

Skippy Device Server

Sergi Blanch-Torné

Controls Software Engineer - Alba Synchrotron

sblanch@cells.es

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Abstract

Following the [wikipedia](#)'s definition: the SCPI “*defines a standard for syntax and commands to use in controlling programmable test and measurement devices*”. Many scientific instrumentation uses this schema for the configuration and operation of the instrument of its purpose.

Alba has used an specific Device Server, under the name *PyVisaInstrWrapper*, to communicate with instruments like scopes, radio frequency generators, arbitrary signal generators and spectrum analyser. This device was an extension from the original *PyScope*, becoming it one of the internal device classes. Before that, there was a C++ device server called *TekDPO7000*. This is a long background on this protocol that helps to provide many improvements to this Device Server. By the way it has started showing certain limitations that may advice bounds of the design. But how this has been developed allows a *refactoring* of the internalities to save those constrains.

1 Design

The main restriction that the *PyVisaInstrWrapper* shows is the dependency on the *PyVisa* subdevice to manage the communications with the instrument. The main issue was the impossibility to define alternatives to the subdevice. Also the growing number of query commands to the instrument has reach the limit of the basic design.

1.1 Machine state

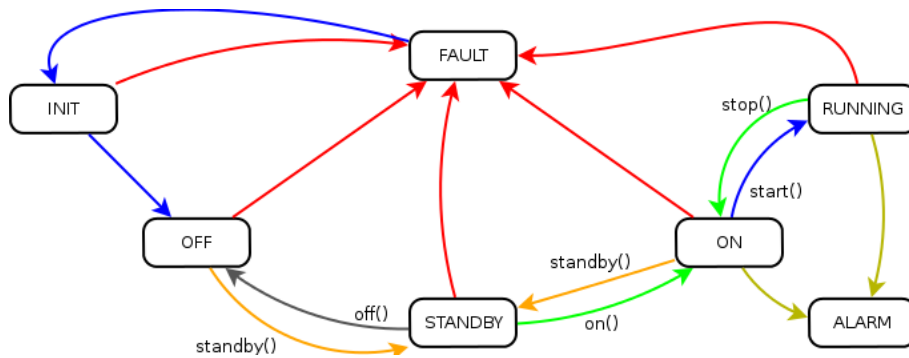


Figure 1: State machine diagram of the Device in the Skippy Device Server

When a device of an instance of the *Skippy* device server is launched, the first state it has is **INIT**, on the left side of the picture 1. When all the internal elements are well initialised, then it changes its state to **OFF**. At this state, the device has an internal object with the responsibility of the communications with an instrument.

Then, if the properties configuration does not say the contrary, the device will try to stablish communication with the instrument. This is reported with the state change to **STANDBY**. The instrument will receive a request to identify itself, and the answer will allow the device to know which instructions set is necessary to talk further with the instrument.

Again, if the properties does not say the contrary, the device create the specific attributes for the identified instrument. Reporting this succeed with a state change to **ON**. If there are attributes to have their value monitored and pushing events, and for the last time, if the properties does not avoid this state

change, the *Start()* process will be launched to have an specific thread in charge of this monitoring. This state corresponds with **RUNNING**.

The figure 1 show other state-change edges with the command name that produces the change. In any case, if something goes wrong, its state will decay to **FAULT**. To recover from fault, the *Init()* command should be called, apart from cases where the device itself can recover the situation to then do the necessary steps to recover normal operation.

1.2 Device Properties

- **Instrument**: mandatory property to configure the instrument that will be introduced to the distributed system via the device.
 - If the content string is a host name, use sockets to communicate with the instrument
 - If the content string is a device name if the class of this subdevice is *PyVisa* or even *[Py]Serial*, it will be used as a bridge to the instrument.
 - If the content string is a serial line file descriptor (for example a */dev/ttySn* or a */dev/ttyrNN*), it will be the way the instrument will be accessed.
 - else, decay to fault state with the appropriate status message
- **Port**: optional property to specify a port, in the socket communication, when it should be different than the default 5025.
- **SerialBaudrate, SerialBytesize, SerialParity, SerialStopbits, SerialTimeout, SerialXonXoff**: optional properties to define the serial line communications when the instrument is accessed by a serial line in the machine where it runs.
- **NumChannels**: optional property to define, in case the instrument has channels, the number of them available.
- **NumFunctions**: optional property to define, in case the instrument has functions, the number of them available.
- **NumMultiple**: more generic than the previous to, and made because of the limitations they have. It is a generalisation for channels and functions. It must be composed by a list of pairs with the *scpiPrefix* (equivalent to the 'ch' or 'fn') followed by the number of them that shall be build.
- **MonitoredAttributes**: When the device is in **RUNNING** state, the attributes listed here will be monitored (having events) with a period said in the attribute *TimeStampsThreshold* (or different if specified with a : separator after the attrName).
- **AutoStandby**: When device startup, try an *standby()* to connect to the instrument authomatically. Default True.
- **AutoOn**: When device startup, try an *on()* begin communication with the instrument. Default True.
- **AutoStart**: When device startup, try an *Start()* to launch the necessary monitor threads (if **MonitoredAttributes** is configured), authomatically. Default True.
- **TxTerminator**: by default the instruments uses '\n' as a Transmission terminator, but there are instruments that requires to use '\r', or both in a certain order like '\r\n'.

1.3 Device Commands

- **IDN()**: Request identification to the instrument.
- **Off()**: Release the communication with the instrument.
- **Standby()**: Open the communications with the instrument and do the identification and attribute builder, but do not allow yet any other query.
- **On()**: Stablish communication with the instrument.
- **Start()**: Start an active monitoring.
- **Stop()**: Stop the active monitoring.

- `AddMonitoring(AttrName)`: Add an attribute to the list of monitored attributes
- `RemoveMonitoring(AttrName)`: Remove an attribute from the list of monitored attributes
- `SetMonitoringPeriod([AttrName,AttrPeriod])`: From the list of already monitored attributes, establish (or change) the period that it is checked. With this command the monitored attribute will become one of the splitted thread monitor, even if the period in the same than the normal periodic. To force to place in this normal monitor list, use period value 0.
- `GetMonitoringPeriod(AttrName)`: Get the period that is checked an attribute monitored. `NaN` if it is not monitored.
- `Exec()`: Expert attribute to look inside the device during execution.
- `CMD()`: Expert command for a direct send of a SCPI command and read the answer.
- `CMDfloat()`: Expert command for a direct send of a SCPI command and read the answer converted to a float list.
- **TODO**: *"DumpAttr([file,time]): Once received, dump the raw data readed from the read of an attribute during the specified seconds"*

1.4 Device Attributes

- `idn`: read attribute with the identification of the instrument linked.
- `QueryWindow`: Expert attribute to configure the number of request sent in parallel to the instrument. Bigger queries will be splitted in subqueries o of this size.
- `TimeStampsThreshold`: This value sets the threshold time to use a cached value or hardware read it.

Other attributes can be built using a [Builder pattern](#). In fact, when the device starts and the instrument is identified, with the information provided in this identification, the device can find how to build the instructions set.

An example of an attribute definition:

```
Attribute('State',
        { 'type': PyTango.CmdArgType.DevBoolean,
          'dim': [0],
          'readCmd': lambda ch,num: "%s%d: DISPLAY?"%(ch,num),
          'writeCmd': lambda ch,num: (lambda value: "%s%d: DISPLAY_%s"%(ch,num,value)),
          'channels': True,
          'functions': True,
        })
```

This example, in a oscilloscope with 4 channels and 4 functions, will setup 8 `READ.WRITE` boolean attributes, called with the pattern: `State{Ch,Fn}[1..4]`. Point to comment is the `readCmd` and the `writeCmd` and the use of `lambdas`. In the `read` case, and because this is an attribute description to build more than one, the `lambda` function is set to build the final command for each of the channels and functions. A bit more complicated is the `write` case, where there are two nested `lambdas`, one used in the attribute build and the other used when write the attribute because is when the value is known.

Another example of an attribute definition:

```
Attribute('Frequency',
        { 'type': PyTango.CmdArgType.DevDouble,
          'dim': [0],
          'readCmd': ":FREQ?",
          'writeCmd': lambda value: ":FREQ_%s"%(str(value)),
          'rampeable': True,
        })
```

That example, in a RF generator, will setup 3 `READ.WRITE` double attributes, called `Frequency`, `FrequencyStep`, `FrequencyStepSpeed`. This describes a behaviour where, when a *frequency* is set, a thread will be launched to each *StepSpeed* seconds, the current value will be increased/decreased by the *Step* in the direction of the setpoint.

Here an example of an spectrum attribute definition:

```

Attribute('Waveform',
    {'type': PyTango.CmdArgType.DevDouble,
     'dim': [1, 40000000],
     'readCmd': lambda ch, num: "WAVEform:SOURce_%s%d; : WAVEform:DATA?"%(ch, num),
     'channels': True,
     'functions': True,
    })

```

With this attribute is broken a backward compatibility with *PyVisaInstrWrapper* because there those spectrum attributes did not follow the naming of name. There is a naming convention in attribute definitions with channels and functions, to the name given in the definition is concatenated at the end two characters (**Ch** or **Fn**) followed by the number of the channel.

There is an alternative that allow to stablish the naming with a bigger flexibility (but not full-free).

```

Attribute('IO',
    {'type': PyTango.CmdArgType.DevString,
     'dim': [0],
     'readCmd': lambda mult, num: "%s%.2d:VALU?" % (mult, num),
     'writeCmd': lambda mult, num: (lambda value: "%s%.2d:VALU_%s"
                                     % (mult, num, value)),
     'multiple': {'scpiPrefix': 'IOPort', 'attrSuffix': 'Port'}
    })

```

This attribute description will generate some attributes under the name patter '*IOPortNN*', and there will be as many as specified in the `NumMultiple` attribute where one of the pairs shall have as first element '*IOPort*'.

1.5 Class Diagram

In figure 2 can be found a UML draw with the class diagram.

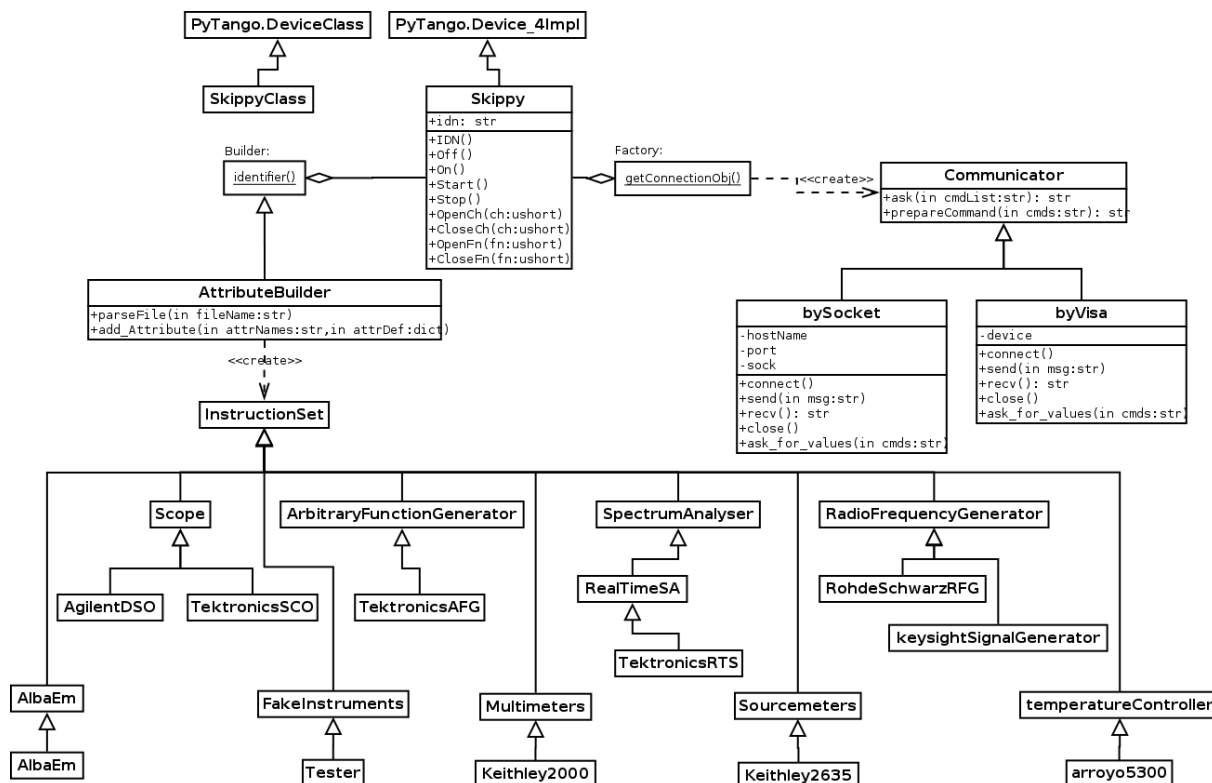


Figure 2: Class diagram of the Skippy device.

1.6 Device features

- Device is capable to dynamically build attributes based on the instrument identification (described in the the particular instruction set).
 - Supported Scalar and Spectrum (1 dimension arrays) attribute definition. Image (2 dimension arrays) are not currently developed, neither in the schedule because they are not needed by

any of the current supported instruments. Although the device is prepared to support them if need be. (Perhaps the frequencies spectra in SpectrumAnalyser).

- The dynamic attributes build after the instrument identification can be Memorized if this has been configured this way in the file with the instruction set.
- Reconnect after network cut (or *PyVisa*) **FIXME**: “*This has been temporally disabled to bug fix it.*”
- Multiple request of data to the instrument: As figure 3 describes, when the device receives a request for reading to the instrument it can manage to cut those requests in subsets to avoid stress in the instrument. The communication itself supports a direct socket connection to the instrument and the use of the *PyVisa* device as a bridge in the communication.

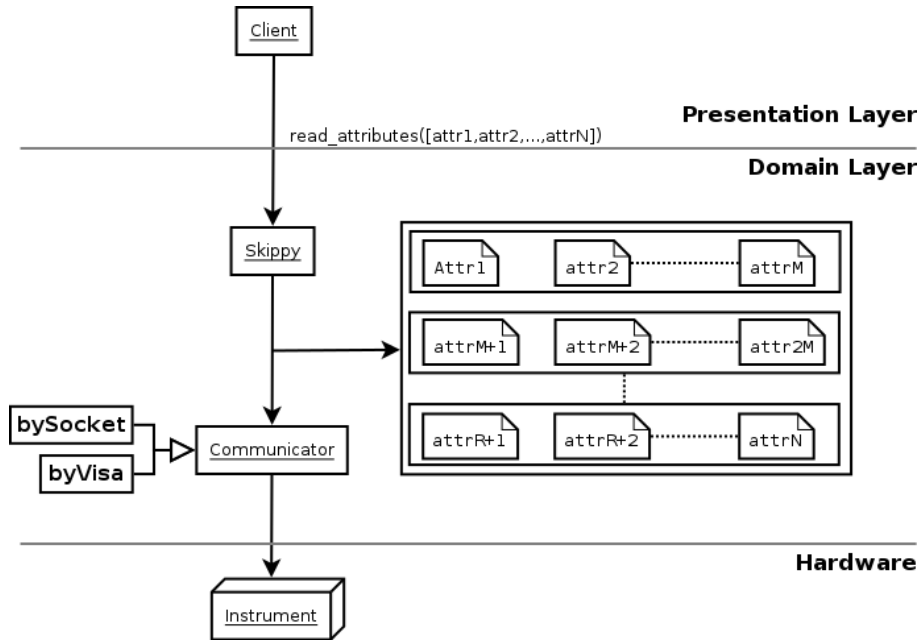


Figure 3: multiple request of readings to the instrument.

- Write process to some attributes would require a smooth ramp. As an example, to change the frequency in the *RFGenerator*, the change would not be set directly (or the timing system will suffer). Then in the build process of an specific attribute with a certain flag of “movability” (name to be determined) two extra attributes, internals in the device, must be built also: a **Step** and a **StepSpeed**. On the write operation a thread is launched and every “StepSpeed” seconds change the value by the content in “Step” in the direction to the final setpoint. This was already implemented in *PyRfSignalGenerator* Class. **FIXME**: “*This will require a refactoring in order to encapsulate the functionality in a responsible object*”.
- Monitor attributes. Having a property with a list of attributes, if they exist in the instrument definition, configure them in events and do a separated thread polling that will emit events on this attributes. This feature is different that setting up a “polling” from tango to the attribute because this fails to use the multiple reading.
 - In the definition of the attribute to be monitored, the *MonitoredAttributes* property, using an specific notation (a ‘:’ followed by a number of seconds) can set up an specific monitoring period for it in particular.
 - * When the monitoring is by the specific period, different attributes with the same period, should be read by the same monitor thread.
 - The use of the commands (*add* and *remove*) to setup this feature is recommended. Together with a set of commands to setup specific monitoring periods.
 - When an attribute is monitored, a `read_attr()` returns the cached value (no hardware read).

- **TODO:** *“Once this monitoring feature is available, other attributes not monitored that have reached some reading frequency, would be included in the monitoring loop (not emitting events) in order to reduce the load of the readings. The frequency reading should be monitored to notice when this has reduced over another threshold to avoid unnecessary readings.”*
- **FIXME:** *“When many attributes are being read, and not by `read_attributes([])`, prioritise. (This happens, for example, when opens the device with `Atkpanel`) ”*

1.7 Known bugs

- **FIXME:** *“When all the monitored attributes are removed, the list ends inconsistent and dirty when newer attributes are added to this list.”*
- **FIXME:** *“The timestamp of an attribute come from when it was read from the hardware. But in case of an `INVALID` value, it will point forever to when it has decay: this produces issues when a plot show this and other attributes with different time scale.”*
- **FIXME:** *“The an instrument is powered off, if there is no attribute monitor the device will not see it until access the hardware. That is, request the state before write will not update the information.”*