefined in sub-classes. These two commands are automatically added to the list of commands defined for a class of devices. They are discussed in chapter [Auto_cmd]
- A method called *always_executed_hook()* always executed for each command before the device state is tested for command execution. This method gives the programmer a hook where he(she) can program some mandatory action which must be done before any command execution. An example of the such action is an hardware access to the device to read its real hardware state.
- A method called *read_attr_hardware()* triggered by the read_attributes CORBA operation. This method is called once for each read_attributes call. This method is virtual and may be redefined in sub-classes.
- A method called *write_attr_hardware()* triggered by the write_attributes CORBA operation. This method is called once for each write_attributes call. This method is virtual and may be redefined in sub-classes.

- Methods for signal management (C++ specific)
- Data members like the device name, the device status, the device state
- Some private methods and data members

The DbDevice class Each DeviceImpl instance is an aggregate with one instance of the DbDevice class. This DbDevice class can be used to query or modify device properties. It provides an easy to use interface for device objects in the database. The description of this class can be found in the Tango API reference documentation available on the Tango WEB pages.

The Command class

Description of the inheritance model Within the TDSOM, each command supported by a device and implemented using the inheritance model is implemented by a separate class. The Command class is the root class for each of these classes. It is an abstract class. It stores the command name, the command argument types and description and mainly defines two methods which are the *execute* and *is_allowed* methods. The *execute* method should be implemented in each sub-class. A default *is_allowed* method exists for command always allowed. A command also stores a parameter which is the command display type. It is also used to select if the command must be displayed according to the application mode (every day operation or expert mode).

Description of the template model Using this method, it is not necessary to create a separate class for each device command. In this method, each command is represented by an instance of one of the template command classes. They are four template command classes. All these classes inherits from the Command class. These four classes are :

1. The **TemplCommand** class. One object of this class must be created for each command without input nor output parameters
2. The **TemplCommandIn** class. One object of this class must be created for each command without output parameter but with input parameter
3. The **TemplCommandOut** class. One object of this class must be created for each command without input parameter but with output parameter
4. The **TemplCommandInOut** class. One object of this class must be created for each command with input and output parameters

These four classes redefine the *execute* and *is_allowed* method of the Command class. These classes provides constructors which allow the user to :

- specify which method must be executed by these classes *execute* method
- optionally specify which method must be executed by these classes *is_allowed* method.

The method specification is done via pointer to method.
Remember that it is possible to mix command implementation method within the same device pattern.

Contents The content of this class can be summarizes as :

- Class constructors and destructor
- Declaration of the *execute* method
- Declaration of the *is_allowed* method
- Methods to read/set class data members
- Methods to extract data from the object used to transfer data on the network
- Methods to insert data into the object used to transfer data on the network
- Class data members like command name, command input data type, command input data description...

The DeviceClass class

Description This class implements all what is specific for a controlled object class. For instance, every device of the same class supports the same list of commands and therefore, this list of available commands is stored in this DeviceClass. The structure returned by the info operation contains a documentation URL[9]. This documentation URL is the same for every device of the same class. Therefore, the documentation URL is a data member of this class. There should have only one instance of this class per device pattern implementation. The device list is also stored in this class. It is an abstract class because the two methods *device_factory()* and *command_factory()* are declared as pure virtual. The rule of the *device_factory()* method is to create all the devices belonging to the device class. The rule of the *command_factory()* method is to create one instance of all the classes needed to support device commands. This class also stored the *attribute_factory* method. The rule of this method is to store in a vector of strings, the name of all the device attributes. This method has a default implementation which is an empty body for device without attribute.

Contents The contents of this class can be summarize as :

- The *command_handler* method
- Methods to access data members.
- Signal related method (C++ specific)
- Class constructor. It is protected to implements the Singleton pattern
- Class data members like the class command list, the device list...

The DbClass class Each DeviceClass instance is an aggregate with one instance of the DbClass class. This DbClass class can be used to query or modify class properties. It provides an easy to use interface for device objects in the database. The description of this class can be found in the reference Tango C++ API documentation available in the Tango WEB pages.

The MultiAttribute class

Description This class is a container for all the TANGO attributes defined for the device. There is one instance of this class for each device. This class is mainly an aggregate of Attribute object(s). It has been developed to ease TANGO attribute management.

Contents The class contents could be summarizes as :

- Miscellaneous methods to retrieve one attribute object in the aggregate
- Method to retrieve a list of attribute with an alarm level defined
- Get attribute number method
- Miscellaneous methods to check if an attribute value is outside the authorized limits
- Method to add messages for all attribute with an alarm set
- Data members with the attribute list

The Attribute class

Description There is one object of this class for each device attribute. This class is used to store all the attribute properties, the attribute value and all the alarm related data. Like commands, this class also stores th attribute display type. It is foreseen to be used by future Tango graphical application toolkit to select if the attribute must be displayed according to the application mode (every day operation or expert mode).

Contents

- Miscellaneous method to get boolean attribute information
- Methods to access some data members
- Methods to get/set attribute properties
- Method to check if the attribute is in alarm condition
- Methods related to attribute data
- Friend function to print attribute properties
- Data members (properties value and attribute data)

The WAttribute class

Description This class inherits from the Attribute class. There is one instance of this class for each writable device attribute. On top of all the data already managed by the Attribute class, this class stores the attribute set value.

Contents Within this class, you will mainly find methods related to attribute set value storage and some data members.

The Attr class Within the TDSOM, each attribute supported by a device is implemented by a separate class. The Attr class is the root class for each of these classes. It is used in conjonction with the Attribute and Wattribute classes to implement Tango attribute behaviour. It defines three methods which are the *is_allowed, read* and *write* methods. A default *is_allowed* method exists for attribute always allowed. Default *read* and *write* empty methods are defined. For readable attribute, it is necessary to overwrite the *read* method. For writable attribute, it is necessary to overwrite the *write* method and for read and write attribute, both methods must be overwritten.

The SpectrumAttr class This class inherits from the Attr class. It is the base class for user spectrum attribute. It is used in conjonction with the Attribute and WAttribute class to implement Tango spectrum attribute behaviour. From the Attr class, it inherits the Attr *is_allowed*, *read* and *write* methods.

The ImageAttr class This class inherits from the SpectrumAttr class. It is the base class for user image attribute. It is used in conjonction with the Attribute and WAttribute class to implement Tango image attribute behaviour. From the Attr class, it inherits the Attr *is_allowed*, *read* and *write* methods.

The StepperMotor class

Description This class inherits from the DeviceImpl class and is the class implementing the controlled object behavior. Each command will trigger a method in this class written by the device server programmer and specific to the object to be controlled. This class also stores all the device specific data.

Definition

```
class StepperMotor: public TANGO_BASE_CLASS
{
public :
   StepperMotor(Tango::DeviceClass *,string &);
   StepperMotor(Tango::DeviceClass *,const char *);
   StepperMotor(Tango::DeviceClass *,const char *,const char *);
   ~StepperMotor() {};

   DevLong dev_read_position(DevLong);
  DevLong dev_read_direction(DevLong);
  bool direct_cmd_allowed(const CORBA::Any &);

  virtual Tango::DevState dev_state();
  virtual Tango::ConstDevString dev_status();

  virtual void always_executed_hook();

  virtual void read_attr_hardware(vector<long> &attr_list);
  virtual void write_attr_hardware(vector<long> &attr_list);

  void read_position(Tango::Attribute &);
22    bool is_Position_allowed(Tango::AttReqType req);
23    void write_SetPosition(Tango::WAttribute &);
24    void read_Direction(Tango::Attribute &);
25
26    virtual void init_device();
27    virtual void delete_device();
28
29    void get_device_properties();
30
31  protected :
32    long axis[AGSM_MAX_MOTORS];
33    DevLong position[AGSM_MAX_MOTORS];
34    DevLong direction[AGSM_MAX_MOTORS];
35    long state[AGSM_MAX_MOTORS];
36
37    Tango::DevLong *attr_Position_read;
38    Tango::DevLong *attr_Direction_read;
39    Tango::DevLong attr_SetPosition_write;
40
41    Tango::DevLong min;
42    Tango::DevLong max;
43
44    Tango::DevLong *ptr;
45  };
46
47  } /* End of StepperMotor namespace */
```

Line 1 : The StepperMotor class inherits from the DeviceImpl class
Line 4-7 : Class constructors and destructor
Line 9 : Method triggered by the DevReadPosition command
Line 10-11 : Methods triggered by the DevReadDirection command
Line 13 : Redefinition of the *dev_state* method of the DeviceImpl class. This method will be triggered by the State command
Line 14 : Redefinition of the *dev_statu*s method of the DeviceImpl class. This method will be triggered by the Status command
Line 16 : Redefinition of the *always_executed_hook* method.
Line 26 : Definition of the *init_device* method (declared as pure virtual by the DeviceImpl class)
Line 27 : Definition of the *delete_device* method
Line 31-45 : Device data

The StepperMotorClass class

Description This class inherits from the DeviceClass class. Like the DeviceClass class, there should be only one instance of the StepperMotorClass. This is ensured because this class is written following the Singleton pattern as defined in [**?**]. All controlled object class data which should be defined only once per class must be stored in this object.

Definition

```
1 class StepperMotorClass : public DeviceClass
2 {
3 public:
4 static StepperMotorClass *init(const char *);
5 static StepperMotorClass *instance();
6 ~StepperMotorClass() {_instance = NULL;}
7
8 protected:
9 StepperMotorClass(string &);
10 static StepperMotorClass *_instance;
11 void command_factory();
12
13 private:
14 void device_factory(Tango_DevVarStringArray *);
15 };
```

Line 1 : This class is a sub-class of the DeviceClass class

Line 4-5 and 9-10: Methods and data member necessary for the Singleton pattern

Line 6 : Class destructor

Line 11 : Definition of the *command_factory* method declared as pure virtual in the DeviceClass call

Line 13-14 : Definition of the *device_factory* method declared as pure virtual in the DeviceClass class

The DevReadPosition class

Description This is the class for the DevReadPosition command. This class implements the *execute* and *is_allowed* methods defined by the Command class. This class is necessary because this command is implemented using the inheritance model.

Definition

```
1   class DevReadPositionCmd : public Command
2   {
3   public:
4       DevReadPositionCmd(const char *,Tango_CmdArgType, Tango_CmdArgType
5       ~DevReadPositionCmd() {};
6
7       virtual bool is_allowed (DeviceImpl *, const CORBA::Any &);
8       virtual CORBA::Any *execute (DeviceImpl *, const CORBA::Any &);
9   };
```

Line 1 : The class is a sub class of the Command class

Line 4-5 : Class constructor and destructor

Line 7-8 : Definition of the *is_allowed* and *execute* method declared as pure virtual in the Command class.

The PositionAttr class

Description This is the class for the Position attribute. This attribute is a scalar attribute and therefore inherits from the Attr base class. This class implements the *read* and *is_allowed* methods defined by the Attr class.

Definition

```
 1  class PositionAttr: public Tango::Attr
 2  {
 3  public:
 4     PositionAttr():Attr("Position",Tango::DEV_LONG,Tango::READ);
 5     ~PositionAttr() {};
 6
 7     virtual void read(Tango::DeviceImpl *dev,Tango::Attribute &att)
 8     {(static_cast<StepperMotor *>(dev))->read_Position(att);}
 9     virtual bool is_allowed(Tango::DeviceImpl *dev,Tango::AttReqType ty
10     {return (static_cast<StepperMotor *>(dev))->is_Position_allowed(ty)
11  };
```

Line 1 : The class is a sub class of the Attr class

Line 4-5 : Class constructor and destructor

Line 7 : Re-definition of the *read* method defined in the Attr class. This is simply a forward to the *read_Position* method of the StepperMotor class

Line 9 : Re-definition of the *is_allowed* method defined in the Attr class. This is also a forward to the *is_Position_allowed* method of the StepperMotor class

Startup of a device pattern

To start the device pattern implementation for stepper motor device, four methods of the StepperMotorClass class must be executed. These methods are :

1. The creation of the StepperMethodClass singleton via its *init*() method
2. The *command_factory*() method of the StepperMotorClass class
3. The *attribute_factory*() method of the StepperMotorClass class. This method has a default empty body for device class without attributes.
4. The *device_factory*() method of the StepperMotorClass class

This startup procedure is described in figure [pattern_startup_fig]

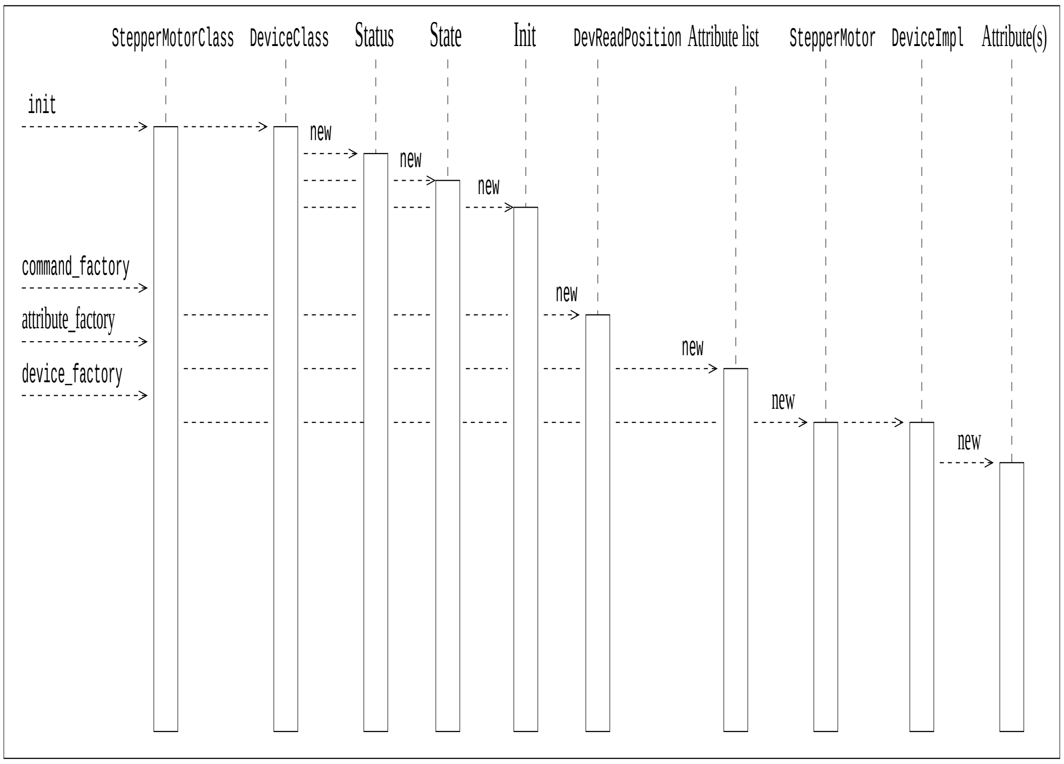


Figure 2: Device pattern startup sequence

. The creation of the StepperMotorClass will automatically create an instance of the DeviceClass class. The constructor of the DeviceClass class will create the Status, State and Init command objects and store them in its command list.

The *command_factory*() method will simply create all the user defined commands and add them in the command list.

The *attribute_factory*() method will simply build a list of device attribute names.

The *device_factory*() method will create each StepperMotor object and store them in the StepperMotorClass instance device list. The list of devices to be created and their names is passed to the *device_factory* method in its input argument. StepperMotor is a sub-class of DeviceImpl class. Therefore, when a StepperMotor object is created, a DeviceImpl object is also created. The DeviceImpl constructor builds all the device attribute object(s) from the attribute list built by the *attribute_factory()* method.

Command execution sequence

The figure [command_timing_fig]

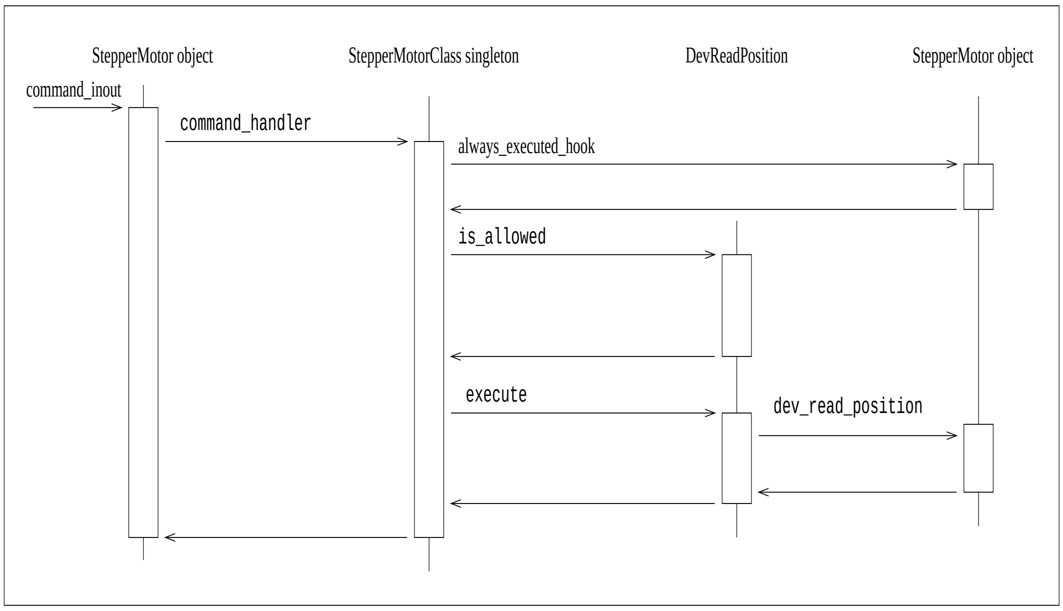


Figure 3: Command execution timing

described how the method implementing a command is executed when a command_inout CORBA operation is requested by a client. The *command_inout* method of the StepperMotor object (inherited from the DeviceImpl class) is triggered by an instance of a class generated by the CORBA IDL compiler. This method calls the *command_handler*() method of the StepperMotorClass object (inherited from the DeviceClass class). The *command_handler* method searches in its command list for the wanted command (using its name). If the command is found, the *always_executed_hook* method of the StepperMotor object is called. Then, the *is_allowed* method of the wanted command is executed. If the *is_allowed* method returns correctly, the *execute* method is executed. The *execute* method extracts the incoming data from the CORBA object use to transmit data over the network and calls the user written method which implements the command.

The automatically added commands

In order to increase the common behavior of every kind of devices in a TANGO control system, three commands are automatically added to each class of devices. These commands are :

- State
- Status
- Init

The default behavior of the method called by the State command depends on the device state. If the device state is ON or ALARM, the method will :

- read the attribute(s) with an alarm level defined

- check if the read value is above/below the alarm level and eventually change the device state to ALARM.
- returns the device state.

For all the other device state, the method simply returns the device state stored in the DeviceImpl class. Nevertheless, the method used to return this state (called *dev_state*) is defined as virtual and can be redefined in DeviceImpl sub-class. The difference between the default State command and the state CORBA attribute is the ability of the State command to signal an error to the caller by throwing an exception.

The default behavior of the method called by the Status command depends on the device state. If the device state is ON or ALARM, the method returns the device status stored in the DeviceImpl class plus additional message(s) for all the attributes which are in alarm condition. For all the other device state, the method simply returns the device status as it is stored in the DeviceImpl class. Nevertheless, the method used to return this status (called *dev_status*) is defined as virtual and can be redefined in DeviceImpl sub-class. The difference between the default Status command and the status CORBA attribute is the ability of the Status command to signal an error to the caller by throwing an exception.

The Init command is used to re-initialize a device without changing its network connection. This command calls the device *delete_device* method and the device *init_device* method. The rule of the *delete_device* method is to free memory allocated in the *init_device* method in order to avoid memory leak.

Reading/Writing attributes

Reading attributes A Tango client is able to read Tango attribute(s) with the CORBA read_attributes call. Inside the device server, this call will trigger several methods of the device class (StepperMotor in our example) :

1. The *always_executed_hook()* method.
2. A method call *read_attr_hardware()*. This method is called one time per read_attributes CORBA call. The aim of this method is to read the device hardware and to store the result in a device class data member.
3. For each attribute to be read
    1. A method called *is_<att name>_allowed()*. The rule of this method is to allow (or disallow) the next method to be executed. It is usefull for device with some attributes which can be read only in some precise conditions. It has one parameter which is the request type (read or write)
    2. A method called *read_<att name>()*. The aim of this method is to extract the real attribute value from the hardware read-out and to store the attribute value into the attribute object. It has one parameter which is a reference to the Attribute object to be read.

The figure [r_attribute_timing_fig] is a drawing of these method calls sequencing. For attribute always readable, a default *is_allowed* method is provided. This method always returns true.

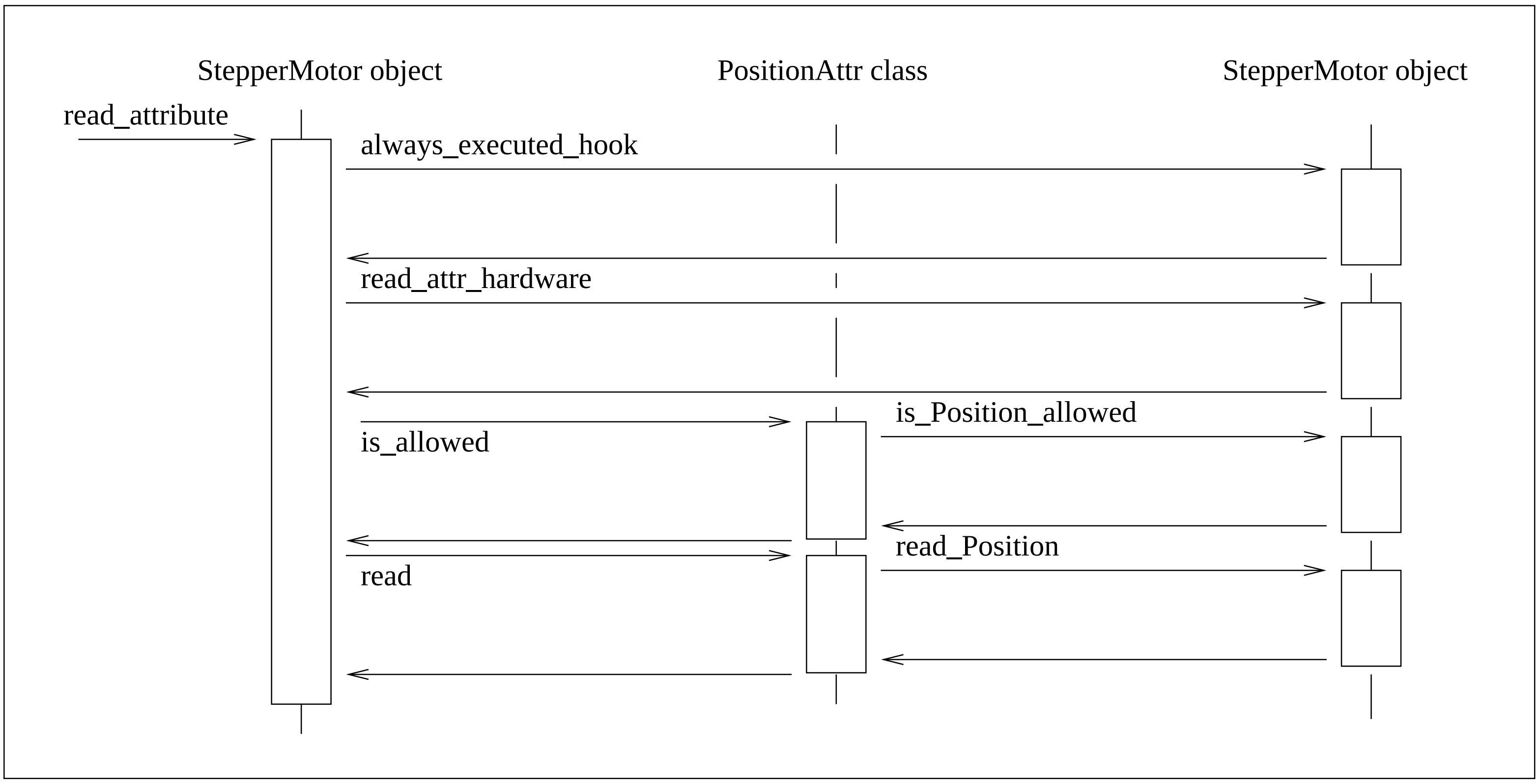


Figure 4: Read attribute sequencing

Writing attributes A Tango client is able to write Tango attribute(s) with the CORBA write_attributes call. Inside a device server, this call will trigger several methods of the device class (StepperMotor in our example)

1. The *always_executed_hook()* method.
2. For each attribute to be written
    1. A method called *is_<att name>_allowed()*. The rule of this method is to allow (or disallow) the next method to be executed. It is usefull for device with some attributes which can be written only in some precise conditions. It has one parameter which is the request type (read or write)
    2. A method called *write_<att name>()*. It has one parameter which is a reference to the WAttribute object to be written. The aim of this method is to get the data to be written from the WAttribute object and to write this value into the corresponding hardware. If the hardware support writing several data in one go, code the hardware access in the *write_attr_harware()* method.
3. The write_attr_hardware() method. The rule of this method is to effectively write the hardware in case it is able to support writing several data

in one go. If this is not the case, don't code this method (a default implementation is coded in the Tango base class) and code the real hardware access in each *write_<att name>()* method.

The figure [w_attribute_timing_fig] is a drawing of these method calls sequencing. For attribute always writeable, a default is_allowed method is provided. This method always allways returns true.

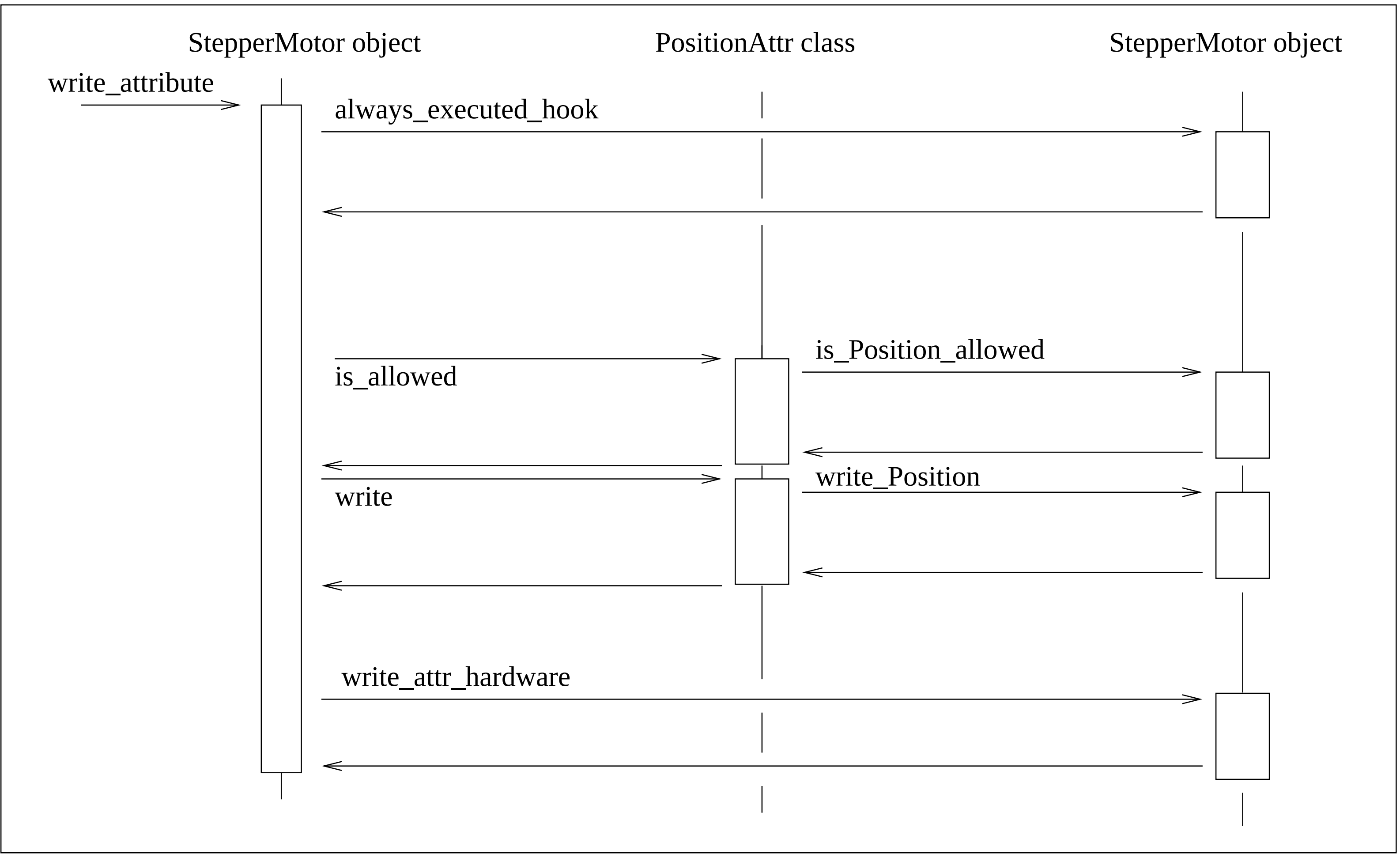


Figure 5: Write attribute sequencing

The device server framework

Vocabulary A device server pattern implementation is embedded in a process called a **device server**. Several instances of the same device server process can be used in a TANGO control system. To identify instances, a device server process is started with an **instance name** which is different for each instance. The device server name is the couple device server executable name/device server instance name. For instance, a device server started with the following command

Perkin id11

starts a device server process with an instance name id11, an executable name Perkin and a device server name Perkin/id11.

The DServer class In order to simplify device server process administration, a device of the DServer class is automatically added to each device server process. Thus, every device server process supports the same set of administration commands. The implementation of this DServer class follows the device pattern and therefore, its device behaves like any other devices. The device name is

dserver/device server executable name/device server instance name

For instance, for the device server process described in chapter [Voc], the dserver device name is dserver/perkin/id11. This name is returned by the adm_name CORBA attribute available for every device. On top of the three automatically added commands, this device supports the following commands :

- DevRestart
- RestartServer
- QueryClass
- QueryDevice
- Kill
- AddLoggingTarget (C++ server only)
- RemoveLoggingTarget (C++ server only)
- GetLoggingTarget (C++ server only)
- GetLoggingLevel (C++ server only)
- SetLoggingLevel (C++ server only)
- StopLogging (C++ server only)
- StartLogging (C++ server only)
- PolledDevice
- DevPollStatus
- AddObjPolling
- RemObjPolling
- UpdObjPollingPeriod
- StartPolling
- StopPolling
- EventSubscriptionChange
- ZmqEventSubscriptionChange
- LockDevice

- UnLockDevice
- ReLockDevices
- DevLockStatus

These commands will be fully described later in this document.

Several controlled object classes can be embedded within the same device server process and it is the rule of this device to create all these device server patterns and to call their command and device factories as described in [Pattern startup]. The name and number of all the classes to be created is known to this device after the execution of a method called *class_factory*. It is the user responsibility to write this method.

The Tango::Util class

Description This class merges a complete set of utilities in the same class. It is implemented as a singleton and there is only one instance of this class per device server process. It is mandatory to create this instance in order to run a device server. The description of all the methods implemented in this class can be found in [**?**].

Contents Within this class, you can find :

- Static method to create/retrieve the singleton object
- Miscellaneous utility methods like getting the server output trace level, getting the CORBA ORB pointer, retrieving device server instance name, getting the server PID and more. Please, refer to [**?**] to get a complete list of all these utility methods.
- Method to create the device pattern implementing the DServer class (*server_init()*)
- Method to start the server (*server_run()*)
- TANGO database related methods

A complete device server Within a complete device server, at least two implementations of the device server pattern are created (one for the dserver object and the other for the class of devices to control). On top of that, one instance of the Tango::Util class must also be created.

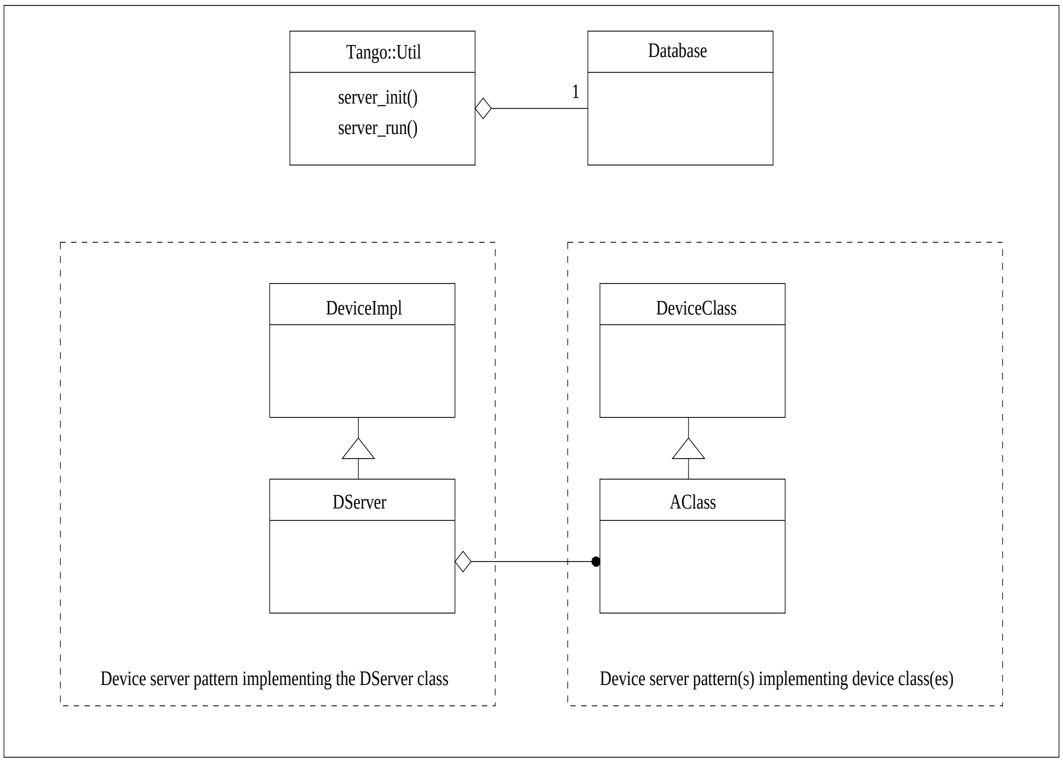

Tango::Util
server_init()
server_run()
Database
1
DeviceImpl
DServer
DeviceClass
AClass
Device server pattern implementing the DServer class
Device server pattern(s) implementing device class(es)

Figure 6: A complete device server

A drawing of a complete device server is in figure [completeDS]

Device server startup sequence The device server startup sequence is the following :

1. Create an instance of the Tango::Util class. This will initialize the CORBA Object Request Broker
2. Called the *server_init* method of the Tango::Util instance The call to this method will :
    1. Create the DServerClass object of the device pattern implementing the DServer class. This will create the dserver object which during its construction will :
        1. Called the *class_factory* method of the DServer object. This method must create all the xxxClass instance for all the device pattern implementation embedded in the device server process.
        2. Call the *command_factory* and *device_factory* of all the classes previously created. The list of devices passed to each call to the *device_factory* method is retrieved from the TANGO database.
3. Wait for incoming request with the *server_run()* method of the Tango::Util class.

Exchanging data between client and server

Exchanging data between clients and server means most of the time passing data between processes running on different computer using the network. Tango limits the type of data exchanged between client and server and defines a way to exchange these data. This chapter details these features. Memory allocation and error reporting are also discussed.

All the rules described in this chapter are valid only for data exchanged between client and server. For device server internal data, classical C++ types can be used.

Command / Attribute data types

Commands have a fixed calling syntax - consisting of one input argument and one output argument. Arguments type must be chosen out of a fixed set of 24 data types. Attributes support a sub-set of these data types (those are the data type with the (1) note) plus the DevEnum data type. The following table details type name, code and the corresponding CORBA IDL types.

The type name used in the type name column of this table is the C++ name. In the IDL file, all the Tango definition are grouped in a IDL module named Tango. The IDL module maps to C++ namespace. Therefore, all the data type are parts of a namespace called Tango.

|c|l| Type name & IDL type Tango::DevBoolean (1) & boolean Tango::DevShort (1) & short Tango::DevEnum (2) & short (See chapter on advanced features) Tango::DevLong (1) & long Tango::DevLong64 (1) & long long Tango::DevFloat (1) & float Tango::DevDouble (1) & double Tango::DevUShort (1) & unsigned short Tango::DevULong (1) & unsigned long Tango::DevULong64 (1) & unsigned long long Tango::DevString (1) & string Tango::DevVarCharArray & sequence of unsigned char Tango::DevVarShortArray & sequence of short Tango::DevVarLongArray & sequence of long Tango::DevVarLong64Array & sequence of long long Tango::DevVarFloatArray & sequence of float Tango::DevVarDoubleArray & sequence of double Tango::DevVarUShortArray & sequence of unsigned short Tango::DevVarULongArray & sequence of unsigned long Tango::DevVarULong64Array & sequence of unsigned long long Tango::DevVarStringArray & sequence of string Tango::DevVarLongStringArray & structure with a sequence of long and a

sequence of string Tango::DevVarDoubleStringArray & structure with a sequence of double

and a sequence of string Tango::DevState (1) & enumeration Tango::DevEncoded (1) & structure with a string and a sequence of char

The CORBA Interface Definition Language uses a type called **sequence** for variable length array. The Tango::DevUxxx types are used for unsigned types. The Tango::DevVarxxxxArray must be used when the data to be transferred are variable length array. The Tango::DevVarLongStringArray and Tango::DevVarDoubleStringArray are structures with two fields which are variable length array of Tango long (32 bits) and variable length array of strings for the Tango::DevVarLongStringArray and variable length array of double and variable length array of string for the Tango::DevVarDoubleStringArray. The Tango::State type is used by the State command to return the device state.

Using data types with C++ Unfortunately, the mapping between IDL and C++ was defined before the C++ class library had been standardized. This explains why the standard C++ string class or vector classes are not used in the IDL to C++ mapping.

TANGO commands/attributes argument types can be grouped on five groups depending on the IDL data type used. These groups are :

1. Data type using basic types (Tango::DevBoolean, Tango::DevShort, Tango::DevEnum, Tango::DevLong, Tango::DevFloat, Tango::DevDouble, Tango::DevUshort and Tango::DevULong)
2. Data type using strings (Tango::DevString type)
3. Data types using sequences (Tango::DevVarxxxArray types except Tango::DevVarLongStringArray and Tango::DevVarDoubleStringArray)
4. Data types using structures (Tango::DevVarLongStringArray and Tango::DevVarDoubleStringArray types)
5. Data type using IDL enumeration (Tango::DevState type)

In the following sub chapters, only summaries of the IDL to C++ mapping are given. For a full description of the C++ mapping, please refer to [**?**]

Basic types For these types, the mapping between IDL and C++ is obvious and defined in the following table.

|c|c|c|c| Tango type name & IDL type & C++ & typedef Tango::DevBoolean & boolean & CORBA::Boolean & unsigned char Tango::DevShort & short & CORBA::Short & short Tango::DevEnum & short & CORBA::Short & Tango::DevLong & long & CORBA::Long & int Tango::DevLong64 & long long & CORBA::LongLong & long long or long (64

bits chip) Tango::DevFloat & float & CORBA::Float & float Tango::DevDouble & double & CORBA::Double & double Tango::DevUShort & unsigned short & CORBA::UShort & unsigned short Tango::DevULong & unsigned long & CORBA::ULong & unsigned long Tango::DevULong64 & unsigned long long & CORBA:ULongLong & unsigned

system-message
WARNING/2 in `tango.rst`, line 5602
Definition list ends without a blank line; unexpected unindent. backrefs:

long long or unsigned long (64 bits chip)

The types defined in the column named C++ should be used for a better portability. All these types are defined in the CORBA namespace and therefore their qualified names is CORBA::xxx. The Tango data type DevEnum is a special case described in detail in the chapter about advanced features.

Strings Strings are mapped to **char ***. The use of *new* and *delete* for dynamic allocation of strings is not portable. Instead, you must use helper functions defined by CORBA (in the CORBA namespace). These functions are :

```
        char *CORBA::string_alloc(unsigned long len);
        char *CORBA::string_dup(const char *);
        void CORBA::string_free(char *);
```

These functions handle dynamic memory for strings. The *string_alloc* function allocates one more byte than requested by the len parameter (for the trailing 0). The function *string_dup* combines the allocation and copy. Both *string_alloc* and *string_dup* return a null pointer if allocation fails. The *string_free* function must be used to free memory allocated with *string_alloc* and *string_dup*. Calling *string_free* for a null pointer is safe and does nothing. The following code fragment is an example of the Tango::DevString type usage

```
1       Tango::DevString str = CORBA::string_alloc(5);
2       strcpy(str,"TANGO");
3
4       Tango::DevString str1 = CORBA::string_dup("Do you want to danse TAN
5
6       CORBA::string_free(str);
7       CORBA::string_free(str1);
```

Line 1-2 : TANGO is a five letters string. The CORBA::string_alloc function parameter is 5 but the function allocates 6 bytes
Line 4 : Example of the CORBA::string_dup function
Line 6-7 : Memory deallocation

Sequences IDL sequences are mapped to C++ classes that behave like vectors with a variable number of elements. Each IDL sequence type results in a separate C++ class. Within each class representing a IDL sequence types, you find the following method (only the main methods are related here) :

1. Four constructors.
    1. A default constructor which creates an empty sequence.
    2. The maximum constructor which creates a sequence with memory allocated for at least the number of elements passed as argument. This does not limit the number of element in the sequence but only the way how memory is allocated to store element
    3. A sophisticated constructor where it is possible to assign the memory used by the sequence with a preallocated buffer.
    4. A copy constructor which does a deep copy
2. An assignment operator which does a deep copy
3. A *length* accessor which simply returns the current number of elements in the sequence

4. A *length* modifier which changes the length of the sequence (which is different than the number of elements in the sequence)

5. Overloading of the [] operator. The subscript operator [] provides access to the sequence element. For a sequence containing elements of type T, the [] operator is overloaded twice to return value of type T & and const T &. Insertion into a sequence using the [] operator for the const T & make a deep copy. Sequence are numbered between 0 and *length*() -1.

Note that using the maximum constructor will not prevent you from setting the length of the sequence with a call to the length modifier. The following code fragment is an example of how to use a Tango::DevVarLongArray type

```
 1      Tango::DevVarLongArray *mylongseq_ptr;
 2      mylongseq_ptr = new Tango::DevVarLongArray();
 3      mylongseq_ptr->length(4);
 4
 5      (*mylongseq_ptr)[0] = 1;
 6      (*mylongseq_ptr)[1] = 2;
 7      (*mylongseq_ptr)[2] = 3;
 8      (*mylongseq_ptr)[3] = 4;
 9
10      // (*mylongseq_ptr)[4] = 5;
11
12      CORBA::Long nb_elt = mylongseq_ptr->length();
13
14      mylongseq_ptr->length(5);
15      (*mylongseq_ptr)[4] = 5;
16
17      for (int i = 0;i < mylongseq_ptr->length();i++)
18           cout << "Sequence elt " << i + 1 << " = " << (*mylongseq_ptr)
```

Line 1 : Declare a pointer to Tango::DevVarLongArray type which is a sequence of long

Line 2 : Create an empty sequence

Line 3 : Change the length of the sequence to 4

Line 5 - 8 : Initialize sequence elements

Line 10 ; Oups !!! The length of the sequence is 4. The behavior of this line is undefined and may be a core can be dumped at run time

Line 12 : Get the number of element actually stored in the sequence

Line 14-15 : Grow the sequence to five elements and initialize element number 5

Line 17-18 : Print sequence element

Another example for the Tango::DevVarStringArray type is given

```
 1      Tango::DevVarStringArray mystrseq(4);
 2      mystrseq.length(4);
 3
 4      mystrseq[0] = CORBA::string_dup("Rock and Roll");
 5      mystrseq[1] = CORBA::string_dup("Bossa Nova");
 6      mystrseq[2] = CORBA::string_dup("Waltz");
 7      mystrseq[3] = CORBA::string_dup("Tango");
 8
 9      CORBA::Long nb_elt = mystrseq.length();
10
11      for (int i = 0;i < mystrseq.length();i++)
12           cout << "Sequence elt " << i + 1 << " = " << mystrseq[i] << er
```

Line 1 : Create a sequence using the maximum constructor
Line 2 : Set the sequence length to 4. This is mandatory even if you used the maximum constructor.
Line 4-7 : Populate the sequence
Line 9 : Get how many strings are stored into the sequence
Line 11-12 : Print sequence elements.

Structures Only three TANGO types are defined as structures. These types are the Tango::DevVarLongStringArray, the Tango::DevVarDoubleStringArray and the Tango::DevEncoded data type. IDL structures map to C++ structures with corresponding members. For the Tango::DevVarLongStringArray, the two members are named *svalue* for the sequence of strings and *lvalue* for the sequence of longs. For the Tango::DevVarDoubleStringArray, the two structure members are called *svalue* for the sequence of strings and *dvalue* for the sequence of double. For the Tango::DevEncoded, the two structure members are called *encoded_format* for a string describing the data coding and *encoded_data* for the data themselves. The encoded_data field type is a Tango::DevVarCharArray. An example of the usage of the Tango::DevVarLongStringArray type is detailed below.

```
1      Tango::DevVarLongStringArray my_vl;
2
3      myvl.svalue.length(2);
4      myvl.svalue[0] = CORBA_string_dup("Samba");
5      myvl.svalue[1] = CORBA_string_dup("Rumba");
6
7      myvl.lvalue.length(1);
8      myvl.lvalue[0] = 10;
```

Line 1 : Declaration of the structure
Line 3-5 : Initialization of two strings in the sequence of string member
Line 7-8 : Initialization of one long in the sequence of long member

The DevState data type The Tango::DevState data type is used to transfer device state between client and server. It is a IDL enumeration. IDL enumerated types map to C++ enumerations (amazing no!) with a trailing dummy enumerator to force enumeration to be a 32 bit type. The first enumerator will have the value 0, the next one will have the value 1 and so on.

```
1      Tango::DevState state;
2
3      state = Tango::ON;
4      state = Tango::FAULT;
```

Passing data between client and server

In order to have one definition of the CORBA operation used to send a command to a device whatever the command data type is, TANGO uses CORBA IDL **any** object.

The IDL type *any* provides a universal type that can hold a value of arbitrary IDL types. Type *any* therefore allows you to send and receive values whose types are not fixed at compile time.

Type *any* is often compared to a void * in C. Like a pointer to void, an *any* value can denote a datum of any type. However, there is an important difference; whereas a void * denotes a completely untyped value that can be interpreted only with advance knowledge of its type, values of type *any* maintain type safety. For example, if a sender places a string value into an *any*, the receiver cannot extract the string as a value of the wrong type. Attempt to read the contents of an *any* as the wrong type cause a run-time error.

Internally, a value of type *any* consists of a pair of values. One member of the pair is the actual value contained inside the *any* and the other member of the pair is the type code. The type code is a description of the value's type. The type description is used to enforce type safety when the receiver extracts the value. Extraction of the value succeeds only if the receiver extracts the value as a type that matches the information in the type code.

Within TANGO, the command input and output parameters are objects of the IDL *any* type. Only insertion/extraction of all types defined as command data types is possible into/from these *any* objects.

C++ mapping for IDL any type The IDL any maps to the C++ class **CORBA::Any**. This class contains a large number of methods with mainly methods to insert/extract data into/from the any. It provides a default constructor which builds an any which contains no value and a type code that indicates "no value". Such an any must be used for command which does not need input or output parameter. The operator **«=** is overloaded many times to insert data into an any object. The operator **»=** is overloaded many times to extract data from an any object.

Inserting/Extracting TANGO basic types The insertion or extraction of TANGO basic types is straight forward using the «= or »= operators. Nevertheless, the Tango::DevBoolean type is mapped to a unsigned char and other IDL types are also mapped to char C++ type (The unsigned is not taken into account in the C++ overloading algorithm). Therefore, it is not possible to use operator overloading for these IDL types which map to C++ char. For the Tango::DevBoolean type, you must use the *CORBA::Any::from_boolean* or *CORBA::Any::to_boolean* intermediate objects defined in the CORBA::Any class.

Inserting/Extracting TANGO strings The «= operator is overloaded for const char * and always makes a deep copy. This deep copy is done using the CORBA::*string_dup* function. The extraction of strings uses the »= overloaded operator. The main point is that the Any object retains ownership of the string, so the returned pointer points at memory inside the Any. This means that you must not deallocate the extracted string and you must treat the extracted string as read-only.

Inserting/Extracting TANGO sequences Insertion and extraction of sequences also uses the overloaded «= and »= operators. The insertion operator is overloaded twice: once for insertion by reference and once for insertion by pointer. If you insert a value by reference, the insertion makes a deep copy. If you insert a value by pointer, the Any assumes the ownership of the pointed-to memory.

Extraction is always by pointer. As with strings, you must treat the extracted pointer as read-only and must not deallocate it because the pointer points at memory internal to the Any.

Inserting/Extracting TANGO structures This is identical to inserting/extracting sequences.

Inserting/Extracting TANGO enumeration This is identical to inserting/extracting basic types

```
 1     CORBA::Any a;
 2     Tango::DevLong l1,l2;
 3     l1 = 2;
 4     a <<= l1;
 5     a >>= l2;
 6
 7     CORBA::Any b;
 8     Tango::DevBoolean b1,b2;
 9     b1 = true;
10     b <<= CORBA::Any::from_boolean(b1);
11     b >>= CORBA::Any::to_boolean(b2);
12
13     CORBA::Any s;
14     Tango::DevString str1,str2;
15     str1 = "I like dancing TANGO";
16     s <<= str1;
17     s >>= str2;
18
19   //   CORBA::string_free(str2);
20   //   a <<= CORBA::string_dup("Oups");
21
22     CORBA::Any seq;
23     Tango::DevVarFloatArray fl_arr1;
24     fl_arr1.length(2);
25     fl_arr1[0] = 1.0;
26     fl_arr1[1] = 2.0;
27     seq <<= fl_arr1;
28     const Tango::DevVarFloatArray *fl_arr_ptr;
29     seq >>= fl_arr_ptr;
30
31   //   delete fl_arr_ptr;
```

Line 1-5 : Insertion and extraction of Tango::DevLong type

Line 7-11 Insertion and extraction of Tango::DevBoolean type using the CORBA::Any::from_boolean and CORBA::Any::to_boolean intermediate structure

Line 13-17 : Insertion and extraction of Tango::DevString type

Line 19 : Wrong ! You should not deallocate a string extracted from an any

Line 20 : Wrong ! Memory leak because the «= operator will do the copy.

Line 22-29 : Insertion and extraction of Tango::DevVarxxxArray types. This is an insertion by reference and the use of the «= operator makes a deep copy of the sequence. Therefore, after line 27, it is possible to deallocate the sequence

Line 31: Wrong.! You should not deallocate a sequence extracted from an any

The insert and extract methods of the Command class In order to simplify the insertion/extraction into/from Any objects, small helper methods have been written in the Command class. The signatures of these methods are :

```
            void extractextract(const CORBA::Any &,<Tango type> &);
            CORBA::Any *insertinsert(<Tango type>);
```

An *extract* method has been written for all Tango types. These method extract the data from the Any object passed as parameter and throw an exception if the Any data type is incompatible with the awaiting type. An *insert* method have been written for all Tango types. These method create an Any object, insert the data into the Any and return a pointer to the created Any. For Tango types mapped to sequences or structures, two *insert* methods have been written: one for the insertion from pointer and the other for the insertion from reference. For Tango strings, two *insert* methods have been written: one for insertion from a classical Tango::DevString type and the other from a const Tango::DevString type. The first one deallocate the memory after the insert into the Any object. The second one only inserts the string into the Any object.

The previous example can be rewritten using the insert/extract helper methods (We suppose that we can use the Command class insert/extract methods)

```
 1      Tango::DevLong l1,l2;
 2      l1 = 2;
 3      CORBA::Any *a_ptr = insert(l1);
 4      extract(*a_ptr,l2);
 5
 6      Tango::DevBoolean b1,b2;
 7      b1 = true;
 8      CORBA::Any *b_ptr = insert(b1);
 9      extract(*b_ptr,b2);
10
11      Tango::DevString str1,str2;
12      str1 = "I like dancing TANGO";
13      CORBA::Any *s_ptr = insert(str1);
14      extract(*s_ptr,str2);
15
16      Tango::DevVarFloatArray fl_arr1;
17      fl_arr1.length(2);
18      fl_arr1[0] = 1.0;
19      fl_arr1[1] = 2.0;
20      insert(fl_arr1);
21      CORBA::Any *seq_ptr = insert(fl_arr1);
22      Tango::DevVarFloatArray *fl_arr_ptr;
23      extract(*seq_ptr,fl_arr_ptr);
```

Line 1-4 : Insertion and extraction of Tango::DevLong type
Line 6-9 : Insertion and extraction of Tango::DevBoolean type
Line 11-14 : Insertion and extraction of Tango::DevString type

Line 16-23 : Insertion and extraction of Tango::DevVarxxxArray types. This is an insertion by reference which makes a deep copy of the sequence. Therefore, after line 20, it is possible to deallocate the sequence

C++ memory management

The rule described here are valid for variable length command data types like Tango::DevString or all the Tango:: DevVarxxxxArray types.

The method executing the command must allocate the memory used to pass data back to the client or use static memory (like buffer declares as object data member. If necessary, the ORB will deallocate this memory after the data have been sent to the caller. Fortunately, for incoming data, the method have no memory management responsibilities. The details about memory management given in this chapter assume that the insert/extract methods of the Tango::Command class are used and only the method in the device object is discussed.

For string Example of a method receiving a Tango::DevString and returning a Tango::DevString is detailed just below

```
 1   Tango::DevString MyDev::dev_string(Tango::DevString argin)
 2   {
 3       Tango::DevString        argout;
 4
 5       cout << "the received string is " << argin << endl;
 6
 7       string str("Am I a good Tango dancer ?");
 8       argout = new char[str.size() + 1];
 9       strcpy(argout,str.c_str());
10
11       return argout;
12   }
```

Note that there is no need to deallocate the memory used by the incoming string. Memory for the outgoing string is allocated at line 8, then it is initialized at the following line. The memory allocated at line 8 will be automatically freed by the usage of the *Command::insert()* method. Using this schema, memory is allocated/freed each time the command is executed. For constant string length, a statically allocated buffer can be used.

```
 1   Tango::ConstDevString MyDev::dev_string(Tango::DevString argin)
 2   {
 3       Tango::ConstDevString   argout;
 4
 5       cout << "the received string is " << argin << endl;
 6
 7       argout = "Hello world";
 8       return argout;
 9   }
```

A Tango::ConstDevString data type is used. It is not a new data Tango data type. It has been introduced only to allows *Command::insert()* method overloading. The argout pointer is initialized at line 7 with memory statically allocated. In this case, no memory will be freed by the *Command::insert()* method. There is also no memory copy in the contrary of the previous example. A buffer defined as object data member can also be used to set the argout pointer.

For array/sequence Example of a method returning a Tango::DevVarLongArray is detailed just below

```
 1   Tango::DevVarLongArray *MyDev::dev_array()
 2   {
 3       Tango::DevVarLongArray  *argout  = new Tango::DevVarLongArray();
 4
 5       long output_array_length = ...;
 6       argout->length(output_array_length);
 7       for (int i = 0;i < output_array_length;i++)
 8           (*argout)[i] = i;
 9
10       return argout;
11   }
```

In this case, memory is allocated at line 3 and 6. Then, the sequence is populated. The sequence is created and returned using pointer. The *Command::insert()* method will insert the sequence into the CORBA::Any object using this pointer. Therefore, the CORBA::Any object will take ownership of the allocated memory. It will free it when it will be destroyed by the CORBA ORB after the data have been sent away. It is also possible to use a statically allocated memory and to avoid copying in the sequence used to returned the data. This is explained in the following example assuming a buffer of long data is declared as device data member and named buffer.

```
1   Tango::DevVarLongArray *MyDev::dev_array()
2   {
3       Tango::DevVarLongArray  *argout;
4
5       long output_array_length = ...;
6       argout = create_DevVarLongArray(buffer,output_array_length);
7       return argout;
8   }
```

At line 3 only a pointer to a DevVarLongArray is defined. This pointer is set at line 6 using the *create_DevVarLongArray()* method. This method will create a sequence using this buffer without memory allocation and with minimum copying. The *Command::insert()* method used here is the same than the one used in the previous example. The sequence is created in a way that the destruction of the CORBA::Any object in which the sequence will be inserted will not destroy the buffer. The following create_xxx methods are defined in the DeviceImpl class :

|c|c| Method name & data type create_DevVarCharArray() & unsigned char create_DevVarShortArray() & short create_DevVarLongArray() & DevLong create_DevVarLong64Array() & DevLong64 create_DevVarFloatArray() & float create_DevVarDoubleArray() & double create_DevVarUShortArray() & unsigned short create_DevVarULongArray() & DevULong create_DevVarULong64Array() & DevULong64

For string array/sequence Example of a method returning a Tango::DevVarStringArray is detailed just below

```
 1   Tango::DevVarStringArray *MyDev::dev_str_array()
 2   {
 3      Tango::DevVarStringArray *argout  = new Tango::DevVarStringArray();
 4
 5      argout->length(3);
 6      (*argout)[0] = CORBA::string_dup("Rumba");
 7      (*argout)[1] = CORBA::string_dup("Waltz");
 8      string str("Jerck");
 9      (*argout)[2] = CORBA::string_dup(str.c_str());
10      return argout;
11   }
```

Memory is allocated at line 3 and 5. Then, the sequence is populated at lines 6,7 and 9. The usage of the *CORBA::string_dup* function also allocates memory. The sequence is created and returned using pointer. The *Command::insert()* method will insert the sequence into the CORBA::Any object using this pointer. Therefore, the CORBA::Any object will take ownership of the allocated memory. It will free it when it will be destroyed by the CORBA ORB after the data have been sent away. For portability reason, the ORB uses the *CORBA::string_free* function to free the memory allocated for each string. This is why the corresponding *CORBA::string_du*p or *CORBA::string_alloc* function must be used to reserve this memory.It is also possible to use a statically allocated memory and to avoid copying in the sequence used to returned the data. This is explained in the following example assuming a buffer of pointer to char is declared as device data member and named int_buffer.

```
1   Tango::DevVarStringArray *DocDs::dev_str_array()
2   {
3      int_buffer[0] = "first";
4      int_buffer[1] = "second";
5
6      Tango::DevVarStringArray *argout;
7      argout = create_DevVarStringArray(int_buffer,2);
8      return argout;
9   }
```

The intermediate buffer is initialized with statically allocated memory at lines 3 and 4. The returned sequence is created at line 7 with the *create_DevVarStringArray()* method. Like for classical array, the sequence is created in a way that the destruction of the CORBA::Any object in which the sequence will be inserted will not destroy the buffer.

For Tango composed types Tango supports only two composed types which are Tango::DevVarLongStringArray and Tango::DevVarDoubleStringArray. These types are translated to C++ structure with two sequences. It is not possible to use memory statically allocated for these types. Each structure element must be initialized as described in the previous sub-chapters using the dynamically allocated memory case.

Reporting errors

Tango uses the C++ try/catch plus exception mechanism to report errors. Two kind of errors can be transmitted between client and server :

1. CORBA system error. These exceptions are raised by the ORB and indicates major failures (A communication failure, An invalid object reference...)
2. CORBA user exception. These kind of exceptions are defined in the IDL file. This allows an exception to contain an arbitrary amount of error information of arbitrary type.

TANGO defines one user exception called **DevFailed**. This exception is a variable length array of **DevError** type (a sequence of DevError). The DevError type is a four fields structure. These fields are :

1. A string describing the type of the error. This string replaces an error code and allows a more easy management of include files.
2. The error severity. It is an enumeration with the three values which are WARN, ERR or PANIC.
3. A string describing in plain text the reason of the error
4. A string describing the origin of the error

The Tango::DevFailed type is a sequence of DevError structures in order to transmit to the client what is the primary error reason when several classes are used within a command. The sequence element 0 must be the DevError structure describing the primary error. A method called *print_exception*() defined in the Tango::Except class prints the content of exception (CORBA system exception or Tango::DevFailed exception). Some static methods of the Tango::Except class called *throw_exception*() can be used to throw Tango::DevFailed exception. Some other static methods called *re_throw_exception()* may also be used when the user want to add a new element in the exception sequence and re-throw the exception. Details on these methods can be found in [**?**].

Example of throwing exception This example is a piece of code from the *command_handler*() method of the DeviceImpl class. An exception is thrown to the client to indicate that the requested command is not defined in the command list.

```
TangoSys_OMemStream o;

o << "Command " << command << " not found" << ends;
Tango::Except::throw_exception("API_CommandNotFound",
                               o.str(),
                               "DeviceClass::command_handler");


try
{
    .....
12      }
13      catch (Tango::DevFailed &e)
14      {
15          TangoSys_OMemStream o;
16
17          o << "Command " << command << " not found" << ends;
18          Tango::Except::re_throw_exception(e,
19                                          "API_CommandNotFound",
20                                          o.str(),
21                                          "DeviceClass::command_handler");
22      }
```

Line 1 : Build a memory stream. Use the TangoSys_MemStream because memory streams are not managed the same way between Windows and Unix

Line 3 : Build the reason string in the memory stream

Line 4-5 : Throw the exception to client using one of the *throw_exception* static method of the Except class. This throw_exception method used here allows the definition of the error type string, the reason string and the origin string of the DevError structure. The remaining DevError field (the error severity) will be set to its default value. Note that the first and third parameters are casted to a *const char* *. Standard C++ defines that such a string is already a *const char* * but the GNU C++ compiler (release 2.95) does not use this type inside its function overloading but rather uses a *char* * which leads to calling the wrong function.

Line 13-22 : Re-throw an already catched tango::DevFailed exception with one more element in the exception sequence.

The Tango Logging Service

A first introduction about this logging service has been done in chapter [sec:The-Tango-Logging]

The TANGO Logging Service (TLS) gives the user the control over how much information is actually generated and to where it goes. In practice, the TLS allows to select both the logging level and targets of any device within the control system.

Logging Targets

The TLS implementation allows each device logging requests to print simultaneously to multiple destinations. In the TANGO terminology, an output destination is called a **logging target**. Currently, targets exist for console, file and log consumer device.

CONSOLE: logs are printed to the console (i.e. the standard output),

FILE: logs are stored in a XML file. A rolling mechanism is used to backup the log file when it reaches a certain size (see below),

DEVICE: logs are sent to a device implementing a well known TANGO interface (see section [sec:Tango-log-consumer] for a definition of the log consumer interface). One implementation of a log consumer associated to a graphical user interface is available within the Tango package. It is called the LogViewer.

The device's logging behavior can be control by adding and/or removing targets.

Note : When the size of a log file (for file logging target) reaches the so-called rolling-file-threshold (rft), it is backuped as current_log_file_name + _1 and a new current_log_file_name is opened. Obviously, there is only one backup file at a time (i.e. any existing backup is destroyed before the current log file is backuped). The default threshold is 20 Mb, the minimum is 500 Kb and the maximum is 1000 Mb.

Logging Levels

Devices can be assigned a logging level. It acts as a filter to control the kind of information sent to the targets. Since, there are (usually) much more low level log statements than high level statements, the logging level also control the amount of information produced by the device. The TLS provides the following levels (semantic is just given to be indicative of what could be log at each level):

OFF: Nothing is logged

FATAL: A fatal error occurred. The process is about to abort

ERROR: An (unrecoverable) error occurred but the process is still alive

WARN: An error occurred but could be recovered locally

INFO: Provides information on important actions performed

DEBUG: Generates detailed information describing the internal behavior of a device

Levels are ordered the following way:

DEBUG < INFO < WARN < ERROR < FATAL < OFF

For a given device, a level is said to be enabled if it is greater or equal to the logging level assigned to this device. In other words, any logging request which level is lower than the device's logging level is ignored.

Note: The logging level can't be controlled at target level. The device's targets shared the same device logging level.

Sending TANGO Logging Messages

Logging macros in C++ The TLS provides the user with easy to use C++ macros with *printf* and *stream* like syntax. For each logging level, a macro is defined in both styles:

- LOG_{FATAL, ERROR, WARN, INFO or DEBUG}
- {FATAL, ERROR, WARN, INFO or DEBUG}_STREAM

These macros are supposed to be used within the device's main implementation class (i.e. the class that inherits (directly or indirectly) from the Tango::DeviceImpl class). In this context, they produce logging messages containing the device name. In other words, they automatically identify the log source. Section [sub:C++-logging-in] gives a trick to log in the name of device outside its main implementation class. Printf like example:

LOG_DEBUG((Msg#%d - Hello world, i++));

Stream like example:

DEBUG_STREAM « Msg# « i++ « - Hello world « endl;

These two logging requests are equivalent. Note the double parenthesis in the printf version.

C++ logging in the name of a device A device implementation is sometimes spread over several classes. Since all these classes implement the same device, their logging requests should be associated with this device name. Unfortunately, the C++ logging macros can't be used because they are outside the device's main implementation class. The Tango::LogAdapter class is a workaround for this limitation.

Any method not member of the device's main implementation class, which send log messages associated to a device must be a member of a class inheriting from the Tango::LogAdapter class. Here is an example:

```
class MyDeviceActualImpl: public Tango::LogAdapter
{
public :
   MyDeviceActualImpl(...,Tango::DeviceImpl *device,...)
   :Tango::LogAdpater(device)
   {
         ....
//
// The following log is associated to the device passed to the construc
//
        DEBUG_STREAM << "In MyDeviceActualImpl constructor" << endl;

        ....
   }
};
```

Writing a device server process

Writing a device server can be made easier by adopting the correct approach. This chapter will describe how to write a device server process. It is divided into the following parts : understanding the device, defining device commands/attributes/pipes, choosing device state and writing the necessary classes. All along this chapter, examples will be given using the stepper motor device server. Writing a device server for our stepper motor example device means writing :

- The *main* function
- The *class_factory* method (only for C++ device server)
- The *StepperMotorClass* class
- The *DevReadPositionCmd* and *DevReadDirectionCmd* classes
- The *PositionAttr*, *SetPositionAttr* and *DirectionAttr* classes
- The *StepperMotor* class.

All these functions and classes will be detailed. The stepper motor device server described in this chapter supports 2 commands and 3 attributes which are :

- Command DevReadPosition implemented using the inheritance model
- Command DevReadDirection implemented using the template command model
- Attribute Position (position of the first motor). This attribute is readable and is linked with a writable attribute (called SetPosition). When the value of this attribute is requested by the client, the value of the associated writable attribute is also returned.

- Attribute SetPosition (writable attribute linked with the Position attribute). This attribute has some properties with user defined default value.
- Attribute Direction (direction of the first motor)

As the reader will understand during the reading of the following sub-chapters, the command and attributes classes (*DevReadPositionCmd*, *DevReadDirectionCmd*, *PositionAttr*, *SetPositionAttr* and *DirectionAttr*) are very simple classes. A tool called **Pogo** has been developped to automatically generate/maintain these classes and to write part of the code needed in the remaining one. See xx to know more on this Pogo tool.

In order to also gives an example of how the database objects part of the Tango device pattern could be used, our device have two properties. These properties are of the Tango long data types and are named “Max” and “Min”.

Understanding the device

The first step before writing a device server is to develop an understanding of the hardware to be programmed. The Equipment Responsible should have description of the hardware and its operating modes (manuals, spec sheets etc.). The Equipment Responsible must also provide specifications of what the device server should do. The Device Server Programmer should demand an exact description of the registers, alarms, interlocks and any timing constraints which have to be kept. It is very important to have a good understanding of the device interfacing before starting designing a new class.

Once the Device Server Programmer has understood the hardware the next important step is to define what is a logical device i.e. what part of the hardware will be abstracted out and treated as a logical device. In doing so the following points of the TDSOM should be kept in mind

- Each device is known and accessed by its ascii name.
- The device is exported onto the network to be imported by applications.
- Each device belongs to a class.
- A list of commands exists per device.
- Applications use the device server api to execute commands on a device.

The above points have to be taken into account when designing the level of device abstraction. The definition of what is a device for a certain hardware is primarily the job of the Device Server Programmer and the Applications Programmer but can also involve the Equipment Responsible. The Device Server Programmer should make sure that the Applications Programmer agrees with her definition of what is a device.

Here are some guidelines to follow while defining the level of device abstraction -

- **efficiency**, make sure that not a too fine level of device abstraction has been chosen. If possible group as many attributes together to form a device. Discuss this with the Applications Programmer to find out what is efficient for her application.
- **hardware independency**, one of the main reasons for writing device servers is to provide the Applications Programmer with a *software* interface as opposed to a *hardware* interface. Hide the hardware structure of the device. For example

if the user is only interested in a single channel of a multichannel device then define each channel to be a logical device. The user should not be aware of hardware addresses or cabling details. The user is very often a scientist who has a physics-oriented world view and not a hardware-oriented world view. Hardware independency also has the advantage that applications are immune to hardware changes to the device

- **object oriented world view**, another *raison d'etre* behind the device server model is to build up an object oriented view of the world. The device should resemble the user's view of the object as closely as possible. In the case of the ESRF's beam lines for example, the devices should resemble beam line scientist's view of the machine.
- **atomism**, each device can be considered like an atom - is a independent object. It should appear independent to the client even if behind the scenes it shares some hardware or software with other objects. This is often the case with multichannel devices where the user would like to see each channel as a device but it is obvious that the channels cannot be programmed completely independently. The logical device is there to hide or make transparent this fact. If it is impossible to send commands to one device without modifying another device then a single device should be made out the two devices.
- **tailored** *vs* **general**, one of the philosophies of the TDSOM is to provide tailored solutions. For example instead of writing one *serial line* class which treats the general case of a serial line device and leaving the device protocol to be implemented in the client the TDSOM advocates implementing a device class which handles the protocol of the device. This way the client only has to know the commands of the class and not the details of the protocol. Nothing prevents the device class from using a general purpose serial line class if it exists of course.

Defining device commands

Each device has a list of commands which can be executed by the application across the network or locally. These commands are the Application Programmer's network knobs and dials for interacting with the device.

The list of commands to be implemented depends on the capabilities of the hardware, the list of sensible functions which can be executed at a distance and of course the functionality required by the application. This implies a close collaboration between the Equipment Responsible, Device Server Programmer and the Application Programmer.

When drawing up the list of commands particular attention should be paid to the following points

- **performance**, no single command should monopolize the device server for a long time (a nominal value for long is one second). Commands should be implemented in such a way that it executes immediately returning with a response. At best try to keep command execution time down to less than the typical overhead of an rpc call i.e. som milliseconds. This of course is not always possible e.g. a serial line device could require 100 milliseconds of protocol exchange. The Device Server Programmer should find the best trade-off between the users requirements and the devices capabilities. If a command implies a sequence of events which could last for a long time then implement the sequence of events in another thread - don't block the device server.

- **robustness**, should be provided which allow the client to recover from error conditions and or do a warm startup.

Standard commands A minimum set of three commands exist for all devices. These commands are

- State which returns the state of a device
- Status which returns the status of the device as a formatted ascii string
- Init which re-initialize a device without changing its network connection

These commands have already been discussed in [Auto_cmd]

Choosing device state

The device state is a number which reflects the availability of the device. To simplify the coding for generic application, a predefined set of states are supported by TANGO. This list has 14 members which are

|c| **State name** ON OFF CLOSE OPEN INSERT EXTRACT MOVING STANDBY FAULT INIT RUNNING ALARM DISABLE UNKNOWN

The names used here have obvious meaning.

Device server utilities to ease coding/debugging

The device server framework supports one set of utilities to ease the process of coding and debugging device server code. This utility is :

1. The device server verbose option

Using this facility avoids the usage of the classical “#ifdef DEBUG” style which makes code less readable.

The device server verbose option Each device server supports a verbose option called **-v**. Four verbose levels are defined from 1 to 4. Level 4 is the most talkative one. If you use the -v option without specifying level, level 4 will be assumed.

Since Tango release 3, a Tango Logging Service has been introduced (detailed in chapter [The-Tango-Logging chapter]). This -v option set-up the logging service. If it used, it will automatically add a *console* target to all devices embedded within the device server process. Level 1 and 2 will set the logging level to all devices embedded within the device server to INFO. Level 3 and 4 will set the logging level to all devices embedded within the device server to DEBUG. All messages sent by the API layer are associated to the administration device.

C++ utilities to ease device server coding Some utilities functions have been added in the C++ release to ease Tango device server development. These utilities allow the user to

- Init a C++ vector from a data of one of the Tango DevVarXXXArray data types
- Init a data of one of the Tango::DevVarxxxArray data type from a C++ vector
- Print a data of one of Tango::DevVarxxxArray data type

They mainly used the "«" operator overloading features. The following code lines are an example of usage of these utilities.

```
 1     vector<string> v1;
 2     v1.push_back("one");
 3     v1.push_back("two");
 4     v1.push_back("three");
 5
 6     Tango::DevVarStringArray s;
 7     s << v1;
 8     cout << s << endl;
 9
10     vector<string> v2;
11     v2 << s;
12
13     for (int i = 0;i < v2.size();i++)
14        cout << "vector element = " << v2[i] << endl;
```

Line 1-4 : Create and Init a C++ string vector
Line 7 : Init a Tango::DevVarStringArray data from the C++ vector
Line 8 : Print all the Tango::DevVarStringArray element in one line of code.
Line 11 : Init a second empty C++ string vector with the content of the Tango::DevVarStringArray

Line 13-14 : Print vector element
Warning: Note that due to a strange behavior of the Windows VC++ compiler compared to other compilers, to use these utilities with the Windows VC++ compiler, you must add the line "using namespace tango" at the beginning of your source file.

Avoiding name conflicts

Namespace are used to avoid name conflicts. Each device pattern implementation is defined within its own namespace. The name of the namespace is the device pattern class name. In our example, the namespace name is *StepperMotor.*

The device server main function

A device server main function (or method) always follows the same framework. It exactly implements all the action described in chapter [Server_startup]. Even if it could be always the same, it has not been included in the library because some linkers are perturbed by the presence of two main functions.

```
 1  #include <tango.h>
 2
 3  int main(int argc,char *argv[])
 4  {
 5
 6      Tango::Util *tg;
 7
 8      try
 9      {
10
11          tg = Tango::Util::init(argc,argv);
12
13          tg->server_init();
14
15          cout << "Ready to accept request" << endl;
16          tg->server_run();
17      }
18      catch (bad_alloc)
19      {
20           cout << "Can't allocate memory!!!" << endl;
21           cout << "Exiting" << endl;
22      }
23      catch (CORBA::Exception &e)
24      {
25           Tango::Except::print_exception(e);
26
27           cout << "Received a CORBA::Exception" << endl;
28           cout << "Exiting" << endl;
29      }
30
31      tg->server_cleanup();
32
33      return(0);
34  }
```

Line 1 : Include the **tango.h** file. This file is a master include file. It includes several other files. The list of files included by tango.h can be found in [**?**]

Line 11 : Create the instance of the Tango::Util class (a singleton). Passing argc,argv to this method is mandatory because the device server command line is checked when the Tango::Util object is constructed.

Line 13 : Start all the device pattern creation and initialization with the *server_init()* method

Line 16 : Put the server in a endless waiting loop with the *server_run()* method. In normal case, the process should never returns from this line.

Line 18-22 : Catch all exceptions due to memory allocation error, display a message to the user and exit

Line 23 : Catch all standard TANGO exception which could occur during device pattern creation and initialization

Line 25 : Print exception parameters

Line 27-28 : Print an additional message

Line 31 : Cleanup the server before exiting by calling the *server_cleanup()* method.

The DServer::class_factory method

As described in chapter [DServer_class], C++ device server needs a *class_factory*() method. This method creates all the device pattern implemented in the device server by calling their *init*() method. The following is an example of a *class_factory* method for a device server with one implementation of the device server pattern for stepper motor device.

```
1   #include <tango.h>
2   #include <steppermotorclass.h>
3
4   void Tango::DServer::class_factory()
5   {
6
7      add_class(StepperMotor::StepperMotorClass::init("StepperMotor"));
8
9   }
```

Line 1 : Include the Tango master include file
Line 2 : Include the steppermotorclass class definition file
Line 7 : Create the StepperMotorClass singleton by calling its *init* method and stores the returned pointer into the DServer object. Remember that all classes for the device pattern implementation for the stepper motor class is defined within a namespace called *StepperMotor*.

Writing the StepperMotorClass class

The class declaration file

```
1   #include <tango.h>
2
3   namespace StepperMotor
4   {
5
6   class StepperMotorClass : public Tango::DeviceClass
7   {
8   public:
9       static StepperMotorClass *init(const char *);
10      static StepperMotorClass *instance();
11      ~StepperMotorClass() {_instance = NULL;}
12
13  protected:
14      StepperMotorClass(string &);
15      static StepperMotorClass *_instance;
16      void command_factory();
17      void attribute_factory(vector<Tango::Attr *> &);
18
19  public:
20      void device_factory(const Tango::DevVarStringArray *);
21   };
22
23   } /* End of StepperMotor namespace */
```

Line 1 : Include the Tango master include file
Line 3 : This class is defined within the *StepperMotor* namespace
Line 6 : Class StepperMotorClass inherits from Tango::DeviceClass
Line 9-10 : Definition of the *init* and *instance* methods. These methods are static and can be called even if the object is not already constructed.
Line 11: The destructor
Line 14 : The class constructor. It is protected and can't be called from outside the class. Only the *init* method allows a user to create an instance of this class. See [**?**] to get details about the singleton design pattern.
Line 15 : The instance pointer. It is static in order to set it to NULL during process initialization phase
Line 16 : Definition of the *command_factory* method
Line 17 : Definition of the *attribute_factory* method
Line 20 : Definition of the *device_factory* method

The singleton related methods

```
 1   #include <tango.h>
 2
 3   #include <steppermotor.h>
 4   #include <steppermotorclass.h>
 5
 6   namespace StepperMotor
 7   {
 8
 9   StepperMotorClass *StepperMotorClass::_instance = NULL;
10
11   StepperMotorClass::StepperMotorClass(string &s):
12   Tango::DeviceClass(s)
13   {
14       INFO_STREAM << "Entering StepperMotorClass constructor" << endl;
15
16       INFO_STREAM << "Leaving StepperMotorClass constructor" << endl;
17   }
18
19
20   StepperMotorClass *StepperMotorClass::init(const char *name)
21   {
22       if (_instance == NULL)
23       {
24             try
25             {
26                  string s(name);
27                  _instance = new StepperMotorClass(s);
28             }
29             catch (bad_alloc)
30              {
31                   throw;
32              }
33        }
34        return _instance;
35   }
36
37   StepperMotorClass *StepperMotorClass::instance()
38   {
39        if (_instance == NULL)
40        {
41              cerr << "Class is not initialised !!" << endl;
42              exit(-1);
43        }
44        return _instance;
45   }
```

Line 1-4 : include files: the Tango master include file (tango.h), the StepperMotorClass class definition file (steppermotorclass.h) and the StepperMotor class definition file (steppermotor.h)

Line 6 : Open the *StepperMotor* namespace.

Line 9 : Initialize the static _instance field of the StepperMotorClass class to NULL

Line 11-18 : The class constructor. It takes an input parameter which is the controlled device class name. This parameter is passed to the constructor of the DeviceClass class. Otherwise, the constructor does nothing except printing a message

Line 20-35 : The *init* method. This method needs an input parameter which is the controlled device class name (StepperMotor in this case). This method checks is the instance is already constructed by testing the _instance data member. If the instance is not constructed, it creates one. If the instance is already constructed, the method simply returns a pointer to it.

Line 37-45 : The *instance* method. This method is very similar to the *init* method except that if the instance is not already constructed. the method print a message and abort the process.

As you can understand, it is not possible to construct more than one instance of the StepperMotorClass (it is a singleton) and the *init* method must be called prior to any other method.

The command_factory method Within our example, the stepper motor device supports two commands which are called DevReadPosition and DevReadDirection. These two command takes a Tango::DevLong argument as input and output parameter. The first command is created using the inheritance model and the second command is created using the template command model.

```
1    void StepperMotorClass::command_factory()
2    {
3            command_list.push_back(new DevReadPositionCmd("DevReadPositio
4                                                                    Tango::DEV_LONG,
5                                                                    Tango::DEV_LONG,
6                                                                    "Motor number (
7                                                                    "Motor position'
```

```
 8
 9            command_list.push_back(
10                new TemplCommandInOut<Tango::DevLong,Tango::DevLong>
11                     ((const char *)"DevReadDirection",
12                      static_cast<Tango::Lg_CmdMethPtr_Lg>
13                              (&StepperMotor::dev_read_direction),
14                      static_cast<Tango::StateMethPtr>
15                              (&StepperMotor::direct_cmd_allowed))
16                                    );
17    }
```

Line 4 : Creation of one instance of the DevReadPositionCmd class. The class is created with five arguments which are the command name, the command type code for its input and output parameters and two strings which are the command input and output parameters description. The pointer returned by the new C++ keyword is added to the vector of available command.

Line 10-14 : Creation of the object used for the DevReadDirection command. This command has one input and output parameter. Therefore the created object is an instance of the TemplCommandInOut class. This class is a C++ template class. The first template parameter is the command input parameter type, the second template parameter is the command output parameter type. The second TemplCommandInOut class constructor parameter (set at line 13) is a pointer to the method to be executed when the command is requested. A casting is necessary to store this pointer as a pointer to a method of the DeviceImpl class[10]. The third TemplCommandInOut class constructor parameter (set at line 15) is a pointer to the method to be executed to check if the command is allowed. This is necessary only if the default behavior (command always allowed) does not fulfill the needs. A casting is necessary to store this pointer as a pointer to a method of the DeviceImpl class. When a command is created using the template command method, the input and output parameters type are determined from the template C++ class parameters.

The device_factory method The *device_factory* method has one input parameter. It is a pointer to Tango::DevVarStringArray data which is the device name list for this class and the instance of the device server process. This list is fetch from the Tango database.

```
void StepperMotorClass::device_factory(const Tango::_DevVarStringArray
 {

     for (long i = 0;i < devlist_ptr->length();i++)
     {
          DEBUG_STREAM << "Device name : " << (*devlist_ptr)[i] << endl

          device_list.push_back(new StepperMotor(this,(*devlist_ptr)[i]
          if (Tango::Util::_UseDb == true)
               export_device(device_list.back());
          else
               export_device(device_list.back(),(*devlist_ptr[i]));
     }
14   }
```

Line 4 : A loop for each device

Line 8 : Create the device object using a StepperMotor class constructor which needs two arguments. These two arguments are a pointer to the StepperMotorClass instance and the device name. The pointer to the constructed object is then added to the device list vector

Line 10-13 : Export device to the outside world using the *export_device* method of the DeviceClass class.

The attribute_factory method The rule of this method is to fulfill a vector of pointer to attributes. A reference to this vector is passed as argument to this method.

```
 1   void StepperMotorClass::attribute_factory(vector<Tango::Attr *> &att_li
 2   {
 3       att_list.push_back(new PositionAttr());
 4
 5       Tango::UserDefaultAttrProp def_prop;
 6       def_prop.set_label("Set the motor position");
 7       def_prop.set_format("scientific;setprecision(4)");
 8       Tango::Attr *at = new SetPositionAttr();
 9       at->set_default_properties(def_prop);
10       att_list.push_back(at);
11
12       att_list.push_back(new DirectcionAttr());
13   }
```

Line 3 : Create the PositionAttr class and store the pointer to this object into the attribute pointer vector.

Line 5-7 : Create a Tango::UserDefaultAttrProp instance and set the label and format properties default values in this object

Line 8 : Create the SetPositionAttr attribute.

Line 9 : Set attribute user default value with the *set_default_properties()* method of the Tango::Attr class.

Line 10 : Store the pointer to this object into the attribute pointer vector.

Line 12 : Create the DirectionAttr class and store the pointer to this object into the attribute pointer vector.

Please, note that in some rare case, it is necessary to add attribute to this list during the device server life cycle. This *attribute_factory()* method is called once during device server start-up. A method *add_attribute()* of the DeviceImpl class allows the user to add a new attribute to the attribute list outside of this *attribute_factory()* method. See [**?**] for more information on this method.

The DevReadPositionCmd class

The class declaration file

```
#include <tango.h>

namespace StepperMotor
```

```
 4  {
 5
 6  class DevReadPositionCmd : public Tango::Command
 7  {
 8  public:
 9      DevReadPositionCmd(const char *,Tango::CmdArgType,
10                             Tango::CmdArgType,
11                             const char *,const char *);
12      ~DevReadPositionCmd() {};
13
14      virtual bool is_allowed (Tango::DeviceImpl *, const CORBA::Any &);
15      virtual CORBA::Any *execute (Tango::DeviceImpl *, const CORBA::Any
16  };
17
18  } /* End of StepperMotor namespace */
```

Line 1 : Include the tango master include file
Line 3 : Open the *StepperMotor* namespace.
Line 6 : The DevReadPositionCmd class inherits from the Tango::Command class
Line 9 : The constructor
Line 12 : The destructor
Line 14 : The definition of the *is_allowed* method. This method is not necessary if the default behavior implemented by the default *is_allowed* method fulfill the requirements. The default behavior is to always allows the command execution (always return true).
Line 15: The definition of the *execute* method

The class constructor The class constructor does nothing. It simply invoke the Command constructor by passing it its five arguments which are:

1. The command name
2. The command input type code
3. The command output type code
4. The command input parameter description
5. The command output parameter description

With this 5 parameters command class constructor, the command display level is not specified. Therefore it is set to its default value (OPERATOR). If the command does not have input or output parameter, it is not possible to use the Command class constructor defined with five parameters. In this case, the command constructor execute the Command class constructor with three elements (class name, input type, output type) and set the input or output parameter description fields with the *set_in_type_desc* or *set_out_type_desc* Command class methods. To set the command display level, it is possible to use a 6 parameters constructor or it is also possible to set it in the constructor code with the *set_disp_level* method. Many Command class constructors are defined. See :raw-latex:‘cite{TANGO_ref_man}‘for a complete list.

system-message

WARNING/2 in `tango.rst`, line 7212

Inline interpreted text or phrase reference start-string without end-string.

The is_allowed method In our example, the DevReadPosition command is allowed only if the device is in the ON state. This method receives two argument which are a pointer to the device object on which the command must be executed and a reference to the command input Any object. This method returns a boolean which must be set to true if the command is allowed. If this boolean is set to false, the DeviceClass *command_handle*r method will automatically send an exception to the caller.

```
1   bool DevReadPositionCmd::is_allowed(Tango::DeviceImpl *device,
2                                        const CORBA::Any &in_any)
3   {
4        if (device->get_state() == Tango::ON)
5             return true;
6        else
7             return false;
8   }
```

Line 4 : Call the *get_state* method of the DeviceImpl class which simply returns the device state

Line 5 : Authorize command if the device state is ON

Line 7 : Refuse command execution in all other cases.

The execute method This method receives two arguments which are a pointer to the device object on which the command must be executed and a reference to the command input Any object. This method returns a pointer to an any object which must be initialized with the data to be returned to the caller.

```
1   CORBA::Any *DevReadPositionCmd::execute(
2                                 Tango::DeviceImpl *device,
3                                 const CORBA::Any &in_any)
4   {
5        INFO_STREAM << "DevReadPositionCmd::execute(): arrived" << endl;
6        Tango::DevLong motor;
7
8        extract(in_any,motor);
9        return insert(
10          (static_cast<StepperMotor *>(device))->dev_read_position(motor
11  }
```

Line 8 : Extract incoming data from the input any object using a Command class *extract* helper method. If the type of the data in the Any object is not a Tango::DevLong, the *extract* method will throw an exception to the client.

Line 9 : Call the stepper motor object method which execute the DevReadPosition command and insert the returned value into an allocated Any object. The Any object allocation is done by the *insert* method which return a pointer to this Any.

The PositionAttr class

The class declaration file

```
 1  #include <tango.h>
 2  #include <steppermotor.h>
 3
 4  namespace StepperMotor
 5  {
 6
 7
 8  class PositionAttr: public Tango::Attr
 9  {
10  public:
11      PositionAttr():Attr("Position",
12                          Tango::DEV_LONG,
13                          Tango::READ_WITH_WRITE,
14                          "SetPosition") {};
15      ~PositionAttr() {};
16
17      virtual void read(Tango::DeviceImpl *dev,Tango::Attribute &att)
18      {(static_cast<StepperMotor *>(dev))->read_Position(att);}
19      virtual bool is_allowed(Tango::DeviceImpl *dev,Tango::AttReqType t
20      {return (static_cast<StepperMotor *>(dev))->is_Position_allowed(ty
21  };
22
23  } /* End of StepperMotor namespace */
24
25  #endif // _STEPPERMOTORCLASS_H
```

Line 1-2 : Include the tango master include file and the steppermotor class definition include file

Line 4 : Open the *StepperMotor* namespace.

Line 8 : The PosiitionAttr class inherits from the Tango::Attr class

Line 11-14 : The constructor with 4 arguments

Line 15 : The destructor

Line 17 : The definition of the *read* method. This method forwards the call to a StepperMotor class method called *read_Position()*

Line 19 : The definition of the *is_allowed* method. This method is not necessary if the default behaviour implemented by the default *is_allowed* method fulfills the requirements. The default behaviour is to always allows the attribute reading (always return true). This method forwards the call to a StepperMotor class method called *is_Position_allowed()*

The class constructor The class constructor does nothing. It simply invoke the Attr constructor by passing it its four arguments which are:

1. The attribute name
2. The attribute data type code
3. The attribute writable type code

4. The name of the associated write attribute

With this 4 parameters Attr class constructor, the attribute display level is not specified. Therefore it is set to its default value (OPERATOR). To set the attribute display level, it is possible to use in the constructor code the *set_disp_level* method. Many Attr class constructors are defined. See :raw-latex:‘cite{TANGO_ref_man}‘for a complete list.

system-message
WARNING/2 in `tango.rst`, line 7358
Inline interpreted text or phrase reference start-string without end-string.

This Position attribute is a scalar attribute. For spectrum attribute, instead of inheriting from the Attr class, the class must inherits from the SpectrumAttr class. Many SpectrumAttr class constructors are defined. See :raw-latex:‘cite{TANGO_ref_man}‘for a complete list.

system-message
WARNING/2 in `tango.rst`, line 7365
Inline interpreted text or phrase reference start-string without end-string.

For Image attribute, instead of inheriting from the Attr class, the class must inherits from the ImageAttr class. Many ImageAttr class constructors are defined. See :raw-latex:‘cite{TANGO_ref_man}‘for a complete list.

system-message
WARNING/2 in `tango.rst`, line 7370
Inline interpreted text or phrase reference start-string without end-string.

The is_allowed method This method receives two argument which are a pointer to the device object to which the attribute belongs to and the type of request (read or write). In the PositionAttr class, this method simply forwards the request to a method of the StepperMotor class called *is_Position_allowed()* passing the request type to this method. This method returns a boolean which must be set to true if the attribute is allowed. If this boolean is set to false, the DeviceImpl read_attribute method will automatically send an exception to the caller.

The read method This method receives two arguments which are a pointer to the device object to which the attribute belongs to and a reference to the corresponding attribute object. This method forwards the request to a StepperMotor class called *read_Position()* passing it the reference on the attribute object.

The StepperMotor class

The class declaration file

```
#include <tango.h>

#define AGSM_MAX_MOTORS 8 // maximum number of motors per device

namespace StepperMotor
{

class StepperMotor: public TANGO_BASE_CLASS
{
public :
   StepperMotor(Tango::DeviceClass *,string &);
   StepperMotor(Tango::DeviceClass *,const char *);
   StepperMotor(Tango::DeviceClass *,const char *,const char *);
   ~StepperMotor() {};

   DevLong dev_read_position(DevLong);
   DevLong dev_read_direction(DevLong);
   bool direct_cmd_allowed(const CORBA::Any &);

   virtual Tango::DevState dev_state();
   virtual Tango::ConstDevString dev_status();

   virtual void always_executed_hook();

   virtual void read_attr_hardware(vector<long> &attr_list);
   virtual void write_attr_hardware(vector<long> &attr_list);

   void read_position(Tango::Attribute &);
   bool is_Position_allowed(Tango::AttReqType req);
   void write_SetPosition(Tango::WAttribute &);
   void read_Direction(Tango::Attribute &);

   virtual void init_device();
   virtual void delete_device();

   void get_device_properties();

protected :
   long axis[AGSM_MAX_MOTORS];
   DevLong position[AGSM_MAX_MOTORS];
   DevLong direction[AGSM_MAX_MOTORS];
   long state[AGSM_MAX_MOTORS];

   Tango::DevLong *attr_Position_read;
   Tango::DevLong *attr_Direction_read;
   Tango::DevLong attr_SetPosition_write;

   Tango::DevLong min;
   Tango::DevLong max;

51      Tango::DevLong *ptr;
52  };
53
54  } /* End of StepperMotor namespace */
```

Line 1 : Include the Tango master include file
Line 5 : Open the *StepperMotor* namespace.
Line 8 : The StepperMotor class inherits from a Tango base class
Line 11-13 : Three different object constructors
Line 14 : The destructor which calls the *delete_device()* method
Line 16 : The method to be called for the execution of the DevReadPosition command. This method must be declared as virtual if it is needed to redefine it in a class inheriting from StepperMotor. See chapter [Inheriting] for more details about inheriting.
Line 17 : The method to be called for the execution of the DevReadDirection command
Line 18 : The method called to check if the execution of the DevReadDirection command is allowed. This method is necessary because the DevReadDirection command is created using the template command method and the default behavior is not acceptable
Line 20 : Redefinition of the *dev_state*. This method is used by the State command
Line 21 : Redefinition of the *dev_status*. This method is used by the Status command
Line 23 : Redefinition of the *always_executed_hook* method. This method is the place to code mandatory action which must be executed prior to any command.
Line 25-31 : Attribute related methods
Line 32 : Definition of the *init_device* method.
Line 33 : Definition of the *delete_device* method
Line 35 : Definition of the *get_device_properties* method
Line 38-50 : Data members.
Line 43-44 : Pointers to data for readable attributes Position and Direction
Line 45 : Data for the SetPosition attribute
Line 47-48 : Data members for the two device properties

The constructors Three constructors are defined here. It is not mandatory to defined three constructors. But at least one is mandatory. The three constructors take a pointer to the StepperMotorClass instance as first parameter[11]. The second parameter is the device name as a C++ string or as a classical pointer to char array. The third parameter necessary only for the third form of constructor is the device description string passed as a classical pointer to a char array.

```
1   #include <tango.h>
2   #include <steppermotor.h>
3
4   namespace StepperMotor
5   {
6
7   StepperMotor::StepperMotor(Tango::DeviceClass *cl,string &s)
8   :TANGO_BASE_CLASS(cl,s.c_str())
9   {
```

```
10      init_device();
11   }
12
13   StepperMotor::StepperMotor(Tango::DeviceClass *cl,const char *s)
14   :TANGO_BASE_CLASS(cl,s)
15   {
16      init_device();
17   }
18
19   StepperMotor::StepperMotor(Tango::DeviceClass *cl,const char *s,const c
20   :TANGO_BASE_CLASS(cl,s,d)
21   {
22      init_device();
23   }
24
25   void StepperMotor::init_device()
26   {
27      cout << "StepperMotor::StepperMotor() create " << device_name << enc
28
29      long i;
30
31      for (i=0; i< AGSM_MAX_MOTORS; i++)
32      {
33         axis[i] = 0;
34         position[i] = 0;
35         direction[i] = 0;
36      }
37
38      ptr = new Tango::DevLong[10];
39
40      get_device_properties();
41   }
42
43   void StepperMotor::delete_device()
44   {
45      delete [] ptr;
46   }
```

Line 1-2 : Include the Tango master include file (tango.h) and the StepperMotor class definition file (steppermotor.h)

Line 4 : Open the *StepperMotor* namespace

Line 7-11 : The first form of the class constructor. It execute the Tango base class constructor with the two parameters. Note that the device name passed to this constructor as a C++ string is passed to the Tango::DeviceImpl constructor as a classical C string. Then the *init_device* method is executed.

Line 13-17 : The second form of the class constructor. It execute the Tango base class constructor with its two parameters. Then the *init_device* method is executed.

Line 19-23: The third form of constructor. Again, it execute the Tango base class constructor with its three parameters. Then the *init_device* method is executed.

Line 25-41 : The *init_device* method. All the device data initialization is done in this method. The device properties are also retrieved from database with a call to the *get_device_properties* method at line 40. The device data member called *ptr* is initialized with allocated memory at line 38. It is not needed to have this pointer, it has been added only for educational purpose.

Line 43-46 : The *delete_device* method. The rule of this method is to free memory allocated in the *init_device* method. In our case , only the device data member *ptr* is allocated in the *init_device* method. Therefore, its memory is freed at line 45. This method is called by the automatically added Init command before it calls the *init_device* method. It is also called by the device destructor.

The methods used for the DevReadDirection command The DevReadDirection command is created using the template command method. Therefore, there is no specific class needed for this command but only one object of the TemplCommandInOut class. This command needs two methods which are the *dev_read_direction* method and the *direct_cmd_allowed* method. The *direct_cmd_allowed* method defines here implements exactly the same behavior than the default one. This method has been used only for pedagogic issue. The *dev_read_direction* method will be executed by the *execute* method of the TemplCommandInOut class. The *direct_cmd_allowed* method will be executed by the *is_allowed* method of the TemplCommandInOut class.

```
 1   DevLong StepperMotor::dev_read_direction(DevLong axis)
 2    {
 3       if (axis < 0 || axis > AGSM_MAX_MOTORS)
 4       {
 5           WARNING_STREAM << "Steppermotor::dev_read_direction(): axis out
 6           WARNING_STREAM << endl;
 7           TangoSys_OMemStream o;
 8
 9           o << "Axis number " << axis << " out of range" << ends;
10           throw_exception("StepperMotor_OutOfRange",
11                           o.str(),
12                           "StepperMotor::dev_read_direction");
13        }
14
15        return direction[axis];
16    }
17
18
19    bool StepperMotor::direct_cmd_allowed(const CORBA::Any &in_data)
20    {
21        INFO_STREAM << "In direct_cmd_allowed() method" << endl;
22
23        return true;
24    }
```

Line 1-16 : The *dev_read_direction* method

Line 5-12 : Throw exception to client if the received axis number is out of range

Line 7 : A TangoSys_OMemStream is used as stream. The TangoSys_OMemStream has been defined in improve portability across platform. For Unix like operating system, it is a ostrtream type. For operating system with a full implementation of the standard library, it is a ostringstream type.

Line 19-24 : The *direct_cmd_allowed* method. The command input data is passed to this method in case of it is needed to take the decision. This data is still packed into the CORBA Any object.

The methods used for the Position attribute

To enable reading of attributes, the StepperMotor class must re-define two or three methods called *read_attr_hardware(), read_<Attribute_name>()* and if necessary a method called

is_<Attribute_name>_allowed(). The aim of the first one is to read the hardware. It will be called only once at the beginning of each read_attribute CORBA call. The second method aim is to build the exact data for the wanted attribute and to store this value into the Attribute object. Special care has been taken in order to minimize the number of data copy and allocation. The data passed to the Attribute object as attribute value is passed using pointers. It must be allocated by the method[12] and the Attribute object will not free this memory. Data members called attr_<Attribute_name>_read are foreseen for this usage. The *read_attr_hardware()* method receives a vector of long which are indexes into the main attributes vector of the attributes to be read. The *read_Position()* method receives a reference to the Attribute object. The third method (*is_Position_allowed()*) aim is to allow or dis-allow, the attribute reading. In some cases, some attributes can be read only if some conditions are met. If this method returns true, the *read_<Attribute_name>()* method will be called. Otherwise, an error will be generated for the attribute. This method receives one argument which is an emumeration describing the attribute request type (read or write). In our example, the reading of the Position attribute is allowed only if the device state is ON.

```
 1  void StepperMotor::read_attr_hardware(vector<long> &attr_list)
 2  {
 3     INFO_STREAM << "In read_attr_hardware for " << attr_list.size();
 4     INFO_STREAM << " attribute(s)" << endl;
 5
 6     for (long i = 0;i < attr_list.size();i++)
 7     {
 8        string attr_name;
 9        attr_name = dev_attr->get_attr_by_ind(attr_list[i]).get_name();
10
11        if (attr_name == "Position")
12        {
13           attr_Position_read = &(position[0]);
14        }
15        else if (attr_name == "Direction")
16        {
17           attr_Direction_read = &(direction[0]);
18        }
19     }
20  }
21
22  void read_Position(Tango::Attribute &att)
```

```
23  {
24     att.set_value(attr_Position_read);
25  }
26
27  bool is_Position_allowed(Tango::AttReqType req)
28  {
29     if (req == Tango::WRITE_REQ)
30        return false;
31     else
32     {
33        if (get_state() == Tango::ON)
34           return true;
35        else
36           return false;
37     }
38  }
```

Line 6 : A loop on each attribute to be read
Line 9 : Get attribute name
Line 11 : Test on attribute name
Line 13 : Read hardware (pretty simple in our case)
Line 24 : Set attribute value in Attribute object using the *set_value()* method. This method will also initializes the attribute quality factor to Tango::ATTR_VALID if no alarm level are defined and will set the attribute returned date. It is also possible to use a method called *set_value_date_quality()* which allows the user to set the attribute quality factor as well as the attribute date.
Line 33 : Test on device state

The methods used for the SetPosition attribute To enable writing of attributes, the StepperMotor class must re-define one or two methods called *write_<Attribute_name>()* and if necessary a method called *is_<Attribute_name>_allowed()*. The aim of the first one is to write the hardware. The *write_Position()* method receives a reference to the WAttribute object. The value to write is in this WAttribute object. The third method (*is_Position_allowed()*) aim is to allow or dis-allow, the attribute writing. In some cases, some attributes can be write only if some conditions are met. If this method returns true, the *write_<Attribute_name>()* method will be called. Otherwise, an error will be generated for the attribute. This method receives one argument which is an emumeration describing the attribute request type (read or write). For read/write attribute, this method is the same for reading and writing. The input argument value makes the difference.

For our example, it is always possible to write the SetPosition attribute. Therefore, the StepperMotor class only defines a *write_SetPosition()* method.

```
void StepperMotor::write_SetPosition(Tango::WAttribute &att)
{
   att.get_write_value(sttr_SetPosition_write);

   DEBUG_STREAM << "Attribute SetPosition value = ";
   DEBUG_STREAM << attr_SetPosition_write << endl;
```

```
 7
 8     position[0] = attr_SetPosition_write;
 9  }
10
11  void StepperMotor::write_attr_hardware(vector<long> &attr_list)
12  {
13
14  }
```

Line 3 : Retrieve new attribute value
Line 5-6 : Send some messages using Tango Logging system
Line 8 : Set the hardware (pretty simple in our case)

Line 11 - 14: The write_attr_hardware() method.
In our case, we don't have to do anything in the *write_attr_hardware()* method. It is coded here just for educational purpose. When its not needed, this method has a default implementation in the Tango base class and it is not mandatory to declare and defin it in your own Tango class

Retrieving device properties Retrieving properties is fairly simple with the use of the database object. Each Tango device is an aggregate with a DbDevice object (see figure [Dvice pattern figure]). This has been grouped in a method called *get_device_properties*(). The classes and methods of the Dbxxx objects are described in the Tango API documentation.

```
 1  void DocDs::get_device_property()
 2  {
 3     Tango::DbData   data;
 4     data.push_back(DbDatum("Max"));
 5     data.push_back(DbDatum("Min"));
 6
 7     get_db_device()->get_property(data);
 8
 9     if (data[0].is_empty()==false)
10        data[0]  >>  max;
11     if (data[1].is_empty()==false)
12        data[1]  >>  min;
13  }
```

Line 4-5 : Two DbDatum (one per property) are stored into a DbData object
Line 7 : Call the database to retrieve properties value
Line 9-10 : If the Max property is defined in the database, extract its value from the DbDatum object and store it in a device data member
Line 11-12 : If the Min property is defined in the database, extract its value from the DbDatum object and store it in a device data member

The remaining methods The remaining methods are the *dev_state, dev_status, always_executed_hook*, *dev_read_position* and *read_Direction()* methods. The *dev_state* method parameters are fixed. It does not receive any input parameter and must return a Tango_DevState data type. The *dev_status* parameters are also fixed. It does not receive any input parameter and must return a Tango string. The *always_executed_hook* receives nothing and return nothing. The *dev_read_position* method input parameter is the motor number as a long and the returned parameter is the motor position also as a long data type. The *read_Direction()* method is the method for reading the Direction attribute.

```
 1  DevLong StepperMotor::dev_read_position(DevLong axis)
 2  {
 3
 4     if (axis < 0 || axis > AGSM_MAX_MOTORS)
 5     {
 6          WARNING_STREAM << "Steppermotor::dev_read_position(): axis out
 7          WARNING_STREAM << endl;
 8
 9          TangoSys_OMemStream o;
10
11          o << "Axis number " << axis << " out of range" << ends;
12          throw_exception("StepperMotor_OutOfRange",
13                          o.str(),
14                          "StepperMotor::dev_read_position");
15     }
16
17     return position[axis];
18  }
19
20  void always_executed_hook()
21  {
22     INFO_STREAM << "In the always_executed_hook method << endl;
23  }
24
25  Tango_DevState StepperMotor::dev_state()
26  {
27     INFO_STREAM << "In StepperMotor state command" << endl;
28     return DeviceImpl::dev_state();
29  }
30
31  Tango_DevString StepperMotor::dev_status()
32  {
33     INFO_STREAM << "In StepperMotor status command" << endl;
34     return DeviceImpl::dev_status();
35  }
36
37  void read_Direction(Tango::Attribute att)
38  {
39     att.set_value(attr_Direction_read);
40  }
```

Line 1-18 : The *dev_read_position* method

Line 6-14 : Throw exception to client if the received axis number is out of range

Line 9 : A TangoSys_OMemStream is used as stream. The TangoSys_OMemStream has been defined in improve portability across platform. For Unix like operating system, it is a ostrtream type. For operating system with a full implementation of the standard library, it is a ostringstream type.

Line 20-23 : The *always_executed_hook* method. It does nothing. It has been included here only as pedagogic usage.

Line 25-29 : The *dev_state* method. It does exactly what the default *dev_state* does. It has been included here only as pedagogic usage

Line 31-35 : The *dev_status* method. It does exactly what the default *dev_statu*s does. It has been included here only as pedagogic usage

Line 37-40 : The *read_Direction* method. Simply set the Attribute object internal value

Device server under Windows

Two kind of programs are available under Windows. These kinds of programs are called console application or Windows application. A console application is started from a MS-DOS window and is very similar to classical UNIX program. A Windows application is most of the time not started from a MS-DOS window and is generally a graphical application without standard input/output. Writing a device server in a console application is straight forward following the rules described in the previous sub-chapters. Writing a device server in a Windows application needs some changes detailed in the following sub-chapters.

The Tango device server graphical interface

Within the Windows operating system, most of the running application has a window user interface. This is also true for the Windows Tango device server. Using or not this interface is up to the device server programmer. The choice is done with an argument to the *server_init()* method of the Tango::Util class. This interface is pretty simple and is based on three windows which are :

- The device server main window
- The device server console window
- The device server help window

The device server main window This window looks like :

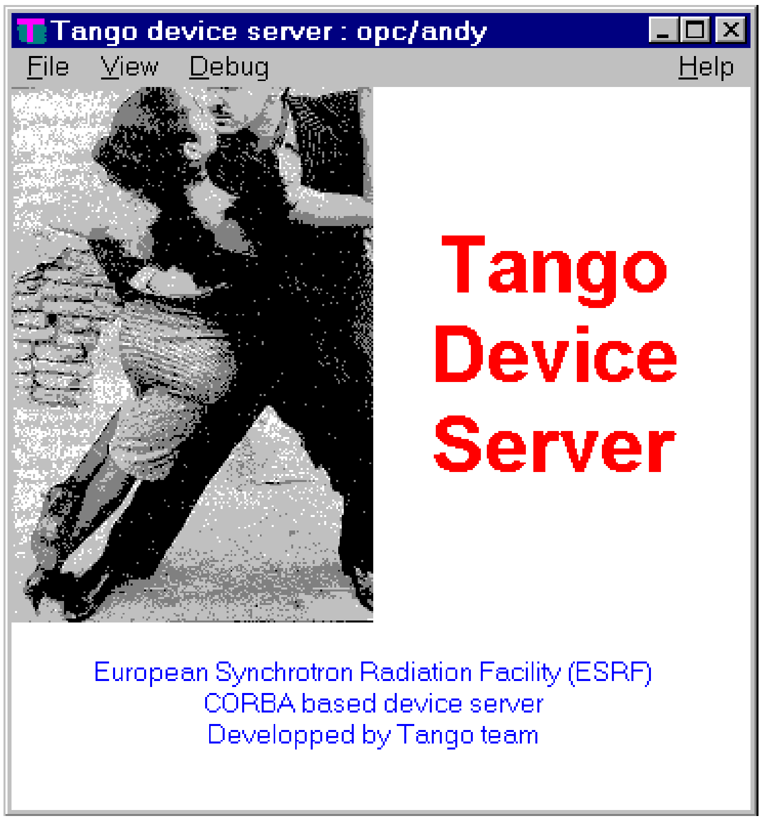
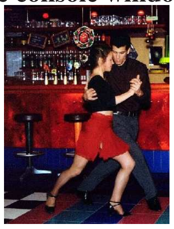

Tango device server : opc/andy
File
View
Debug
Help
Tango
Device
Server
European Synchrotron Radiation Facility (ESRF)
CORBA based device server
Developped by Tango team

Figure 7: Tango device server main window

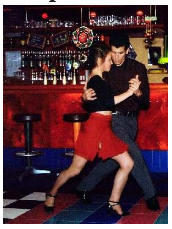
Four menus are available in this window. The File menu allows the user to exit the device server. The View menu allows you to display/hide the device server console window. The Debug menu allows the user to change the server output verbose level. All the outputs goes to the console window even if it is hidden. The Help menu displays the help window. The device server name is displayed in the window title. The text displayed at the bottom of the window has a default value (the one displayed in this window dump) but may be changed by the device server programmer using the *set_main_window_text()* method of the Tango::Util class. If used, this method must be called prior to the call of the *server_init()* method. Refer to [**?**] for a complete description of this method.

The console window This window looks like :



It simply displays all the logging** message when a console target is used in the device server.

The help window This window looks like :



This window displays

- The device server name
- The Tango library release
- The Tango IDL definition release
- The device server release. The device server programmer may set this release number using the *set_server_version()* method of the Tango::Util class. If used, this must be done prior to the call of the *server_init()* method. If the *set_server_version()* method is not used, x.y is displays as version number. Refer to [**?**] for a complete description of this method.

MFC device server

There is no *main* function within a classical MFC program. Most of the time, your application is represented by one instance of a C++ class which inherits from the MFC CWinApp class. This CWinApp class has several methods that you may overload in your application class. For a device server to run correctly, you must overload two methods of the CWinApp class. These methods are the *InitInstance()* and *ExitInstance()* methods. The rule of these methods is obvious following their names.

Remember that if the Tango device server graphical user interface is used, you must link your device server with the Tango windows resource file. This is done by adding the Tango resource file to the Project Settings/Link/Input/Object, library modules window in VC++.

The InitInstance method The code to be added here is the equivalent of the code written in a classical *main()* function. Don't forget to add the *tango.h* file in the list of included files.

```
BOOL FluidsApp::InitInstance()
{
   AfxEnableControlContainer();

// Standard initialization
// If you are not using these features and wish to reduce the size
//  of your final executable, you should remove from the following
//  the specific initialization routines you do not need.

 #ifdef _AFXDLL
   Enable3dControls();            // Call this when using MFC in a sharec
 #else
   Enable3dControlsStatic();     // Call this when linking to MFC static
```

```
14   #endif
15     Tango::Util *tg;
16     try
17     {
18
19         tg = Tango::Util::init(m_hInstance,m_nCmdShow);
20
21         tg->server_init(true);
22
23         tg->server_run();
24
25     }
26     catch (bad_alloc)
27     {
28         MessageBox((HWND)NULL,"Memory error","Command line",MB_ICONSTOP)
29         return(FALSE);
30     }
31     catch (Tango::DevFailed &e)
32     {
33         MessageBox((HWND)NULL,,e.errors[0].desc.in(),"Command line",MB_I
34         return(FALSE);
35     }
36     catch (CORBA::Exception &)
37     {
38         MessageBox((HWND)NULL,"Exception CORBA","Command line",MB_ICONST
39         return(FALSE);
40     }
41
42     m_pMainWnd = new CWnd;
43     m_pMainWnd->Attach(tg->get_ds_main_window());
44
45     return TRUE;
46   }
```

Line 19 : Initialise Tango system. This method also analises the argument used in command line.

Line 21 : Create Tango classes requesting the Tango Windows graphical interface to be used

Line 23 : Start Network listener. Note that under NT, this call returns in the contrary of UNIX like operating system.

Line 26-30 : Display a message box in case of memory allocation error and leave method with a return value set to false in order to stop the process

Line 31-35 : Display a message box in case of error during server initialization phase.

Line 36-40 : Display a message box in case of error other than memory allocation. Leave method with a return value set to false in order to stop the process.

Line 37-38 : Create a MFC main window and attach the Tango graphical interface main window to this MFC window.

The ExitInstance method This method is called when the application is stopped. For Tango device server, its rule is to destroy the Tango::Util singleton if this one has been correctly constructed.

```
 1  int FluidsApp::ExitInstance()
 2  {
 3     bool del = true;
 4
 5     try
 6     {
 7         Tango::Util *tg = Tango::Util::instance();
 8     }
 9     catch(Tango::DevFailed)
10     {
11         del = false;
12     }
13
14     if (del == true)
15         delete (Tango::Util::instance());
16
17     return CWinApp::ExitInstance();
18  }
```

Line 7 : Try to retrieve the Tango::Util singleton. If this one has not been constructed correctly, this call will throw an exception.

Line 9-12 : Catch the exception in case of incomplete Tango::Util singleton construction

Line 14-15 : Delete the Tango::Util singleton. This will unregister the Tango device server from the Tango database.

Line 17 : Execute the *ExitInstance* method of the CWinApp class.

If you don't want to use the Tango device server graphical interface, do not pass any parameter to the *server_init()* method and instead of the code display in lines 37 and 38 in the previous example of the *InitInstance()* method, use your own code to initialize your own application.

Example of how to build a Windows device server MFC based This sub-chapter gives an example of what it is needed to do to build a MFC Windows device server. Rather than being a list of actions to strictly follow, this is some general rules of how using VC++ to build a Tango device server using MFC.

1. Create your device server using Pogo. For a class named MyMotor, the following files will be needed : *class_factory.cpp*, *MyMotorClass.h*, *MyMotorClass.cpp*, *MyMotor.h* and *MyMotor.cpp.*

2. On a Windows computer running VC++, create a new project of type "MFC app Wizard (exe)" using static MFC libs. Ask for a dialog based project without ActiveX controls.

3. Copy the five files generated by Pogo to the Windows computer and add them to your project

4. Remove the dialog window files (xxxDlg.cpp and xxxDlg.h), the Resource include file and the resource script file from your project

5. Add #include <stdafx.h> as first line of the include files list in *class_factory.cpp*, *MyMotorClass.cpp* and *MyMotor.cpp* file. Also add your own directory and the Tango include directory to the project pre-compiler include directories list.

6. Enable RTTI in your project settings (see chapter [Compiling NT])

7. Change your application class:

    1. Add the definition of an *ExitInstance* method in the declaration file. (xxx.h file)
    2. Remove the include of the dialog window file in the xxx.cpp file and add an include of the Tango master include files (tango.h)
    3. Replace the *InitInstance*() method as described in previous sub-chapter. (xx.cpp file)
    4. Add an *ExitInstance()* method as described in previous sub-chapter (xxx.cpp file)

8. Add all the libraries needed to compile a Tango device server (see chapter [Compiling NT]) and the Tango resource file to the linker Object/Libraries modules.

Win32 application

Even if it is more natural to use the C++ structure of the MFC class to write a Tango device server, it is possible to write a device server as a Win32 application. Instead of having a *main()* function as the application entry point, the operating system, provides a *WinMain()* function as the application entry point. Some code must be added to this *WinMain* function in order to support Tango device server. Don't forget to add the *tango.h* file in the list of included files. If you are using the project files generated by Pogo, don't forget to change the linker SUBSYSTEM option to Windows (Under Linker/System in the project properties window).

```
int APIENTRY WinMain(HINSTANCE hInstance,
                     HINSTANCE hPrevInstance,
                     LPSTR     lpCmdLine,
                     int       nCmdShow)
{
   MSG msg;
   Tango::Util *tg;

   try
   {
       tg = Tango::Util::init(hInstance,nCmdShow);

       string txt;
       txt = "Blabla first line\n";
       txt = txt + "Blabla second line\n";
```

```
16            txt = txt + "Blabla third line\n";
17            tg->set_main_window_text(txt);
18            tg->set_server_version("2.2");
19
20            tg->server_init(true);
21
22            tg->server_run();
23
24        }
25        catch (bad_alloc)
26        {
27            MessageBox((HWND)NULL,"Memory error","Command line",MB_ICONSTOP
28            return (FALSE);
29        }
30        catch (Tango::DevFailed &e)
31        {
32            MessageBox((HWND)NULL,e.errors[0].desc.in(),"Command line",MB_I
33            return (FALSE);
34        }
35        catch (CORBA::Exception &)
36        {
37            MessageBox((HWND)NULL,"Exception CORBA","Command line",MB_ICONS
38            return(FALSE);
39        }
40
41        while (GetMessage(&msg, NULL, 0, 0))
42        {
43            TranslateMessage(&msg);
44            DispatchMessage(&msg);
45        }
46
47        delete tg;
48
49        return msg.wParam;
50    }
```

Line 11 : Create the Tango::Util singleton

Line 13-18 : Set parameters for the graphical interface

Line 20 : Initialize Tango device server requesting the display of the graphical interface

Line 22 : Run the device server

Line 25-39 : Display a message box for all the kinds of error during Tango device server initialization phase and exit WinMain function.

Line 41-45 : The Windows message loop

Line 47 : Delete the Tango::Util singleton. This class destructor unregisters the device server from the Tango database.

Remember that if the Tango device server graphical user interface is used, you must add the Tango windows resource file to your project.

If you don't want to use the tango device server graphical user interface, do not use any parameter in the call of the *server_init()* method and do not link your device server with the Tango Windows resource file.

Device server as service

With Windows, if you want to have processes which survive to logoff sequence and/or are automatically started during computer startup sequence, you have to write them as service. It is possible to write Tango device server as service. You need to

1. Write a class which inherits from a pre-written Tango class called NTService. This class must have a *start* method.
2. Write a main function following a predefined skeleton.

The service class It must inherits from the *NTService* class and defines a *start* method. The NTService class must be constructed with one argument which is the device server executable name. The *start* method has three arguments which are the number of arguments passed to the method, the argument list and a reference to an object used to log info in the NT event system. The first two args must be passed to the Tango::Util::init method and the last one is used to log error or info messages. The class definition file looks like

```
 1  #include <tango.h>
 2  #include <ntservice.h>
 3
 4  class MYService: public Tango::NTService
 5  {
 6  public:
 7     MYService(char *);
 8
 9     void start(int,char **,Tango::NTEventLogger *);
10  };
```

Line 1-2 : Some include files
Line 4 : The MYService class inherits from *Tango::NTService* class
Line 7 : Constructor with one parameter

Line 9 : The *start()* method
The class source code looks like

```
#include <myservice.h>
#include <tango.h>

using namespace std;

MYService::MYService(char *exec_name):NTService(exec_name)
{
}

void MYService::start(int argc,char **argv,Tango::NTEventLogger *logge
{
   Tango::Util *tg;
13      try
14      {
15         Tango::Util::_service = true;
16
17         tg = Tango::Util::init(argc,argv);
18
19         tg->server_init();
20
21         tg->server_run();
22      }
23      catch (bad_alloc)
24      {
25         logger->error("Can't allocate memory to store device object");
26      }
27      catch (Tango::DevFailed &e)
28      {
29         logger->error(e.errors[0].desc.in());
30      }
31      catch (CORBA::Exception &)
32      {
33         logger->error("CORBA Exception");
34      }
35   }
```

Line 6-8 : The MYService class constructor code.

Line 15 : Set to true the *_service* static variable of the *Tango::Util* class.

Line 17-21 : Classical Tango device server startup code

Line 23-34 : Exception management. Please, note that within a service. it is not possible to print data on a console. This method receives a reference to a logger object. This object sends all its output to the Windows event system. It is used to send messages when an exception has occurred.

The main function The main function is used to create one instance of the class describing the service, to check the service option and to run the service. The code looks like :

```
1    #include <tango.h>
2    #include <MYService.h>
3
4    using namespace std;
5
6
7    int main(int argc,char *argv[])
8    {
9       MYService service(argv[0]);
10
11      int ret;
12      if ((ret = service.options(argc,argv)) <= 0)
13          return ret;
14
15        service.run(argc,argv);
16
17        return 0;
18    }
```

Line 9 : Create one instance of the MYService class with the executable name as parameter

Line 12 : Check service option with the *options()* method inherited from the NTService class.

Line 15 : Run the service. The *run()* method is inherited from the NTService class. This method will after some NT initialization sequence execute the user *start()* method.

Service options and messages When a Tango device server is written as a Windows service, it supports several new options. These option are linked to Windows service usage.

Before it can be used, a service must be installed. A name and a title is associated to each service. For Tango device server used as service, the service name is build from the executable name followed by the underscore character and the instance name. For example, a device server service executable file named “opc” and started with “fluids” as instance name, will be named “opc_fluids”. The title string is built from the service executable name followed by the sentence “Tango device server” and the instance name between parenthesis. In the previous example, the service title will be “opc Tango device server (fluids)”. Once a service is installed, you can configure it with the “Services” application of the control panel. Services title are displayed by this application and allow the user to select one specific service. Once a service is selected, it is possible to start/stop it and to configure its startup type as manual (with the Services application) or as automatic. When the automatic mode is chosen, the service starts when the computer is started. In this case, the service executable code must resides on the computer local disk.

Tango device server logs message in the Windows event system when the service is started or stopped. You can see these messages with the “Event Viewer” application (Start->Programs->Administrative tools->Event Viewer) and choose the Application events.

The new options are -i, -s, -u, -h and -d.

- -i : Install the service
- -s : Install the service and choose the automatic startup mode
- -u : Un-install the service
- -dbg : Run in console mode to debug service. The service must have been installed prior to used it. The classical -v device server option can be used with the -d option.

On the command line, all these options must be used after the device server instance name (“opc fluids -i” to install the service, “opc fluids -u” to un-install the service, “opc fluids -v -d” to debug the service)

Tango device server using MFC as Windows service If your Tango device server uses MFC and must be written as a Windows NT service, follow these rules :

- Don't forget to add the *stdafx.h* file as the first file included in all the source files making the project.
- Comment out the definition of VC_EXTRALEAN in the *stdafx.h* file.
- Change the pre-processor definitions, replace _WINDOWS by _CONSOLE
- Add the /SUBSYSTEM:CONSOLE option in the linker options window of the project settings.
- Add a call to initialize the MFC (*AfxWinInit()*) in the service main function

```
 1  int main(int argc,char *argv[])
 2  {
 3     if (!AfxWinInit(::GetModuleHandle(NULL),NULL,::GetCommandLine(),0))
 4     {
 5        cerr << "Can't initialise MFC !" << endl;
 6        return -1;
 7     }
 8
 9     service serv(argv[0]);
10
11     int ret;
12     if ((ret = serv.options(argc,argv)) <= 0)
13          return ret;
14
15     serv.run(argc,argv);
16
17     return 0;
18  }
```

Line 3 : The MFC classes are initialized with the *AfxWinInit()* function call.

Compiling, linking and executing a TANGO device server process

Compiling and linking a C++ device server

On UNIX like operating system

Supported development tools The supported compiler for Linux is **gcc** release 3.3 and above. Please, note that to debug a Tango device server running under Linux, **gdb** release 7 and above is needed in order to correctly handle threads.

Compiling TANGO for C++ uses omniORB (release 4) as underlying CORBA Object Request Broker [**?**] and starting with Tango 8, the ZMQ library. To compile a TANGO device server, your include search path must be set to :

- The omniORB include directory
- The ZMQ include directory
- The Tango include directory
- Your development directory

Linking To build a running device server process, you need to link your code with several libraries. Nine of them are always the same whatever the operating system used is. These nine libraries are:

- The Tango libraries (called **libtango** and **liblog4tango**)
- Three omniORB package libraries (called **libomniORB4**, **libomniDynamic4** and **libCOS4)**
- The omniORB threading library (called **libomnithread**)
- The ZMQ library (callled **libzmq**)

On top of that, you need additional libraries depending on the operating system :

- For Linux, add the posix thread library (**libpthread**)

The following table summarizes the necessary options to compile a Tango C++ device server. Please, note that starting with Tango 8 and for gcc release 4.3 and later, some C++11 code has been used. This requires the compiler option -std=c++0x. Obviously, the options -I and -L must be updated to reflect your file system organization.

|c|c|m70mm| Operating system & Compiling option & Linking option Linux gcc &
-D_REENTRANT -std=c++0x -I.. & -L.. -ltango -llog4tango

system-message
WARNING/2 in `tango.rst`, line 8582
Definition list ends without a blank line; unexpected unindent. backrefs:

-lomniORB4 -lomniDynamic4 -lCOS4 -lomnithread -lzmq -lpthread
The following is an example of a Makefile for Linux. Obviously, all the paths are set to the ESRF file system structure.

```
#
# Makefile to generate a Tango server
#

CC = c++
BIN_DIR = ubuntu1104
TANGO_HOME = /segfs/tango

INCLUDE_DIRS = -I $(TANGO_HOME)/include/$(BIN_DIR) -I .


LIB_DIRS = -L $(TANGO_HOME)/lib/$(BIN_DIR)


CXXFLAGS = -D_REENTRANT -std=c++0x $(INCLUDE_DIRS)
LFLAGS = $(LIB_DIRS) -ltango \
                     -llog4tango \
                     -lomniORB4 \
                     -lomniDynamic4 \
                     -lCOS4 \
21                       -lomnithread \
22                       -lzmq \
23                       -lpthread
24
25
26  SVC_OBJS = main.o \
27             ClassFactory.o \
28             SteppermotorClass.o \
29             Steppermotor.o \
30             SteppermotorStateMachine.o
31
32
33  .SUFFIXES: .o .cpp
34  .cpp.o:
35      $(CC) $(CXXFLAGS) -c $<
36
37
38  all: StepperMotor
39
40  StepperMotor: $(SVC_OBJS)
41      $(CC) $(SVC_OBJS) -o $(BIN_DIR)/StepperMotor $(LFLAGS)
42
43  clean:
44      rm -f *.o core
```

Line 5-7 : Define Makefile macros
Line 9-10 : Set the include file search path
Line 12 : Set the linker library search path
Line 15 : The compiler option setting
Line 16-23 : The linker option setting
Line 26-30 : All the object files needed to build the executable
Line 33-35 : Define rules to generate object files
Line 38 : Define a "all" dependency
Line 40-41 : How to generate the StepperMotor device server executable
Line 43-44 : Define a "clean" dependency

On Windows using Visual Studio Supported Windows compiler for Tango is Visual Studio 2008 (VC 9), Visual Studio 2010 (VC10) and Visual Studio 2013 (VC12). Most problems in building a Windows device server revolve around the /M compiler switch family. This switch family controls which run-time library names are embedded in the object files, and consequently which libraries are used during linking. Attempt to mix and match compiler settings and libraries can cause link error and even if successful, may produce undefined run-time behavior.

Selecting the correct /M switch in Visual Studio is done through a dialog box. To open this dialog box, click on the "Project" menu (once the correct project is selected in the Solution Explorer window) and select the "Properties" option. To change the compiler switch open the "C/C++" tree and select "Code Generation". The following options are supported.

- Multithreaded = /MT

- Multithreaded DLL = /MD
- Debug Multithreaded = /MTd
- Debug Multithreaded DLL = /MDd

Compiling a file with a value of the /M switch family will impose at link phase the use of libraries also compiled with the same value of the /M switch family. If you compiled your source code with the /MT option (Multithreaded), you must link it with libraries also compiled with the /MT option.

On both 32 or 64 bits computer, omniORB and TANGO relies on the preprocessor identifier **WIN32** being defined in order to configure itself. If you build an application using static libraries (option /MT or /MTd), you must add **_WINSTATIC** to the list of the preprocessor identifiers. If you build an application using DLL (option /MD or /MDd), you must add **LOG4TANGO_HAS_DLL** and **TANGO_HAS_DLL** to the list of preprocessor identifiers.

To build a running device server process, you need to link your code with several libraries on top of the Windows libraries. These libraries are:

- The Tango libraries (called **tango.lib** and **log4tango.lib** or **tangod.lib** and **log4tangod.lib** for debug mode)
- The omniORB package libraries (see next table)

|c|c| Compile mode & Libraries Debug Multithreaded & omniORB4d.lib, omniDynamic4d.lib, omnithreadd.lib

and COS4d.lib Multithreaded & omniORB4.lib, omniDynamic4.lib, omnithread.lib and

COS4.lib Debug Multithreaded DLL & omniORB420_rtd.lib, omniDynamic420_rtd.lib,

omnithread40_rtd.lib, & and COS420_rtd.lib Multithreaded DLL & omniORB420_rt.lib, omniDynamic420_rt.lib,

omnithread40_rt.lib & and COS420_rt.lib

- The ZMQ library (**zmq.lib** or **zmqd.lib** for debug mode)
- Windows network libraries (**mswsock.lib** and **ws2_32.lib**)
- Windows graphic library (**comctl32.lib**)

To add these libraries in Visual Studio, open the project property pages dialog box and open the "Link" tree. Select "Input" and add these library names to the list of library in the "Additional Dependencies" box.

The "Win32 Debug" or "Win32 Release" configuration that you change within the Configuration Manager window changes the /M switch compiler. For instance, if you select a "Win32 Debug" configuration in a non-DLL project, use the omniORB4d.lib, omniDynamic4d.lib and omnithreadd.lib libraries plus the tangod.lib, log4tangod.lib and zmqd.lib libraries. If you select the "Win32 Release" configuration, use the omniORB4.lib, omniDynamic4.lib and omnithread.lib libraries plus the tango.lib, log4tango.lib and zmq.lib libraries.

WARNING: In some cases, the Microsoft Visual Studio wizard used during project creation generates one include file called *Stdafx.h*. If this file itself includes windows.h file, you have to add the preprocessor macro _WIN32_WINNT and set it to 0x0500.

Running a C++ device server

To run a C++ Tango device server, you must set an environment variable. This environment variable is called **TANGO_HOST** and has a fixed syntax which is

TANGO_HOST=<host>:<port>

The host field is the host name where the TANGO database device server is running. The port field is the port number on which this server is listening. For instance, a valid syntax is TANGO_HOST=dumela:10000. For UNIX like operating system, setting environment variable is possible with the *export* or *setenv* command depending on the shell used. For Windows, setting environment variable is possible with the "Environment" tab of the "System" application in the control panel.

If you need to start a Tango device server on a pre-defined port (For Tango database device server or device server without database usage), you must use one of the underlying ORB option *endPoint* like

myserver myinstance_name -ORBendPoint giop:tcp::<port number>

Advanced programming techniques

The basic techniques for implementing device server pattern are required by each device server programmer. In certain situations, it is however necessary to do things out of the ordinary. This chapter will look into programming techniques which permit the device server serve more than simply the network.

Receiving signal

It is **UNSAFE** to use any CORBA call in a signal handler. It is also UNSAFE to use some system calls in a signal handler. Tango device server solved this problem by using threads. A specific thread is started to handle signals. Therefore, every Tango device server is automatically a threaded process. This allows the programmer to write the code which must be executed when a signal is received as ordinary code. All device server threads masks all signals except the specific signal thread which is permanently waiting for signal. If a signal is sent to a device server process, only the signal thread will receive it because it is the single thread which does not mask signals.

Nevertheless, signal management is not trivial and some care have to be taken. The signal management differs from operating system to operating system. It is not recommended that you install your own signal routine using any of the signal routines provided by the operating system calls or library.

Using signal It is possible for C++ device server to receive signals from drivers or other processes. The TDSOM supports receiving signal at two levels: the device level and the class level. Supporting signal at the device level means that it is possible to specify interest into receiving signal on a device basis. This feature is supported via three methods defined in the DeviceImpl class. These methods are called *register_signal*, *unregister_signal* and s*ignal_handler*.

The ***register_signal*** method has one parameter which is the signal number. This method informs the device server signal system that the device want to be informed when the signal passed as parameter is received by the process. There is a special case for Linux as explained in the previous sub-chapter. It is possible to register a signal to be executed in the a signal handler context (with all its restrictions). This is done with a second parameter to this *register_signal* method. This second parameter is simply a boolean data. If it is true, the signal_handler will be executed in a signal handler context in the device server main thread. A default value (false) has been defined for this parameter.

The ***unregister_signal*** method also have an input parameter which is the signal number. This method removes the device from the list of object which should be warned when the signal is received by the process.

The ***signal_handler*** method is the method which is triggered when a signal is received if the corresponding *register_signal* has been executed. This method is defined as virtual and can be redefined by the user. It has one input argument which is the signal number.

The same three methods also exist in the DeviceClass class. Their action and their usage are similar to the DeviceImpl class methods. Installing a signal at the class level does not mean that all the device belonging to this class will receive the signal. This only means that the *signal_handler* method of the DeviceClass instance will be executed. This is useful if an action has to be executed once for a class of devices when a signal is received.

The following code is an example with our stepper motor device server configured via the database to serve three motors. These motors have the following names : id04/motor/01, id04/motor/02 and id04/motor/03. The signal SIGALRM (alarm signal) must be propagated only to the motor number 2 (id04/motor/02)

```
void StepperMotor::init_device()
{
    cout << "StepperMotor::StepperMotor() create motor " << dev_name <

    long i;

    for (i=0; i< AGSM_MAX_MOTORS; i++)
    {
        axis[i] = 0;
        position[i] = 0;
        direction[i] = 0;
    }

    if (dev_name == "id04/motor/02")
        register_signal(SIGALRM);
}

StepperMotor::~StepperMotor()
{
    unregister_signal(SIGALRM);
}

void StepperMotor::signal_handler(long signo)
{
    INFO_STREAM << "Inside signal handler for signal " << signo << enc

//  Do what you want here

}
```

The *init_device* method is modified.

Line 14-15 : The device name is checked and if it is the correct name, the device is registered in the list of device wanted to receive the SIGALARM signal.

The destructor is also modified

Line 20 : Unregister the device from the list of devices which should receives the SIGALRM signal. Note that unregister a signal for a device which has not previously registered its interest for this signal does nothing.

The *signal_handler* method is redefined

Line 25 : Print signal number

Line 27 : Do what you have to do when the signal SIGALRM is received.

If all devices must be warned when the device server process receives the signal SIGALRM, removes line 14 in the *init_device* method.

Exiting a device server gracefully A device server has to exit gracefully by unregistering itself from the database. The necessary action to gracefully exit are automatically executed on reception of the following signal :

- SIGINT, SIGTERM and SIGQUIT for device server running on Linux
- SIGINT, SIGTERM, SIGABRT and SIGBREAK for device server running on Windows

This does not prevents device server to also register interest at device or class levels for those signals. The user installed *signal_handler* method will first be called before the graceful exit.

Inheriting

This sub-chapter details how it is possible to inherit from an existing device pattern implementation. As the device pattern includes more than a single class, inheriting from an existing device pattern needs some explanations.

Let us suppose that the existing device pattern implementation is for devices of class A. This means that classes A and AClass already exists plus classes for all commands offered by device of class A. One new device pattern implementation for device of class B must be written with all the features offered by class A plus some new one. This is easily done with the inheritance. Writing a device pattern implementation for device of class B which inherits from device of class A means :

- Write the BClass class
- Write the B class
- Write B class specific commands
- Eventually redefine A class commands

The miscellaneous code fragments given below detail only what has to be updated to support device pattern inheritance

Writing the BClass As you can guess, BClass has to inherit from AClass. The *command_factory* method must also be adapted.

```
 1  namespace B
 2  {
 3
 4  class BClass : public A::AClass
 5  {
 6  .....
 7  }
 8
 9  BClass::command_factory()
10  {
11      A::AClass::command_factory();
12
13      command_list.push_back(....);
14  }
15
16  } /* End of B namespace */
```

Line 1 : Open the B namespace
Line 4 : BClass inherits from AClass which is defined in the A namespace.
Line 11 : Only the *command_factory* method of the BClass will be called at start-up. To create the AClass commands, the *command_factory* method of the AClass must also be executed. This is the reason of the line
Line 13 : Create BClass commands

Writing the B class As you can guess, B has to inherits from A.

```
 1  namespace B
 2  {
 3
 4  class B : public A:A
 5  {
 6     .....
 7  };
 8
 9  B::B(Tango::DeviceClass *cl,const char *s):A::A(cl,s)
10  {
11     ....
12     init_device();
13  }
14
15  void B::init_device()
16  {
17     ....
18  }
19
20  } /* End of B namespace */
```

Line 1 : Open the B namespace.

Line 4 : B inherits from A which is defined in the A namespace
Line 9 : The B constructor calls the right A constructor

Writing B class specific command Noting special here. Write these classes as usual

Redefining A class command It is possible to redefine a command which already exist in class A **only if the command is created using the inheritance model** (but keeping its input and output argument types). The method which really execute the class A command is a method implemented in the A class. This method must be defined as **virtual.** In class B, you can redefine the method executing the command and implement it following the needs of the B class.

Using another device pattern implementation within the same server

It is often necessary that inside the same device server, a method executing a command needs a command of another class to be executed. For instance, a device pattern implementation for a device driven by a serial line class can use the command offered by a serial line class embedded within the same device server process. To execute one of the command (or any other CORBA operations/attributes) of the serial line class, just call it as a normal client will do by using one instance of the DeviceProxy class. The ORB will recognize that all the devices are inside the same process and will execute calls as a local calls. To create the DeviceProxy class instance, the only thing you need to know is the name of the device you gave to the serial line device. Retrieving this could be easily done by a Tango device property. The DeviceProxy class is fully described in Tango Application Programming Interface (API) reference WEB pages

Device pipe

What a Tango device pipe is has been defined in the Chapter 3 about device server model. How you read or write a pipe in a client software is documented in chapter 4 about the Tango API. In this section, we describe how you can read/write into/from a device pipe on the server side (In a Tango class with pipe).

Client reading a pipe When a client reads a pipe, the following methods are executed in the Tango class:

1. The *always_executed_hook()* method.
2. A method called *is_<pipe_name>_allowed()*. The rule of this method is to allow (or disallow) the next method to be executed. It is usefull for device with some pipes which can be read only in some precise conditions. It has one parameter which is the request type (read or write)
3. A method called *read_<pipe_name>()*. The aim of this method is to store the pipe data in the pipe object. It has one parameter which is a reference to the Pipe object to be read.

The figure [r_pipe_timing_fig-1] is a drawing of these method calls sequencing for our class StepperMotor with one pipe named DynData.

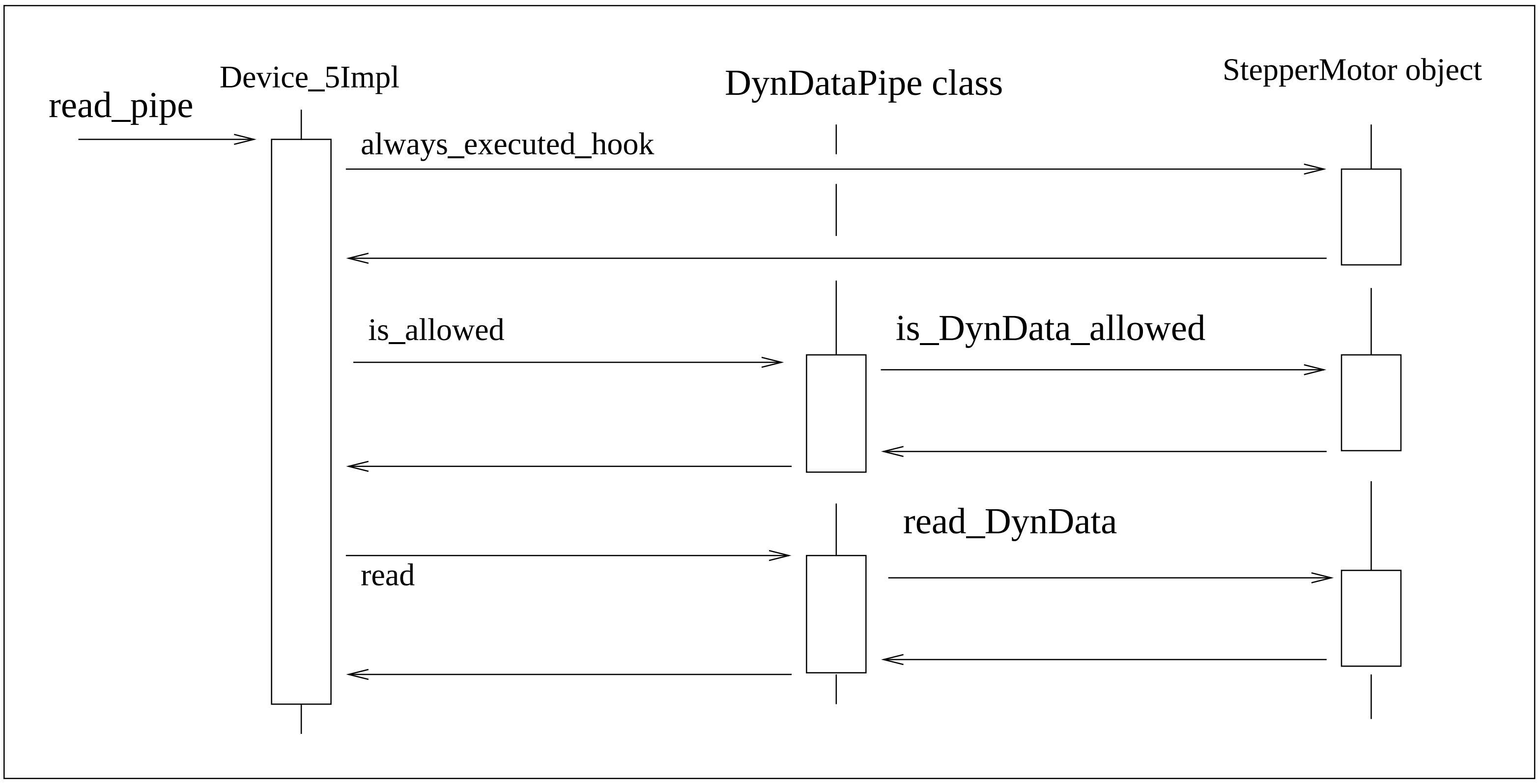


Figure 8: Read pipe sequencing

The class DynDataPipe is a simple class which follow the same skeleton from one Tango class to another. Therefore, this class is generated by the Tango code generator Pogo and the Tango class developper does not have to modify it. The method *is_DynData_allowed()* is relatively simple and in most cases the default code generated by Pogo is enough. The method *read_DynData()* is the method on which the Tango class developper has to concentrate on. The following code is one example of these two methods.

```
bool StepperMotor::is_DynData_allowed(Tango::PipeReqType req)
{
    if (get_state() == Tango::ON)
        return true;
    else
        return false;
}

void StepperMotor::read_DynData(Tango::Pipe &pipe)
{
    nb_call++;
    if (nb_call % 2 == 0)
    {
```

```
14            pipe.set_root_blob_name("BlobCaseEven");
15
16            vector<string> de_names {"EvenFirstDE","EvenSecondDE"};
17            pipe.set_data_elt_names(de_names);
18
19            dl = 666;
20            v_db.clear();
21            v_db.push_back(1.11);
22            v_db.push_back(2.22);
23
24            pipe << dl << v_db;
25        }
26        else
27        {
28            pipe.set_root_blob_name("BlobCaseOdd");
29
30            vector<string> de_names {"OddFirstDE"};
31            pipe.set_data_elt_names(de_names);
32
33            v_str.clear();
34            v_str.push_back("Hola");
35            v_str.push_back("Salut");
36            v_str.push_back("Hi");
37
38            pipe << v_str;
39        }
40    }
```

The *is_DynData_allowed* method is defined between lines 1 and 7. It is allowed to read or write the pipe only is the device state is ON. Note that the input parameter req is not used. The parameter allows the user to know the type of request. The data type PipeReqType is one enumeration with two possible values which are READ_REQ and WRITE_REQ.

The *read_DynData* method is defined between lines 9 and 40. If the number of times this method has been called is even, the pipe contains two data elements. The first one is named EvenFirstDE and its data is a long. The second one is named EvenSecondDE and its data is an array of double. If the number of call is odd, the pipe contains only one data element. Its name is OddFirstDe and its data is an array of strings. Data are inserted into the pipe at lines 24 and 38. The variables nb_call, dl, v_db and v_str are device data member and therefore declare in the .h file. Refer to pipe section in chapter 3 and to the API reference documentation (in Tango WEB pages) to learn more on how you can insert data into a pipe and to know how data are organized within a pipe.

Client writing a pipe When a client writes a pipe, the following methods are executed in the Tango class:

1. The *always_executed_hook()* method.
2. A method called *is_<pipe_name>_allowed()*. The rule of this method is to allow (or disallow) the next method to be executed. It is usefull for device

with some pipes which can be read only in some precise conditions. It has one parameter which is the request type (read or write)

3. A method called *write_<pipe_name>()*. It has one parameter which is a reference to the WPipe object to be written. The aim of this method is to get the data to be written from the WPipe oject and to write them into the corresponding Tango class objects.

The figure [w_pipe_timing_fig-1-1] is a drawing of these method calls sequencing for our class StepperMotor with one pipe named DynData.

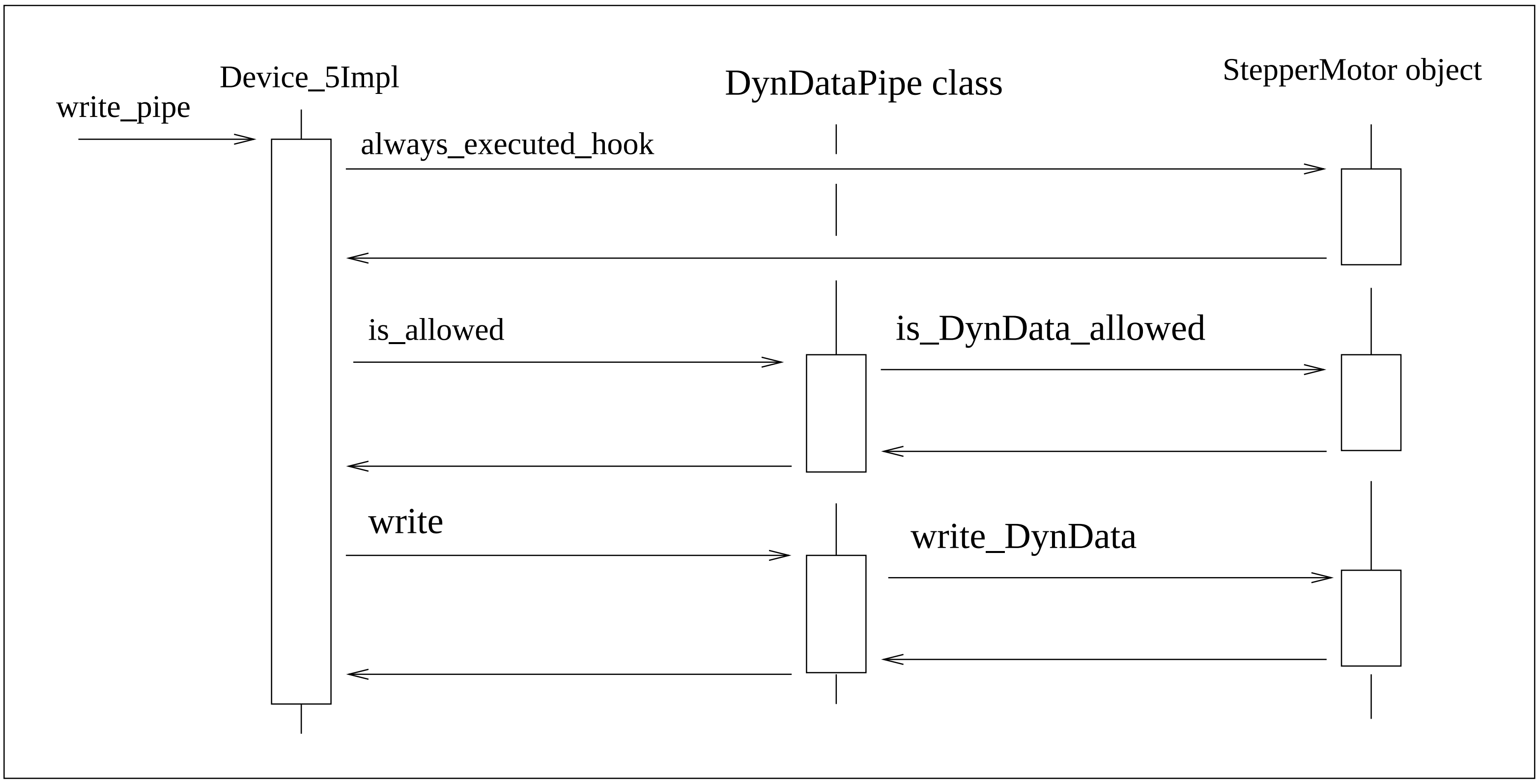


Figure 9: Write pipe sequencing

The class DynDataPipe is a simple class which follow the same skeleton from one Tango class to another. Therefore, this class is generated by the Tango code generator Pogo and the Tango class developper does not have to modify it. The method *is_DynData_allowed()* is relatively simple and in most cases the default code generated by Pogo is enough. The method *write_DynData()* is the method on which the Tango class developper has to concentrate on. The following code is one example of the *write_DynData()* method.

```
void StepperMotor::write_DynData(Tango::WPipe &w_pipe)
{
   string str;
4        vector<float> v_fl;
5
6        w_pipe >> str >> v_fl;
7        .....
8    }
```

In this example, we know that the pipe will always contain a srting followed by one array of float. On top of that, we are not niterested by the

data element names. Data are extracted from the pipe at line 6 and are available for further use starting at line 7. If the content of the pipe is not a string followed by one array of float, the data extraction line (6) will throw one exception which will be reported to the client who has tried to write the pipe. Refer to pipe section in chapter 3 and to the API reference documentation (in Tango WEB pages) to learn more on how you can insert data into a pipe and to know how data are organized within a pipe.

[BlackPicture]|image|

Advanced features

Attribute alarms

Each Tango attribute two several alarms. These alarms are :

- A four thresholds level alarm
- The read different than set (RDS) alarm

The level alarms

This alarm is defined for all Tango attribute read type and for numerical data type. The action of this alarm depend on the attribute value when it is read :

- If the attribute value is below or equal the attribute configuration **min_alarm** parameter, the attribute quality factor is switched to Tango::ATTR_ALARM and if the device state is Tango::ON, it is switched to Tango::ALARM.
- If the attribute value is below or equal the attribute configuration **min_warning** parameter, the attribute quality factor is switched to Tango::ATTR_WARNING and if the device state is Tango::ON, it is switched to Tango::ALARM.
- If the attribute value is above or equal the attribute configuration **max_warning** parameter, the attribute quality factor is switched to Tango::ATTR_WARNING and if the device state is Tango::ON, it is switched to Tango::ALARM.
- If the attribute value is above or equal the attribute configuration **max_alarm** parameter, the attribute quality factor is switched to Tango::ATTR_ALARM and if the device state is Tango::ON, it is switched to Tango::ALARM.

If the attribute is a spectrum or an image, then the alarm is set if any one of the attribute value satisfies the above criterium. By default, these four parameters are not defined and no check will be done.

The following figure is a drawing of attribute quality factor and device state values function of the the attribute value.

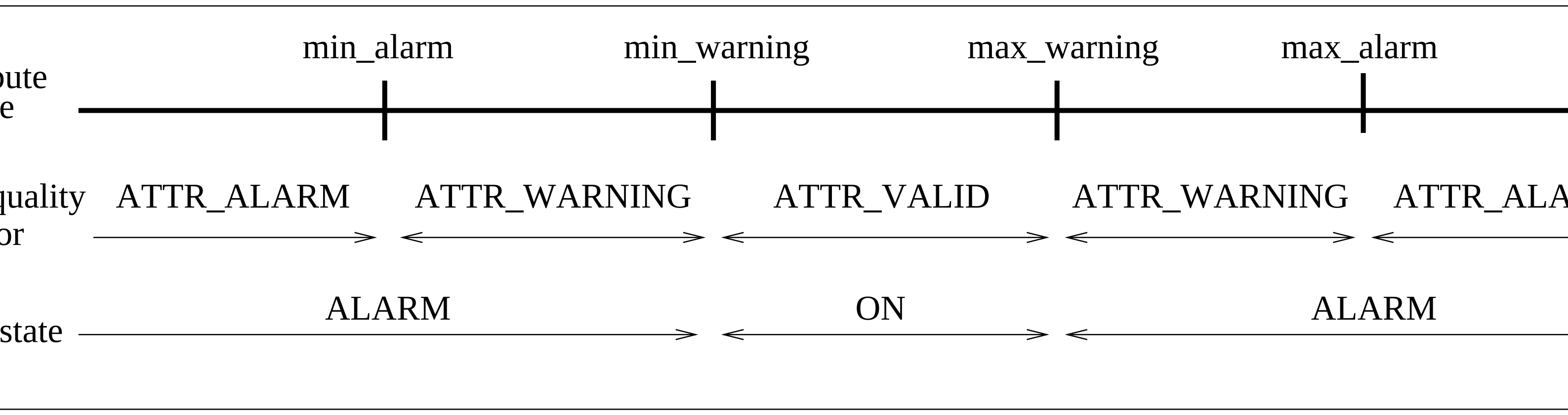


Figure 10: Level alarm

If the min_warning and max_warning parameters are not set, the attribute quality factor will simply change between Tango::ATTR_ALARM and Tango::ATTR_VALID function of the attribute value.

The Read Different than Set (RDS) alarm

This alarm is defined only for attribute of the Tango::READ_WRITE and Tango::READ_WITH_WRITE read/write type and for numerical data type. When the attribute is read (or when the device state is requested), if the difference between its read value and the last written value is something more than or equal to an authorized delta and if at least a certain amount of milli seconds occurs since the last write operation, the attribute quality factor will be set to Tango::ATTR_ALARM and if the device state is Tango::ON, it is switched to Tango::ALARM. If the attribute is a spectrum or an image, then the alarm is set if any one of the attribute value's satisfies the above criterium. This alarm configuration is done with two attribute configuration parameters called **delta_val** and **delta_t**. By default, these two parameters are not defined and no check will be done.

Enumerated attribute

Since Tango release 9, enumerated attribute is supported using the new data type DevEnum. This data type is not a real C++ enumeration because:

1. The enumerated value allways start with 0
2. Values are consecutive
3. It is transferred on the network as DevShort data type

One enumeration label is associated to each enumeration value. For the Tango kernel, it is this list of enumeration labels which will define the possible enumeration values. For instance if the enumeration has 3 labels, its value must be between 0 and 2. There are two ways to define the enumeration labels:

1. At attribute creation time. This is the most common case when the list of possible enumeration values and labels are known at compile time. The Tango code generator Pogo generates for you the code needed to pass the enumeration labels to the Tango kernel.

2. In the user code when the enumeration values and labels are not known at compile time but retrieved during device startup phase. The user gives the possible enumeration values to the Tango kernel using the Attribute class *set_properties()* method.

A Tango client is able to retrieve the enumeration labels in the attribute configuration returned by instance by a call to the *DeviceProxy::get_attribute_config()* method. Using the *DeviceProxy::set_attribute_config()* call, a user may change the enumeration labels but not their number.

Usage in a Tango class

Within a Tango class, you set the attribute value with a C++ enum or a DevShort variable. In case a DevShort variable is used, its value will be checked according to the enumeration labels list given to Tango kernel.

Setting the labels with enumeration compile time knowledge In such a case, the enumeration labels are given to Tango at the attribute creation time in the *attribute_factory* method of the XXXClass class. Let us take one example

```
 1   enum class Card: short
 2   {
 3       NORTH = 0,
 4       SOUTH,
 5       EAST,
 6       WEST
 7   };
 8
 9   void XXXClass::attribute_factory(vector<Tango::Attr *> &att_list)
10   {
11       .....
12       TheEnumAttrib   *theenum = new TheEnumAttrib();
13       Tango::UserDefaultAttrProp theenum_prop;
14       vector<string> labels = {"North","South","East","West"};
15       theenum_prop.set_enum_labels(labels);
16       theenum->set_default_properties(theenum_prop);
17       att_list.push_back(theenum);
18       .....
19    }
```

line 1-7 : The definition of the enumeration (C++11 in this example)
line 14 : A vector of strings with the enumeration labels is created. Because there is no way to get the labels from the enumeration definition, they are re-defined here.
line 15 : This vector is given to the theenum_prop object which contains the user default properties

line 16 : The user default properties are associated to the attribute
In most cases, all this code will be automatically generated by the Tango code generator Pogo. It is given here for completness.

Setting the labels without enumeration compile time knowledge In such a case, the enumeration labels are retrieved by the user in a way specific to the device and passed to Tango using the Attribute class *set_properties()* method. Let us take one example

```
 1   void MyDev::init_device()
 2   {
 3       ...
 4
 5       Attribute &att = get_device_attr()->get_attr_by_name("TheEnumAtt")
 6       MultiAttrProp<DevEnum> multi_prop;
 7       att.get_properties(multi_prop);
 8
 9       multi_prop.enum_labels = {....};
10       att.set_properties(multi_prop);
11       ....
12    }
```

line 5 : Get a reference to the attribute object
line 7 : Retrieve the attribute properties
line 9 : Initialise the attribute labels in the set of attribute properties
line 10 : Set the attribute properties

Setting the attribute value It is possible to set the attribute value using either a classical DevShort variable or using a variable of the C++ enumeration. The following example is when you have compile time knowledge of the enumeration definition. We assume that the enumeration is the same than the one defined above (Card enumeration)

```
1   enum Card points;
2
3   void MyDev::read_TheEnum(Attribute &att)
4   {
5       ...
6       points = SOUTH;
7       att.set_value(&points);
8   }
```

line 1 : One instance of the Card enum is created (named points)
line 6 : The enumeration is initialized

line 7 : The value of the attribute object is set using the enumeration (by pointer)
To get the same result using a classical DevShort variable, the code looks like

```
1   DevShort sh;
2
3   void MyDev::read_TheEnum(Attribute &att)
4   {
5       ...
6       sh = 1;
7       att.set_value(&sh);
8   }
```

line 1 : A DevShort variable is created (named sh)
line 6 : The variable is initialized
line 7 : The value of the attribute object is set using the DevShort variable (by pointer)

Usage in a Tango client

Within a Tango client, you insert/extract enumerated attribute value in/from DeviceAttribute object with a C++ enum or a DevShort variable. The later case is for generic client which do not have compile time knowledge of the enumeration. The code looks like

```
1   DeviceAttribute da = the_dev.read_attribute("TheEnumAtt");
2   Card ca;
3   da >> ca;
4
5   DeviceAttribute db = the_dev.read_attribute("TheEnumAtt");
6   DevShort sh;
7   da >> sh;
```

line 2-3 : The attribute value is extracted in a C++ enumeration variable
line 6-7 : The attribute value is extracted in a DevShort variable

Device polling

Introduction

Each tango device server automatically have a separate polling thread pool. Polling a device means periodically executing command on a device (or reading device attribute) and storing the results (or the thrown exception) in a polling buffer. The aim of this polling is threefold :

- Speed-up response time for slow device
- Get a first-level history of device command output or attribute value
- Be the data source for the Tango event system

Speeding-up response time is achieved because the command_inout or read_attribute CORBA operation is able to get its data from the polling buffer or from the a real access to the device. For "slow" device, getting the data from the buffer is much faster than accessing the device. Returning a first-level command output history (or attribute value history) to a client is possible due to the polling buffer which is managed as a circular buffer. The history is the contents of this circular buffer. Obviously, the history depth is limited to the depth of the circular buffer. The polling is also the data source for the event system because detecting an event means being able to regularly read the data, memorize it and declaring that it is an event after some comparison with older values.

Starting with Tango 9, the default polling algorithm has been modifed. However, it is still possible to use the polling as it was in Tango releases prior to release 9. See chaper on polling configuration to get details on this.

Configuring the polling system

Configuring what has to be polled and how It is possible to configure the polling in order to poll :

- Any command which does not need input parameter
- Any attribute

Configuring the polling is done by sending command to the device server administration device automatically implemented in every device server process. Seven commands are dedicated to this feature. These commands are

AddObjPolling It add a new object (command or attribute) to the list of object(s) to be polled. It is also with this command that the polling period is specified.

RemObjPolling To remove one object (command or attribute) from the polled object(s) list

UpdObjPollingPeriod Change one object polling period

StartPolling Starts polling for the whole process

StopPolling Stops polling for the whole process

PolledDevice Allow a client to know which device are polled

DevPollStatus Allow a client to precisely knows the polling status for a device

All the necessary parameters for the polling configuration are stored in the Tango database. Therefore, the polling configuration is not lost after a device server process stop and restart (or after a device server process crash!!).

It is also possible to automatically poll a command (or an attribute) without sending command to the device server administration device. This request some coding (a method call) in the device server software during the command or attribute creation. In this case, for every devices supporting this command or this attribute, polling configuration will be automatically updated in the database and the polling will start automatically at each device server process startup. It is possible to stop this behavior on a device basis by sending a RemObjPolling command to the device server administration device. The following piece of code shows how the source code should be written.

```
void DevTestClass::command_factory()
{
...
    command_list.push_back(new IOStartPoll("IOStartPoll",
                                           Tango::DEV_VOID,
                                           Tango::DEV_LONG,
                                           "Void",
                                           "Constant number"));
    command_list.back()->set_polling_period(400);
...
}

```

```
13
14   void DevTestClass::attribute_factory(vector<Tango::Attr *> &att_list)
15   {
16   ...
17       att_list.push_back(new Tango::Attr("String_attr",
18                                            Tango::DEV_STRING,
19                                            Tango::READ));
20       att_list.back()->set_polling_period(250);
21   ...
22   }
```

A polling period of 400 mS is set for the command called “IOStartPoll” at line 10 with the *set_polling_period* method of the Command class. Therefore, for a device of this class, the polling thread will start polling its IOStartPoll command at process start-up except if a RemObjPolling indicating this device and the IOStartPoll command has already been received by the device server administration device. This is exactly the same behavior for attribute. The polling period for attribute called “String_attr” is defined at line 20.

Configuring the polling means defining device attribute/command polling period. The polling period has to be chosen with care. If reading an attribute needs 200 mS, there is no point to poll this attribute with a polling period equal or even below 200 mS. You should also take into account that some free time has to be foreseen for external request(s) on the device. On average, for one attribute needing X mS as reading time, define a polling period which is equal to 1.4 X (280 mS for our example of one attribute needing 200 mS as reading time). In case the polling tuning is given to external user, Tango provides a way to define polling period minimun threshold. This is done using device properties. These properties are named *min_poll_period*, *cmd_min_poll_period* and *attr_min_poll_period*. The property min_poll_period (mS) defined a minimun polling period for the device. The property cmd_min_poll_period allows the definition of a minimun polling period for a specific device command. The property attr_min_poll_period allows the definition of a minimun polling period for one device attribute. In case these properties are defined, it is not possible to poll the device command/attribute with a polling period below those defined by these properties. See Appendix A on device parameter to get a precise syntax description for these properties.

The Jive:raw-latex:*cite{Jive doc}* tool also allows a graphical device polling configuration.

Configuring the polling threads pool Starting with Tango release 7, a Tango device server process may have several polling threads managed as a pool. For instance, this could be usefull in case of devices within the same device server process but accessed by different hardware channel when one of the channel is not responding (Thus generating long timeout and de-synchronising the polling thread). By default, the polling threads pool size is set to 1 and all the polled object(s) are managed by the same thread (idem polling system in Tango releases older than release 7) . The configuration of the polling thread pool is done using two properties associated to the device server administration device. These properties are named:

- *polling_threads_pool_size* defining the maximun number of threads that you can have in the pool

- *polling_threads_pool_conf* defining which threads in the pool manages which device

The granularity of the polling threads pool tuning is the device. You cannot ask the polling threads pool to have thread number 1 in charge of attribute *att1* of device *dev1* and thread number 2 to be in charge of *att2* of the same device *dev1*.

When you require a new object (command or attribute) to be polled, two main cases may arrive:

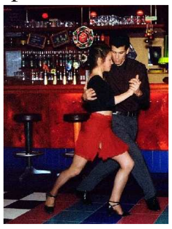
1. Some polled object(s) belonging to the device are already polled by one of the polling threads in the pool: There is no new thread created. The object is simply added to the list of objects to be polled for the existing thread

2. There is no thread already created for the device. We have two sub-cases:

    1. The number of polling threads is less than the polling_threads_pool_size: A new thread is created and started to poll the object (command or attribute)

    2. The number of polling threads is already equal to the polling_threads_pool_size: The software search for the thread with the smallest number of polled objects and add the new polled object to this thread

Each time the polling threads pool configuration is changed, it is written in the database using the polling_threads_pool_conf property. If the behaviour previously described does not fulfill your needs, it is possible to update the polling_threads_pool_conf property in a graphical way using the Tango Astor [**?**] tool or manually using the Jive tool [**?**]. These changes will be taken into account at the next device server process start-up. At start-up, the polling threads pool will allways be configured as required by the polling_threads_pool_conf property. The syntax used for this property is described in the Reference part of the Appendix [cha:Reference-part]. The following window dump is the Astor tool window which allows polling threads pool management.



In this example, the polling threads pool size to set to 9 but only 4 polling threads are running. Thread 1 is in charge of all polled objects related to device pv/thread-pool/test-1 and pv/thread-pool/test-2. Thread 2 is in charge of all polled objects related to device pv/thread-pool/test-3. Thread 3 is in charge of all polled objects related to device pv/thread-pool/test-5 anf finally, thread 4 is in charge of all polled objects for devices pv/thread-pool/test-4, pv/thread-pool/test-6 and pv/thread-pool/test-7.

It's also possible to define the polling threads pool size programmatically in the main function of a device server process using the *Util::set_polling_threads_pool_size()* method before the call to the *Util::server_init()* method

Choosing polling algorithm Starting with Tango 9, you can choose between two different polling algorithm:

- The polling as it was in Tango since it has been introduced. This means:
    - For one device, always poll attribute one at a time even if the polling period is the same (use of read_attribute instead of read_attributes)
    - Do not allow the polling thread to be late: If it is the case (because at the end of polling object 1, the time is greater than the polling date of object 2), discard polling object and inform event user by sending one event with error (Polling thread is late and discard....)
- New polling algorithm introduced in Tango 9 as the default one. This means:
    - For one device, poll all attributes with the same polling period using a single device call (read_attributes)
    - Allow the polling thread to be late but only if number of late objects decreases.

The advantages of new polling algorithm are

1. In case of several attributes polled on the same device at the same period a lower device occupation time by the polling thread (due to a single read_attributes() call instead of several single read_attribute() calls)
2. Less "Polling thread late" errors in the event system in case of device with non constant response time

The drawback is

1. The loss of attribute individual timing data reported in the polling thread status

It is still possible to return to pre-release 9 polling algorithm. To do so, you can use the device server process administration device *polling_before_9* property by setting it to true. It is also possible to choose this pre-release 9 algorithm in device server process code in the main function of the process using the *Util::set_polling_before_9()* method.

Reading data from the polling buffer

For a polled command or a polled attribute, a client has three possibilities to get command result or attribute value (or the thrown exception) :

- From the device itself
- From the polling buffer
- From the polling buffer first and from the device if data in the polling buffer are invalid or if the polling is badly configured.

The choice is done during the command_inout CORBA operation by positioning one of the operation parameter. When reading data from the polling buffer, several error cases are possible

- The data in the buffer are not valid any more. Every time data are requested from the polling buffer, a check is done between the client request date and the date when the data were stored in the buffer. An exception is thrown if the delta is greater than the polling period multiplied by a "too old" factor. This factor has a default value and is up-datable via a device property. This is detailed in the reference part of this manual.
- The polling is correctly configured but there is no data yet in the polling buffer.

Retrieving command/attribute result history

The polling thread stores the command result or attribute value in circular buffers. It is possible to retrieve an history of the command result (or attribute value) from these polling buffers. Obviously the history is limited by the depth of the circular buffer. For commands, a CORBA operation called *command_inout_history_2* allows this retrieval. The client specifies the command name and the record number he want to retrieve. For each record, the call returns the date when the command was executed, the command result or the exception stack in case of the command failed when it was executed by the polling thread. In such a case, the exception stack is sent as a structure member and not as an exception. The same thing is available for attribute. The CORBA operation name is *read_attribute_history_2*. For these two calls, there is no check done between the call date and the record date in contrary of the call to retrieve the last command result (or attribute value).

Externally triggered polling

Sometimes, rather than polling a command or an attribute regulary with a fixed period, it is more interesting to manually decides when the polling must occurs. The Tango polling system also supports this kind of usage. This is called *externally triggered polling*. To define one attribute (or command) as externally triggered, simply set its polling period to 0. This can be done with the device server administration device AddObjPolling or UpdObjPollingPeriod command. Once in this mode, the attribute (or command) polling is triggered with the *trigger_cmd_polling()* method (or *trigger_attr_polling()* method) of the Util class. The following piece of code shows how this method could be used for one externally triggered command.

```
 1   .....
 2
 3   string ext_polled_cmd("MyCmd");
 4   Tango::DeviceImpl *device = .....;
 5
 6   Tango::Util *tg = Tango::Util::instance();
 7
 8   tg->trigger_cmd_polling(device,ext_polled_cmd);
 9
10   .....
```

line 3 : The externally polled command name
line 4 : The device object
line 8 : Trigger polling of command MyCmd

Filling polling buffer

Some hardware to be interfaced already returned an array of pair value, timestamp. In order to be read with the *command_inout_history* or *read_attribute_history* calls, this array has to be transferred in the attribute or command polling buffer. This is possible only for attribute or command configured in the externally triggered polling mode. Once in externally triggered polling mode, the attribute (or command) polling buffer is filled with the *fill_cmd_polling_buffer()* method (or *fill_attr_polling_buffer()* method) of the Util class. For command, the user uses a template class called *TimedCmdData* for each element of the command history. Each element is stored in a stack in one instance of a template class called *CmdHistoryStack.* This object is one of the argument of the fill_cmd_polling_buffer() method. Obviously, the stack depth cannot be larger than the polling buffer depth. See [sub:The-device-polling-prop] to learn how the polling buffer depth is defined. The same way is used for attribute with the *TimedAttrData* and *AttrHistoryStack* template classes. These classes are documented in [**?**]. The following piece of code fills the polling buffer for a command called MyCmd which is already in externally triggered mode. It returns a DevVarLongArray data type with three elements. This example is not really something you will find in a real hardware interface. It is only to demonstrate the fill_cmd_polling_buffer() method usage. Error management has also been removed.

```
....

Tango::DevVarLongArray dvla_array[4];

for(int i = 0;i < 4;i++)
{
    dvla_array[i].length(3);
    dvla_array[i][0] = 10 + i;
    dvla_array[i][1] = 11 + i;
    dvla_array[i][2] = 12 + i;
}

Tango::CmdHistoryStack<DevVarLongArray> chs;
chs.length(4);

for (int k = 0;k < 4;k++)
{
    time_t when = time(NULL);

    Tango::TimedCmdData<DevVarLongArray> tcd(&dvla_array[k],when);
    chs.push(tcd);
}

Tango::Util *tg = Tango::Util::instance();
string cmd_name("MyCmd");
DeviceImpl *dev = ....;

tg->fill_cmd_polling_buffer(dev,cmd_name,chs);

.....
```

Line 3-11 : Simulate data coming from hardware

Line 13-14 : Create one instance of the CmdHistoryStack class and reserve space for one history of 4 elements

Line 16-17 : A loop on each history element

Line 18 : Get date (hardware simulation)

Line 20 : Create one instance of the TimedCmdData class with data and date

Line 21 : Store this command history element in the history stack. The element order will be the insertion order whatever the element date is.

Line 28 : Fill command polling buffer

After one execution of this code, a command_inout_history() call will return one history with 4 elements. The first array element of the oldest history record will have the value 10. The first array element of the newest history record will have the value 13. A command_inout() call with the data source parameter set to CACHE will return the newest history record (ie an array with values 13,14 and 15). A command_inout() call with the data source parameter set to DEVICE will return what is coded is the command method. If you execute this code a second time, a command_inout_history() call will return an history of 8 elements.

The next example fills the polling buffer for an attribute called MyAttr which is already in externally triggered mode. It is a scalar attribute of the DevString data type. This example is not really something you will find in a real hardware interface. It is only to demonstrate the fill_attr_polling_buffer() method usage with memory management issue. Error management has also been removed.

```
 1   ....
 2
 3   AttrHistoryStack<DevString> ahs;
 4   ahs.length(3);
 5
 6   for (int k = 0;k < 3;k++)
 7   {
 8       time_t when = time(NULL);
 9
10       DevString *ptr = new DevString [1];
11       ptr = CORBA::string_dup("Attr history data");
12
13       TimedAttrData<DevString> tad(ptr,Tango::ATTR_VALID,true,when);
14       ahs.push(tad);
15   }
16
17   Tango::Util *tg = Tango::Util::instance();
18   string attr_name("MyAttr");
19   DeviceImpl *dev = ....;
20
21   tg->fill_attr_polling_buffer(dev,attr_name,ahs);
22
23   .....
```

Line 3-4 : Create one instance of the AttrHistoryStack class and reserve space for an history with 3 elements

Line 6-7 : A loop on each history element

Line 8 : Get date (hardware simulation)

Line 10-11 : Create a string. Note that the DevString object is created on the heap

Line 13 : Create one instance of the TimedAttrData class with data and date requesting the memory to be released.

Line 14 : Store this attribute history element in the history stack. The element order will be the insertion order whatever the element date is.

Line 21 : Fill command polling buffer

It is not necessary to return the memory allocated at line 10. The *fill_attr_polling_buffer()* method will do it for you.

Setting and tuning the polling in a Tango class

Even if the polling is normally set and tuned with external tool like Jive, it is possible to set it directly into the code of a Tango class. A set of methods belonging to the *DeviceImpl* class allows the user to deal with polling. These methods are:

- *is_attribute_polled()* and *is_command_polled()* to check if one command/attribute is polled
- *get_attribute_poll_period()* and *get_command_poll_period()* to get polled object polling period
- *poll_attribute()* and *poll_command()* to poll command or attribute
- *stop_poll_attribute()* and *stop_poll_command()* to stop polling a command or an attribute

The following code snippet is just an exmaple of how these methods could be used. They are documented in [**?**]

```
         [Program Listing: poll_in_ds.cpp.lines
        void MyClass::read_attr(Tango::Attribute &attr)
        {
            ...
            ...

            string att_name("SomeAttribute");
            string another_att_name("AnotherAttribute");

            if (is_attribute_polled(att_name) == true)
                stop_poll_attribute(att_name);
            else
                poll_attribute(another_att_name,500);

            ....
            ....

        }

    ]
```

Threading

When used with C++, Tango used omniORB as underlying ORB. This CORBA implementation is a threaded implementation and therefore a C++ Tango device server or client are multi-threaded processes.

Device server process

A classical Tango device server without any connected clients has eight threads. These threads are :

- The main thread waiting in the ORB main loop
- Two ORB implementation threads (the POA thread)
- The ORB scavanger thread
- The signal thread
- The heartbeat thread (needed by the Tango event system)
- Two Zmq implementation threads

On top of these eight threads, you have to add the thread(s) used by the polling threads pool. This number depends on the polling thread pool configuration and could be between 0 (no polling at all) and the maximun number of threads in the pool.

A new thread is started for each connected client. Device server are mostly used to interface hardware which most of the time does not support multi-threaded access. Therefore, all remote calls executed from a client are serialized within the device server code by using mutual exclusion. See chapter [sub:Serialization-model-within] on which serialization model are available. In order to limit thread number, the underlying ORB (omniORB) is configured to shutdown threads dedicated to client if the connection is inactive for more than 3 minutes. To also limit thread number, the ORB is configured to create one thread per connection up to 55 threads. When this level is reached, the threading model is automatically switch to a thread pool model with up to 100 threads. If the number of threads decrease down to 50, the threading model will return to thread per connection model.

If you are using event, the event system for its internal heartbeat system periodically (every 200 seconds) sends a command to the device server administration device. As explained above, a thread is created to execute these command. The omniORB scavanger will terminate this thread before the next event system heartbeat command arrives. For example, if you have a device server with three connected clients using only event, the process thread number will permanently change between 8 and 11 threads.

In summary, the number of threads in a device server process can be evaluated with the following formula:

8 + k + m

k is the number of polling threads used from the polling threads pool and m is the number of threads used for connected clients.

Serialization model within a device server Four serialization models are available within a device server. These models protect all requests coming from the network but also requests coming from the polling thread. These models are:

1. Serialization by device. All access to the same device are serialized. As an example, let's take a device server implementing one class of device with two instances (dev1 and dev2). Two clients are connected to these devices (client1 and client2). Client2 will not be able to access dev1 if client1 is using it. Nevertheless, client2 is able to access dev2 while client1 access dev1 (There is one mutual exclusion object by device)

2. Serialization by class. With non multi-threaded legacy software, the preceding scenario could generate problem. In this mode of serialization, client2 is not able to access dev2 while client1 access dev1 because dev2 and dev1 are instances of the same class (There is one mutual exclusion object by class)

3. Serialization by process. This is one step further than the previous case. In this mode, only one client can access any device embedded within the device server at a time. There is only one mutual exclusion object for the whole process)

4. No serialization. This is an exotic kind of serialization and **should be used with extreme care** only with device which are fully thread safe. In this model, most of the device access are not serialized at all. Due to Tango internal structure, the *get_attribute_config*, *set_attribute_config*, *read_attributes* and *write_attributes* CORBA calls are still protected. Reading the device state and status via commands or via CORBA attribute is also protected.

By default, every Tango device server is in serialization by device mode. A method of the Tango::Util class allows to change this default behavior.

```
#include <tango.h>

int main(int argc,char *argv[])
{

    try
    {

        Tango::Util *tg = Tango::Util::init(argc,argv);

        tg->set_serial_model(Tango::BY_CLASS);

        tg->server_init();

        cout << "Ready to accept request" << endl;
        tg->server_run();
    }
    catch (bad_alloc)
    {
```

```
20              cout << "Can't allocate memory!!!" << endl;
21              cout << "Exiting" << endl;
22          }
23          catch (CORBA::Exception &e)
24          {
25              Tango::Except::print_exception(e);
26
27              cout << "Received a CORBA::Exception" << endl;
28              cout << "Exiting" << endl;
29          }
30
31          return(0);
32      }
```

The serialization model is set at line 11 before the server is initialized and the infinite loop is started. See [**?**] for all details on the methods to set/get serialization model.

Attribute Serialization model Even with the serialization model described previously, in case of attributes carrying a large number of data and several clients reading this attribute, a device attribute serialization has to be followed. Without this level of serialization, for attribute using a shared buffer, a thread scheduling may happens while the device server process is in the CORBA layer transferring the attribute data on the network. Three serialization models are available for attribute serialization. The default is well adapted to nearly all cases. Nevertheless, if the user code manages several attributes data buffer or if it manages its own buffer protection by one way or another, it could be interesting to tune this serialization level. The available models are:

1. Serialization by kernel. This is the default case. The kernel is managing the serialization

2. Serialization by user. The user code is in charge of the serialization. This serialization is done by the use of a omni_mutex object. An omni_mutex is an object provided by the omniORB package. It is the user responsability to lock this mutex when appropriate and to give this mutex to the Tango kernel before leaving the attribute read method

3. No serialization.

By default, every Tango device attribute is in serialization by kernel. Methods of the Tango::Attribute class allow to change the attribute serialization behavior and to give the user omni_mutex object to the kernel.

```
void MyClass::init_device()
{
   ...
   ...
   Tango::Attribute &att = dev_attr->get_attr_by_name("TheAttribute");
   att.set_attr_serial_model(Tango::ATTR_BY_USER);
   ....
   ....

10  }
11
12
13  void MyClass::read_TheAttribute(Tango::Attribute &attr)
14  {
15     ....
16     ....
17     the_mutex.lock();
18     ....
19     // Fill the attribute buffer
20     ....
21     attr.set_value(buffer,....);
22     attr->set_user_attr_mutex(&the_mutex);
23  }
```

The serialization model is set at line 6 in the init_device() method. The user omni_mutex is passed to the Tango kernel at line 22. This omni_mutex object is a device data member. See [?] for all details on the methods to set attribute serialization model.

Client process

Clients are also multi threaded processes. The underlying C++ ORB (omniORB) try to keep system resources to a minimum. To decrease process file descriptors usage, each connection to server is automatically closed if it is idle for more than 2 minutes and automatically re-opened when needed. A dedicated thread is spawned by the ORB to manage this automatic closing connection (the ORB scavenger thread).

Threrefore, a Tango client has two threads which are:

1. The main thread
2. The ORB scavanger thread

If the client is using the event system and as Tango is using the event push-push model, it has to be a server for receiving the events. This increases the number of threads. The client now has 6 threads which are:

- The main thread
- The ORB scavenger thread
- Two Zmq implementation threads
- Two Tango event system related threads (the KeepAliveThread and the EventConsumer thread)

Generating events in a device server

The server is at the origin of events. It will fire events as soon as they occur. Standard events (*change*, *periodic* and *archive*) are detected automatically in the polling thread and fired as soon as they are detected. The *periodic* events can only be handled by the polling thread. *Change, Data ready* and *archive* events can also be pushed from the device server code. To allow a client to subscribe to events of non polled attributes the server has to declare that events are pushed from the code. Three methods are available for this purpose:

```
Attr::set_change_event(bool implemented, bool detect = true);
Attr::set_archive_event(bool implemented, bool detect = true);
Attr::set_data_ready_event( bool implemented);
```

where *implemented*=true indicates that events are pushed manually from the code and *detect*=true (when used) triggers the verification of the same event properties as for events send by the polling thread. When setting *detect*=false, no value checking is done on the pushed value! The class DeviceImpl also supports the first two methods with an addictional parameter attr_name defining the attribute name.

To push events manually from the code a set of data type dependent methods can be used:

```
DeviceImpl::push_change_event (string attr_name, ....);
DeviceImpl::push_archive_event(string attr_name, ....);
```

For the data ready event, a DeviceImpl class method has to be used to push the event.

```
DeviceImpl::push_data_ready_event(string attr_name,Tango::DevLong ctr);
```

See the class documentation for all available interfaces.

For non-standard events a single call exists for pushing the data to the CORBA Notification Service (omniNotify). Clients who are subscribed to this event have to know what data type is in the DeviceAttribute and unpack it accordingly.

To push non-standard events, use the following api call is available to all device servers :

```
DeviceImpl::push_event( string attr_name,
             vector<string> &filterable_names,
             vector<double> &filterable_vals,
             Attribute &att)
```

where *attr_name* is the name of the attribute. *Filterable_names* and *filterable_vals* represent any filterable data which can be used by clients to filter on. Here is a typical example of what a server will need to do to send its own events. We are in the read method of the Sinusoide attribute. This attribute is readable as any other attribute but an event is sent if its value is positive when it is read. On top of that, this event is sent with one filterable field called value which is set to the attribute value.

```
void MyClass::read_Sinusoide(Tango::Attribute &attr)
 {
   ...
      struct timeval tv;
      gettimeofday(&tv, NULL);
      sinusoide = 100 * sin( 2 * 3.14 * frequency * tv.tv_sec);

      if (sinusoide >= 0)
 9        {
10           vector<string> filterable_names;
11           vector<double> filterable_value;
12
13           filterable_names.push_back("value");
14           filterable_value.push_back((double)sinusoide);
15
16           push_event( attr.get_name(),
17                       filterable_names, filterable_value,
18                       &sinusoide);
19        }
20     ....
21     ....
22
23  }
```

line 13-14 : The filter pair name/value is initialised
line 16-18 : The event is pushed

Using multicast protocol to transfer events

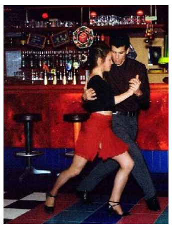
This feature is available starting with Tango 8.1. Transferring events using a multicast protocol means delivering the events to a group of clients simultaneously in a single transmission from the event source. Tango, through ZMQ, uses the OpenPGM multicating protocol. This is one implementation of the PGM protocol defined by the RFC 3208 (Reliable multicasting protocol). Nevertheless, the default event communication mode is unicast and propagating events via multicasting requires some specific configuration.

Configuring events to use multicast transport

Before using multicasting transport for event(s), you have to choose which address and port have to be used. In a IP V4 network, only a limited set of addresses are associated with multicasting. These are the IP V4 addresses between

224.0.1.0 and 238.255.255.255

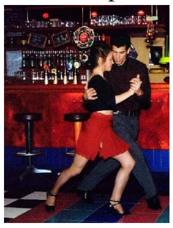
Once the address is selected, you have to choose a port number. Together with the event name, these are the two minimum configuration informations which have to be provided to Tango to get multicast transport. This configuration is done using the **MulticastEvent** free property associated to the **CtrlSystem** object.



In the above window dump of the Jive tool, the *change* event on the *state* attribute of the *dev/test/11* device has to be transferred using multicasting with the address *226.20.21.22* and the port number *2222*. The exact definition of this CtrlSystem/MulticastEvent property for one event propagated using multicast is

```
CtrlSystem->MulticastEvent:   Multicast address,
                              port number,
                              [rate in Mbit/sec],
                              [ivl in seconds],
                              event name
```

Rate and Ivl are optional properties. In case several events have to be transferred using multicasting, simply extend the MulicastEvent property with the configuration parameters related to the other events. There is only one MultiCastEvent property per Tango control system. The underlying multicast protocol (PGM) is rate limited. This means that it limits its network bandwidth usage to a user defined value. The optional third configuration parameter is the maximum rate (in Mbit/sec) that the protocol will use to transfert this event. Because PGM is a reliable protocol, data has to be buffered for re-transmission in case a receiver signal some lost data. The optional forth configuration parameter specify the maximum amount of time (in seconds) that a receiver can be absent for a multicast group before unrecoverable data loss will occur. Exercise care when setting large recovery interval as the data needed for recovery will be held in memory. For example, a 60 seconds (1 minute) recovery interval at a data rate of 1 Gbit/sec requires a 7 GBytes in-memory buffer. Whan any of these two optional parameters are not set, the default value (defined in next sub-chapter) are used. Here is another example of events using multicasting configuration



In this example, there are 5 events which are transmitted using multicasting:

1. Event *change* for attribute *state* on device *dev/test/11* which uses multicasting address *226.20.21.22* and port number *2222*
2. Event *periodic* for attribute *state* on device *dev/test/10* which uses multicasting address *226.20.21.22* and port number *3333*
3. Event *change* for attribute *ImaAttr* on device *et/ev/01* which uses multicasting address *226.30.31.32* and port number *4444*. Note that this event uses a rate set to *40 Mbit/sec* and a ivl set to *20 seconds*.
4. Event *change* for attribute *event_change_tst* on device *dev/test/12* which uses multicasting address *226.20.21.22* and port number *2233*
5. Event *archive* for attribute *event_change_tst* on device *dev/tomasz/3* which uses multicasting address *226.20.21.22* and port number *2234*

Default multicast related properties

On top of the MulticastEvent property previously described, Tango supports three properties to defined default value for multicast transport tuning. These properties are:

- **MulticastRate** associated to the CtrlSystem object. This defines the maximum rate will will be used by the multicast protocol when transferring event. The unit is Mbit/sec. In case this property is not defined, the Tango library used a value of 80 Mbit/sec.
- **MulticastIvl** associated to the CtrlSystem object. It specifies the maximum time (in sec) during which data has to be buffered for re-transmission in case a receiver signals some lost data. The unit is seconds. In case this property is not defined, the Tango library takes a value of 20 seconds.
- **MulticastHops** associated to the CtrlSystem object. This property defines the maximum number of element (router), the multicast packet is able to cross. Each time one element is crossed, the value is decremented. When it reaches 0, the packet is not transferred any more. In case this property is not defined, the Tango library uses a value of 5.

Memorized attribute

It is possible to ask Tango to store in its database the last written value for attribute of the SCALAR data format and obviously only for READ_WRITE or READ_WITH_WRITE attribute. This is fully automatic. During device startup phase, for all device memorized attributes, the value written in the database is fetched and applied. A write_attribute call can be generated to apply the memorized value to the attribute or only the attribute set point can be initialised. The following piece of code shows how the source code should be written to set an attribute as memorized and to initialise only the attribute set point.

```
1  void DevTestClass::attribute_factory(vector<Tango::Attr *> &att_list)
2   {
3       ...
4       att_list.push_back(new String_attrAttr());
5       att_list.back()->set_memorized();
6       att_list.back()->set_memorized_init(false);
7       ...
8   }
```

Line 4 : The attribute to be memorized is created and inserted in the attribute vector.
Line 5 : The *set_memorized()* method of the attribute base class is called to define the attribute as memorized.
Line 6 : The set_memorized_init() method is called with the parameter false to define that only the set point should be initialsied.

Forwarded attribute

Definition

Let's take an example to explain what is a forwarded attribute. We assume we have to write a Tango class for a ski lift in a ski resort somewhere in the Alps. Obviously, the ski lift has a motor for which we already have a Tango class. This motor Tango class has one attribute *speed*. But for the ski lift, the motor speed is not the only thing which has to be controlled. For instance, you also want to give access to the wind sensor data installed on the top of the ski lift. Therefore, you write a ski-lift Tango class representing the whole ski-lift system. This ski-lift class will have at least two attributes which are:

1. The wind speed at the top of the ski-lift
2. The motor speed

The ski-lift Tango class motor speed attribute is nothing more than the motor Tango class speed attribute. All the ski-lift class has to do for this attribute is to forward the request (read/write) to the speed attribute of the motor Tango class. The speed attribute of the ski-lift Tango class is a **forwarded attribute** while the speed attribute of the motor Tango class is its **root attribute**.

A forwarded attribute get its configuration from its root attribute and it forwards to its root attribute

- Its read / write / write_read requests
- Its configuration change
- Its event subscription
- Its locking behavior

As stated above, a forwarded attribute has the same configuration than its root attribute except its *name* and *label* which stays local. All other attribute configuration parameters are forwarded to the root attribute. If a root attribute configuration parameter is changed, the forwarded attribute is informed (via event) and its local configuration is also modified.

The association between the forwarded attribute and its root attribute is done using a property named

__root_att

belonging to the forwarded attribute. This property value is simply the name of the root attribute. Muti-control system is supported and this __root_att attribute property value can be something like *tango://my_tango_host:10000/my/favorite/dev/the_root_attribute*. The name of the root attribute is included in attribute configuration.

It is forbidden to poll a forwarded attribute and one exception is thrown if such a case happens. Polling has to be done on the root attribute. Nevertheless, if the root attribute is polled, a request to read the forwarded attribute with the DeviceProxy object source parameter set to CACHE_DEVICE or CACHE will get its data from the root attribute polling buffer.

If you subscribe to event(s) on a forwarded attribute, the subscription is forwarded to the root attribute. When the event is received by the forwarded attribute, the attribute name in the event data is modified to reflect the forwarded attribute name and the event is pushed to the original client(s).

When a device with forwarded attribute is locked, the device to which the root attribute belongs is also locked.

Coding

As explained in the chapter Writing a Tango device server, each Tango class attribute is implemented via a C++ class which has to inherit from either *Attr*, *SpectrumAttr* or *ImageAttr* according to the attribute data format. For forwarded attribute, the related class has to inherit from the **FwdAttr** class whatever its data format is. For classical attribute, the programmer can define in the Tango class code default value for the attribute properties using one instance of the *UserDefaultAttrProp* class. For forwarded attribute, the programmer has to create one instance of the **UserDefaultFwdAttrProp** class but only the attribute label can be defined. One example of how to program a forwarded attribute is given below

```
 1   class MyFwdAttr: public Tango::FwdAttr
 2   {
 3   public:
 4       MyFwdAttr(const string &_n):FwdAttr(_n) {};
 5       ~MyFwdAttr() {};
 6   };
 7
 8   void DevTestClass::attribute_factory(vector<Tango::Attr *> &att_list)
 9   {
10      ...
11      MyFwdAttr *att1 = new MyFwdAttr("fwd_att_name");
12      Tango::UserDefaultFwdAttrProp att1_prop;
13      att1_prop.set_label("Gasp a fwd attribute");
14      att1->set_default_properties(att1_prop);
15      att_list.push_back(att1);
16      ...
17   }
```

Line 1 : The forwarded attribute class inherits from FwdAttr class.
Line 4-5 : Only constructor and destructor methods are required
Line 11 : The attribute object is created
Line 12-14 : A default value for the forwarded attribute label is defined.
Line 15: The forwarded attribute is added to the list of attribute

In case of error in the forwarded attribute configuration (for instance missing __root_att property), the attribute is not created by the Tango kernel and is therefore not visible for the external world. The state of the device to which the forwarded attribute belongs to is set to ALARM (if not already FAULT) and a detailed error report is available in the device status. In case a device with forwarded attribute(s) is started before the device(s) with the root attribute(s), the same principle is used: forwarded attribute(s) are not created, device state is set to ALARM and device status is reporting the error. When the device(s) with the root attribute will start, the forwarded attributes will automatically be created.

Transferring images

Some optimized methods have been written to optimize image transfer between client and server using the attribute DevEncoded data type. All these methods have been merged in a class called EncodedAttribute. Within this class, you will find methods to:

- Encode an image in a compressed way (JPEG) for images coded on 8 (gray scale), 24 or 32 bits
- Encode a grey scale image coded on 8 or 16 bits
- Encode a color image coded on 24 bits

- Decode images coded on 8 or 16 bits (gray scale) and returned a 8 or bits grey scale image
- Decode color images transmitted using a compressed format (JPEG) and returns a 32 bits RGB image

The following code snippets are examples of how these methods have to be used in a server and in a client. On the server side, creates an instance of the EncodedAttribute class within your object

```
class MyDevice::Tango::Device_4Impl
 {
     ...
     Tango::EncodedAttribute jpeg;
     ...
 }
```

In the code of your device, use an encoding method of the EncodedAttribute class

```
1  void MyDevice::read_Encoded_attr_image(Tango::Attribute &att)
2  {
3       ....
4       jpeg.encode_jpeg_gray8(imageData,256,256,50.0);
5       att.set_value(&jpeg);
6  }
```

Line 4: Image encoding. The size of the image is 256 by 256. Each pixel is coded using 8 bits. The encoding quality is defined to 50 in a scale of 0 - 100. imageData is the pointer to the image data (pointer to unsigned char)

Line 5: Set the value of the attribute using a *Attribute::set_value()* method.

On the client side, the code is the following (without exception management)

```
 1     ....
 2     DeviceAttribute da;
 3     EncodedAttribute att;
 4     int width,height;
 5     unsigned char *gray8;
 6
 7     da = device.read_attribute("Encoded_attr_image");
 8     att.decode_gray8(&da,&width,&height,&gray8);
 9     ....
10    delete [] gray8;
11    ...
```

The attribute named Encoded_attr_image is read at line7. The image is decoded at line 8 in a 8 bits gray scale format. The image data are stored in the buffer pointed to by gray8. The memory allocated by the image decoding at line 8 is returned to the system at line 10.

Device server with user defined event loop

Sometimes, it could be usefull to write your own process event handling loop. For instance, this feature can be used in a device server process where the ORB is only one of several components that must perform event handling. A device server with a graphical user interface must allow the GUI to handle windowing events in addition to allowing the ORB to handle incoming requests. These types of device server therefore perform non-blocking event handling. They turn the main thread of control over each of the vvarious event-handling sub-systems while not allowing any of them to block for significants period of time. The *Tango::Util* class has a method called *server_set_event_loop()* to deal with such a case. This method has only one argument which is a function pointer. This function does not receive any argument and returns a boolean. If this boolean is true, the device server process exits. The device server core will call this function in a loop without any sleeping time between the call. It is the user responsability to implement in this function some kind of sleeping mechanism in order not to make this loop too CPU consuming. The code of this function is executed by the device server main thread. The following piece of code is an example of how you can use this feature.

```
bool my_event_loop()
{
   bool ret;

   some_sleeping_time();

   ret = handle_gui_events();

   return ret;
}

int main(int argc,char *argv[])
{
   Tango::Util *tg;
   try
   {
      // Initialise the device server
      //----------------------------------------
      tg = Tango::Util::init(argc,argv);

      tg->set_polling_threads_pool_size(5);

      // Create the device server singleton
      //        which will create everything
      //----------------------------------------
      tg->server_init(false);

      tg->server_set_event_loop(my_event_loop);

      // Run the endless loop
      //----------------------------------------
      cout << "Ready to accept request" << endl;
      tg->server_run();
   }
   catch (bad_alloc)
```

```
36       {
37       ...
```

The device server main event loop is set at line 29 before the call to the Util::server_run() method. The function used as server loop is defined between lines 2 and 11.

Device server using file as database

For device servers not able to access the Tango database (most of the time due to network route or security reason), it is possible to start them using file instead of a real database. This is done via the device server

-file=<file name>

command line option. In this case,

- Getting, setting and deleting class properties
- Getting, setting and deleting device properties
- Getting, setting and deleting class attribute properties
- Getting, setting and deleting device attribute properties

are handled using the specified file instead of the Tango database. The file is an ASCII file and follows a well-defined syntax with predefined keywords. The simplest way to generate the file for a specific device server is to use the Jive application. See [**?**] to get Jive documentation. The Tango database is not only used to store device configuration parameters, it is also used to store device network access parameter (the CORBA IOR). To allow an application to connect to a device hosted by a device server using file instead of database, you need to start it on a pre-defined port, and you must use one of the underlying ORB option called *endPoint* like

myserver myinstance_name -file=/tmp/MyServerFile -ORBendPoint giop:tcp::<port number>

to start your device server. The device name passed to the client application must also be modified in order to refect the non-database usage. See [DeviceNaming] to learn about Tango device name syntax. Nevertheless, using this Tango feature prevents some other features to be used :

- No check that the same device server is running twice.
- No device or attribute alias name.
- In case of several device servers running on the same host, the user must manually manage a list of already used network port.

Device server without database

In some very specific cases (Running a device server within a lab during hardware development...), it could be very useful to have a device server able to run even if there is no database in the control system. Obviously, running a Tango device server without a database means loosing Tango features. The lost features are :

- No check that the same device server is running twice.
- No device configuration via properties.

- No event generated by the server.
- No memorized attributes
- No device attribute configuration via the database.
- No check that the same device name is used twice within the same control system.
- In case of several device servers running on the same host, the user must manually manage a list of already used network port.

To run a device server without a database, the **-nodb** command line option must be used. One problem when running a device server without the database is to pass device name(s) to the device server. Within Tango, it is possible to define these device names at two different levels :

1. At the command line with the **-dlist** option: In case of device server with several device pattern implementation, the device name list given at command line is only for the last device pattern created in the *class_factory()* method. In the device name list, the device name separator is the comma character.
2. At the device pattern implementation level: In the class inherited from the Tango::DeviceClass class via the re-definition of a well defined method called *device_name_factory()*

If none of these two possibilities is used, the tango core classes defined one default device name for each device pattern implementation. This default device name is *NoName*. Device definition at the command line has the highest priority.

Example of device server started without database usage

Without database, you need to start a Tango device server on a pre-defined port, and you must use one of the underlying ORB option called *endPoint* like

myserver myinstance_name -ORBendPoint giop:tcp::<port number> -nodb -dlist a/b/c

The following is two examples of starting a device server not using the database when the *device_name_factory()* method is not re-defined.

- StepperMotor et -nodb -dlist id11/motor/1,id11/motor/2

  This command line starts the device server with two devices named *id11/motor/1* and *id11/motor/2*
- StepperMotor et -nodb

  This command line starts a device server with one device named *NoName*

When the *device_name_factory()* method is re-defined within the StepperMotorClass class.

```
void StepperMotorClass::device_name_factory(vector<string> &list)
{
    list.push_back("sr/cav-tuner/1");
    list.push_back("sr/cav-tuner/2");
}
```

- StepperMotor et -nodb
  This commands starts a device server with two devices named *sr/cav-tuner/1* and *sr/cav-tuner/2*.

- StepperMotor et -nodb -dlist id12/motor/1
  Starts a device server with only one device named id12/motor/1

Connecting client to device within a device server started without database

In this case, the host and port on which the device server is running are part of the device name. If the device name is *a/b/c*, the host is *mycomputer* and the port *1234*, the device name to be used by client is

mycomputer:1234/a/b/c#dbase=no

See appendix [DeviceNaming] for all details about Tango object naming.

Multiple database servers within a Tango control system

Tango uses MySQL as database and allows access to this database via a specific Tango device server. It is possible for the same Tango control system to have several Tango database servers. The host name and port number of the database server is known via the TANGO_HOST environment variable. If you want to start several database servers in order to prevent server crash, use the following TANGO_HOST syntax

TANGO_HOST=<host_1>:<port_1>,<host_2>:<port_2>,<host_3>:<port_3>

All calls to the database server will automatically switch to a running servers in the given list if the one used dies.

The Tango controlled access system

User rights definition

Within the Tango controlled system, you give rights to a user. User is the name of the user used to log-in the computer where the application trying to access a device is running. Two kind of users are defined:

1. Users with defined rights
2. Users without any rights defined in the controlled system. These users will have the rights associated with the pseudo-user called All Users

The controlled system manages two kind of rights:

- Write access meaning that all type of requests are allowed on the device
- Read access meaning that only read-like access are allowed (write_attribute, write_read_attribute and set_attribute_config network calls are forbidden). Executing a command is also forbidden except for commands defined as **Allowed commands**. Getting a device state or status using the command_inout call is always allowed. The definition of the allowed commands is done at the device class level. Therefore, all devices belonging to the same class will have the allowed commands set.

The rights given to a user is the check result splitted in two levels:

1. At the host level: You define from which hosts the user may have write access to the control system by specifying the host name. If the request comes from a host which is not defined, the right will be Read access. If nothing is defined at this level for the user, the rights of the All Users user will be used. It is also possible to specify the host by its IP address. You can define a host family using wide-card in the IP address (eg. 160.103.11.* meaning any host with IP address starting with 160.103.11). Only IP V4 is supported.
2. At the device level: You define on which device(s) request are allowed using device name. Device family can be used using widecard in device name like domin/family/*

Therefore, the controlled system is doing the following checks when a client try to access a device:

- Get the user name
- Get the host IP address
- If rights defined at host level for this specific user and this IP address, gives user temporary write acccess to the control system
- If nothing is specified for this specific user on this host, gives to the user a temporary access right equal to the host access rights of the All User user.
- If the temporary right given to the user is write access to the control system
    - If something defined at device level for this specific user
        - If there is a right defined for the device to be accessed (or for the device family), give user the defined right
        - Else
            - If rights defined for the All Users user for this device, give this right to the user
            - Else, give user the Read Access for this device
    - Else
        - If there is a right defined for the device to be accessed (or for the device family) for the All User user, give user this right
        - Else, give user the Read Access right for this device
- Else, access right will be Read Access

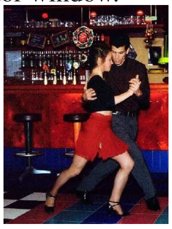
Then, when the client tries to access the device, the following algorithm is used:

- If right is Read Access
    - If the call is a write type call, refuse the call
    - If the call is a command execution
        - If the command is one of the command defined in the Allowed commands for the device class, send the call
        - Else, refuse the call

All these checks are done during the DeviceProxy instance constructor except those related to the device class allowed commands which are checked during the command_inout call.

To simplify the rights management, give the All Users user host access right to all hosts (.*.*.*) and read access to all devices (/*/*). With such a set-up for this user, each new user without any rights defined in the controlled access will have only Read Access to all devices on the control system but from any hosts. Then, on request, gives Write Access to specific user on specific host (or family) and on specific device (or family).

The rights managements are done using the Tango Astor:raw-latex:*cite{Astor_doc}* tool which has some graphical windows allowing to grant/revoke user rights and to define device class allowed commands set. The following window dump shows this Astor window.



In this example, the user taurel has Write Access to the device sr/d-ct/1 and to all devices belonging to the domain fe but only from the host pcantares He has read access to all other devices but always only from the host pcantares. The user verdier has write access to the device sys/dev/01 from any host on the network 160.103.5 and Read Access to all the remaining devices from the same network. All the other users has only Read Access but from any host.

Running a Tango control system with the controlled access

All the users rights are stored in two tables of the Tango database. A dedicated device server called **TangoAccessControl** access these tables without using the classical Tango database server. This TangoAccessControl device server must be configured with only one device. The property **Services** belonging to the free object **CtrlSystem** is used to run a Tango control system with its controlled access. This property is an array of string with each string describing the service(s) running in the control system. For controlled access, the service name is AccessControl. The service instance name has to be defined as tango. The device name associated with this service must be the name of the TangoAccessControl server device. For instance, if the TangoAccessControl device server device is named *sys/access_control/1*, one element of the Services property of the CtrlSystem object has to be set to

AccessControl/tango:sys/access_control/1

If the service is defined but without a valid device name corresponding to the TangoAccessControl device server, all users from any host will have write access (simulating a Tango control system without controlled access). Note that this device server connects to the MySQL database and therefore may need the MySQL connection related environment variables MYSQL_USER and MYSQL_PASSWORD described in [sub:Db-Env-Variables]

Even if a controlled access system is running, it is possible to by-pass it if, in the environment of the client application, the environment variable SUPER_TANGO is defined to true. If for one reason or another, the controlled access server is defined but not accessible, the device right checked at that time will be Read Access.

[FourRicardo]|image|

Reference part

This chapter is only part of the TANGO device server reference guide. To get reference documentation about the C++ library classes, see :raw-latex:‘cite{TANGO_ref_man}‘. To get reference documentation about the Java classes, also see :raw-latex:‘cite{TANGO_ref_man}‘.

Device parameter

A black box, a device description field, a device state and status are associated with each TANGO device.

The device black box

The device black box is managed as a circular buffer. It is possible to tune the buffer depth via a device property. This property name is

device name->blackbox_depth

A default value is hard-coded to 50 if the property is not defined. This black box depth property is retrieved from the Tango property database during the device creation phase.

The device description field

There are two ways to intialise the device description field.

- At device creation time. Some constructors of the DeviceImpl class supports this field as parameter. If these constructor are not used, the device description field is set to a default value which is *A Tango device*.
- With a property. A description field defines with this method overrides a device description defined at construction time. The property name is

  device name->description

The device state and status

Some constructors of the DeviceImpl class allows the initialisation of device state and/or status or device creation time. If these fields are not defined, a default value is applied. The default state is Tango::UNKOWN, the default status is *Not Initialised.*

The device polling

Seven device properties allow the polling tunning. These properties are described in the following table

|c|c|c| **Property name & property rule & default value** poll_ring_depth & Polling buffer depth & 10 cmd_poll_ring_depth & Cmd polling buffer depth & attr_poll_ring_depth & Attr polling buffer depth & poll_old_factor & Data too old factor & 4 min_poll_period & Minimun polling period & cmd_min_poll_period & Min. polling period for cmd & attr_min_poll_period & Min. polling period for attr &

The rule of the poll_ring_depth property is obvious. It defines the polling ring depth for all the device polled command(s) and attribute(s). Nevertheless, when filling the polling buffer via the fill_cmd_polling_buffer() (or fill_attr_polling_buffer()) method, it could be helpfull to define specific polling ring depth for a command (or an attribute). This is the rule of the cmd_poll_ring_depth and attr_poll_ring_depth properties. For each polled object with specific polling depth (command or attribute), the syntax of this property is the object name followed by the ring depth (ie State,20,Status,15). If one of these properties is defined, for the specific command or attribute, it will overwrite the value set by the poll_ring_depth property. The poll_old_factor property allows the user to tune how long the data recorded in the polling buffer are valid. Each time some data are read from the polling buffer, a check is done between the date when the data were recorded in the polling buffer and the date when the user request these data. If the interval is greater than the object polling period multiply by the value of the poll_old_factor factory, an exception is returned to the caller. These two properties are defined at device level and therefore, it is not possible to tune this parameter for each polled object (command or attribute). The last 3 properties are dedicated to define a polling period minimum threshold. The property min_poll_period defines in (mS) a device minimum polling period. Property cmd_min_poll_period defines (in mS) a minimum polling period for a specific command. The syntax of this property is the command name followed by the minimum polling period (ie MyCmd,400). Property attr_min_poll_period defines (in mS) a minimum polling period for a specific attribute. The syntax of this property is the attribute name followed by the minimum polling period (ie MyAttr,600). These two properties has a higher priority than the min_poll_period property. By default these three properties are not defined mening that there is no minimun polling period.

Four other properties are used by the Tango core classes to manage the polling thread. These properties are :

- polled_cmd to memorize the name of the device polled command
- polled_attr to memorize the name of the device polled attribute
- non_auto_polled_cmd to memorize the name of the command which shoule not be polled automatically at the first request
- non_auto_polled_attr to memorize the name of the attribute which should not be polled automatically at the first request

You don't have to change these properties values by yourself. They are automatically created/modified/deleted by Tango core classes.

The device logging

The Tango Logging Service (TLS) uses device properties to control device logging at startup (static configuration). These properties are described in the following table

|c|c|c| **Property name & property rule & default value** logging_level & Initial device logging level & WARN logging_target & Initial device logging target & No default logging_rft & Logging rolling file threshold & 20 Mega bytes logging_path & Logging file path & & & C:/tango-<logging name> (Windows)

- The logging_level property controls the initial logging level of a device. Its set of possible values is: OFF, FATAL, ERROR, WARN, INFO or DEBUG. This property is overwritten by the verbose command line option (-v).

- The logging_target property is a multi-valued property containing the initial target list. Each entry must have the following format: target_type::target_name (where target_type is one of the supported target types and target_name, the name of the target). Supported target types are: *console*, *file* and *device*. For a device target, target_name must contain the name of a log consumer device (as defined in [sec:Tango-log-consumer]). For a file target, target_name is the name of the file to log to. If omitted the device's name is used to build the file name (domain_family_member.log). Finally, target_name is ignored in the case of a console target. The TLS does not report any error occurred while trying to setup the initial targets.

  – Logging_target property example :
    logging_target = [console, file, file::/home/me/mydevice.log, device::tmp/log/1
    In this case, the device will automatically logs to the standard output, to its default file (which is something like domain_family_member.log), to a file named mydevice.log and located in /home/me. Finally, the device logs are also sent to a log consumer device named tmp/log/1.

- The logging_rft property specifies the rolling file threshold (rft), of the device's file targets. This threshold is expressed in Kb. When the size of a log file reaches the so-called rolling-file-threshold (rft), it is backuped as *current_log_file_name* + *_1* and a new current_log_file_name is opened. Obviously, there is only one backup file at a time (i.e. any existing backup is destroyed before the current log file is backuped). The default threshold is 20 Mb, the minimum is 500 Kb and the maximum is 1000 Mb.

- The logging_path property overwrites the TANGO_LOG_PATH environment variable. This property can only be applied to a DServer class device and has no effect on other devices.

Device attribute

Attribute are configured with two kind of parameters: Parameters hard-coded in source code and modifiable parameters

Hard-coded device attribute parameters

Seven attribute parameters are defined at attribute creation time in the Tango class source code. Obviously, these parameters are not modifiable except with a new source code compilation. These parameters are

|c|c| Parameter name & Parameter description name & Attribute name data_type & Attribute data type data_format & Attribute data format writable & Attribute read/write type max_dim_x & Maximum X dimension max_dim_y & Maximum Y dimension writable_attr_name & Associated write attribute level & Attribute display level root_attr_name & Root attribute name

The Attribute data type Thirteen data types are supported. These data types are

- Tango::DevBoolean

- Tango::DevShort
- Tango::DevLong
- Tango::DevLong64
- Tango::DevFloat
- Tango::DevDouble
- Tango::DevUChar
- Tango::DevUShort
- Tango::DevULong
- Tango::DevULong64
- Tango::DevString
- Tango::DevState
- Tango::DevEncoded

The attribute data format Three data format are supported for attribute

|c|c| Format & Description Tango::SCALAR & The attribute value is a single number Tango::SPECTRUM & The attribute value is a one dimension number Tango::IMAGE & The attribute value is a two dimension number

The max_dim_x and max_dim_y parameters These two parameters defined the maximum size for attributes of the SPECTRUM and IMAGE data format.

|c|c|c| data format & max_dim_x & max_dim_y Tango::SCALAR & 1 & 0 Tango::SPECTRUM & User Defined & 0 Tango::IMAGE & User Defined & User Defined

For attribute of the Tango::IMAGE data format, all the data are also returned in a one dimension array. The first array is value[0],[0], array element X is value[0],[X-1], array element X+1 is value[1][0] and so forth.

The attribute read/write type Tango supports four kind of read/write attribute which are :

- Tango::READ for read only attribute
- Tango::WRITE for writable attribute
- Tango::READ_WRITE for attribute which can be read and write
- Tango::READ_WITH_WRITE for a readable attribute associated to a writable attribute (For a power supply device, the current really generated is not the wanted current. To handle this, two attributes are defined which are *generated_current* and *wanted_current*. The *wanted_current* is a Tango::WRITE attribute. When the *generated_current* attribute is read, it is very convenient to also get the *wanted_current* attribute. This is exactly what the Tango::READ_WITH_WRITE attribute is doing)

When read, attribute values are always returned within an array even for scalar attribute. The length of this array and the meaning of its elements is detailed in the following table for scalar attribute.

|c|c|c|c| Name & Array length & Array[0] & Array[1] Tango::READ & 1 & Read value & Tango::WRITE & 1 & Last write value & Tango::READ_WRITE & 2 & Read value & Last write value Tango::READ_WITH_WRITE & 2 & Read value & Associated attributelast

system-message
WARNING/2 in `tango.rst`, line 11391
Definition list ends without a blank line; unexpected unindent. backrefs:

write value

When a spectrum or image attribute is read, it is possible to code the device class in order to send only some part of the attribute data (For instance only a Region Of Interest for an image) but never more than what is defined by the attribute configuration parameters max_dim_x and max_dim_y. The number of data sent is also transferred with the data and is named **dim_x** and **dim_y**. When a spectrum or image attribute is written, it is also possible to send only some of the attribute data but always less than max_dim_x for spectrum and max_dim_x * max_dim_y for image. The following table describe how data are returned for spectrum attribute. dim_x is the data size sent by the server when the attribute is read and dim_x_w is the data size used during the last attribute write call.

|c|c|c|c| Name & Array length & Array[0->dim_x-1] & Array[dim_x -> dim_x + dim_x_w -1]

system-message
ERROR/3 in `tango.rst`, line 11408
Unexpected indentation. backrefs:

Tango::READ & dim_x & Read values & Tango::WRITE & dim_x_w & Last write values & Tango::READ_WRITE & dim_x + dim_x_w & Read value & Last write

system-message
WARNING/2 in `tango.rst`, line 11411
Block quote ends without a blank line; unexpected unindent. backrefs:

values Tango::READ_WITH_WRITE & dim_x + dim_x_w & Read value & Associated

system-message
WARNING/2 in `tango.rst`, line 11413
Definition list ends without a blank line; unexpected unindent. backrefs:

attributelast write values

The following table describe how data are returned for image attribute. dim_r is the data size sent by the server when the attribute is read (dim_x * dim_y) and dim_w is the data size used during the last attribute write call (dim_x_w * dim_y_w).

|c|c|c|c| Name & Array length & Array[0->dim_r-1] & Array[dim_r-> dim_r + dim_w -1]

system-message

ERROR/3 in `tango.rst`, line 11422

Unexpected indentation. backrefs:

> Tango::READ & dim_r & Read values & Tango::WRITE & dim_w & Last write values & Tango::READ_WRITE & dim_r + dim_w & Read value & Last write values Tango::READ_WITH_WRITE & dim_r + dim_w & Read value & Associated

system-message

WARNING/2 in `tango.rst`, line 11426

Block quote ends without a blank line; unexpected unindent. backrefs:

attributelast write values

Until a write operation has been performed, the last write value is initialized to *0* for scalar attribute of the numeriacal type, to *Not Initialised* for scalar string attribute and to *true* for scalar boolean attribute. For spectrum or image attribute, the last write value is initialized to an array of one element set to *0* for numerical type, to an array of one element set to *true* for boolean attribute and to an array of one element set to *Not initialized* for string attribute

The associated write attribute parameter This parameter has a meaning only for attribute with a Tango::READ_WITH_WRITE read/write type. This is the name of the associated write attribute.

The attribute display level parameter This parameter is only an help for graphical application. It is a C++ enumeration starting at 0. The code associated with each attribute display level is defined in the following table (Tango::DispLevel).

|c|c| **name & Value** Tango::OPERATOR & 0 Tango::EXPERT & 1

This parameter allows a graphical application to support two types of operation :

- An operator mode for day to day operation
- An expert mode when tuning is necessary

According to this parameter, a graphical application knows if the attribute is for the operator mode or for the expert mode.

The root attribute name parameter In case the attribute is a forwarded one, this parameter is the name of the associated root attribute. In case of classical attribute, this string is set to Not specified.

Modifiable attribute parameters

Each attribute has a configuration set of 20 modifiable parameters. These can be grouped in three different purposes:

1. General purpose parameters
2. Alarm related parameters
3. Event related parameters

General purpose parameters Eight attribute parameters are modifiable at run-time via a device call or via the property database.

|c|c| **Parameter name & Parameter description** description & Attribute description label & Attribute label unit & Attribute unit standard_unit & Conversion factor to MKSA unit display_unit & The attribute unit in a printable form format & How to print attribute value min_value & Attribute min value max_value & Attribute max value enum_labels & Enumerated labels memorized & Attribute memorization

The **description** parameter describes the attribute. The **label** parameter is used by graphical application to display a label when this attribute is used in a graphical application. The **unit** parameter is the attribute value unit. The **standard_unit** parameter is the conversion factor to get attribute value in MKSA units. Even if this parameter is a number, it is returned as a string by the device *get_attribute_config* call. The **display_unit** parameter is the string used by graphical application to display attribute unit to application user. The **enum_labels** parameter is defined only for attribute of the DEV_ENUM data type. This is a vector of strings with one string for each enumeration label. It is an ordered list.

The format attribute parameter This parameter specifies how the attribute value should be printed. It is not valid for string attribute. This format is a string of C++ streams manipulators separated by the **;** character. The supported manipulators are :

- fixed
- scientific
- uppercase
- showpoint
- showpos
- setprecision()
- setw()

Their definition are the same than for C++ streams. An example of format parameter is
scientific;uppercase;setprecision(3)
. A class called Tango::AttrManip has been written to handle this format string. Once the attribute format string has been retrieved from the device, its value can be printed with
cout « Tango::AttrManip(format) « value « endl;
.

The min_value and max_value parameters These two parameters have a meaning only for attribute of the Tango::WRITE read/write type and for numerical data types. Trying to set the value of an attribute to something less than or equal to the min_value parameter is an error. Trying to set the value of the attribute to something more or equal to the max_value parameter is also an error. Even if these parameters are numbers, they are returned as strings by the device *get_attribute_config()* call.

These two parameters have no meaning for attribute with data type DevString, DevBoolean or DevState. An exception is thrown in case the user try to set them for attribute of these 3 data types.

The memorized attribute parameter This parameter describes the attribute memorization. It is an enumeration with the following values:

- NOT_KNOWN : The device is too old to return this information.
- NONE : The attribute is not memorized
- MEMORIZED : The attribute is memorized
- MEMORIZED_WRITE_INIT : The attribute is memorized and the memorized value is applied at device initialization time.

The alarm related configuration parameters Six alarm related attribute parameters are modifiable at run-time via a device call or via the property database.

|c|c| **Parameter name & Parameter description** min_alarm & Attribute low level alarm max_alarm & Attribute high level alarm min_warning & Attribute low level warning max_warning & Attribute high level warning delta_t & delta time for RDS alarm (mS) delta_val & delta value for RDS alarm (absolute)

These parameters have no meaning for attribute with data type DevString, DevBoolean or DevState. An exception is thrown in case the user try to set them for attribute of these 3 data types.

The min_alarm and max_alarm parameters These two parameters have a meaning only for attribute of the Tango::READ, Tango::READ_WRITE and Tango::READ_WITH_WRITE read/write type and for numerical data type. When the attribute is read, if its value is something less than or equal to the min_alarm parameter or if it is something more or equal to the max_alarm parameter, the attribute quality factor will be set to Tango::ATTR_ALARM and if the device state is Tango::ON, it is switched to Tango::ALARM. Even if these parameters are numbers, they are returned as strings by the device *get_attribute_config()* call.

The min_warning and max_warning parameters These two parameters have a meaning only for attribute of the Tango::READ, Tango::READ_WRITE and Tango::READ_WITH_WRITE read/write type and for numerical data type. When the attribute is read, if its value is something less than or equal to the min_warning parameter or if it is something more or equal to the max_warning parameter, the attribute quality factor will be set to Tango::ATTR_WARNING and if the device state is Tango::ON, it is switched to Tango::ALARM. Even if these parameters are numbers, they are returned as strings by the device *get_attribute_config()* call.

The delta_t and delta_val parameters These two parameters have a meaning only for attribute of the Tango::READ_WRITE and Tango::READ_WITH_WRITE read/write type and for numerical data type. They specify if and how the RDS alarm is used. When the attribute is read, if the difference between its read value and the last written value is something more than or equal to the delta_val parameter and if at least delta_val milli seconds occurs since the last write operation, the attribute quality factor will be set to Tango::ATTR_ALARM and if the device state is Tango::ON, it is switched to Tango::ALARM. Even if these parameters are numbers, they are returned as strings by the device *get_attribute_config()* call.

The event related configuration parameters Six event related attribute parameters are modifiable at run-time via a device call or via the property database.

|c|c| Parameter name & Parameter description rel_change & Relative change triggering change event abs_change & Absolute change triggering change event period & Period for periodic event archive_rel_change & Relative change for archive event archive_abs_change & Absolute change for archive event archive_period & Period for change archive event

The rel_change and abs_change parameters Rel_change is a property with a maximum of 2 values (comma separated). It specifies the increasing and decreasing relative change of the attribute value (w.r.t. the value of the previous change event) which will trigger the event. If the attribute is a spectrum or an image then a change event is generated if any one of the attribute value's satisfies the above criterium. It's the absolute value of these values which is taken into account. If only one value is specified then it is used for the increasing and decreasing change.

Abs_change is a property of maximum 2 values (comma separated). It specifies the increasing and decreasing absolute change of the attribute value (w.r.t the value of the previous change event) which will trigger the event. If the attribute is a spectrum or an image then a change event is generated if any one of the attribute value's satisfies the above criterium. If only one value is specified then it is used for the increasing and decreasing change. If no values are specified then the relative change is used.

The periodic period parameter The minimum time between events (in milliseconds). If no property is specified then a default value of 1 second is used.

The archive_rel_change, archive_abs_change and archive_period parameters archive_rel_change is an array property of maximum 2 values which specifies the positive and negative relative change w.r.t. the previous attribute value which will trigger the event. If the attribute is a spectrum or an image then an archive event is generated if any one of the attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no properties are specified then a default fo +-10% is used

archive_abs_change is an array property of maximum 2 values which specifies the positive and negative absolute change w.r.t the previous attribute value which will trigger the event. If the attribute is a spectrum or an image then an archive event is generated if any one of the attribute value's satisfies the above criterium. If only one property is specified then it is used for the positive and negative change. If no properties are specified then the relative change is used.

archive_period is the minimum time between archive events (in milliseconds). If no property is specified, no periodic archiving events are send.

Setting modifiable attribute parameters

A default value is given to all modifiable attribute parameters by the Tango core classes. Nevertheless, it is possible to modify these values in source code at attribute creation time or via the database. Values retrieved from the database have a higher priority than values given at attribute creation time. The attribute parameters are therefore initialized from:

1. The Database
2. If nothing in database, from the Tango class default
3. If nothing in database nor in Tango class default, from the library default value

The default value set by the Tango core library are

|c|c|c| **Parameter type & Parameter name & Library default value** & description & No description & label & attribute name & unit & One empty string & standard_unit & No standard unit & display_unit & No display unit & format & 6 characters with 2 decimal & min_value & Not specified & max_value & Not specified & min_alarm & Not specified & max_alarm & Not specified & min_warning & Not specified & max_warning & Not specified & delta_t & Not specified & delta_val & Not specified & rel_change & Not specified & abs_change & Not specified & period & 1000 (mS) & archive_rel_change & Not specified & archive_abs_change & Not specified & archive_period & Not specified

It is possible to set modifiable parameters via the database at two levels :

1. At class level
2. At device level. Each device attribute have all its modifiable parameters sets to the value defined at class level. If the setting defined at class level is not correct for one device, it is possible to re-define it.

If we take the example of a class called *BumperPowerSupply* with three devices called *sr/bump/1*, *sr/bump/2* and *sr/bump/3* and one attribute called *wanted_current*. For the first two bumpers, the max_value is equal to 500. For the third one, the max_value is only 400. If the max_value parameter is defined at class level with the value 500, all devices will have 500 as max_value for the *wanted_current* attribute. It is necessary to re-defined this parameter at device level in order to have the max_value for device sr/bump/3 set to 400.

For the description, label, unit, standard_unit, display_unit and format parameters, it is possible to return them to their default value by setting them to an empty string.

Resetting modifiable attribute parameters

It is possible to reset attribute parameters to their default value at any moment. This could be done via the network call available through the DeviceProxy::set_attribute_config() method family. This call takes attribute parameters as strings. The following table describes which string has to be used to reset attribute parameters to their default value. In this table, the user default are the values given within Pogo in the Properties tab of the attribute edition window (or in in Tango class code using the Tango::UserDefaultAttrProp class).

|c|c| **Input string & Action** Not specified & Reset to **library** default & & & Reset to Tango **class** default if any & Otherwise, reset to **user** default (if any) or to **library**

system-message
WARNING/2 in `tango.rst`, line 11783
Definition list ends without a blank line; unexpected unindent. backrefs:

default

Let's take one exemple: For one attribute belonging to a device, we have the following attribute parameters:

|c|c|c|c| **Parameter name & Def. class & Def. user & Def. lib** standard_unit & & & No standard unit min_value & & 5 & Not specified max_value & 50 & & Not specified rel_change & 5 & 10 & Not specified

The string Not specified sent to each attribute parameter will set attribute parameter value to No standard unit for standard_unit, Not specified for min_value, Not specified for max_value and Not specified as well for rel_change. The empty string sent to each attribute parameter will result with No stanadard unit for standard_unit, 5 for min_value, Not specified for max_value and 10 for rel_change. The string NaN will give No standard unit for standard_unit, 5 for min_value, 50 for max_value and 5 for rel_change.

C++ specific: Instead of the string Not specified and NaN, the preprocessor define **AlrmValueNotSpec** and **NotANumber** can be used.

Device pipe

Pipe are configured with two kind of parameters: Parameters hard-coded in source code and modifiable parameters

Hard-coded device pipe parameters

Three pipe parameters are defined at pipe creation time in the Tango class source code. Obviously, these parameters are not modifiable except with a new source code compilation. These parameters are

|c|c| **Parameter name & Parameter description** name & Pipe name writable & Pipe read/write type disp_level & Pipe display level

The pipe read/write type. Tango supports two kinds of read/write pipe which are :

- Tango::PIPE_READ for read only pipe
- Tango::PIPE_READ_WRITE for pipe which can be read and written

The pipe display level parameter This parameter is only an help for graphical application. It is a C++ enumeration starting at 0. The code associated with each pipe display level is defined in the following table (Tango::DispLevel).

|c|c| **name & Value** Tango::OPERATOR & 0 Tango::EXPERT & 1

This parameter allows a graphical application to support two types of operation :

- An operator mode for day to day operation
- An expert mode when tuning is necessary

According to this parameter, a graphical application knows if the pipe is for the operator mode or for the expert mode.

Modifiable pipe parameters

Each pipe has a configuration set of 2 modifiable parameters. These parameters are modifiable at run-time via a device call or via the property database.

|c|c| **Parameter name & Parameter description** description & Pipe description label & Pipe label

The **description** parameter describes the pipe. The **label** parameter is used by graphical application to display a label when this pipe is used in a graphical application.

Setting modifiable pipe parameters

A default value is given to all modifiable pipe parameters by the Tango core classes. Nevertheless, it is possible to modify these values in source code at pipe creation time or via the database. Values retrieved from the database have a higher priority than values given at pipe creation time. The pipe parameters are therefore initialized from:

1. The Database
2. If nothing in database, from the Tango class default
3. If nothing in database nor in Tango class default, from the library default value

The default value set by the Tango core library are

|c|c| **Parameter name & Library default value** description & No description label & pipe name

It is possible to set modifiable parameters via the database at two levels :

1. At class level
2. At device level. Each device pipe have all its modifiable parameters sets to the value defined at class level. If the setting defined at class level is not correct for one device, it is possible to re-define it.

This is the same principle than the one used for attribute configuration modifiable parameters.

Resetting modifiable pipe parameters

It is possible to reset pipe parameters to their default value at any moment. This could be done via the network call available through the DeviceProxy::set_pipe_config() method family. It uses the same principle than the one used for resetting modifiable attribute pipe parameters. Refer to their documentation if you want to know details about this feature.

Device class parameter

A device documentation field is also defined at Tango device class level. It is defined as Tango device class level because each device belonging to a Tango device class should have the same behaviour and therefore the same documentation. This field is store in the DeviceClass class. It is possible to set this field via a class property. This property name is

class name->doc_url

and is retrieved when instance of the DeviceClass object is created. A default value is defined for this field.

The device black box

This black box is a help tool to ease debugging session for a running device server. The TANGO core software records every device request in this black box. A tango client is able to retrieve the black box contents with a specific CORBA operation available for every device. Each black box entry is returned as a string with the following information :

- The date where the request has been executed by the device. The date format is dd/mm/yyyy hh24:mi:ss:SS (The last field is the second hundredth number).
- The type of CORBA requests. In case of attributes, the name of the requested attribute is returned. In case of operation, the operation type is returned. For "command_inout" operation, the command name is returned.
- The client host name

Automatically added commands

As already mentionned in this documentation, each Tango device supports at least three commands which are State, Status and Init. The following array details command input and output data type

|c|c|c| **Command name & Input data type & Output data type** State & void & Tango::DevState Status & void & Tango::DevString Init & void & void

The State command

This command gets the device state (stored in its *device_state* data member) and returns it to the caller. The device state is a variable of the Tango_DevState type (packed into a CORBA Any object when it is returned by a command)

The Status command

This command gets the device status (stored in its *device_status* data member) and returns it to the caller. The device status is a variable of the string type.

The Init command

This commands re-initialise a device keeping the same network connection. After an Init command executed on a device, it is not necessary for client to re-connect to the device. This command first calls the device *delete_device()* method and then execute its *init_device()* method. For C++ device server, all the memory allocated in the *init_device()* method must be freed in the *delete_device()* method. The language device desctructor automatically calls the *delete_device()* method.

DServer class device commands

As already explained in [DServer_class], each device server process has its own Tango device. This device supports the three commands previously described plus 32 commands which are DevRestart, RestartServer, QueryClass, QueryDevice, Kill, QueryWizardClassProperty, QueryWizardDevProperty, QuerySubDevice, the polling related commands which are StartPolling, StopPolling, AddObjPolling, RemObjPolling, UpdObjPollingPeriod, PolledDevice and DevPollStatus, the device locking related commands which are LockDevice, UnLockDevice, ReLockDevices and DevLockStatus, the event related commands called EventSubscriptionChange, ZmqEventSubscriptionChange and EventConfirmSubscription and finally the logging related commands which are AddLoggingTarget, RemoveLoggingTarget, GetLoggingTarget, GetLoggingLevel, SetLoggingLevel, StopLogging and StartLogging. The following table give all commands input and output data types

|c|c|c| Command name & Input data type & Output data type State & void & Tango::DevState Status & void & Tango::DevString Init & void & void DevRestart & Tango::DevString & void RestartServer & void & void QueryClass & void & Tango::DevVarStringArray QueryDevice & void & Tango::DevVarStringArray Kill & void & void QueryWizardClassProperty & Tango::DevString & Tango::DevVarStringArray QueryWizardDevProperty & Tango::DevString & Tango::DevVarStringArray QuerySubDevice & void & Tango::DevVarStringArray StartPolling & void & void StopPolling & void & void AddObjPolling & Tango::DevVarLongStringArray & void RemObjPolling & Tango::DevVarStringArray & void UpdObjPollingPeriod & Tango::DevVarLongStringArray & void PolledDevice & void & Tango::DevVarStringArray DevPollStatus & Tango::DevString & Tango::DevVarStringArray LockDevice & Tango::DevVarLongStringArray & void UnLockDevice & Tango::DevVarLongStringArray & Tango::DevLong ReLockDevices & Tango::DevVarStringArray & void DevLockStatus & Tango::DevString & Tango::DevVarLongStringArray EventSubscribeChange & Tango::DevVarStringArray & Tango::DevLong ZmqEventSubscriptionChange & Tango::DevVarStringArray &

Tango::DevVarLongStringArray EventConfirmSubscription & Tango::DevVarStringArray & void AddLoggingTarget & Tango::DevVarStringArray & void RemoveLoggingTarget & Tango::DevVarStringArray & void GetLoggingTarget & Tango::DevString & Tango::DevVarStringArray GetLoggingLevel & Tango::DevVarStringArray &

Tango::DevVarLongStringArray SetLoggingLevel & Tango::DevVarLongStringArray & void StopLogging & void & void StartLogging & void & void

The device description field is set to “A device server device”. Device server started with the -file command line option also supports a command called QueryEventChannelIOR. This command is used interanally by the Tango kernel classes when the event system is used with device server using database on file.

The State command

This device state is always set to ON

The Status command

This device status is always set to “The device is ON” followed by a new line character and a string describing polling thread status. This string is either “The polling is OFF” or “The polling is ON” according to polling state.

The DevRestart command

The DevRestart command restart a device. The name of the device to be re-started is the command input parameter. The command destroys the device by calling its destructor and re-create it from its constructor.

The RestartServer command

The DevRestartServer command restarts all the device pattern(s) embedded in the device server process. Therefore, all the devices implemented in the server process are destroyed and re-built[13]. The network connection between client(s) and device(s) implemented in the device server process is destroyed and re-built.

Executing this command allows a complete restart of the device server without stopping the process.

The QueryClass command

This command returns to the client the list of Tango device class(es) embedded in the device server. It returns only class(es) implemented by the device server programmer. The DServer device class name (implemented by the TANGO core software) is not returned by this command.

The QueryDevice command

This command returns to the client the list of device name for all the device(s) implemented in the device server process. Each device name is returned using the following syntax :

<class name>::<device name>

The name of the DServer class device is not returned by this command.

The Kill command

This command stops the device server process. In order that the client receives a last answer from the server, this command starts a thread which will after a short delay, kills the device server process.

The QueryWizardClassProperty command

This command returns the list of property(ies) defined for a class stored in the device server process property wizard. For each property, its name, a description and a default value is returned.

The QueryWizardDevProperty command

This command returns the list of property(ies) defined for a device stored in the device server process property wizard. For each property, its name, a description and a default value is returned.

The QuerySubDevice command

This command returns the list of sub-device(s) imported by each device within the server. A sub-device is a device used (to execute command(s) and/or to read/write attribute(s)) by one of the device server process devices. There is one element in the returned strings array for each sub-device. The syntax of each string is the device name, a space and the sub-device name. In case of device server process starting threads using a sub-device, it is not possible to link this sub-device to any process devices. In such a case, the string contains only the sub-device name

The StartPolling command

This command starts the polling thread

The StopPolling command

This command stops the polling thread

The AddObjPolling command

This command adds a new object in the list of object(s) to be polled. The command input parameters are embedded within a Tango::DevVarLongStringArray data type with one long data and three strings. The input parameters are:

|c|c| **Command parameter & Parameter meaning** svalue[0] & Device name svalue[1] & Object type (“command“ or “attribute“) svalue[2] & Object name lvalue[0] & polling period in mS

The object type string is case independent. The object name string (command name or attribute name) is case dependant. This command does not start polling if it is stopped. This command is not allowed in case the device is locked and the command requester is not the lock owner.

The RemObjPolling command

This command removes an object of the list of polled objects. The command input data type is a Tango::DevVarStringArray with three strings. These strings meaning are :

|c|c| **String & Meaning** string[0] & Device name string[1] & Object type (“command“ or “attribute“) string[2] & Object name

The object type string is case independent. The object name string (command name or attribute name) is case dependant. This command is not allowed in case the device is locked and the command requester is not the lock owner.

The UpdObjPollingPeriod command

This command changes the polling period for a specified object. The command input parameters are embedded within a Tango::DevVarLongStringArray data type with one long data and three strings. The input parameters are:

|c|c| **Command parameter & Parameter meaning** svalue[0] & Device name svalue[1] & Object type ("command" or "attribute") svalue[2] & Object name lvalue[0] & new polling period in mS

The object type string is case independent. The object name string (command name or attribute name) is case dependant. This command does not start polling if it is stopped. This command is not allowed in case the device is locked and the command requester is not the lock owner.

The PolledDevice command

This command returns the name of device which are polled. Each string in the Tango::DevVarStringArray returned by the command is a device name which has at least one command or attribute polled. The list is alphabetically sorted.

The DevPollStatus command

This command returns a polling status for a specific device. The input parameter is a device name. Each string in the Tango::DevVarStringArray returned by the command is the polling status for each polled device objects (command or attribute). For each polled objects, the polling status is :

- The object name
- The object polling period (in mS)
- The object polling ring buffer depth
- The time needed (in mS) for the last command execution or attribute reading
- The time since data in the ring buffer has not been updated. This allows a check of the polling thread
- The delta time between the last records in the ring buffer. This allows checking that the polling period is respected by the polling thread.
- The exception parameters in case of the last command execution or the last attribute reading failed.

A new line character is inserted between each piece of information.

The LockDevice command

This command locks a device for the calling process. The command input parameters are embedded within a Tango::DevVarLongStringArray data type with one long data and one string. The input parameters are:

|c|c| **Command parameter & Parameter meaning** svalue[0] & Device name lvalue[0] & Lock validity

The UnLockDevice command

This command unlocks a device. The command input parameters are embedded within a Tango::DevVarLongStringArray data type with one long data and one string. The input parameters are:

|c|c| **Command parameter & Parameter meaning** svalue[0] & Device name lvalue[0] & Force flag

The force flag parameter allows a client to unlock a device already locked by another process (for admin usage only)

The ReLockDevices command

This command re-lock devices. The input argument is the list of devices to be re-locked. It's an error to re-lock a device which is not already locked.

The DevLockStatus command

This command returns a device locking status to the caller. Its input parameter is the device name. The output parameters are embedded within a Tango::DevVarLongStringArray data type with three strings and six long. These data are

|c|c| **Command parameter & Parameter meaning** svalue[0] & Locking string svalue[1] & CPP client host IP address or Not defined svalue[2] & Java VM main class for Java client or Not defined lvalue[0] & Lock flag (1 if locked, 0 othterwise) lvalue[1] & CPP client host IP address or 0 for Java locker lvalue[2] & Java locker UUID part 1or 0 for CPP locker lvalue[3] & Java locker UUID part 2 or 0 for CPP locker lvalue[4] & Java locker UUID part 3 or 0 for CPP locker lvalue[5] & Java locker UUID part 4 or 0 for CPP locker

The EventSubscriptionChange command (C++ server only)

This command is used as a piece of the heartbeat system between an event client and the device server generating the event. There is no reason to generate events if there is no client which has subscribed to it. It is used by the *DeviceProxy::subscribe_event()* method and one of the event thread on the client side to inform the server to keep on generating events for the attribute in question. It reloads the subscription timer with the current time. Events are not generated when there are no clients subscribed within the last 10 minutes. The input parameters are:

|c|c| **Command parameter & Parameter meaning** argin[0] & Device name argin[1] & Attribute name argin[2] & action (subscribe or unsubsribe) argin[3] & event name (change, periodic, archive,attr_conf)

The command output data is the simply the Tango release used by the device server process. This is necessary for compatibility reason.

The ZmqEventSubscriptionChange command

This command is used as a piece of the heartbeat system between an event client and the device server generating the event when client and/or device server uses Tango release 8 or above. There is no reason to generate events if there is no client which has subscribed to it. It is used by the *DeviceProxy::subscribe_event()* method and one of the event thread on the client side to inform the server to keep on generating events for the attribute in question. It reloads the subscription timer with the current time. Events are not generated when there are no clients subscribed within the last 10 minutes. The input parameters are the same than the one used for the EventSubscriptionChange command. They are:

|c|c| Command in parameter & Parameter meaning argin[0] & Device name argin[1] & Attribute name argin[2] & action (subscribe or unsubsribe) argin[3] & event name (change, periodic, archive,attr_conf)

The command output parameters aer all the necessary data to build one event connection between a client and the device server process generating the events. This means:

|c|c| Command out parameter & Parameter meaning svalue[0] & Heartbeat ZMQ socket connect end point svalue[1] & Event ZMQ socket connect end point lvalue[0] & Tango lib release used by device server lvalue[1] & Device IDL release lvalue[2] & Subscriber HWM lvalue[3] & Rate (Multicasting related) lvalue[4] & IVL (Multicasting related)

The EventConfirmSubscription command

This command is used by client to regularly notify to device server process their interest in receiving events. If this command is not received, after a delay of 600 sec (10 mins), event(s) will not be sent any more. The input parameters for the EventConfirmSubscription command must be a multiple of 3. They are 3 parameters for each event confirmed by this command. Per event, these parameters are:

|c|c| Command in parameter & Parameter meaning argin[x] & Device name argin[x + 1] & Attribute name argin[x + 2] & Event name

The AddLoggingTarget command

This command adds one (or more) logging target(s) to the specified device(s). The command input parameter is an array of string logically composed of {device_name, target_type::target_name} groups where the elements have the following semantic:

- device_name is the name of the device which logging behavior is to be controlled. The wildcard is supported to apply the modification to all devices encapsulated within the device server (e.g. to ask all devices to log to the same device target).

- target_type::target_name: target_type is one of the supported target types and target_name, the name of the target. Supported target types are: *console*, *file* and *device*. For a device target, target_name must contain the name of a log consumer device (as defined in [sec:Tango-log-consumer]). For a file target, target_name is the full path to the file to log to. If omitted the device's name is used to build the file name (domain_family_member.log). Finally, target_name is ignored in the case of a console target and can be omitted.

This command is not allowed in case the device is locked and the command requester is not the lock owner.

The RemoveLoggingTarget command

Remove one (or more) logging target(s) from the specified device(s).The command input parameter is an array of string logically composed of {device_name, target_type::target_name} groups where the elements have the following semantic:

- device_name: the name of the device which logging behavior is to be controlled. The wildcard is supported to apply the modification to all devices encapsulated within the device server (e.g. to ask all devices to stop logging to a given device target).
- target_type::target_name: target_type is one of the supported target types and target_name, the name of the target. Supported target types are: *console*, *file* and *device*. For a device target, target_name must contain the name of a log consumer device (as defined in [sec:Tango-log-consumer]). For a file target, target_name is the full path to the file to log to. If omitted the device's name is used to build the file name (domain_family_member.log). Finally, target_name is ignored in the case of a console target and can be omitted.

The wildcard is supported for target_name. For instance, RemoveLoggingTarget ([, device::*) removes all the device targets from all the devices running in the device server. This command is not allowed in case the device is locked and the command requester is not the lock owner.

The GetLoggingTarget command

Returns the current target list of the specified device. The command parameter device_name is the name of the device which logging target list is requested. The list is returned as a DevVarStringArray containing target_type::target_name elements.

The GetLoggingLevel command

Returns the logging level of the specified devices. The command input parameter device_list contains the names of the devices which logging target list is requested. The wildcard is supported to get the logging level of all the devices running within the server. The string part of the result contains the name of the devices and its long part contains the levels. Obviously, result.lvalue[i] is the current logging level of the device named result.svalue[i].

The SetLoggingLevel command

Changes the logging level of the specified devices. The string part of the command input parameter contains the device names while its long part contains the logging levels. The set of possible values for levels is: 0=OFF, 1=FATAL, 2=ERROR, 3=WARNING, 4=INFO, 5=DEBUG.

The wildcard is supported to assign all devices the same logging level. For instance, SetLoggingLevel ([3]) set the logging level of all the devices running within the server to WARNING. This command is not allowed in case the device is locked and the command requester is not the lock owner.

The StopLogging command

For all the devices running within the server, StopLogging saves their current logging level and set their logging level to OFF.

The StartLogging command

For each device running within the server, StartLogging restores their logging level to the value stored during a previous StopLogging call.

DServer class device properties

This device has two properties related to polling threads pool management plus another one for the choice of polling algorithm. These properties are described in the following table

|c|c|c| **Property name & property rule & default value** polling_threads_pool_size & Max number of thread in the polling pool

& 1 polling_threads_pool_conf & Polling threads pool configuration & polling_before_9 & Choice of the polling algorithm & false

The rule of the polling_threads_pool_size is to define the maximun number of thread created for the polling threads pool size. The rule of the polling_threads_pool_conf is to define which thread in the pool is in charge of all the polled object(s) of which device. This property is an array of strings with one string per used thread in the pool. The content of the string is simply a device name list with device name splitted by a comma. Example of polling_threads_pool_conf property for 3 threads used:

```
dserver/<ds exec name>/<inst. name>/polling_threads_pool_conf-> the/dev
                     the/dev/02,the/dev/06
                     the/dev/03
```

Thread number 2 is in charge of 2 devices. Note that there is an entry in this list only for the used threads in the pool.

The rule of the polling_before_9 property is to select the polling algorithm which was used in Tango device server process before Tango release 9.

Tango log consumer

The available Log Consumer

One implementation of a log consumer associated to a graphical user interface is available within Tango. It is a standalone java application called **LogViewer** based on the publicly available chainsaw application from the log4j package. It supports two way of running which are:

- The static mode: In this mode, LogViewer is started with a parameter which is the name of the log consumer device implemented by the application. All messages sent by devices with a logging target type set to *device* and with a logging target name set to the same device name than the device name passed as application parameter will be displayed (if the logging level allows it).
- The dynamic mode: In this mode, the name of the log consumer device implemented by the application is build at application startup and is dynamic. The user with the help of the graphical interface chooses device(s) for which he want to see log messages.

The Log Consumer interface

A Tango Log Consumer device is nothing but a tango device supporting the following tango command :

void log (Tango::DevVarStringArray details)

where details is an array of string carrying the log details. Its structure is:

- details[0] : the timestamp in millisecond since epoch (01.01.1970)
- details[1] : the log level
- details[2] : the log source (i.e. device name)
- details[3] : the log message
- details[4] : the log NDC (contextual info) - Not used but reserved
- details[5] : the thread identifier (i.e. the thread from which the log request comes from)

These log details can easily be extended. Any tango device supporting this command can act as a device target for other devices.

Control system specific

It is possible to define a few control system parameters. By control system, we mean for each set of computers having the same database device server (the same TANGO_HOST environment variable)

The device class documentation default value

Each control system may have it's own default device class documentation value. This is defined via a class property. The property name is

Default->doc_url

It's retrieved if the device class itself does not define any doc_url property. If the Default->doc_url property is also not defined, a hard-coded default value is provided.

The services definition

The property used to defined control system services is named **Services** and belongs to the free object **CtrlSystem**. This property is an array of strings. Each string defines a service available within the control system. The syntax of each service definition is
    Service name/Instance name:service device name

Tuning the event system buffers (HWM)

Starting with Tango release 8, ZMQ is used for the event based communication between clients and device server processes. ZMQ implementation provides asynchronous communication in the sense that the data to be transmitted is first stored in a buffer and then really sent on the network by dedicated threads. The size of this buffers (on client and device server side) is called High Water Mark (HWM) and is tunable. This is tunable at several level.

1. The library set a default value of **1000** for both buffers (client and device server side)
2. Control system properties used to tune these size are named **DSEventBufferHwm** (device server side) and **EventBufferHwm** (client side). They both belongs to the free object **CtrlSystem**. Each property is the max number of events storable in these buffer.
3. At client or device server level using the library calls *Util::set_ds_event_buffer_hwm()* documented in [**?**] or *ApiUtil::set_event_buffer_hwm()* documented in [sec:Tango::ApiUtil]
4. Using environment variables TANGO_DS_EVENT_BUFFER_HWM or TANGO_EVENT_BUFFER_HWM

Allowing NaN when writing attributes (floating point)

A property named **WAttrNaNAllowed** belonging to the free object **CtrlSystem** allows a Tango control system administrator to allow or disallow NaN numbers when writing attributes of the DevFloat or DevDouble data type. This is a boolean property and by default, it's value is taken as false (Meaning NaN values are rejected).

Tuning multicasting event propagation

Starting with Tango 8.1, it is possible to transfer event(s) between devices and clients using a multicast protocol. The properties **MulticastEvent**, **MulticastRate**, **MulticastIvl** and **MulticastHops** also belonging to the free object **CtrlSystem** allow the user to configure which events has to be sent using multicasting and with which parameters. See chapter Advanced features/Using multicast protocol to transfer events to get details about these properties.

Summary of CtrlSystem free object properties

The following table summarizes properties defined at control system level and belonging to the free object CtrlSystem

|c|c|c| **Property name & property rule & default value** Services & List of defined services & No default DsEventBufferHwm & DS event buffer high water mark & 1000 EventBufferHwm & Client event buffer high water mark & 1000 WAttrNaNAllowed & Allow NaN when writing attr. & false MulticastEvent & List of multicasting events & No default MulticastRate & Rate for multicast event transport & 80 MulticastIvl & Time to keep data for re-transmission & 20 MulticastHops & Max number of eleemnts to cross & 5

C++ specific

The Tango master include file (tango.h)

Tango has a master include file called
tango.h
This master include file includes the following files :

- Tango configuration include file : **tango_config.h**
- CORBA include file : **idl/tango.h**
- Some network include files for WIN32 : **winsock2.h** and **mswsock.h**
- C++ streams include file :
  - **iostream**, **sstream** and **fstream**
- Some standard C++ library include files : **memory, string** and **vector**
- A long list of other Tango include files

Tango specific pre-processor define

The tango.h previously described also defined some pre-processor macros allowing Tango release to be checked at compile time. These macros are:

- TANGO_VERSION_MAJOR
- TANGO_VERSION_MINOR
- TANGO_VERSION_PATCH

For instance, with Tango release 8.1.2, TANGO_VERSION_MAJOR will be set to 8 while TANGO_VERSION_MINOR will be 1 and TANGO_VERSION_PATCH will be 2.

Tango specific types

Operating system free type Some data type used in the TANGO core software have been defined. They are described in the following table.

|c|c| **Type name & C++ name** TangoSys_MemStream & stringstream TangoSys_OMemStream & ostringstream TangoSys_Pid & int TangoSys_Cout & ostream

These types are defined in the tango_config.h file

Template command model related type As explained in [Command fact], command created with the template command model uses static casting. Many type definition have been written for these casting.

|c|c|c| Class name & Command allowed method (if any) & Command execute method

system-message

ERROR/3 in `tango.rst`, line 12709

Unexpected indentation. backrefs:

> TemplCommand & Tango::StateMethodPtr & Tango::CmdMethPtr TemplCommandIn & Tango::StateMethodPtr & Tango::CmdMethPtr_xxx TemplCommandOut & Tango::StateMethodPtr & Tango::xxx_CmdMethPtr TemplCommandInOut & Tango::StateMethodPtr & Tango::xxx_CmdMethPtr_yyy

The **Tango::StateMethPtr** is a pointer to a method of the DeviceImpl class which returns a boolean and has one parameter which is a reference to a const CORBA::Any obect.

The **Tango::CmdMethPtr** is a pointer to a method of the DeviceImpl class which returns nothing and needs nothing as parameter.

The **Tango::CmdMethPtr_xxx** is a pointer to a method of the DeviceImpl class which returns nothing and has one parameter. xxx must be set according to the method parameter type as described in the next table

|c|c| Tango type & short cut (xxx) Tango::DevBoolean & Bo Tango::DevShort & Sh
> Tango::DevLong & Lg Tango::DevFloat & Fl Tango::DevDouble & Db Tango::DevUshort & US Tango::DevULong & UL Tango::DevString & Str Tango::DevVarCharArray & ChA Tango::DevVarShortArray & ShA Tango::DevVarLongArray & LgA Tango::DevVarFloatArray & FlA Tango::DevVarDoubleArray & DbA Tango::DevVarUShortArray & USA Tango::DevVarULongArray & ULA Tango::DevVarStringArray & StrA Tango::DevVarLongStringArray & LSA Tango::DevVarDoubleStringArray & DSA Tango::DevState & Sta

For instance, a pointer to a method which takes a Tango::DevVarStringArray as input parameter must be statically casted to a Tango::CmdMethPtr_StrA, a pointer to a method which takes a Tango::DevLong data as input parameter must be statically casted to a Tango::CmdMethPtr_Lg.

The **Tango::xxx_CmdMethPtr** is a pointer to a method of the DeviceImpl class which returns data of one of the Tango type and has no input parameter. xxx must be set according to the method return data type following the same rules than those described in the previous table. For instance, a pointer to a method which returns a Tango::DevDouble data must be statically casted to a Tango::Db_CmdMethPtr.

The **Tango::xxx_CmdMethPtr_yyy** is a pointer to a method of the DeviceImpl class which returns data of one of the Tango type and has one input parameter of one of the Tango data type. xxx and yyy must be set according to the method return data type and parameter type following the same rules than those described in the previous table. For instance, a pointer to a method which returns a Tango::DevDouble data and which takes a Tango::DevVarLongStringArray must be statically casted to a Tango::Db_CmdMethPtr_LSA.

All those type are defined in the tango_const.h file.

Tango device state code

The Tango::DevState type is a C++ enumeration starting at 0. The code associated with each state is defined in the following table.

|c|c| **State name & Value** Tango::ON & 0 Tango::OFF & 1 Tango::CLOSE & 2 Tango::OPEN & 3 Tango::INSERT & 4 Tango::EXTRACT & 5 Tango::MOVING & 6 Tango::STANDBY & 7 Tango::FAULT & 8 Tango::INIT & 9 Tango::RUNNING & 10 Tango::ALARM & 11 Tango::DISABLE & 12 Tango::UNKNOWN & 13

A strings array called **Tango::DevStateName** can be used to get the device state as a string. Use the Tango device state code as index into the array to get the correct string.

Tango data type

A "define" has been created for each Tango data type. This is summarized in the following table

|c|c|c| **Type name & Type code & Value** Tango::DevBoolean & Tango::DEV_BOOLEAN & 1 Tango::DevShort & Tango::DEV_SHORT & 2 Tango::DevLong & Tango::DEV_LONG & 3 Tango::DevFloat & Tango::DEV_FLOAT & 4 Tango::DevDouble & Tango::DEV_DOUBLE & 5 Tango::DevUShort & Tango::DEV_USHORT & 6 Tango::DevULong & Tango::DEV_ULONG & 7 Tango::DevString & Tango::DEV_STRING & 8 Tango::DevVarCharArray & Tango::DEVVAR_CHARARRAY & 9 Tango::DevVarShortArray & Tango::DEVVAR_SHORTARRAY & 10 Tango::DevVarLongArray & Tango::DEVVAR_LONGARRAY & 11 Tango::DevVarFloatArray & Tango::DEVVAR_FLOATARRAY & 12 Tango::DevVarDoubleArray & Tango::DEVVAR_DOUBLEARRAY & 13 Tango::DevVarUShortArray & Tango::DEVVAR_USHORTARRAY & 14 Tango::DevVarULongArray & Tango::DEVVAR_ULONGARRAY & 15 Tango::DevVarStringArray & Tango::DEVVAR_STRINGARRAY & 16 Tango::DevVarLongStringArray & Tango::DEVVAR_LONGSTRINGARRAY & 17 Tango::DevVarDoubleStringArray & Tango::DEVVAR_DOUBLESTRINGARRAY & 18 Tango::DevState & Tango::DEV_STATE & 19 Tango::ConstDevString & Tango::CONST_DEV_STRING & 20 Tango::DevVarBooleanArray & Tango::DEVVAR_BOOLEANARRAY & 21 Tango::DevUChar & Tango::DEV_UCHAR & 22 Tango::DevLong64 & Tango::DEV_LONG64 & 23 Tango::DevULong64 & Tango::DEV_ULONG64 & 24 Tango::DevVarLong64Array & Tango::DEVVAR_LONG64ARRAY & 25 Tango::DevVarULong64Array & Tango::DEVVAR_ULONG64ARRAY & 26 Tango::DevInt & Tango::DEV_INT & 27 Tango::DevEncoded & Tango::DEV_ENCODED & 28 Tango::DevEnum & Tango::DEV_ENUM & 29 Tango::DevPipeBlob & Tango::DEV_PIPE_BLOB & 30 Tango::DevVarStateArray & Tango::DEVVAR_STATEARRAY & 31

For command which do not take input parameter, the type code Tango::DEV_VOID (value = 0) has been defined.

A strings array called **Tango::CmdArgTypeName** can be used to get the data type as a string. Use the Tango data type code as index into the array to get the correct string.

Tango command display level

Like attribute, Tango command has a display level. The Tango::DispLevel type is a C++ enumeration starting at 0. The code associated with each command display level is already described in page

As for attribute, this parameter allows a graphical application to support two types of operation :

- An operator mode for day to day operation
- An expert mode when tuning is necessary

According to this parameter, a graphical application knows if the command is for the operator mode or for the expert mode.

Device server process option and environment variables

Classical device server

The synopsis of a device server process is
ds_name instance_name [OPTIONS]
The supported options are :

- **-h, -? -help**
  Print the device server synopsis and a list of instance name defined in the database for this device server. An instance name in not mandatory in the command line to use this option
- **-v[trace level]**
  Set the verbose level. If no trace level is given, a default value of 4 is used
- **-file=<file name path>**
  Start a device server using an ASCII file instead of the Tango database.
- **-nodb**
  Start a device server without using the database.
- **-dlist <device name list>**
  Give the device name list. This option is supported only with the -nodb option.
- **ORB options** (started with -ORBxxx)
  Options directly passed to the underlying ORB. Should be rarely used except the -ORBendPoint option for device server not using the database

Device server process as Windows service

When used as a Windows service, a Tango device server supports several new options. These options are :

- **-i**
  Install the service
- **-s**
  Install the service and choose the automatic startup mode
- **-u**
  Un-install the service
- **-dbg**

Run in console mode to debug service. The service must have been installed prior to use it.

Note that these options must be used after the device server instance name.

Environment variables

A few environment variables can be used to tune a Tango control system. TANGO_HOST is the most important one but on top it, some Tango features like Tango logging service or controlled access (if used) can be tuned using environment variable. If these environment variables are not defined, the software searches in the file **$HOME/.tangorc** for its value. If the file is not defined or if the environment variable is also not defined in this file, the software searches in the file **/etc/tangorc** for its value. For Windows, the file is **$TANGO_ROOT/tangorc** TANGO_ROOT being the mandatory environment variable of the Windows binary distribution.

TANGO_HOST This environment variable is the anchor of the system. It specifies where the Tango database server is running. Most of the time, its syntax is

TANGO_HOST=<host>:<port>

host is the name of the computer where the database server is running and port is th eport number on which it is litenning. If you want to have a Tango control system which has several database servers (but only one database) in order to survive a database server crashes, use the following syntax

TANGO_HOST=<host_1>:<port_1>,<host_2>:<port_2>,<host_3>:<port_3>

Obviously, host_1 is the name of the computer where the first database server is running, port_1 is the port number on which this server is listenning. host_2 is the name of the computer where the second database server is running and port_2 is its port number. All access to database will automatically switch from one server to another one in the list if the one which was used has died.

Tango Logging Service (TANGO_LOG_PATH) The TANGO_LOG_PATH environment variable can be used to specify the log files location. If not set it defaults to /tmp/tango-<user logging name> under Unix and C:/tango-<user logging name> under Windows. For a given device-server, the files are actually saved into $TANGO_LOG_PATH/{ server_name}/{ server_instance_name}. This means that all the devices running within the same process log into the same directory.

The database and controlled access server (MYSQL_USER, MYSQL_PASSWORD, MYSQL_HOST and MYSQL_DATABASE) The Tango database server and the controlled access server (if used) need to connect to the MySQL database. They are using four environment variables called MYSQL_USER, MYSQL_PASSWORD to know which user/password they must use to access the database, MYSQL_HOST in case the MySQL database is running on another host and MYSQL_DATABASE to specify the name of the database to connect to. The MYSQL_HOST environment variable allows you to specify the host and port number where MySQL is running. Its syntax is

host:port

The port definition is optional. If it is not specified, the default MySQL port will be used. If these environment variables are not defined, they will connect to the DBMS using the root login on localhost with the MySQL default port number (3306). The

MYSQL_DATABASE environment variable has to be used in case your are using the same Tango Database device server executable code to connect to several Tango databases each of them having a different name.

The controlled access Even if a controlled access system is running, it is possible to by-pass it if in the environment of the client application the environment variable SUPER_TANGO is defined to true.

The event buffer size If required, the event buffer used by the ZMQ software could be tuned using environment variables. These variables are named TANGO_DS_EVENT_BUFFER_HWM for the event buffer on a device server side and TANGO_EVENT_BUFFER_HWM for the event buffer on the client size. Both of them are a number which is the maximum number of events which could be stored in these buffers.

The TANGO IDL file : Module Tango

The fundamental idea of a device as a network object which has methods and data has been retained for TANGO. In TANGO objects are real C++/Java objects which can be instantiated and accessed via their methods and data by the client as if they were local objects. This interface is defined in CORBA IDL. The fundamental interface is Device. All TANGO control objects will be of this type i.e. they will implement and offer the Device interface. Some wrapper classes group in an API will hide the calls to the Device interface from the client so that the client will only see the wrapper classes. All CORBA details will be hidden from the client as far as possible.

Aliases

AttributeConfigList

typedef sequence<AttributeConfig> AttributeConfigList;

AttributeConfigList_2

typedef sequence<AttributeConfig_2> AttributeConfigList_2;

AttributeConfigList_3

typedef sequence<AttributeConfig_3> AttributeConfigList_3;

AttributeConfigList_5

typedef sequence<AttributeConfig_5> AttributeConfigList_5;

AttributeDimList

typedef sequence<AttributeDim> AttributeDimList;

AttributeValueList

typedef sequence<AttributeValue> AttributeValueList;

AttributeValueList_3

typedef sequence<AttributeValue_3> AttributeValueList_3;

AttributeValueList_4

typedef sequence<AttributeValue_4> AttributeValueList_4;

AttributeValueList_5

typedef sequence<AttributeValue_5> AttributeValueList_5;

AttrQualityList

typedef sequence<AttrQuality> AttrQualityList;

CppClntIdent

typedef unsigned long CppClntIdent;

DevAttrHistoryList

typedef sequence<DevAttrHistory> DevAttrHistoryList;

DevAttrHistoryList_3

typedef sequence<DevAttrHistory_3> DevAttrHistoryList_3;

DevBoolean

typedef boolean DevBoolean;

DevCmdHistoryList

typedef sequence<DevCmdHistory> DevCmdHistoryList

DevCmdInfoList

typedef sequence<DevCmdInfo> DevCmdInfoList;

DevCmdInfoList_2

typedef sequence<DevCmdInfo_2> DevCmdInfoList_2;

DevDouble

typedef double DevDouble;

DevErrorList

typedef sequence<DevError> DevErrorList;

DevErrorListList

typedef sequence<DevErrorList> DevErrorListList;

DevFloat

typedef float DevFloat;

DevLong

typedef long DevLong;

DevShort

typedef short DevShort;

DevString

typedef string DevString;

DevULong

typedef unsigned long DevULong;

DevUShort

typedef unsigned short DevUShort;

DevVarCharArray

typedef sequence<octet> DevVarCharArray;

DevVarDoubleArray

typedef sequence<double> DevVarDoubleArray;

DevVarEncodedArray

typedef sequence<DevEncoded> DevVarEncodedArray;

DevVarFloatArray

typedef sequence<float> DevVarFloatArray;

DevVarLongArray

typedef sequence<long> DevVarLongArray;

DevVarPipeDataEltArray

typedef sequence<DevPipeDataElt> DevVarPipeDataEltArray;

DevVarShortArray

typedef sequence<short> DevVarShortArray;
DevVarStateArray

typedef sequence<DevState> DevVarStateArray;

DevVarStringArray

typedef sequence<string> DevVarStringArray;

DevVarULongArray

typedef sequence<unsigned long> DevVarULongArray;

DevVarUShortArray

typedef sequence<unsigned short> DevVarUShortArray;

EltInArrayList

typedef sequence<EltInArray> EltInArrayList;****

system-message
WARNING/2 in `tango.rst`, line 13173
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 13173
Inline strong start-string without end-string.

JavaUUID

typedef unsigned long long JavaUUID[2];
PipeConfigList

typedef sequence<PipeConfig> PipeConfigList;
NamedDevErrorList

typedef sequence<NamedDevError> NamedDevErrorList;

TimeValList

typedef sequence<TimeVal> TimeValList;****

system-message
WARNING/2 in `tango.rst`, line 13187
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 13187
Inline strong start-string without end-string.

Enums

AttrDataFormat

```
    enum AttrDataFormat
    {
      SCALAR,
      SPECTRUM,
      IMAGE,
      FMT_UNKNOWN

};
```

AttributeDataType

```
    enum AttributeDataType
    {
      ATT_BOOL,
      ATT_SHORT,
      ATT_LONG,
      ATT_LONG64,
      ATT_FLOAT,
      ATT_DOUBLE,
      ATT_UCHAR,
      ATT_USHORT,
      ATT_ULONG,
      ATT_ULONG64,
      ATT_STRING,
      ATT_STATE,
      DEVICE_STATE,
      ATT_ENCODED,
      ATT_NO_DATA

};
```

AttrQuality

```
    enum AttrQuality
    {
      ATTR_VALID,
      ATTR_INVALID,
      ATTR_ALARM,
      ATTR_CHANGING,
      ATTR_WARNING

  };
```

AttrWriteType

```
enum AttrWriteType
{
    READ,
    READ_WITH_WRITE,
    WRITE,
    READ_WRITE,
    WT_UNKNOWN

};
```

DispLevel

```
enum DispLevel
{
    OPERATOR,
    EXPERT,
    DL_UNKNOWN

};
```

DevSource

```
enum DevSource
{
    DEV,
    CACHE,
    CACHE_DEV

};
```

DevState

```
enum DevState
{
    ON,
    OFF,
    CLOSE,
    OPEN,
    INSERT,
    EXTRACT,
    MOVING,
    STANDBY,
    FAULT,
    INIT,
    RUNNING,
    ALARM,
```

DISABLE,
  UNKNOWN

};

ErrSeverity
enum ErrSeverity
{
  WARN,
  ERR,
  PANIC

};

LockerLanguage
enum LockerLanguage
{
  CPP,
  JAVA

};
PipeWriteType

enum PipeWriteType
{
  PIPE_READ,
  PIPE_READ_WRITE,
  PIPE_WT_UNKNOWN
};

Structs

ArchiveEventProp
struct ArchiveEventProp
{
  string rel_change;
  string abs_change;
  string period;
  DevVarStringArray extensions;

};****
****
AttributeAlarm

system-message
WARNING/2 in `tango.rst`, line 13402
Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13402

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13403

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13403

Inline strong start-string without end-string.

struct AttributeAlarm
{
  string min_alarm;
  string max_alarm;
  string min_warning;
  string max_warning;
  string delta_t;
  string delta_val;
  DevVarStringArray extensions;

};****
****

AttDataReady

system-message

WARNING/2 in `tango.rst`, line 13424

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13424

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13425

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13425

Inline strong start-string without end-string.

struct AttributeAlarm
{
string name;
long data_type;
long ctr;

};
****

AttributeConfig

system-message

WARNING/2 in `tango.rst`, line 13439

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 13439

Inline strong start-string without end-string.

struct AttributeConfig
{
string name;
AttrWriteType writable;
AttrDataFormat data_format;
long data_type;
long max_dim_x;
long max_dim_y;
string description;
string label;
string unit;
string standard_unit;
string display_unit;
string format;
string min_value;
string max_value;
string min_alarm;
string max_alarm;
string writable_attr_name;
DevVarStringArray extensions;

};

AttributeConfig_2
struct AttributeConfig_2
{
string name;
AttrWriteType writable;
AttrDataFormat data_format;
long data_type;

```
    long max_dim_x;
    long max_dim_y;
    string description;
    string label;
    string unit;
    string standard_unit;
    string display_unit;
    string format;
    string min_value;
    string max_value;
    string min_alarm;
    string max_alarm;
    string writable_attr_name;
    DispLevel level;
    DevVarStringArray extensions;

};
```

AttributeConfig_3

```
struct AttributeConfig_3
{
    string name;
    AttrWriteType writable;
    AttrDataFormat data_format;
    long data_type;
    long max_dim_x;
    long max_dim_y;
    string description;
    string label;
    string unit;
    string standard_unit;
    string display_unit;
    string format;
    string min_value;
    string max_value;
    string writable_attr_name;
    DispLevel level;
    AttributeAlarm alarm;
    EventProperties event_prop;
    DevVarStringArray extensions;
    DevVarStringArray sys_extensions;

};
```

AttributeConfig_5

```
struct AttributeConfig_5
{
    string name;
    AttrWriteType writable;
    AttrDataFormat data_format;
    long data_type;
    boolean memorized;
    boolean mem_init;
    long max_dim_x;
    long max_dim_y;
    string description;
    string label;
    string unit;
    string standard_unit;
    string display_unit;
    string format;
    string min_value;
    string max_value;
    string writable_attr_name;
    DispLevel level;
    string root_attr_name;
    DevVarStringArray enum_labels;
    AttributeAlarm att_alarm;
    EventProperties event_prop;
    DevVarStringArray extensions;
    DevVarStringArray sys_extensions;

};
```

AttributeDim

```
struct AttributeDim
{
    long dim_x;
    long dim_y;

};
```

AttributeValue

```
struct AttributeValue
{
    any value;
    AttrQuality quality;
    TimeVal time;
    string name;
    long dim_x;
    long dim_y;

};
```

AttributeValue_3

```
struct AttributeValue_3
{
    any value;
    AttrQuality quality;
    TimeVal time;
```

```
  string name;
  AttributeDim r_dim;
  AttributeDim w_dim;
  DevErrorList err_list;

};
```

AttributeValue_4

```
struct AttributeValue_4
{
  AttrValUnion value;
  AttrQuality quality;
  AttrDataFormat data_format;
  TimeVal time;
  string name;
  AttributeDim r_dim;
  AttributeDim w_dim;
  DevErrorList err_list;

};
```

AttributeValue_5

```
struct AttributeValue_5
{
  AttrValUnion value;
  AttrQuality quality;
  AttrDataFormat data_format;
  long data_type;
  TimeVal time;
  string name;
  AttributeDim r_dim;
  AttributeDim w_dim;
  DevErrorList err_list;

};
```

ChangeEventProp

```
struct ChangeEventProp
{
  string rel_change;
  string abs_change;
  DevVarStringArray extensions;

};
```

DevAttrHistory

```
struct DevAttrHistory
{
  boolean attr_failed;
  AttributeValue value;
```

```
    DevErrorList errors;

};
```

DevAttrHistory_3

```
struct DevAttrHistory_3
{
    boolean attr_failed;
    AttributeValue_3 value;

};
```

DevAttrHistory_4

```
struct DevAttrHistory_4
{
    string name;
    TimeValList dates;
    any value;
    AttrQualityList quals;
    EltInArrayList quals_array;
    AttributeDimList r_dims;
    EltInArrayList r_dims_array;
    AttributeDimList w_dims;
    EltInArrayList w_dims_array;
    DevErrorListList errors;
    EltInArrayList errors_array;

};
```

DevAttrHistory_5

```
struct DevAttrHistory_5
{
    string name;
    AttrDataFormat data_format;
    long data_type;
    TimeValList dates;
    any value;
    AttrQualityList quals;
    EltInArrayList quals_array;
    AttributeDimList r_dims;
    EltInArrayList r_dims_array;
    AttributeDimList w_dims;
    EltInArrayList w_dims_array;
    DevErrorListList errors;
    EltInArrayList errors_array;

};
```

DevCmdHistory

```
struct DevCmdHistory
{
  TimeVal time;
  boolean cmd_failed;
  any value;
  DevErrorList errors;

};
```

DevCmdHistory_4

```
struct DevCmdHistory_4
{
  TimeValList dates;
  any value;
  AttributeDimList dims;
  EltInArrayList dims_array;
  DevErrorListList errors;
  EltInArrayList errors_array;
  long cmd_type;

};
```

DevCmdInfo

```
struct DevCmdInfo
{
  string cmd_name;
  long cmd_tag;
  long in_type;
  long out_type;
  string in_type_desc;
  string out_type_desc;

};
```

DevCmdInfo_2

```
struct DevCmdInfo_2
{
  string cmd_name;
  DispLevel level;
  long cmd_tag;
  long in_type;
  long out_type;
  string in_type_desc;
  string out_type_desc;

};
```

DevEncoded

```
struct DevEncoded
{
  DevString encoded_format;
  DevVarCharArray encoded_data;

};
```

DevError

```
struct DevError
{
  string reason;
  ErrSeverity severity;
  string desc;
  string origin;

};
```

DevInfo

```
struct DevInfo
{
  string dev_class;
  string server_id;
  string server_host;
  long server_version;
  string doc_url;

};
```

DevInfo_3

```
struct DevInfo_3
{
  string dev_class;
  string server_id;
  string server_host;
  long server_version;
  string doc_url;
  string dev_type;

};
```

DevIntrChange

```
struct DevIntrChange
{
  boolean dev_started;
  DevCmdInfoList_2 cmds;
  AttributeConfigList_5 atts;

};
```

DevPipeBlob

```
struct DevPipeBlob
{
  string name;
  DevVarPipeDataEltArray blob_data;

};
```

DevPipeData

```
struct DevPipeData
{
  string name;
  TimeVal time;
  DevPipeBlob data_blob;

};
```

DevPipeDataElt

```
struct DevPipeDataElt
{
  string name;
  AttrValUnion value;
  DevVarPipeDataEltArray inner_blob;
  string inner_blob_name;

};
```

DevVarDoubleStringArray

```
struct DevVarDoubleStringArray
{
  DevVarDoubleArray dvalue;
  DevVarStringArray svalue;

};
```

DevVarLongStringArray

```
struct DevVarLongStringArray
{
  DevVarLongArray lvalue;
  DevVarStringArray svalue;

};
```

EltInArray

```
struct EltInArray
{
  long start;
  long nb_elt;

};
```

EventProperties

```
struct EventProperties
{
  ChangeEventProp ch_event;
  PeriodicEventProp per_event;
  ArchiveEventProp arch_event;

};
```

JavaClntIdent

```
struct JavaClntIdent
{
  string MainClass;
  JavaUUID uuid;

};
```

NamedDevError

```
struct NamedDevError
{
  string name;
  long index_in_call;
  DevErrorList err_list;

};
```

PeriodicEventProp

```
struct PeriodicEventProp
{
  string period;
  DevVarStringArray extensions;

};
```

PipeConfig

```
struct PipeConfig
{
  string name;
  string description;
  string label;
  DispLevel level;
  PipeWriteType writable;
  DevVarStringArray extensions;

};
```

TimeVal

```
struct TimeVal
{
  long tv_sec;
```

```
        long tv_usec;
        long tv_nsec;

};
```

ZmqCallInfo

```
    struct ZmqCallInfo
    {
        long version;
        unsigned long ctr;
        string method_name;
        DevVarCharArray oid;
        boolean call_is_except;
    };
```

Unions

AttrValUnion

```
    union AttrValUnion switch (AttributeDataType)
    {
    case ATT_BOOL:
        DevVarBooleanArray bool_att_value;
    case ATT_SHORT:
        DevVarShortArray short_att_value;
    case ATT_LONG:
        DevVarLongArray long_att_value;
    case ATT_LONG64:
        DevVarLong64Array long64_att_value;
    case ATT_FLOAT:
        DevVarFloatArray float_att_value;
    case ATT_DOUBLE:
        DevVarDoubleArray double_att_value;
    case ATT_UCHAR
        DevVarCharArray uchar_att_value;
    case ATT_USHORT:
        DevVarUShortArray ushort_att_value;
    case ATT_ULONG:
        DevVarULongArray ulong_att_value;
    case ATT_ULONG64:
        DevVarULong64Array ulong64_att_value;
    case ATT_STRING:
        DevVarStringArray string_att_value;
    case ATT_STATE:
        DevVarStateArray state_att_value;
    case DEVICE_STATE:
        DevState dev_state_att;
    case ATT_ENCODED:
        DevVarEncodedArray encoded_att_value;
    case ATT_NO_DATA:
        DevBoolean union_no_data;
```

};****
****

ClntIdent

system-message
WARNING/2 in `tango.rst`, line 14253
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14253
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14254
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14254
Inline strong start-string without end-string.

```
union ClntIdent switch (LockerLanguage)
{
case CPP:
  CppClntIdent cpp_clnt;
case JAVA:
  JavaClntIdent java_clnt;
};
```

Exceptions

DevFailed

```
exception DevFailed
{
  DevErrorList errors;
```

};****
****

MultiDevFailed

system-message
WARNING/2 in `tango.rst`, line 14282
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14282
Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 14283

Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 14283

Inline strong start-string without end-string.

```
exception MultiDevFailed
{
  NamedDevErrorList errors;

};
```

Interface Tango::Device

The fundamental interface for all TANGO objects. Each Device is a network object which can be accessed locally or via network. The network protocol on the wire will be IIOP. The Device interface implements all the basic functions needed for doing generic synchronous and asynchronous I/O on a device. A Device object has data and actions. Data are represented in the form of Attributes. Actions are represented in the form of Commands. The CORBA Device interface offers attributes and methods to access the attributes and commands. A client will either use these methods directly from C++ or Java or access them via wrapper classes implemented in a API. The Device interface describes only the remote network interface. Implementation features like threads, command security, priority etc. are dealt with in server side of the device server model.

Attributes

adm_name
readonly attribute string adm_name;

adm_name (readonly) - administrator device unique ascii identifier

description
readonly attribute string description;

description (readonly) - general description of device

name
readonly attribute string name;

name (readonly) - unique ascii identifier

state
readonly attribute DevState state;

state (readonly) - device state

status
readonly attribute string status;
status (readonly) - device state as ascii string

Operations

black_box
DevVarStringArray black_box(in long number)

raises(DevFailed);
read list of last N commands executed by clients
Parameters:

number – of commands to return
Returns:

list of command and clients

command_inout
any command_inout(in string command, in any argin)

raises(DevFailed);
execute a command on a device synchronously with no input parameter and one one output parameter
Parameters:

command – ascii string e.g. On
argin – command input parameter e.g. float
Returns:

command result.

command_list_query
DevCmdInfoList command_list_query()

raises(DevFailed);
query device to see what commands it supports
Returns:

list of commands and their types

command_query
DevCmdInfo command_query(in string command)

raises(DevFailed);
query device to see command argument
Parameters:

command – name

Returns:

command and its types

get_attribute_config

AttributeConfigList get_attribute_config(in DevVarStringArray names)

raises(DevFailed);

read the configuration for a variable list of attributes from a device

Parameters:

name – list of attribute names to read

Returns:

list of attribute configurations read

info

DevInfo info()

raises(DevFailed);

return general information about object e.g. class, type, ...

Returns:

device info

ping

void ping()

raises(DevFailed);

ping a device to see if it alive

read_attributes

AttributeValueList read_attributes(in DevVarStringArray names)

raises(DevFailed);

read a variable list of attributes from a device

Parameters:

name – list of attribute names to read

Returns:

list of attribute values read

set_attribute_config

void set_attribute_config(in AttributeConfigList new_conf)

raises(DevFailed);

set the configuration for a variable list of attributes from the device
Parameters:

new_conf – list of attribute configuration to be set

write_attributes
void write_attributes(in AttributeValueList values)

raises(DevFailed);
write a variable list of attributes to a device
Parameters:

values – list of attribute values to write

Interface Tango::Device_2

interface Device_2 inherits from Tango::Device
The updated Tango device interface. It inherits from Tango::Device and therefore supports all attribute/operation defined in the Tango::Device interface. Two CORBA operations have been modified to support more parameters (command_inout_2 and read_attribute_2). Three CORBA operations now retrun a different data type (command_list_query_2, command_query_2 and get_attribute_config)

Operations

command_inout_2
any command_inout_2(in string command, in any argin, in DevSource source)

raises(DevFailed);
execute a command on a device synchronously with no input parameter and one one output parameter
Parameters:

command – ascii string e.g. On
argin – command input parameter
source – data source
Returns:

command result.

command_inout_history_2
DevCmdHistoryList command_inout_history_2(in string command, in long n)

raises(DevFailed);
Get command result history from polling buffer. Obviously, the command must be polled.
Parameters:

command – ascii string e.g. On
n – record number

Returns:

list of command result (or exception parameters if the command failed).

command_list_query_2
DevCmdInfoList_2 command_list_query_2()

raises(DevFailed);
query device to see what commands it supports
Returns:

list of commands and their types

command_query_2
DevCmdInfo_2 command_query_2(in string command)

raises(DevFailed);
query device to see command argument
Parameters:

command – name

Returns:

command and its types

get_attribute_config_2
AttributeConfigList_2 get_attribute_config_2(in DevVarStringArray names)

raises(DevFailed);
read the configuration for a variable list of attributes from a device
Parameters:

name – list of attribute names to read

Returns:

list of attribute configurations read

read_attributes_2
AttributeValueList read_attributes_2(in DevVarStringArray names, in DevSource source)

raises(DevFailed)
read a variable list of attributes from a device
Parameters:

name – list of attribute names to read

Returns:

list of attribute values read ****

system-message
WARNING/2 in `tango.rst`, line 14574
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14574
Inline strong start-string without end-string.

read_attribute_history_2
DevAttrHistoryList read_attributes_history_2(in string name, in long n)

raises(DevFailed)
Get attribute value history from polling buffer. Obviously, the attribute must be polled.
Parameters:

name – Attribute name to read history
n – Record number

Returns:

list of attribute value (or exception parameters if the attribute failed).

Interface Tango::Device_3

interface Device_3 inherits from Tango::Device_2
The updated Tango device interface for Tango release 5. It inherits from Tango::Device_2 and therefore supports all attribute/operation defined in the Tango::Device_2 interface. Six CORBA operations now return a different data type (read_attributes_3, write_attributes_3, read_attribute_history_3, info_3, get_attribute_config_3 and set_attribute_config_3)

Operations

read_attributes_3
AttributeValueList_3 read_attributes_3(in DevVarStringArray names, in DevSource source)

raises(DevFailed);
read a variable list of attributes from a device
Parameters:

name – list of attribute names to read
source – data source

Returns:

list of attribute values read ****

system-message
WARNING/2 in `tango.rst`, line 14624
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14624
Inline strong start-string without end-string.

write_attributes_3
void write_attributes_3(in AttributeValueList values)

raises(DevFailed, MultiDevFailed);
write a variable list of attributes to a device
Parameters:

values – list of attribute values to write

read_attribute_history_3
DevAttrHistoryList_3 read_attributes_history_3(in string name, in long n)

raises(DevFailed)
Get attribute value history from polling buffer. Obviously, the attribute must be polled.
Parameters:

name – Attribute name to read history
n – Record number
Returns:

list of attribute value (or exception parameters if the attribute failed).

info_3
DevInfo_3 info()

raises(DevFailed);
return general information about object e.g. class, type, ...
Returns:

device info

get_attribute_config_3
AttributeConfigList_3 get_attribute_config_3(in DevVarStringArray names)

raises(DevFailed);
read the configuration for a variable list of attributes from a device
Parameters:

name – list of attribute names to read

Returns:

list of attribute configurations read

set_attribute_config_3

void set_attribute_config_3(in AttributeConfigList_3 new_conf)

raises(DevFailed);

set the configuration for a variable list of attributes from the device

Parameters:

new_conf – list of attribute configuration to be set

Interface Tango::Device_4

interface Device_4 inherits from Tango::Device_3

The updated Tango device interface for Tango release 7. It inherits from Tango::Device_3 and therefore supports all attribute/operation defined in the Tango::Device_3 interface.

Operations

read_attributes_4

AttributeValueList_4 read_attributes_4(in DevVarStringArray names, in DevSource source,in ClntIdent cl_ident)

raises(DevFailed);

read a variable list of attributes from a device

Parameters:

name – list of attribute names to read
source – data source
cl_ident – client identificator

Returns:

list of attribute values read ****

system-message

WARNING/2 in `tango.rst`, line 14719
Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 14719
Inline strong start-string without end-string.

write_attributes_4

void write_attributes_3(in AttributeValueList_4 values, in ClniIdent cl_ident)

raises(DevFailed, MultiDevFailed);
write a variable list of attributes to a device
Parameters:

values – list of attribute values to write

cl_ident – client identificator

command_inout_4
any command_inout_4(in string command, in any argin, in DevSource source, In ClntIdent cl_ident)

raises(DevFailed);
Execute a command on a device synchronously with one input parameter and one one output parameter
Parameters:

command – ascii string e.g. On
argin – command input parameter
source – data source
cl_ident – client identificator
Returns:

command result

read_attribute_history_4
DevAttrHistory_4 read_attributes_history_4(in string name, in long n)

raises(DevFailed)
Get attribute value history from polling buffer. Obviously, the attribute must be polled.
Parameters:

name – Attribute name to read history
n – Record number
Returns:

Attribute value (or exception parameters if the attribute failed) coded in a structure.

command_inout_history_4
DevCmdHistory_4 command_inout_history_4(in string command, in long n)

raises(DevFailed);
Get command value history from polling buffer. Obviously, the command must be polled.
Parameters:

name – Command name to read history
n – Record number

Returns:

Command value (or exception paramteters) coded in a structure

write_read_attribute_4
AttributeValueList_4 write_read_attribute_4(in AttributeValueList_4 values, in ClntIdent cl_ident)

raises(DevFailed,MultiDevFailed);
Write then read a variable list of attributes from a device
Parameters:

values – list of attribute values to write
cl_ident – client identificator
Returns:

list of attribute values read

set_attribute_config_4
void set_attribute_config_4(in AttributeConfigList_3 new_conf, in ClntIdent cl_ident)

raises(DevFailed);
set the configuration for a variable list of attributes from the device
Parameters:

new_conf – list of attribute configuration to be set

cl_ident – client identificator
Interface Tango::Device_4

interface Device_4 inherits from Tango::Device_3
The updated Tango device interface for Tango release 7. It inherits from
Tango::Device_3 and therefore supports all attribute/operation defined in the
Tango::Device_3 interface.

Interface Tango::Device_5

interface Device_5 inherits from Tango::Device_4
The updated Tango device interface for Tango release 9. It inherits from
Tango::Device_4 and therefore supports all attribute/operation defined in the
Tango::Device_4 interface.

operations

get_attribute_config_5
AttributeConfigList_5 get_attribute_config_5(in DevVarStringArray names)

raises(DevFailed);
read the configuration for a variable list of attributes from a device

Parameters:

name – list of attribute names to read

Returns:

list of attribute configurations read

set_attribute_config_5

void set_attribute_config_5(in AttributeConfigList_5 new_conf, in ClntIdent cl_ident)

raises(DevFailed);

set the configuration for a variable list of attributes from the device

Parameters:

new_conf – list of attribute configuration to be set

cl_ident – client identificator

read_attributes_5

AttributeValueList_5 read_attributes_5(in DevVarStringArray names, in DevSource source,in ClntIdent cl_ident)

raises(DevFailed);

read a variable list of attributes from a device

Parameters:

name – list of attribute names to read
source – data source
cl_ident – client identificator

Returns:

list of attribute values read

write_read_attributes_5

AttributeValueList_5 write_read_attributes_5(in AttributeValueList_4 values, in DevVarStringArray r_names, in ClntIdent cl_ident)

raises(DevFailed,MultiDevFailed);

Write then read a variable list of attributes from a device

Parameters:

values – list of attribute values to write
r_names – list of attribute to read
cl_ident – client identificator

Returns:

list of attribute values read****

read_attribute_history_5

system-message
WARNING/2 in `tango.rst`, line 14905
Inline strong start-string without end-string.

system-message
WARNING/2 in `tango.rst`, line 14905
Inline strong start-string without end-string.

DevAttrHistory_5 read_attributes_history_5(in string name, in long n)

raises(DevFailed)
Get attribute value history from polling buffer. Obviously, the attribute must be polled.
Parameters:

name – Attribute name to read history
n – Record number
Returns:

Attribute value (or exception parameters if the attribute failed) coded in a structure.
get_pipe_config_5

PipeConfigList get_pipe_config_5(in DevVarStringArray names)

raises(DevFailed);
read the configuration for a variable list of pipes from a device
Parameters:

name – list of pipe names to read
Returns:

list of pipe configurations
set_pipe_config_5

void set_pipe_config_5(in PipeConfigList new_conf, in ClntIdent cl_ident)

raises(DevFailed);
set the configuration for a variable list of pipes from the device
Parameters:

new_conf – list of pipe configuration to be set

cl_ident – client identificator****
read_pipe_5

system-message

WARNING/2 in `tango.rst`, line 14948
Inline strong start-string without end-string.

system-message

WARNING/2 in `tango.rst`, line 14948
Inline strong start-string without end-string.

DevPipeData read_pipe_5(in string name, in ClntIdent cl_ident)

raises(DevFailed);
read a pipe from a device
Parameters:

name – pipe name to read
cl_ident – client identificator
Returns:

Pipe value

write_pipe_5
void write_pipe_5(in DevPipeData value, in ClniIdent cl_ident)

raises(DevFailed);
write a pipe to a device
Parameters:

value – new pipe value to write

cl_ident – client identificator
write_read_pipe_5

DevPipeData write_read_pipe_5(in DevPipeData value, in ClntIdent cl_ident)

raises(DevFailed);
Write then read a pipe from a device
Parameters:

value – New pipe value to write
cl_ident – client identificator
Returns:
pipe values read

Tango object naming (device, attribute and property)

Device name

A Tango device name is a three fields name. The field separator is the **/** character. The first field is named **domain**, the second field is named **family** and the last field is named **member**.A tango device name looks like

domain/family/member

It is a hierarchical notation. The member specifies which element within a family. The family specifies which kind of equipment within a domain. The domain groups devices related to which part of the accelerator/experiment they belongs to. At ESRF, some of the machine control system domain name are SR for the storage ring, TL1 for the transfer line 1 or SY for the synchrotron booster. For experiment, ID11 is the domain name for all devices belonging to the experiment behind insertion device 11. Here are some examples of Tango device name used at the ESRF :

- **sr/d-ct/1** : The current transformer. The domain part is sr for storage ring. The family part is d-ct for diagnostic/current transformer and the member part is 1
- **fe/v-pen/id11-1** : A Penning gauge. The domain part is fe for front-end. The family part is v-pen for vacuum/penning and the member name is id11-1 to specify that this is the first gauge on the front-end part after the insertion device 11

Full object name

The device name as described above is not enough to cover all Tango usage like device server without database or device access for multi control system. With the naming schema, we must also be able to name attribute and property. Therefore, the full naming schema is

[protocol://][host:port/]device_name[/attribute][->property][#dbase=xx]

The protocol, host, port, attribute, property and dbase fields are optional. The meaning of these fields are :

00.00.0000

: Specifies which protocol is used (Tango or Taco). Tango is the default

: The supported value for xx is *yes* and *no*. This field is used to specify that the device is a device served by a device server started with or without database usage. The default value is *dbase=yes*

: This field has different meaning according to the dbase value. If *dbase=yes* (the default), the host is the host where the control system database server is running and port is the database server port. It has a higher priority than the value defined by the TANGO_HOST environment variable. If *dbase=no*, host is the host name where the device server process serving the device is running and port is the device server process port.

: The attribute name

: The property name

The host:port and dbase=xx fields are necessary only when creating the DeviceProxy object used to remotely access the device. The -> characters are used to specify a property name.

Some examples

Full device name examples

- **gizmo:20000/sr/d-ct/1** : Device sr/d-ct/1 running in a specified control system with the database server running on a host called gizmo and using the port number 20000. The TANGO_HOST environment variable will not be used.
- **tango://freak:2345/id11/rv/1#dbase=no** : Device served by a device server started without database. The server is running on a host called freak and use port number 2345. //freak:2345/id11/rv/1#dbase=no is also possible for the same device.
- **Taco://sy/ps-ki/1** : Taco device sy/ps-ki/1

Attribute name examples

- **id11/mot/1/Position** : Attribute position for device id11/mot/1
- **sr/d-ct/1/Lifetime** : Attribute lifetime for Tango device sr/d-ct/1

Attribute property name

- **id11/rv/1/temp->label** : Property label for attribute temp for device id11/rv/1.
- **sr/d-ct/1/Lifetime->unit** : The unit property for the Lifetime attribute of the sr/d-ct/1 device

Device property name

- **sr/d-ct/1->address** : the address property for device sr/d-ct/1

Class property name

- **Starter->doc_url** : The doc_url property for a class called Starter

Device and attribute name alias

Within Tango, each device or attribute can have an alias name defined in the database. Every time a device or an attribute name is requested by the API's, it is possible to use the alias. The alias is simply an open string stored in the database. The rule of the alias is to give device or attribute name a name more natural from the physicist point of view. Let's imagine that for experiment, the sample position is described by angles called teta and psi in physics book. It is more natural for physicist when they move the motor related to sample position to use *teta* and *psi* rather device name like *idxx/mot/1* or *idxx/mot/2*. An attribute alias is a synonym for the four fields used to name an attribute. For instance, the attribute *Current* of a power-supply device called *sr/ps/dipole* could have an alias *DipoleCurrent*. This alias can be used when creating an instance of a AttributeProxy class instead of the full attribute name which is *sr/ps/dipole/Current*. Device alias name are uniq within a Tango control system. Attribute alias name are also uniq within a Tango control system.

Reserved words and characters, limitations

From the naming schema described above, the reserved characters are **:,#,/** and the reserved string is : **->**. On top of that, the dbt_update tool (tool to fulfill database from the content of a file) reserved the **device** word

The device name, its domain, member and family fields and its alias are stored in the Tango database. The default maximum size for these items are :

|c|c| **Item & max length** device name & 255 domain field & 85 family field & 85 member field & 85 device alias name & 255

The device name, the command name, the attribute name, the property name, the device alias name and the device server name are **case insensitive**.

Starting a Tango control system

Without database

When used without database, there is no additional process to start. Simply starts device server using the -nodb option (and eventually the -dlist option) on specific port. See [sec:Device-server-without] to find informations on how to start/write Tango device server not using the database.

With database

Starting the Tango control system simply means starting its database device server on a well defined host using a well defined port. Use the host name and the port number to build the TANGO_HOST environment variable. See [Env variable] to find how starting a device server on a specific host. Obviously, the underlying database software (MySQL) must be started before the Tango database device server. The Tango database server connects to MySQL using a default logging name set to root. You can change this behaviour with the MYSQL_USER and MYSQL_PASSWORD environment variables. Define them before starting the database server.

If you are using the Tango administration graphical tool called **Astor**, you also need to start a specific Tango device server called **Starter** on each host where Tango device server(s) are running. See [**?**] for Astor documentation. This starter device server is able to start even before the Tango database device server is started. In this case, it will enter a loop in which it periodically tries to access the Tango database device. The loop exits and the server starts only if the database device access succeed.

With database and event

For Tango releases lower than 8

On top of what is described in the previous chapter, using event means using CORBA Notification service. Start one Notification Service daemon on each host where device server(s) used via events are running. The Notification Service daemon event channel factory IOR has to be registered in the Tango database. This is done with the **notifd2db** command. The notification daemon is a process with a high thread number. By default, Unix like operating systems reserve a big amount of memory for each thread stack (8 MByte for Linux/Ubuntu, 10 MByte for Linux/RedHat 4). If your process has several hundreds of threads, this could generate a too high memory requirement on virtual memory and even exceed the maximun allowed memory per process (3 GBytes on Linux for 32 bits computer). The notification service daemon works very well with a value of only 2 Mybtes for thread stack. The Unix command line ulimit -s 2048 asks the operating system to give 2 Mbytes for each thread stack. Example of starting and registering a Notification Service daemon on a UNIX like operating system

```
1   ulimit -s 2048
2   notifd -n -DDeadFilterInterval=300 &
3   notifd2db
```

The Notification Service daemon is started at line 2. Its -DDeadFilterInterval option is used to specify some internal cleaning of dead objects within the notification service. The -n option is used to disable the use of the CORBA Naming Service for registering the default event channel factory. The registration of the Notification Service daemon in the Tango database is done at line 2.

It differs on a Windows computer

```
1   notifd -n -DDeadFilterInterval=300 -DFactoryIORFileName=C:\Temp\evfact.
2   notifd2db C:\Temp\evfact.ior
```

For release 8 and above

A new event system has been implemented starting with Tango release 8. With this new event system, the CORBA Notification service is not needed any more. This means that **as soon** as all Tango device server processes running on a host and all clients using events from their devices used Tango 8, it is not required to start any process other than the device servers and the clients. You can forget the previous sub-chapter!

With file used as database

When used with database on file, there is no additional process to start. Simply starts device server using the -file option specifying file name port. See [sec:Device-server-file] to find informations on how to start Tango device server using database on file.

With file used as database and event

For Tango releases lower than 8

Using event means using CORBA Notification service. Start one Notification Service daemon on the host where device server(s) using events are running. The Notification Service daemon event channel factory IOR has to be registered in the file(s) use as database. This is done with the **notifd2db** command. Example of starting and registering a Notification Service daemon on a UNIX like operating system

```
1   notifd -n -DDeadFilterInterval=300 &
2   notifd2db -o /var/myfile.res
```

The Notification Service daemon is started at line 1. Its -n option is used to disable the use of the CORBA Naming Service for registering the default event channel factory. The registration of the Notification Service daemon in the file used as database is done at line 2 with its **-o** command line option.

It differs on a Windows computer because the name of the file used by the CORBA notification service to store its channel factory IOR must be specified using its -D command line option. This file name has also to be passed to the notifd2db command.

```
notifd -n -DDeadFilterInterval=300 -DFactoryIORFileName=C:\Temp\evfact.
notifd2db C:\Temp\evfact.ior -o C:\Temp\myfile.res
```

For release 8 and above

A new event system has been implemented starting with Tango release 8. With this new event system, the CORBA Notification service is not needed any more. This means that **as soon** as all clients using events from devices embedded in the device server use Tango 8, it is not required to start any process other than the device server and its clients.

With the controlled access

Using the Tango controlled access means starting a specific device server called TangoAccessControl. By default, this server has to be started with the instance name set to 1 and its device name is sys/access_control/1. The command line to start this device server is:

```
TangoAccessControl 1
```

This server connects to MySQL using a default logging name set to root. You can change this behaviour with the MYSQL_USER and MYSQL_PASSWORD environment variables. Define them before starting the controlled access device server. This server also uses the MYSQL_HOST environment variable if you need to connect it to some MySQL server running on another host. The syntax of this environment varaible is host:port. Port is optional and if it is not defined, the MySQL default port is used (3306). If it is not defined at all, a connection to the localhost is made. This controlled access system uses the Tango database to retrieve user rights and it is not possible to run it in a Tango control system running without database.

The notifd2db utility

The notifd2db utility usage (For Tango releases lower than 8)

The notifd2db utility is used to pass to Tango the necessary information for the Tango servers or clients to build connection with the CORBA notification service. Its usage is:

notifd2db [notifd2db_IOR_file] [host] [-o Device_server_database_file_name] [-h]

The [notifd2db_IOR_file] parameter is used to specify the file name used by the notification service to store its main IOR. This parameter is not mandatoty. Its default value is /tmp/rdfact.ior. The [host] parameter is ued to specify on which host the notification service should be exported. The default value is the host on which the command is run. The [-o Device_server_database_file_name] is used in case of event and device server started with the file as database (the -file device server command line option). The file name used here must be the file name used by the device server in its -file option. The [-h] option is just to display an help message. Notifd2db utility usage example:

notifd2db

to register notification service on the current host using the default notifictaion service IOR file name.

notifd C:\Temp\nd.ior

to register a notification service with IOR file named C:\Temp\nd.ior.

notifd -o /var/my_ds_file.res

to register notification service in the /var/my_ds_file.res file used by a device server started with the device server -file command line option.

The property file syntax

Property file usage

A property file is a file where you store all the property(ies) related to device(s) belonging to a specific device server process. In this file, one can find:

- Which device(s) has to be created for each Tango class embedded in the device server process
- Device(s) properties
- Device(s) attribute properties

This type of file is not required by a Tango control system. These informations are stored in the Tango database and having them also in a file could generate some data duplication issues. Nevertheless, in some cases, it could very very helpful to generate this type of file. These cases are:

1. If you want to run a device server process on a host which does not have access to the Tango control system database. In such a case, the user can generate the file from the database content and run the device server process using this file as database (-file option of device server process)
2. In case of massive property changes where no tool will be more adapted than your favorite text editor. In such a case, the user can generate a file from the database content, change/add/modify file contents using his favorite tool and then reload file content into the database.

Jive:raw-latex:*cite{Jive doc}* is the tool provided to generate and load a property file. To generate a device server process properties file, select your device server process in the Server tab, right click and select Save Server Data. A file selection window pops up allowing you to choose your file name and path. To reload a file in the Tango database, click on File then Load Property File.

Property file syntax

```
\textbf{1 }#----------------------------------------------------------
# SERVER TimeoutTest/manu, TimeoutTest device declaration
#---------------------------------------------------------
```

```
 4
 5  TimeoutTest/manu/DEVICE/TimeoutTest: "et/to/01",\
 6                                       "et/to/02",\
 7                                       "et/to/03"
 8
 9
10  # --- et/to/01 properties
11
12  et/to/01->StringProp: Property
13  et/to/01->ArrayProp: 1,\
14                       2,\
15                       3
16  et/to/01->attr_min_poll_period: TheAttr,\
17                                  1000
18  et/to/01->AnotherStringProp: "A long string"
19  et/to/01->ArrayStringProp: "the first prop",\
20                             "the second prop"
21
22  # --- et/to/01 attribute properties
23
24  et/to/01/TheAttr->display_unit: 1.0
25  et/to/01/TheAttr->event_period: 1000
26  et/to/01/TheAttr->format: %4d
27  et/to/01/TheAttr->min_alarm: -2.0
28  et/to/01/TheAttr->min_value: -5.0
29  et/to/01/TheAttr->standard_unit: 1.0
30  et/to/01/TheAttr->__value: 111
31  et/to/01/BooAttr->event_period: 1000doc_url
32  et/to/01/TestAttr->display_unit: 1.0
33  et/to/01/TestAttr->event_period: 1000
34  et/to/01/TestAttr->format: %4d
35  et/to/01/TestAttr->standard_unit: 1.0
36  et/to/01/DbAttr->abs_change: 1.1
37  et/to/01/DbAttr->event_period: 1000
38
39  CLASS/TimeoutTest->InheritedFrom:   Device_4Impl
40  CLASS/TimeoutTest->doc_url:   "http://www.esrf.fr/some/path"
```

Line 1 - 3: Comments. Comment starts with the '#' character

Line 4: Blank line

Line 5 - 7: Devices definition. DEVICE is the keyword to declare a device(s) definition sequence. The general syntax is:

<DS name>/<inst name>/DEVICE/<Class name>: dev1,dev2,dev3

Device(s) name can follow on next line if the last line character is '\' (see line 5,6). The " characters around device name are generated by the Jive tool and are not mandatory.

Line 12: Device property definition. The general device property syntax is

<device name>**->**<property name>: <property value>

In case of array, the array element delimiter is the character ','. Array definition can be splitted on several lines if the last line character is '\'. Allowed characters after the ':' delimiter are space, tabulation or nothing.

Line 13 - 15 and 16 - 17: Device property (array)

Line 18: A device string property with special characters (spaces). The " character is used to delimit the string

Line 24 - 37: Device attribute property definition. The general device attribute property syntax is

<device name>/<attribute name>**->**<property name>: <property value>

Allowed characters after the ':' delimiter are space, tabulation or nothing.

Line 39 - 40: Class property definition. The general class property syntax is

CLASS/<class name>**->**<property name>: <property value>

CLASS is the keyword to declare a class property definition. Allowed characters after the ':' delimiter are space, tabulation or nothing. On line 40, the " characters around the property value are mandatory due to the '/' character contains in the property value.

List of pictures

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10 OMG home page

Advanced CORBA programming with C++ by M.Henning and S.Vinosky (Addison-Wesley 1999)

TANGO home page

ALBA home page

Soleil home page

MySQL home page

MySQL and mSQL by Randy Jay Yarger, George Reese and Tim King (O'Reilly 1999)

Tango classes on-line documentation

C++ programming language third edition by Stroustrup (Addison-Wesley)

Design Patterns by Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides (Addison-Wesley 1995)

omniORB home page

The Common Object Request Broker: Architecture and Specification Revision 2.3 available from OMG home page

Java Pro - June 1999 : Plugging memory leak by Tony Leung

CVS WEB page - http://www.cyclic.com

POGO home page

JacORB home page
Tango ATK reference on-line documentation
The Notification Service specification available from OMG home page - http://www.omg.org
ASTOR home page
Elettra home page
JIVE home page
Tango ATK Tutorials
ZMQ home page
Tango class development reference documentation

system-message
ERROR/3 in `tango.rst`, line 15622
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15623
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15624
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15627
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15628
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15629
Duplicate substitution definition name: "image". backrefs:

[1] TACO stands for **T**elescope and **A**ccelerator **C**ontrolled with **O**bjects

[2] TANGO stands for **TA**co **N**ext **G**eneration **O**bject

[3] CORBA stands for **C**ommon **O**bject **R**equest **B**roker **A**rchitecture

[4] In contrary to the state_handler method of the TACO device server model which is not specific to each command.

[5] TANGO attributes were known as signals in the TACO device server model

[6] Properties were known as resources in the TACO device server model

[7] note: the polling is not synchronized is currently not synchronized on the hour

[8] The default is_allowed method behavior is to always allows the command

[9] URL stands for **U**niform **R**esource **L**ocator

[10] The StepperMotor class inherits from the DeviceImpl class and therefore is a DeviceImpl

[11] The StepperMotorClass inherits from the DeviceClass and therefore is a DeviceClass

[12] It can also be data declared as object data members or memory declared as static

[13] Their black-box is also destroyed and re-built

system-message
ERROR/3 in `tango.rst`, line 15630
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15631
Duplicate substitution definition name: "image". backrefs:

system-message
ERROR/3 in `tango.rst`, line 15632
Duplicate substitution definition name: "image". backrefs:

system-message
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Duplicate substitution definition name: "image". backrefs:

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Duplicate substitution definition name: "image". backrefs:

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Duplicate substitution definition name: "image". backrefs:

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Duplicate substitution definition name: "image". backrefs:

system-message

ERROR/3 in `tango.rst`, line 15643

Duplicate substitution definition name: "image". backrefs:

system-message

ERROR/3 in `tango.rst`, line 15644

Duplicate substitution definition name: "image". backrefs:

system-message

ERROR/3 in `tango.rst`, line 15645

Duplicate substitution definition name: "image". backrefs:

system-message

ERROR/3 in `tango.rst`, line 15646

Duplicate substitution definition name: "image". backrefs: