


GEN&lti>CAM		
Version 2.1.1	Standard	

GenICam Standard



Generic Interface for Cameras

Version 2.1.1

GEN<i>CAM

Table of Contents

1	OVERVIEW.....	5
2	GENAPI MODULE – CONFIGURING THE CAMERA	7
2.1	INTRODUCTION	7
2.2	BASIC STRUCTURE OF THE CAMERA DESCRIPTION FILE	8
2.3	NODES, INTERFACES, AND ABSTRACT FEATURES	10
2.4	GETTING AND SETTING VALUES	11
2.5	ACCESS MODE	12
2.6	CACHING.....	16
2.7	IDENTIFYING AND VERSIONING A CAMERA DESCRIPTION FILE.....	20
2.7.1	<i>Versioning the Schema</i>	<i>21</i>
2.7.2	<i>Versioning the Camera Description File</i>	<i>21</i>
2.7.3	<i>Identifying and Caching the Camera Description File</i>	<i>22</i>
2.8	AVAILABLE NODE TYPES.....	22
2.8.1	<i>Node</i>	<i>22</i>
2.8.2	<i>Category.....</i>	<i>25</i>
2.8.3	<i>Register.....</i>	<i>27</i>
2.8.4	<i>Arrays and Selectors</i>	<i>29</i>
2.8.5	<i>Integer, IntReg, MaskedIntReg.....</i>	<i>30</i>
2.8.6	<i>StructReg</i>	<i>33</i>
2.8.7	<i>Boolean.....</i>	<i>34</i>
2.8.8	<i>Command</i>	<i>35</i>
2.8.9	<i>Float, FloatReg</i>	<i>35</i>
2.8.10	<i>Enumeration, EnumEntry</i>	<i>36</i>
2.8.11	<i>StringReg.....</i>	<i>38</i>
2.8.12	<i>String (v1.1)</i>	<i>38</i>
2.8.13	<i>SwissKnife, IntSwissKnife, Converter, and IntConverter</i>	<i>38</i>
2.8.14	<i>ConfRom, TextDesc, and IntKey.....</i>	<i>41</i>
2.8.15	<i>DcamLock and SmartFeature</i>	<i>42</i>
2.8.16	<i>Port</i>	<i>43</i>
2.8.17	<i>Group element.....</i>	<i>44</i>
2.9	AVAILABLE INTERFACES.....	45
2.9.1	<i>Integer Interface.....</i>	<i>45</i>
2.9.2	<i>IFloat Interface</i>	<i>45</i>
2.9.3	<i>IString Interface</i>	<i>46</i>
2.9.4	<i>IEnumeration Interface</i>	<i>46</i>
2.9.5	<i>ICommand Interface.....</i>	<i>46</i>
2.9.6	<i>IBoolean Interface.....</i>	<i>46</i>
2.9.7	<i>IRegister Interface.....</i>	<i>46</i>
2.9.8	<i>ICategory Interface</i>	<i>47</i>
2.9.9	<i>IPort Interface</i>	<i>47</i>
2.9.10	<i>ISelector Interface.....</i>	<i>47</i>
3	APPENDIX.....	48

		
Version 2.1.1	Standard	

3.1	ENDIANESS OF GIGE VISION CAMERAS	48
3.1.1	<i>Behavior of products based on schema version 1.1 and newer</i>	48
3.1.2	<i>Behavior of products based on schema version 1.0</i>	49
3.1.3	<i>Passing the schema version to the IPort implementation</i>	49
3.2	DEFAULT VALUES OF OPTIONAL NODE ELEMENTS AND ATTRIBUTES	50
4	ACKNOWLEDGEMENTS	54
5	RIGHTS AND TRADEMARKS	54
6	INDEX	55

HISTORY

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1.0	13.06.2006	Fritz Dierks, Basler	Released version as voted on during the Montreal meeting
1.1 draft 1	25.03.2008	Fritz Dierks, Basler	First draft for version 1.1
2.0	06.11.2009	Fritz Dierks, Basler	Released
2.0.1	17.10.2013	Fritz Dierks, Basler	Fixed some minor miss-spellings and added some clarifications
2.1	30.09.2015	Fritz Dierks, Basler Rene Weber, Baumer	<ul style="list-style-type: none"> - Added a description of default values which are either already given in the schema or in the reference implementation - Added ValidValueSet - Added clarifications provided by Eric Bourbonnais, Dalsa
2.1.1	18.01.2016	Fritz Dierks, Basler Mattias Josefsson, Sick	<ul style="list-style-type: none"> - Fixed several typos

1 Overview

Today's digital cameras are packed with much more functionality than just delivering an image. Processing the image and appending the results to the image data stream, controlling external hardware, and doing the real-time part of the application have become common tasks for machine vision cameras. As a result, the programming interface for cameras has become more and more complex.

The goal of GenICam is to provide a generic programming interface for all kinds of cameras. No matter what interface technology the cameras are using or what features they are implementing, the application programming interface (API) should be always the same (see Figure 1).

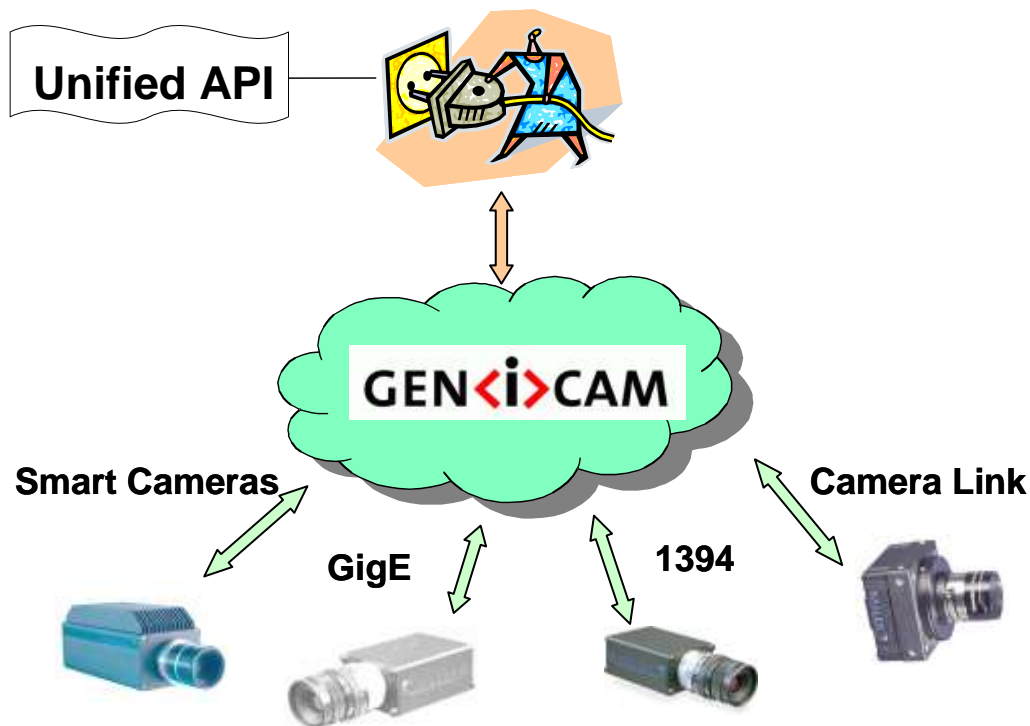




Figure 1 The GenICam vision

The **GenICam** standard consists of multiple **modules** according to the main tasks to be solved:

- **GenApi** : Application programming interface (API) for configuring a camera
- **GenTL** : API for transport layer (TL) that allows grabbing images
- **SFNC** : Standard Feature Naming Convention
- **CLProtocol** : API for interfacing Camera Link camera to GenAPI.

		
Version 2.1.1	Standard	

- **GenCP** : Generic Control Protocol

Modules can be released independently from each other.

2 GenApi Module – Configuring the Camera

2.1 Introduction

The GenApi module deals with the problem of how to configure a camera. The key idea is to make camera manufacturers provide machine readable versions of the manuals for their cameras. These **camera description files** contain all of the required information to automatically map a camera's **features** to its **registers**.

A typical feature would be the camera's gain and the user's attempt might be, for example, to set *Gain*=42. Using GenICam, a piece of generic software will be able to read the camera's description file and figure out that setting the *Gain* to 42 means writing a value of 0x2A to a register located at 0x0815. Other tasks involved might be to check in advance whether the camera possesses a *Gain* feature and to check whether the new value is consistent with the allowed *Gain* range.

Note that adding a new feature to a camera just means extending the camera's description file, thus making the new feature immediately available to all GenICam aware applications.

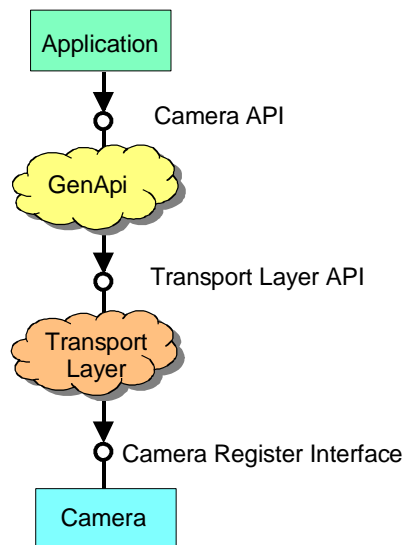


Figure 2 Layers for accessing a camera

Figure 2 shows the layers involved in configuring a camera. The application requires a **camera API** that allows dealing with the camera's features, for example, by writing code which looks like this:

```
Camera.Gain = 42;
```

The GenApi module will translate this call into a series of calls to register access functions provided by the **transport layer API**, for example, like this:

```
TransportLayer.WriteRegister( 0x0815, 0x2A, 2 ); // address, data, length
```

Finally, the transport layer will deliver the calls to the **camera interface**. GenApi currently assumes that the camera is configured using a flat register space.

The GenICam standard defines the **syntax** of the camera description file plus the **semantics** of the transport layer API. In addition, the GenICam standard recommends – but does not enforce – the usage of certain **names** and **types** for common features such as *Gain* or *Shutter*.

The standard does not contain the actual code for reading the description file and translating features to registers, nor does it contain the transport layer code. Everyone is free to do their own implementation. There is, however, a **reference implementation** available that can be freely used.

Note that the **GenApi** section in this document deals with the camera description file only. It is intended to help the GenICam user to understand the key ideas behind the GenApi module and to enable people to write their own camera description files. The GenApi reference implementation comes with a reference manual showing how an end user can use the GenApi module even without a deeper understanding of the concepts laid out in this section.

2.2 Basic Structure of the Camera Description File

The camera is described by means on an **XML file** containing a set of nodes with each node having a **type** and a unique **name**. Nodes can link to each other and each connection plays a certain **role**. Figure 3 shows a very simple example in graphical notation. The nodes are shown as bubbles labeled "type::name," and the links are shown as arrows labeled with the role name.

There are two special nodes: the **Root** node from which one can start walking the node graph and the **Device** node that provides the connection to the transport layer.¹

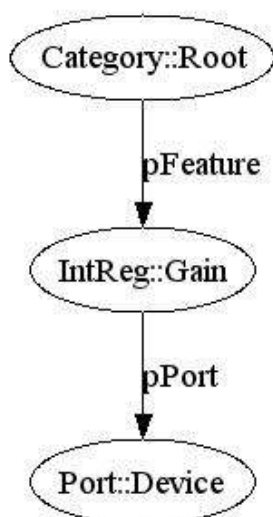




Figure 3 Topology of a graph constructed from a simple configuration file

¹ Note that GenApi can be used to access other register based devices in addition to cameras.

		
Version 2.1.1	Standard	

The *Gain* node in Figure 3 is of the *IntReg* type, which allows the extraction an integer from a register. Looked at from the *Root* node, it is a feature of the camera. The *Root* node, therefore, contains a link named *pFeature* referencing the *Gain* node. To read and write the *Gain* registers, the *Gain* node needs access to the camera port, and thus it contains a link to the *Device* node. The link is named *pPort* and references the *Device* node.

The *Gain* node contains all of the information required to extract a two byte unsigned integer in *BigEndian* mode. The complete camera description file looks like this:

```
<?xml version="1.0" encoding="utf-8"?>

<RegisterDescription
  ModelName="Example01"
  VendorName="Test"
  ToolTip="Example 01 from the GenApi standard"
  StandardNameSpace="None"
  SchemaMajorVersion="1"
  SchemaMinorVersion="1"
  SchemaSubMinorVersion="0"
  MajorVersion="1"
  MinorVersion="0"
  SubMinorVersion="0"
  ProductGuid="1F3C6A72-7842-4edd-9130-E2E90A2058BA"
  VersionGuid="7645D2A1-A41E-4ac6-B486-1531FB7BECE6"
  xmlns="http://www.genicam.org/GenApi/Version_1_1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.genicam.org/GenApi/Version_1_1
    http://www.genicam.org/GenApi/GenApiSchema_Version_1_1.xsd">

  <Category Name="Root">
    <ToolTip>Entry for traversing the node graph</ToolTip>
    <pFeature>Gain</pFeature>
  </Category>

  <IntReg Name="Gain">
    <ToolTip>Access node for the camera's Gain feature</ToolTip>
    <Address>0x0815</Address>
    <Length>2</Length>
    <AccessMode>RW</AccessMode>
    <pPort>Device</pPort>
    <Sign>Unsigned</Sign>
    <Endianness>BigEndian</Endianness>
  </IntReg>

  <Port Name="Device">
    <ToolTip> Port node giving access to the camera</ToolTip>
  </Port>

</RegisterDescription>
```

The `<?xml>` node is a processing element giving hints about the encoding of the file and is always the same.

The `<RegisterDescription>` element is the outermost bracket encapsulating all nodes of the camera. The camera is identified by the *ModelName* and *VendorName* attributes (model

“Example01” from vendor “Test” in this case). The other attributes are explained later in section 2.7.

Inside the <RegisterDescription> element, the nodes are lying in a flat order. Each node has a unique **Name** attribute and can be linked by sub-elements named **pRole** containing the *Name* of some other node.

Each node has an optional <ToolTip> element that contains a short description. The *Gain* node has additional elements that depend on its actual *IntReg* type and tells us, for example, the *Address* of the register or its *Length*. The default value is an empty string.

Typically, an implementation will create one software object per node and will link these objects together according to the logical links described in the XML file.² The nodes can either be retrieved by their (unique) name or can be found by traversing the node graph starting with the root node. Once the user has a pointer to the node, he can access that feature through the node object's programming interface.

The syntax of the XML file is defined in the **XML schema** given by the *schemaLocation*-attribute. The schema is part of the standard. This document explains the ideas and overall structure of GenICam. The schema and its embedded reference documentation describe the formal details. In case of doubt, the schema's content overrides the content of this text.

The file location http://www.genicam.org/GenApi/GenApiSchema_Version_1_1.xsd is mandatory for the camera configuration file but can be overridden at runtime.

2.3 Nodes, Interfaces, and Abstract Features

Each **node** in the camera description file describes a single item. Depending on the item's nature, the node is of a specific **node type** and has a specific **interface**. The following interfaces are currently available³ (each one is given with the typical widget used to map it on a graphical user interface):

- *Integer* – maps to a slider with value, min, max, and increment
- *IFloat* – maps to a slider with value, min, and max plus a physical unit.
- *IString* – maps to an edit box showing a string
- *IEnumeration* – maps to a drop down box
- *ICommand* – maps to a command button
- *IBoolean* – maps to a check box
- *IRegister* – maps to an edit box showing a hex string
- *ICategory* – maps to an entry in a tree structuring the camera's features
- *IPort* – maps to the camera port and is typically not shown graphically

² The actual implementation may split some of the XML nodes into a set of multiple implementation nodes.

³ This list contains only interfaces representing a specific type. The reference implementation contains more interfaces.

The signature of the interfaces is given in more detail in section 2.9. The available node types are described in section 2.8. There might be multiple **node types** implementing the same **interface type**. The *Integer* interface, for example, is (among others) implemented by the following node types:

- *IntReg* – extracts an integer lying byte-bounded in a register
- *MaskedIntReg* – extracts an integer packed into a register, e.g., from bit 8 to bit 12
- *Integer* – merges the integer's value, min, max, and increment properties from different nodes

Each node type extracts an integer from different sources in a different way. The output of all of these nodes, however, can be used as type-safe input for all links where an integer is required.

Abstract features are always described in terms of an **interface type**, a **name**, and a **meaning**. For example, the *Gain* (name) of a camera might be defined as an *Integer* (interface type) and might describe the amplification inside a camera (meaning). Note that other possible definitions exist, e.g., the *Gain* could be defined as an *IEnumeration* or as an *IFloat*.

2.4 Getting and Setting Values

When the user reads or writes the value of a node, this node will trigger a cascade of read and write operations within the node graph. To illustrate this, Figure 4 shows a more elaborate example for the *Gain* feature. The *Gain* feature is exposed via an *Integer* interface that lets the user get and set the feature's *Value* and lets her read (among other things) the feature's *Min* and *Max* value. The example in Figure 4 assumes that the camera has three registers, one for the *Gain Value* itself, one for its *Min* value, and one for its *Max* value. From each of these registers, the corresponding value is extracted using an *IntReg* node. The *Integer* node with the name *Gain* then collects the data and merges them, exposing the results with an *Integer* interface.

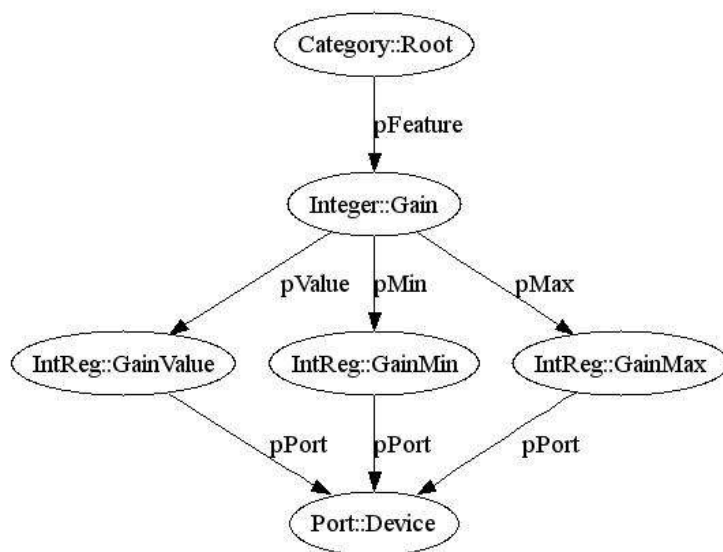


Figure 4 Example of the control flow when getting and setting features

If the user reads the value of the *Gain* node, the call will be dispatched to the *GainValue* node, which will in turn use the *IPort* interface from the *Device* node to ask for the right register.

If the user attempts to set the value of the *Gain* node, the implementation might decide to check the range first by reading the *Min* and *Max* values from the corresponding *GainMin* and *GainMax* nodes. If the value is inside the allowed range, the *Gain* node then will write it via the *GainValue* node and the *Device* node to the camera. Note that the implementation might cache the *Min* and *Max* values depending on the *Cacheable* attribute of the corresponding *IntReg* nodes.

2.5 Access Mode

Each node has an **access mode** defined according to the following table:

Readable	Writable	Implemented	Access Mode
*	*	0	NI – not implemented
0	0	1	NA – not available
0	1	1	WO – write only
1	0	1	RO – read only
1	1	1	RW – readable and writable

1 = yes, 0 = no, * = don't care

A feature may be implemented in a camera, but be temporarily not available. If it is available, then it is, by definition, also implemented and may be readable and/or writable.

Some nodes have elements to control accessibility, for example, the register node (see section 2.8.3). In addition, GenICam provides three mechanisms to change the accessibility at runtime:

- A feature can be temporarily **locked** depending on the value of another node. While locked, a feature is not writable. In terms of the table above, the writable flag is temporarily forced to 0.
- A feature can be temporarily **not available** depending on the value of another node. In terms of the table above, the writable and the readable flags are temporarily forced to 0.
- A feature can be **not implemented** at all depending on the value of another node. In terms of the table above, the implemented flag is permanently forced to 0. As oppose to the **locked** and **not available**, a feature with **not implemented** access mode cannot be dynamical changed.

The distinction between being available and being implemented has been made because a GUI might want to handle the two cases differently. A feature being not implemented at all will never be shown to the user and a feature being temporarily not available will be grayed out and the value will be replaced, e.g., by “—”. A temporarily locked feature will be grayed out, but the feature’s value may still be displayed.

A hardware *Trigger* that can be switched *On* and *Off* is a typical example for making a feature **temporarily not available**. If switched *On*, an additional feature, the *TriggerPolarity*, becomes available and denotes whether the hardware signal should be interpreted as an *ActiveHigh* or an *ActiveLow* signal. If the *Trigger* is switched *Off*, the *TriggerPolarity* is meaningless and should be grayed out.

Figure 5 shows how this information is handled in the camera description file. The *Trigger* and the *TriggerPolarity* feature are implemented using nodes of the *Enumeration* type that map a set of enumeration entries to integer numbers. For example, the entries for the *Trigger* feature are *On*=1 and *Off*=0. The integer numbers are mapped to registers using nodes of the *IntReg* type.

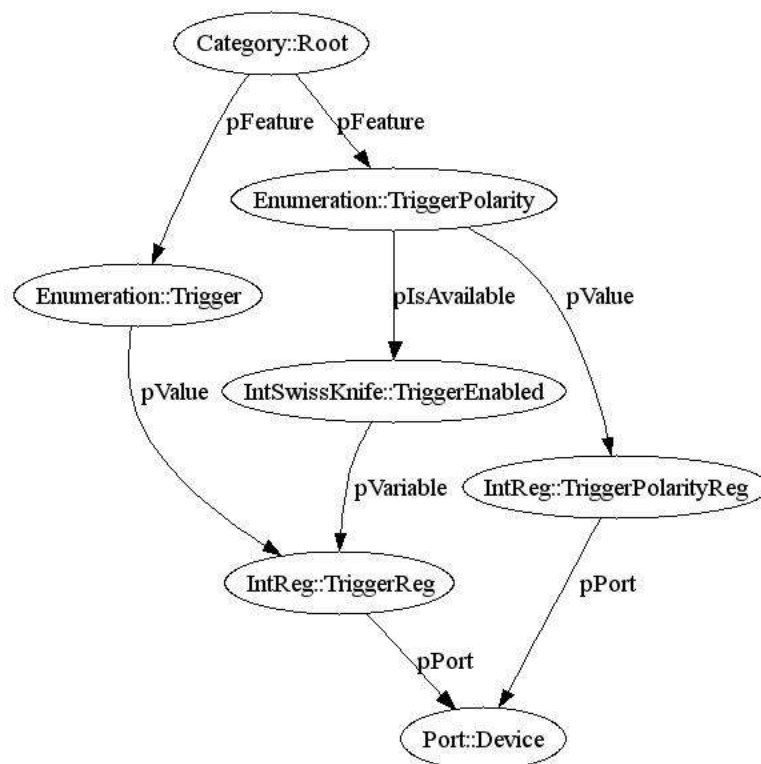


Figure 5 Controlling whether a feature is accessible

The *TriggerPolarity* node has a *pIsAvailable* link that needs to point to a node exposing an *Integer* interface. If the value of this node is zero, the node is temporarily not accessible.⁴

In the example, *pIsAvailable* could directly point to *TriggerReg* because *Trigger=On* is mapped to 1 and *Trigger=Off* is mapped to 0. If this is not the case, a node of the *IntSwissKnife* type comes in handy. It computes an integer result from any number of other integer nodes using a mathematical formula. In the XML file, the node looks like this:

```

<IntSwissKnife Name="TriggerEnabled">
  <ToolTip>Determines if the Trigger feature is switched on</ToolTip>
  <pVariable Name="TRIGGER">TriggerReg</pVariable>
  <Formula>TRIGGER==1</Formula>
</IntSwissKnife>

```

The mathematical formula in the *<Formula>* entry is evaluated, yielding the result of the node. Before the evaluation, the symbolic names of the variables are replaced by the integer values of the corresponding nodes. In the example, there is only one *<pVariable>* entry pointing to the *TriggerReg* node and having the symbolic name *TRIGGER*. This is also found in the formula that reads “*TRIGGER==1*”.

So if the graphical user interface is updated, it will ask the *TriggerPolarity* node whether it is enabled. The *TriggerPolarity* node will in turn check the *IntSwissKnife*, which will in turn compute the outcome from the value of the *TriggerReg* node.

⁴ This follows the C/C++ semantic for interpreting integers as Boolean values.

The *BytesPerPacket* feature of DCAM compliant 1394 cameras is a typical example for making a feature **temporarily locked**. The user can change this camera parameter, but only if the DMA of the PC adapter card is not yet set up for grabbing.⁵ Setting up the DMA means that the transport layer asks the camera for the *BytesPerPacket* parameter and configures that value to the DMA. After this has been done, *BytesPerPacket* must not be changed until the transport layer releases the DMA. In the meantime, the parameter must be locked in the camera.

Note that the camera itself has no way of knowing whether the DMA is set up or not. As a consequence, the “normal” nodes in the camera description files cannot be used for controlling the lock status of *BytesPerPacket*.

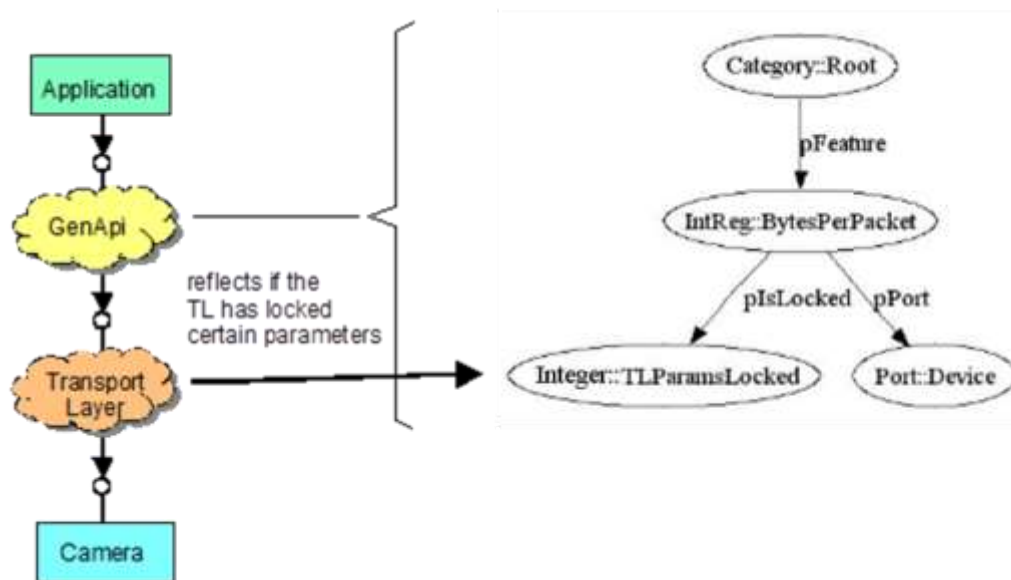


Figure 6 Locking a feature

The solution within GenApi is to provide a floating *Integer* node *TLParamsLocked* (see Figure 6). The *BytesPerPacket* links to this node with a *pIsLocked* link. The transport layer (TL) needs to reflect its DMA status by updating the value of the *TLParamsLocked* node. Before it sets up the DMA, it locks the respective camera parameters (e.g., *BytesPerPacket*) by setting *TLParamsLocked* to 1, and after the grab has been finished, it sets *TLParamsLocked* 0 again. Changing the *TLParamsLocked* node will in turn update the lock status of all dependent nodes, for example, the *BytesPerPacket* node.

Note that in order for this scheme to work generically, *TLParamsLocked* must be a standard node name and the transport layer must have access to the GenApi interface of the camera. In addition, the designer of the camera description file must be aware of which parameters will be locked by the transport layer. This information is included in the transport layer standard,

⁵ The reason is that the DMA of a OHCI compliant PC adapter card needs to know the *BytesPerPacket* parameter in advance of the data transfer to ensure that the frames are transferred to memory without causing CPU load.

e.g., the DCAM specification, which specifies that during grab the number of packages per frame and the package size must be fixed.

A family of cameras where some members have a *Gamma* feature implemented and some do not is a typical example for a feature being **not implemented**. If the cameras have an **inquiry bit** advertising whether the camera has the *Gamma* feature implemented or not, you can maintain one camera description file for the whole family of cameras.

Figure 7 shows how to handle that case with GenICam. The *Gamma* feature node has a *pIsImplemented* link to a *GammaInq* node mapping to the inquiry bit in the camera. Multiple inquiry bits are typically packed into one register. For extracting the bits, the *MaskedIntReg* node type is used. It works like an *IntReg* node, but in addition, you can denote which bit or which contiguous group of bits you want to be extracted as an integer.

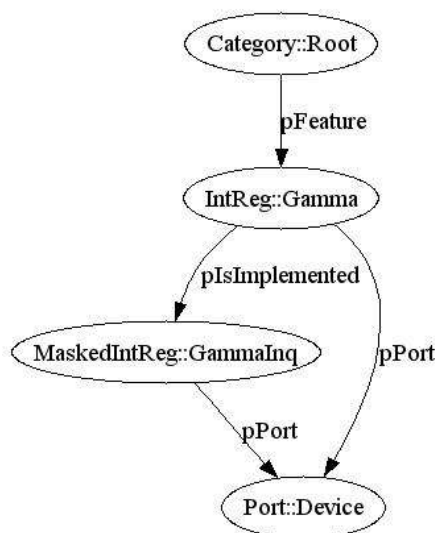


Figure 7 Checking whether a feature is implemented

2.6 Caching

If an implementation supports checking ranges, presence, and enable status for each write access, it would normally trigger a cascade of read accesses to the camera. However, most of the values required for validation do not change frequently or at all and can thus be cached. The camera description file contains all of the necessary means to ensure the cache's coherency.

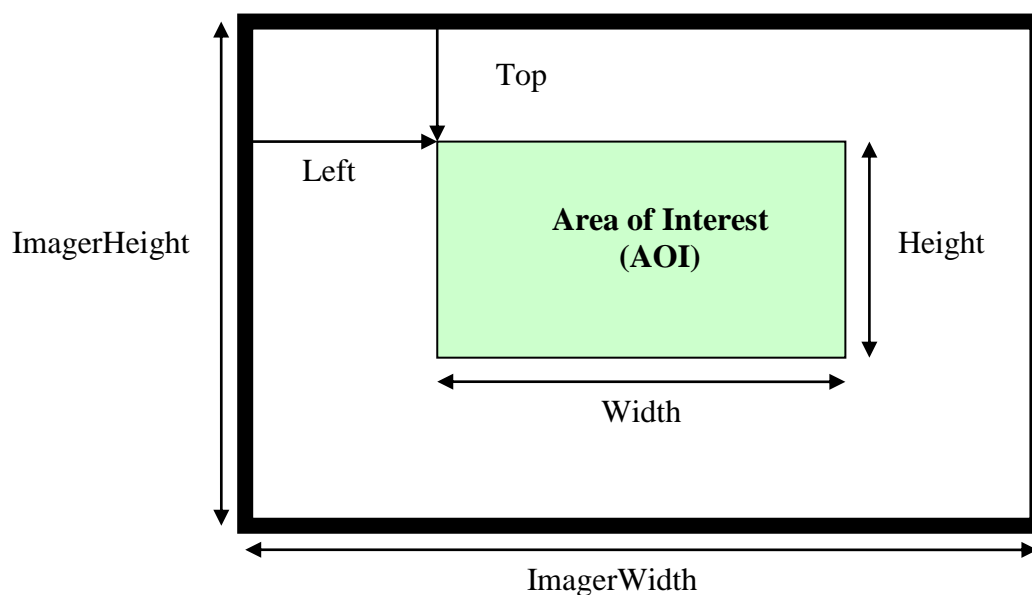


Figure 8 Area of Interest

To explain this, a more elaborate example must be used. Figure 8 shows an area of interest (AOI) on the imager in a camera. The camera will send only the data from within the AOI, which is given as a rectangle defined by the parameters *Top*, *Left*, *Width*, and *Height*.

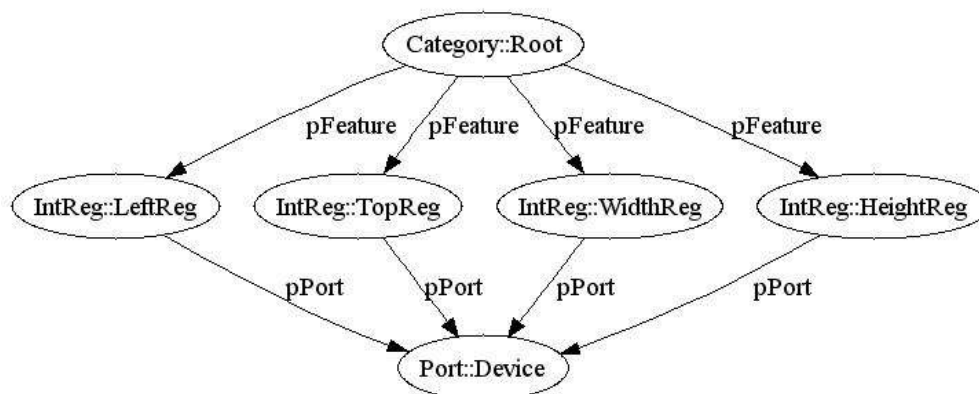


Figure 9 Controlling the Area of Interest

Each of these four parameters is exposed through a register as shown in Figure 9. This simple scheme, however, cannot deal with the fact that none of the four parameters has an unlimited range. Assuming that the pixel coordinates start with 0, the following restrictions apply:

$$0 \leq \text{Left} \leq \text{ImagerWidth} - \text{Width}$$

$$0 \leq \text{Top} \leq \text{ImagerHeight} - \text{Height}$$

$$1 \leq \text{Width} \leq \text{ImagerWidth} - \text{Left}$$

$$1 \leq \text{Height} \leq \text{ImagerHeight} - \text{Top}$$

To take these restrictions into account, the maximum values for each of the four parameters must be computed using *SwissKnife* nodes; the minimum values are fixed. The resulting GenApi node graph is shown in Figure 10. Note that a second layer of *Integer* nodes has been introduced and that the maximum values are taken from *IntSwissKnife* nodes.

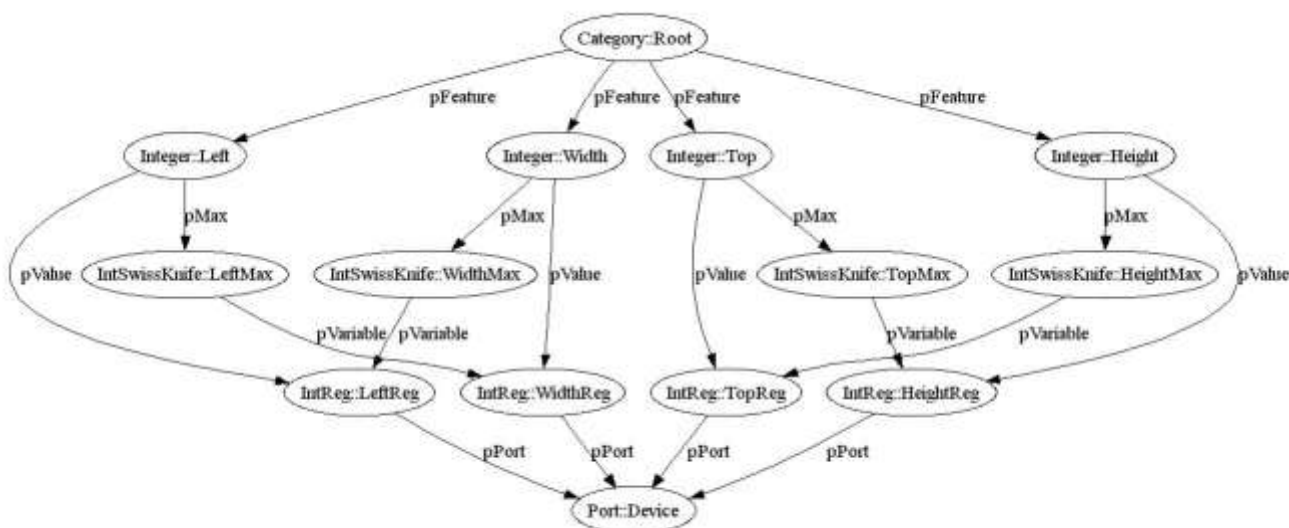


Figure 10 Controlling the Area of Interest while taking restrictions into account

Assuming an imager with VGA resolution (640x480), the XML code for the *TopMax* node might look like this:

```
<IntSwissKnife Name="TopMax">
  <pVariable Name="CURHEIGHT">HeightReg</pVariable>
  <Formula>480-CURHEIGHT</Formula>
</IntSwissKnife>
```

Returning to the topic of caching, you would not want the *HeightReg* to be read each time you set the *Left* feature, nor would you want the *TopMax* node to be evaluated each time. This is indeed not necessary if (and only if) you are certain that *HeightReg* will only change when the GenApi itself writes a new value to that register. If this is the case, you can cache the values of *HeightReg* and *TopMax*.

If the user writes a new value to *HeightReg*, the *HeightReg* cache can be updated immediately, and the *TopMax* cache needs to be invalidated. The next time someone accesses the *Left* node, it will read *TopMax*, thereby creating a new cache entry for *TopMax*.

As a rule, all clients of a node are informed if the node changes its content so that the clients can invalidate their caches.

Normally, the links between the nodes in the camera description file contain all of the information needed so that the implementation can deal with the caching without the user needing to worry about it. However, there are certain cases where the camera itself contains more dependencies than those directly described by the nodes.

Some cameras contain a feature called *Binning*. When *Binning* is switched on, the charge from adjacent pixels is merged together, yielding a larger full well at the cost of lower resolution. Assuming a VGA resolution imager, typical configurations are:

- No Binning (640 x 480)
- Horizontal Binning (320 x 480)
- Vertical Binning (640 x 240)
- Full Binning (320 x 240)

In GenICam, this feature would be described using an enumeration with the four entries given above (see Figure 11). However, changing the binning also means changing the imager size – not the real physical imager, but rather the logical imager size that imposes the restrictions on the AOI parameters.

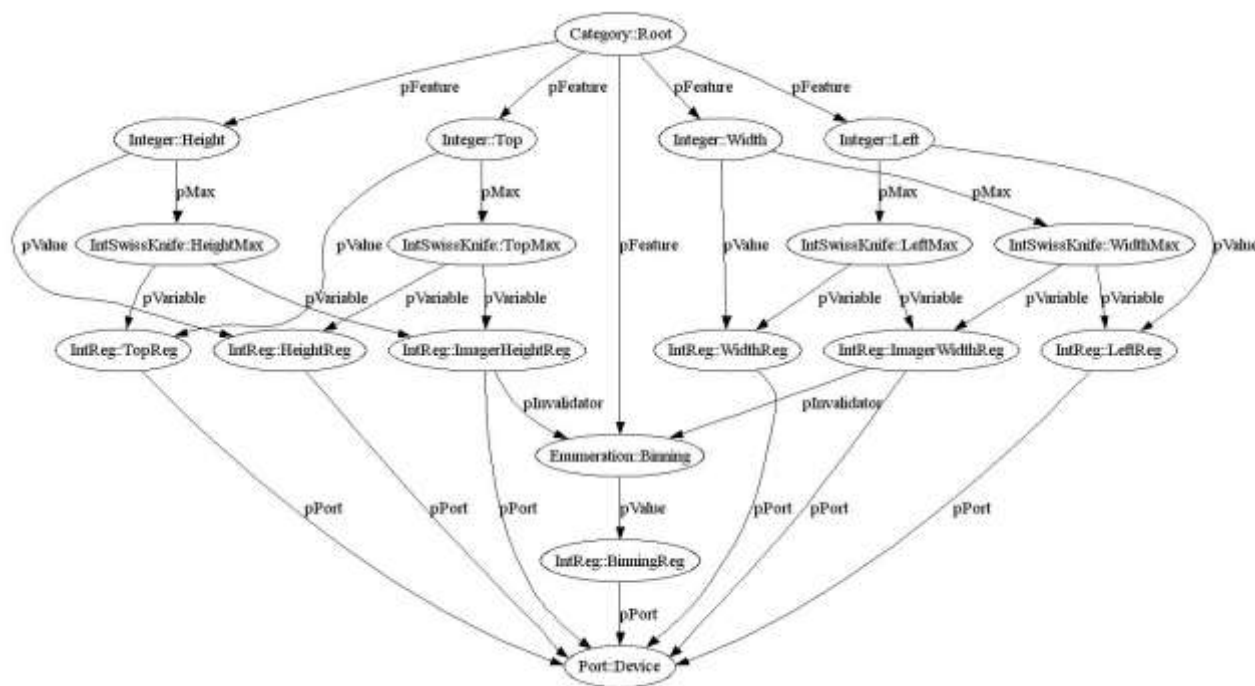


Figure 11 Controlling the Area of Interest taking binning into account

Let's assume that the camera provides the information about the current (logical) imager size with a register. As shown in Figure 11, this introduces two new nodes: *ImagerHeightReg* and *ImagerWidthReg*. The XML code for *TopMax* then looks like this:

```
<IntSwissKnife Name="TopMax">
  <pVariable Name="CURHEIGHT">HeightReg</pVariable>
  <pVariable Name="IMAGERHEIGHT">ImagerHeightReg</pVariable>
  <Formula>IMAGERHEIGHT-CURHEIGHT</Formula>
</IntSwissKnife>
```

As we have seen, the value of *ImagerHeightReg* will change if the user changes the *Binning* feature. However, there is no data flow between the two nodes. To make sure that the node

cache for *ImagerHeightReg* will be invalidated when the content of the *BinningReg* node changes, a *<pInvalidator>* link must be introduced between the two nodes. The sole purpose of this link is to document the hidden dependency between the two features and to make sure that the cache is always coherent.

2.7 Identifying and Versioning a Camera Description File

It must be possible to identify a camera description file, and thus the described camera, in a unique manner. In addition, a camera description file will typically evolve over time, e.g., when features are added to the corresponding camera product. This creates the necessity for a versioning mechanism. The GenApi syntax itself will also evolve over time, e.g., when new node types are added, thus a versioning mechanism for the schema is also required.

The necessary means are found in the attribute list of the *<RegisterDescription>* element, which is the outermost bracket of the XML file. Here is an example:

```
<RegisterDescription
  ModelName="Example01"
  VendorName="Test"
  ToolTip="Example 01 from the GenApi standard"
  StandardNameSpace="None"
  SchemaMajorVersion="1"
  SchemaMinorVersion="1"
  SchemaSubMinorVersion="0"
  MajorVersion="1"
  MinorVersion="0"
  SubMinorVersion="0"
  ProductGuid="1F3C6A72-7842-4edd-9130-E2E90A2058BA"
  VersionGuid="7645D2A1-A41E-4ac6-B486-1531FB7BECE6"
  xmlns="http://www.genicam.org/GenApi/Version_1_1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.genicam.org/GenApi/Version_1_1
  ../GenApiSchema_Version_1_1.xsd">
```

The camera described is identified by the *VendorName*: / *ModelName* pair. Assuming that vendor names are mutually exclusive due to trade marks, this scheme creates unique names. The *ToolTip* attribute is used to provide additional information about the device that can be displayed to the user, e.g., in a selection list of devices found on a bus.

The attribute *StandardNameSpace* is deprecated (for details see section 2.8.1).



The versioning of the different items in a camera description file follows common rules, and a three part **version number** is used:

<Major>.<Minor>.<SubMinor>

An example would be '1.4.2'.

The following **compatibility rules** apply:

- Files with a higher Major version number are not backward compatible
- Files with a higher Minor version number are backward compatible

		
Version 2.1.1	Standard	

- Changes in the SubMinor version number are bug fixes only; always use the file with the highest available SubMinor version number

Example: Version 1.3.0 is compatible with version 1.1.*, 1.2.* and 1.3.* (where * means *don't care*). It is not compatible with version 2.*.*. If version 1.3.2 is available, it should be used instead of 1.3.0.

2.7.1 Versioning the Schema

The attributes *SchemaMajorVersion*, *SchemaMinorVersion*, and *SchemaSubMinorVersion* describe the version of the GenApi schema used for the XML file. These attributes are mandatory. They are for information purposes. In addition, the Major and Minor schema version numbers are encoded in the namespace (see *xmlns* entry) and the schema's file name (see *xsi:schemaLocation* entry).

In the example, the namespace reads “http://www.genicam.org/GenApi/Version_1_1”. A program seeking the schema file might either retrieve it over the internet using the URL or look at the file path given optionally in the second part of the *schemaLocation*. In the example, the path reads “[../GenApi/GenApiSchema_Version_1_1.xsd](#)” and assumes that the XML file is stored within the folder structure of the GenICam reference implementation.

The *xmlns:xsi* entry “<http://www.w3.org/2001/XMLSchema-instance>” describes the namespace of the schema language itself.

Note that an implementation supporting, e.g., schemas up to version 1.3.* must have three schema files present: for versions 1.0.*, 1.2.*, and 1.3.*. This is required for backward compatibility – since older XML files come with an older namespace, they need older schema files. On the other hand, an XML file using a later schema version not yet supported by the implementation, say 1.4.*, needs to be rejected, hence the necessity to have the version number coded in the schema's namespace.

2.7.2 Versioning the Camera Description File

The *MajorVersion*, *MinorVersion*, and *SubMinorVersion* attributes describe the version of XML file itself. The camera vendor is responsible for following the compatibility rules.

What does backward compatibility mean with respect to camera description files? Assume a camera that in version 1.0 has only a single feature implemented. Now assume the camera's firmware is extended to have another feature. There are two ways to deal with this situation in the camera description file. If the feature is just added to the XML file, this implicitly states that the feature is always there. Because this is not true with older cameras, the new file will not be backward compatible, and consequently it must get the version number 2.0.

A second, smarter way to deal with the situation is to introduce an inquiry register in the camera(!) where the user can check to see if the new feature is present or not. The new feature can now be added in a way that lets the user learn from the access mode of the feature whether the feature is present or not. This makes the new file backward compatible and its version number would be 1.1. Of course, this is possible only if an inquiry mechanism has been implemented in the camera from the beginning. The benefit of using the second method is that only one camera description file must be maintained for a whole family of cameras.

Note that **compatibility** refers only to the **feature nodes** and the underlying **register layout**. However it does not refer to **implementation nodes** (for details see section 2.8.2).

2.7.3 Identifying and Caching the Camera Description File

Loading a camera description file may involve one or more pre-processing steps. To speed things up, the pre-processed XML file can be cached. For caching, a key is required that uniquely identifies the camera description file. A combination of the `<RegisterDescription>` element's *VendorName*, *ModelName*, *MajorVersion*, *MinorVersion*, and *SubMinorVersion* attributes would be sufficient, but is a bit clumsy to use.

The *VersionGuid* and *ProductGuid* are no longer used; they are kept in the schema for backward compatibility. GenICam description file must however have a valid GUID in those fields. Note that for caching purposes a hash over the XML file's content should be used.

2.8 Available Node Types

This section gives a brief description of each available node type, of their behavior, usage, and most interesting parameters. In addition, there is a formal description for the XML layout of each node in an XML schema file included with the GenICam standard. This schema file can be read by most XML editors and will greatly simplify creating camera description files by providing a syntax check and context sensitive fill-in helpers.

This document refers to the **GenApi schema version 1.1** found in the file *GenApiSchema_Version_1_1.xsd*. Note that in subsequent versions of the standard, additional node types, elements, and attributes may be added, however, backward compatibility will be maintained if at all possible.

Some node types have elements or attributes which are only an optional part of a valid XML device description file. The default values for this elements and attributes are listed in the Appendix "Default values of optional Node elements and attributes" (section 3.2).

2.8.1 Node

The *Node* type contains those elements and attributes common to all other node types. A stand-alone *Node* node is pretty useless, but is possible for testing purposes. Here is an example:


```

<Node Name="Gain" NameSpace="Standard">
  <Extension>
    <MyElement>Something vendor specific</MyElement>
  </Extension>
  <ToolTip>The amplification of the camera</ToolTip>
  <Description>A more elaborated description</Description>
  <DisplayName>Gain</DisplayName>
  <Visibility>Expert</Visibility>
  <EventID>12fc</EventID>
  <pIsImplemented>SomeNode1</pIsImplemented>
  <pIsAvailable>SomeNode2</pIsAvailable>
  <pIsLocked>SomeNode3</pIsLocked>
  <pError>NodeIndicatingAnError</pError>
  <ImposedAccessMode>R0</ImposedAccessMode>
  <pAlias>SomeNode4</pAlias>

```

Each node has a *Name* attribute. The *Name* must be **unique** within the camera description file. Names can be composed of alphanumeric characters [A-Za-z0-9]. The schema also allows the use of the underscore '_', but not as a leading character. This is because the reference implementation uses a leading underscore for implementation related names.

Each *Name* lives inside a **name space** which is identified by the *NameSpace* attribute of the node which can have two possible values: *Custom* or *Standard*. If it is *Custom*, any name can be used as long as it is unique within the camera description file.

If it is *Standard*, it must come from the **standard feature name lists** (SFNC). The SFNC is mostly interface agnostic and contains only very few interface specific features. In order to advertise which interface is used the floating node DeviceTLType should be implemented (for details see SFNC). Typical entries are

- *IIDC* : cameras following the **1394 IIDC** standard (also called **DCAM** standard)
- *GEV* : cameras following the **GigE Vision** standard
- *CL* : cameras following the **Camera Link** standard
- *U3V* : cameras following the **USB3 Vision** standard
- *CXP* : cameras following the **CoaXPRESS** standard
- *CLHS* : cameras following the **Camera Link HS** standard
- *None* : no standard is used

The *StandardNameSpace* attribute of the enclosing *<RegisterDescription>* element (see section 2.7) is deprecated since it does not reflect new interface types like, e.g. CXP.

A Node can have a *MergePriority* attribute which can have the values +1, 0, or -1. It controls the way two XML files A and B are merged to a target file C. A is called the target file and B is called the inject file. Nodes are compared based on their *Name* attribute only.

- If a node is present only in A or B it is copied to C
- If a non-Category node is present in A and B the following rules apply (note that the *MergePriority* attribute of the target file A is ignored):
 - If the node from the injected file B has *MergePriority* = +1 it is copied to C.

- If the node from B has MergePriority = -1 the corresponding node from A it is copied to C.
- If the node from B has MergePriority = 0 (default) or the MergeAttribute is missing an error occurs.
- If a Category node is present in A and B the Category node from the target file A is copied to C with the <pFeature> entries from file B added while avoiding duplicates.

A Node can have an *ExposeStatic* attribute which can have the values *Yes* or *No* to be missing. It controls which node is exposed in the static use case to the customer. The following rules apply:

- Features are exposed if they don't have *ExposeStatic=No* set
- Non-Features are exposed only if they have *ExposeStatic=Yes* set

An <Extension> element can be used to add custom specific data to a camera description file. All elements placed inside the <Extension> element are ignored.

The <ToolTip> element gives a short description of the node. It may also be used as a brief description for reference documentation automatically generated from the camera description file.

The <Description> element gives a more detailed description of the node. It may also be used as a long description for reference documentation automatically generated from the camera description file.

The <DisplayName> element lets you define feature captions that might be used instead of the feature's *Name*.

The <Visibility> element defines the user level that should get access to the feature. Possible values are: *Beginner*, *Expert*, *Guru*, and *Invisible*. The latter is required to make a feature show up in the API, but not in the GUI (see section 2.8.2).

The <EventID> element is used for delivering asynchronous events. A camera might send an event package to indicate that one or more data item in the camera has changed its value. GenICam handles the event by invalidating the nodes corresponding to the data items. The nodes are found by the EventID which is a hexadecimal number which comes with the event package from the camera. Each node can have one (optional) EventID element.

The <pIsImplemented>, <pIsAvaliable>, and <pIsLocked> elements contains the names of nodes implementing an IInteger interface. If these elements are present, they influence the access mode of this node as described in section 2.5.

The <pBlockPolling> element bocks the polling on a node with a *PollingTime* entry if the target of the element is !=0.

An <ImposedAccessMode> element can be used to narrow the access mode resulting from other nodes.

<pAlias> points to another node which describes the same feature in a different manner. This feature will be mainly used in a GUI: a Category might be replaced by its alias if not all members are shown; an integer and a flat node might be aliases of each other if they show the raw and the abs value of a feature.

<pCastAlias> points to another node which describes the same feature in a way that the original node and the cast alias node can be casted into each other.

<IsDepercated> denotes that the corresponding feature is deprecated and should not be used for new designs anymore.

<Streamable> denotes that the corresponding feature is prepared to be stored to and loaded from a file via the GenApi node tree. The idea is to persist the state of a camera by storing the features marked as Streamable and restore the state by writing those features back to the node tree.

<pError> points to an enumeration which is checked after setting the value of a node. The enumeration must have one entry with IntValue 0 which indicates no error. If another value is set an exception is thrown with the *DisplayName* and the *ToolTip* of the EnumEntry as error message.

<DocuURL> Provides a http URL pointing to a location were documentation for the node can be found. The notation can contain Variables in the form \$(NAME) were NAME is either a Node name or one of the following special names:

- Sys::NodeName : Name of the current node
- Sys::ModelName: content of the XML file's ModelName attribute
- Sys::VendorName: content of the XML file's VendorName attribute
- Sys::StandardNamespace: content of the XML file's StandardNamespace attribute
- Sys::GenApiVersion : version of the GenApi software
(<Major>.<Minor>.<SubMinor>)
- Sys::DeviceVersion : version of the device (<Major>.<Minor>.<SubMinor>)
- Sys::SchemaVersion : version of the schema (<Major>.<Minor>.<SubMinor>)
- Sys::Application: Name of the executable file
- Sys::OperatingSystem: Name of the operating system.
Format "Windows5.1_SP3.0"
- Sys::Language: Name of the operating system's locale ID.
Format "German"

2.8.2 Category

The *Category* node is used to group features that should be presented to the user. It implements the *ICategory* interface and inherits all *Node* elements. It also contains a list of <pFeature> elements that point to the features contained in the category. Categories can contain other categories, thus forming a tree of arbitrary depth.

There is one special *Category* node with the standard name *Root*⁶ that is the basis of the category tree. Users may want to start browsing the features of a camera from here. The following example creates the node graph shown in Figure 12:

⁶ The feature *ICategory::Root* is defined in all standard name spaces.

```

<Category Name="Root" Namespace="Standard" >
  <pFeature>ScalarFeatures</pFeature>
  <pFeature>Trigger</pFeature>
</Category>

<Category Name="ScalarFeatures" >
  <pFeature>Shutter</pFeature>
  <pFeature>Gain</pFeature>
  <pFeature>Offset</pFeature>
  <pFeature>WhiteBalance</pFeature>
</Category>

<Category Name="WhiteBalance" >
  <pFeature>RedGain</pFeature>
  <pFeature>BlueGain</pFeature>
</Category>

<Category Name="Trigger" >
  <pFeature>TriggerMode</pFeature>
  <pFeature>TriggerPolarity</pFeature>
</Category>

```

Note that a user accessing the nodes by browsing the **category tree** is intended only to see **features nodes** in the first layer below the *Category* nodes. Nodes deeper in the graph are called **implementation nodes** and are retrievable only by name or in a special browse mode that the implementation might provide for debugging purposes. Note that the names and the layout of the implementation nodes may change without notice in a new release of a camera description file, even if the vendor declares it backward compatible (see also section 2.7.3).

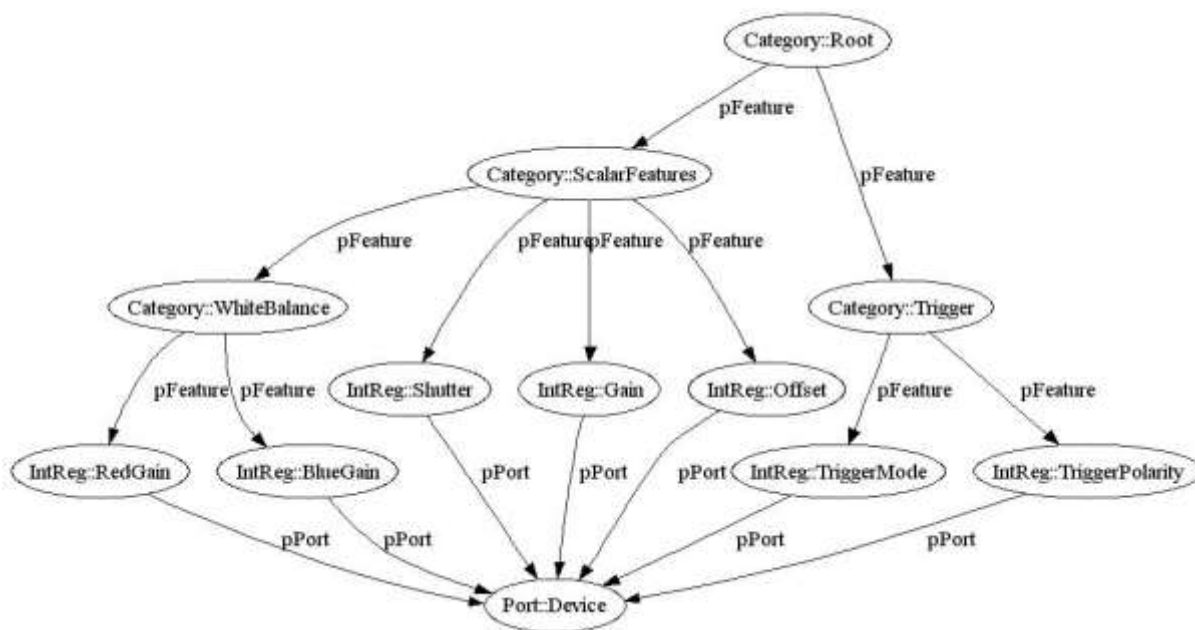


Figure 12 A tree of categories

2.8.3 Register

The *Register* node maps to a contiguous array of bytes in the register space of the camera. The *Register* node implements the *IRegister* interface and inherits its elements and attributes from the *Node* node. It in turn leaves its elements and nodes to all specialized register access nodes, such as *IntReg*, *StringReg*, etc. A *Register* node, however, can also be instantiated on its own giving access to the raw binary data. Here is a simple example:

```
<Register Name="SensorTemperature">
  <Address>0xff00</Address>
  <Length>4</Length>
  <AccessMode>RO</AccessMode>
  <pPort>Device</pPort>
  <Cacheable>No</Cacheable>
  <PollingTime>10000</PollingTime>
</Register>
```

The example exposes the temperature of the camera's sensor. The temperature can change at any time and is therefore not cacheable. If displayed, it should be polled every 10000 ms.

The *<Address>* element gives the address of the register in the camera's register space.

The *<Length>* element gives the length of the register in bytes. Alternatively the length can be read from another node using an *<pLength>* entry.

The *<AccessMode>* element can have the values RW (read/write), RO (read only), or WO (write only) and indicates what the camera can deliver.

The *<pPort>* element contains the name of a Port node that gives access to the camera's register space (for details see section 2.8.16).

The *<Cacheable>* element can have the values *NoCache*, *WriteThrough*, and *WriteAround*. *WriteThrough* means that a value written to the camera is written to the cache as well. *WriteAround* means that only read values are written to the cache. The latter behavior makes sense, for example, with an *IFloat::Gain* node where the user can write any value, but when reading back, will retrieve a value that has been rounded by the camera to a value the internal analog-to-digital converter is able to deliver. Note that caching is an optional feature of any implementation.

The *<PollingTime>* element denotes a recommended time interval [in ms] after which a node should be invalidated. Note that polling is an optional feature of any implementation and the polling time is a hint only.

Instead of a single *<Address>* entry, a register can have multiple entries for the *<Address>*, *<pAddress>*, and/or *<IntSwissKnife>* types. The values of these entries are summed, yielding the address of the register node.

The *<pAddress>* element points to a node implementing an *IInteger* interface delivering a contribution to the final address.

The *<IntSwissKnife>* element can be used to compute an address contribution from multiple sources (for details see section 2.8.12).

The *<pIndex Offset="12">* element points to a node implementing an *IInteger* interface delivering an *index*. The element has an attribute *Offset*. The product of index and Offset is

added to the address. Alternatively the offset can be taken from a node *<pIndex pOffset="OffsetValue">*. If neither Offset nor pOffset attribute is given the register's length is taken as offset.

The *<pInvalidator>* element contains the name of a node that when changed, will invalidate the content of this node as described in section 2.6.

The following example shows how to use this mechanism for indirect addressing (see also Figure 13):

```

<Integer Name="BaseAddress">
  <Value>0xff00</Value>
</Integer>

<IntReg Name="Gain">
  <Address>0x04</Address>
  <pAddress>BaseAddress</pAddress>
  <Length>4</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>LittleEndian</Endianness>
</IntReg>

<IntReg Name="Offset">
  <Address>0x08</Address>
  <pAddress>BaseAddress</pAddress>
  <Length>4</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>LittleEndian</Endianness>
</IntReg>

```

This example mimics a C/C++ struct of the form:

```

struct {
    // BaseAddress 0xff00
    uint32_t Reserved;
    uint32_t Gain;      // Offset 0x04
    uint32_t Offset;    // Offset 0x08
};

```

The value for the struct's base address comes from a *BaseAddress* constant integer node and is fed into the node using a *<pAddress>* element. Each element of the (*Gain* and *Offset*) struct has an offset that is added to the base address using an *<Address>* element.

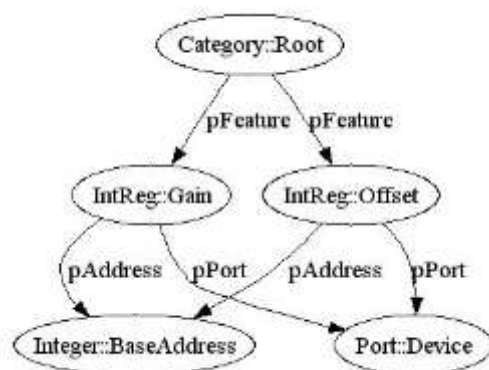


Figure 13 Indirect addressing: mapping a C/C++ struct

Note that this mechanism is used very frequently with 1394 DCAM compliant cameras where the whole standard register block has a common base address that must be parsed from a IEEE 1212 configuration ROM structure at run-time (see also the *ConfRom* node type).

2.8.4 Arrays and Selectors

Indirect addressing as described in the previous chapter is also used for accessing arrays. The following example shows how this is done (see also Figure 14):

```

<Integer Name="LUTIndex">
  <Value>0</Value>
  <Min>0</Min>
  <Max>255</Max>
  <pSelected>LUTEntry</pSelected>
</Integer>

<IntReg Name="LUTEntry">
  <IntSwissKnife Name="LUTEntryAddress">
    <pVariable Name="INDEX">LUTIndex</pVariable>
    <Formula>0xff00 + INDEX * 4</Formula>
  </IntSwissKnife>
  <Length>4</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>LittleEndian</Endianness>
</IntReg>

```

A LUT Entry element is used as a pointer into the LUT. The address of this element is computed using an embedded *<IntSwissKnife>* element that computes the address of the *LUTEntry* element according to the formula: $BaseAddress + LUTIndex \cdot \text{sizeof}(LUTEntry)$. The *LUTIndex* is a “floating” *Integer* node that is not connected to the camera. Instead, it starts with *<Value>* and can be changed between *<Min>* and *<Max>* by the user.

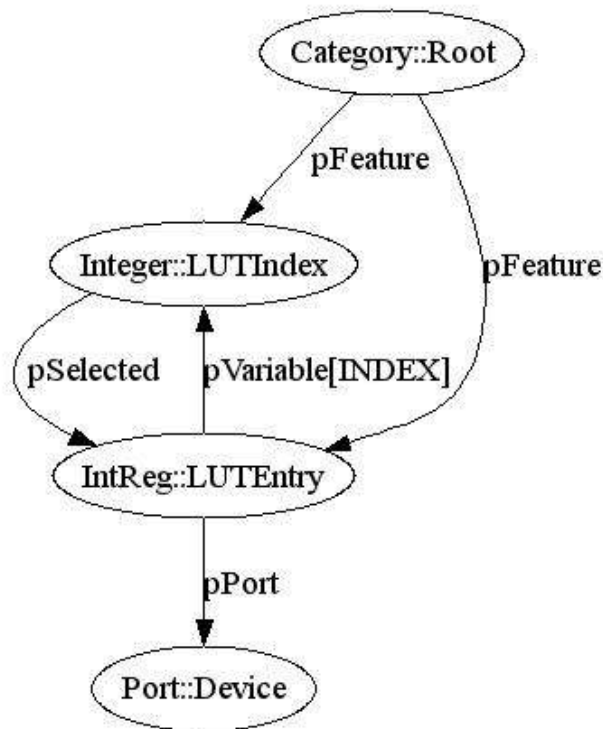


Figure 14 Accessing a LUT array

The fact that the LUTIndex can be used to select a specific LUTEntry is made explicit by the *<pSelected>* element in the LUTIndex node. Nodes implementing an *Integer* or an *IEnumeration* interface can have any number of *pSelected* entries to indicate that the **selected nodes** will show a different value depending on the value of **selector node**. Information whether a node is a selector and which are the selected nodes can be retrieved using the *ISelector* interface which has the according methods *IsSelector* and *GetSelectedFeatures*. Using this interface a GUI can for example show a list of LUTEntries because it knows that if it runs LUTIndex (selector) from min to max it will retrieve an array of different values from LUTEntry (selected).

Note that the selector and the indirect addressing scheme can also be used to access **multi-dimensional arrays** via multiple indices.

2.8.5 Integer, IntReg, MaskedIntReg

The *Integer* interface provides access to signed 64 bit integer variables that have a *Value* restricted by the *Minimum*, *Maximum*, and *Increment* parameters according to the formulas:

$$Value = Minimum + i \cdot Increment \quad \text{with} \quad 0 \leq i \leq \frac{Maximum - Minimum}{Increment}$$

The *IntReg* node maps to byte-aligned integer registers. It inherits the elements and attributes from *Register* nodes. Below is an example mapping to a 2 byte unsigned integer.


```

<IntReg Name="Gain">
  <Address>0x1234</Address>
  <Length>2</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>BigEndian</Endianness>
</IntReg>

```

For example, the default [*Minimum*, *Maximum*] range of an integer is created from the native *Minimum* / *Maximum* of its number representation. For an *<Integer>* node (int64_t) this would be [INT64_MIN, INT64_MAX]. For the *<IntReg>* node shown above (uint16_t) this would be [0, UINT16_MAX].

The *<Sign>* element can have the value *Singed* or *Unsigned*. Since all GenApi integer values are internally represented as signed 64-bit, register with less than 64-bit are automatically convert to a signed int64. The *Sign* element is used to manage sign bit extension while converting a register to a value. Unsigned int64 registers are not available since they cannot be converted to unsigned int64. The largest unsigned integer accessible with a *MaskedIntReg* (see below) equals $2^{63}-1$.

The *<Endianness>* element can have the values *LittleEndian* or *BigEndian* and refers to the endianness of the device as seen through the transport layer. The transport layer must attempt to not change the endianness. Note that the implementation must be aware of whether it is running itself on a little-endian or big-endian machine.

Sometimes integers are not byte aligned, but are packed into a register. In this case, a *MaskedIntReg* is used. It inherits the elements and attributes from the *Register* node. The following XML code is an example for a 12 bit integer packed into a 2 byte register. The *<LSB>* and *<MSB>* elements denote the least significant bit and the most significant bit respectively.

```

<MaskedIntReg Name="Offset">
  <Address>0x2345</Address>
  <Length>2</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <LSB>11</LSB>
  <MSB>0</MSB>
  <Sign>Unsigned</Sign>
  <Endianness>BigEndian</Endianness>
</MaskedIntReg>

```

In the case where only a single bit must be mapped – which is quite common for presence inquiry bits – instead of using an *<LSB>* and an *<MSB>* element with the same value, you can also use a *<Bit>* entry.

```

<MaskedIntReg Name="OffsetInq">
  <Address>0x2345</Address>
  <Length>2</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Bit>15</Bit>
  <Sign>Unsigned</Sign>
  <Endianness>BigEndian</Endianness>

```

</MaskedIntReg>

The numbering of the bits differs between big-endian and little-endian as is shown for a 32 bit integer below:

Little-Endian:	MSB	...	LSB
	31	...	0
Big-Endian:	MSB	...	LSB
	0	...	31

The LSB is the bit which maps to the 2^0 digit. Note that with big-endian the equation $MSB \leq LSB$ holds true while with little-endian the opposite holds true: $LSB \leq MSB$.

The *Integer* node type is used to merge the *Value* and the *Minimum*, *Maximum*, *Increment* and *ValidValueSet* parameters from different sources. The *Integer* node inherits the elements and attributes from the *Node* node. The value of the dynamic parameters are read from the <pValue> element. The restriction parameters can be overwritten either with constants using the <Min>, <Max>, <Inc>, and <ValidValueSet> elements or with pointers to other Integer nodes using the <pMin>, <pMax>, and <pInc> elements.

The <ValidValueSet> element is used to inform the users that the integer has a limited number of valid values. This element is useful for cases like binning where the set of valid values cannot be described with an increment. The “;” character is used to mark the separation between valid values. The user only receives the value of the set that are between min and max.

```
<Integer Name="Binning">
  <pValue>BinningReg</pValue>
  <ValidValuesSet>1;2;4;8;16</ValidValuesSet>
</Integer>
```

The Value normally comes from another node using the <pValue> element. Alternatively, a constant can be given inside a <Value> element. In this case, the node is a “floating” variable that can be set by the user to any value allowed by the restriction parameters. The given constant is the start value. A typical example is the following *Index* node that can be set to the values 0, 2, 4, ..., 254:

```
<Integer Name="Index">
  <Value>0</Value>
  <Min>0</Min>
  <Max>255</Max>
  <Inc>2</Inc>
</Integer>
```

If the <pValue> element is used with an *Integer* node it can be optionally surrounded by any numbers of <pValueCopy> elements like in the following example.

```
<Integer Name="Replicator">
  <pValueCopy>SomeInt1</pValueCopy>
  <pValue>SomeInt2</pValue>
  <pValueCopy>SomeInt3</pValueCopy>
  <pValueCopy>SomeInt4</pValueCopy>
</Integer>
```


The *GetValue* method returns the value read from the *pValue* sub-node. The *SetValue* method writes to the *pValue* and the *pValueCopy* sub-nodes in the order in which they are given in the XML file. The [min, max] boundaries of the sub-nodes are combined to find the largest boundary which will fit all sub-nodes. The increments of all sub-nodes must be the same; otherwise the node becomes not writable. The *ValidValueSet* only considered the *pValue* node and ignores all *pValueCopy*.

The Integer node can also work like a multiplexer or a value table like shown in the following examples:

```
<Integer Name="Multiplexer">
  <pIndex>Selector</pIndex>
  <pValueIndexed Index="10">SomeInt1</pValue>
  <pValueIndexed Index="20">SomeInt2</pValue>
  <ValueDefault>0</ ValueDefault>
</Integer>

<Integer Name="Table">
  <pIndex>Selector</pIndex>
  <ValueIndexed Index="10">100</Value>
  <ValueIndexed Index="20">200</Value>
  <pValueDefault>SomeNode</pValueDefault>
</Integer>
```

The *<pIndex>* entry refers to an Integer node. Depending on its value one of the *<ValueIndexed>* or *<pValueIndexed>* entries is selected which behave like *Value* or *pValue* entries respectively. The two entry types can be mixed. If the index does not match any element the value given in *<ValueDefault>* or *<pValueDefault>* respectively is returned. Note that selecting an entry also forwards its properties *Unit* and *Representation*.

The *<Unit>* element denotes the physical meaning of a number.

The *<Representation>* element gives a hint about how to display the integer. If the element is *Linear* or *Logarithmic*, a slider with the appropriate behavior should be implemented. If the element is *Boolean*, a checkbox should be used. *PureNumber* means to use an edit box only with decimal display; *HexNumber* means the same with hexadecimal display. *IPV4Address* and *MACAddress* mean to show the numbers like an IP address (IP version 4) or a MAC address respectively.

Integer, *IntReg* and *MaskedInt* nodes can also have an *<pSelected>* element. For a description see section 2.8.4.

2.8.6 StructReg

MaskedInt node are often used to pick a field of bits from a register. If a complete *MaskedInt* entry is used, for each bit there is a lot of unnecessarily copied data in the camera description file because the different *MaskedInt* entries share most of their elements like, e.g. the *<pPort>* element, the *<Endianess>* etc.

In order to overcome this the *StructReg* node has been introduced. Here an example:

```
<StructReg Comment="VFormat7InqReg">
```

```

<ToolTip>Inquiry register for video format 7 color codes</ToolTip>
<Address>0x14</Address>
<pAddress>VFormat7ModeCsrBase</pAddress>
<Length>4</Length>
<AccessMode>RO</AccessMode>
<pPort>Device</pPort>
<Endianess>BigEndian</Endianess>
<StructEntry Name="VFormat7Mono8InqReg">
  <ToolTip>Inquiry for ColorCode Mono8</ToolTip>
  <Bit>31</Bit>
</StructEntry>
<StructEntry Name="VFormat7YUV422InqReg">
  <ToolTip>Inquiry for ColorCode YUV8 422</ToolTip>
  <Bit>29</Bit>
</StructEntry>
<StructEntry Name="VFormat7Raw8InqReg">
  <Bit>24</Bit>
</StructEntry>
</StructReg>

```

The *StructReg* node contains the same elements as the *MaskedInt* element. In addition it contains one or more *<StructEntry>* elements which in turn can contain again the same elements as the *MaskedInt* element. A pre-processor replaces the *StructReg* node with a set of *MaskedInt* nodes: From each *<StructEntry>* element one *MaskedInt* node is created which gets the *Name* attribute from the *StructEntry* element, all its sub-elements, plus all elements from the *StructReg* node which are not present already in the *<StructEntry>* element. Thus the first *MaskedInt* node created from the example above would look like this.

```

<MaskedInt Name="VFormat7Mono8InqReg ">
  <Address>0x14</Address>
  <pAddress>VFormat7ModeCsrBase</pAddress>
  <Length>4</Length>
  <AccessMode>RO</AccessMode>
  <pPort>Device</pPort>
  <Endianess>BigEndian</Endianess>
  <ToolTip>Inquiry for ColorCode Mono8</ToolTip>
  <Bit>31</Bit>
</MaskedInt>

```

Note that the *<ToolTip>* element was selected from the *<StructEntry>* element, not from the *<StructReg>* node. In contrast the entry with the Name *VFormat7Raw8InqReg* would inherit the *<ToolTip>* element from the *<StructReg>* node because it has no own. The *<StructReg>* element has an *Comment* attribute which describes it.

2.8.7 Boolean

The *Boolean* node maps the integer value in the *<OnValue>* element to true and the integer value in the *<OffValue>* element to false. The *Boolean* node implements the *IBoolean* interface and inherits the elements and attributes from the *Node* node. The following example shows how to use this capacity for a Trigger node that can be displayed in a GUI as a check box:

```

<Boolean Name="Trigger">
  <pValue>TriggerReg</pValue>
  <OnValue>1</OnValue>
  <OffValue>0</OffValue>
</Boolean>

<IntReg Name="TriggerReg">
  <Address>0x6789</Address>
  <Length>1</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>BigEndian</Endianness>
</IntReg>

```

The *Boolean* node's value is either taken from another node referenced by a *<pValue>* entry or holds its own value initialized by the content of the *<Value>* entry.

2.8.8 Command

The *ICommand* interface lets the user submit a command by calling the method *Execute* and then poll to learn if the execution has been accomplished by calling the method *IsDone*. Note that *IsDone* always read the device register regardless of the state of the caches.

The corresponding *Command* node inherits the elements and attributes of the *Node* node.

In addition it has a *CommandValue* element which holds an integer constant which is written into a node which is referenced to by a *pValue* element. Writing the command value submits the command. *IsDone* reads the value back and returns false as long as return value equals the command value. If the node is *WriteOnly* *IsDone* always returns *true*. In order to make a floating *Command* node possible instead of a *pValue* element also a *Value* element is allowed. The *CommandValue* can alternatively also be taken from *pCommandValue*. A *<PollingTime>* entry can be used to handle self-clearing commands: While the command is active the node is invalidated each time the *PollingTime* expires. If a call to *IsDone* reveals that the command is gone idle the polling stops. If the command is write only no polling takes place. The state of other nodes can depend on the completion of the *Command* therefore applications that do not implement the event based polling should always wait for the command completion by calling *IsDone* immediately after the *Execute*.

2.8.9 Float, FloatReg

The *IFloat* interface has a definition similar to the definition of the *IInteger* interface as described in the section above. It has a *Value* that is restricted by the *Minimum* and *Maximum* parameters, but in contrast to integer, the increment exists only optional and is not verified on writing. Note that the increment does only make sense if it is a constant. In addition, *IFloat* exposes a *Unit* that is just a string for display purposes.

The *Float* node is built analogously to the *Integer* node in that it has the *<Value>*, *<Min>*, *<Max>*, *<Inc>*, or *<pValue>*, *<pMin>*, *<pMax>*, *<pInc>* restriction parameters respectively. In addition, it can have a *<Representation>* element that can take the values *Linear*, *Logarithmic*, or *PureNumber*, a *<Unit>* element that contains the unit as a string, a *<DisplayNotation>* element which can have the value *Automatic*, *Fixed*, and *Scientific*, and a

<DisplayPrecision> elements which is a non-negative number. The last two elements map to the corresponding stdio items. Here an example:

```
<Float Name="Exposure">
  <pValue>ExposureReg</pValue>
  <Min>0.02</Min>
  <Max>10.0</Max>
  <Unit>ms</Unit>
  <Representation>PureNumber</Representation>
  <DisplayNotation>Fixed</DisplayNotation>
  <DisplayPrecision>3</DisplayPrecision>
</Float>
```

As you can see in the example, <DisplayPrecision> is the amount of all digits left and right of the decimal point. This applies to all <DisplayNotation> in the same manner.

The Float node can also work like a multiplexer or a value table like shown in the following examples:

```
<Float Name="Multiplexer">
  <pIndex>Selector</pIndex>
  <pValueIndexed Index="10">SomeFloat1</pValue>
  <pValueIndexed Index="20">SomeFloat2</pValue>
  <ValueDefault>0</ ValueDefault>
</Float>

<Float Name="Table">
  <pIndex>Selector</pIndex>
  <ValueIndexed Index="10">100</Value>
  <ValueIndexed Index="20">200</Value>
  <pValueDefault>SomeNode</pValueDefault>
</Float>
```

The <pIndex> entry refers to an Integer node. Depending on its value one of the <ValueIndexed> or <pValueIndexed> entries is selected which behave like *Value* or *pValue* entries respectively. Note that selecting an entry also means forwarding its properties *Unit*, *Representation*, **DisplayNotation**, and *DisplayPrecision*.

The two entry types can be mixed. If the index does not match the value given in <ValueDefault> or <pValueDefault> respectively is returned.

A *FloatReg* node can be used to extract a floating point value from a byte aligned register. The *FloatReg* node inherits the elements and nodes of the *Register* node. It also has an <Endianess> element. The *Length* can be either 4 bytes (single precision float) or 8 bytes (double precision float). The number format has to be according to IEEE standard 754-1985.

2.8.10 Enumeration, EnumEntry

The *Enumeration* node maps a **name** to an **index value** and implements the *IEnumeration* interface. The *Enumeration* node holds a list of *EnumEntries* with each representing a possible {name, index} pair. The *Enumeration* node inherits the elements and attributes of the *Node* node. In addition, it has either a <Value> element that represents the current index value or a <pValue> element that connects to a node with an *IInteger* interface.

The following example shows a complete MaskedInt entry hows an *Enumeration* describing the camera's *ColorCode*. If the *ColorCodeReg* is set to 1, for example, the camera is configured to *Mono16*.

```
<Enumeration Name="ColorCode">
  <EnumEntry Name="Mono8">
    <Value>0</Value>
  </EnumEntry>
  <EnumEntry Name="Mono16">
    <Value>1</Value>
  </EnumEntry>
  <EnumEntry Name="YUV422">
    <Value>3</Value>
  </EnumEntry>
  <pValue>ColorCodeReg</pValue>
</Enumeration>

<IntReg Name="ColorCodeReg">
  <Address>0x1234</Address>
  <Length>1</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
  <Sign>Unsigned</Sign>
  <Endianness>BigEndian</Endianness>
</IntReg>
```

Quite often, some of the EnumEntries in the list are temporarily unavailable and thus should not be presented to the user. To describe this with GenICam, you can have *<pIsImplemented>* and *<pIsAvailable>* elements in the *EnumEntry* sub-nodes, just as you can have with any other node.

Typically, the implementation will pre-process the camera description file and will create a separate node with the *Name* "EnumerationName_EnumEntryName" for each *EnumEntry*. Instead of the *EnumEntry* itself, a *<pEnumEntry>* element is placed in the *Enumeration* node. The original name of the *EnumEntry* is copied to the *<Symbolic>* element inside the newly created *EnumEntry* node. The index value represented by the EnumEntry is copied to the *EnumEntry*'s *<Value>* element. Note that *<pEnumEntry>* entries must not be set manually.

Sometimes it makes sense to map a list of EnumEntries to a list of numbers. For example an Enumeration *GainList* could have the values {Low, Mean, High} and have a Float alias *GainAbs* with the values {1.0, 10.0, 100.0}. In order to express this, *<EnumEntry>* elements supports a *<NumericValue>* entry which holds the float number alias of the respective entry. If the entry is not present the default *NumericValue* is the integer value of the EnumEntry. An Enumeration can be referenced inside the XML file by a float pointer, e.g. the *<pValue>* pointer of a Float node. On reading the *NumericValue* of the current EnumEntry is retrieved. On writing the absolute difference between the value written and the *NumericValues* of all writable EnumEntries are computed and the *EnumEntry* with the smallest absolute difference is chosen.

Enumeration nodes can also have an *<pSelected>* element. For a description see section 2.8.4.

If an Enumeration nodes has a *<PollingTime>* entry the polling takes only place while the enumeration's value is set to the value of an EnumEntry which has a *<IsSelfClearing>* entry

set to *Yes*. In the following example the *Action* node will be invalidated every 10 ms if *Action==Active*. If the node's value is read while *Action==Active* the reading will be performed ignoring the cache. As soon as the reading reveals that *Action==Idle* the polling will stop and the cache will be active again.

```
<Enumeration Name="Action">
  <EnumEntry Name="Idle">
    <Value>0</Value>
  </EnumEntry>
  <EnumEntry Name="Active">
    <Value>1</Value>
    <IsSelfClearing>Yes</IsSelfClearing>
  </EnumEntry>
  <pValue>ActionReg</pValue>
  <PollingTime>10</PollingTime>
</Enumeration>
```

2.8.11 StringReg

A string is a (possibly null-terminated) ASCII string placed somewhere in the address space of the camera. A string is exposed via an *IString* interface. The example below shows how to extract the model name of the camera using a *StringReg* node. We assume that the *ModelName* can have a maximum of 128 bytes including the terminating null character.

```
<StringReg Name="ModelName">
  <Address>0x1234</Address>
  <Length>128</Length>
  <AccessMode>RO</AccessMode>
  <pPort>Device</pPort>
</StringReg>
```

You can get and set a string through the *IString* interface.

2.8.12 String (v1.1)

A *String* node is floating node which can hold any string value.

```
<String Name="ModelName">
  <Value>This initializes the node's value</Value>
</String>
```

2.8.13 SwissKnife, IntSwissKnife, Converter, and IntConverter

To do mathematical computations within GenICam, the *SwissKnife* node dealing with float numbers and the *IntSwissKnife* node dealing with integers have been introduced. Both have the same syntax.

The following example shows how the product of two numbers is computed. The *XTimesY* node exposes an *IInteger* interface reading 504 (=12*42):


```

<IntSwissKnife Name="XTimesY">
  <pVariable Name="X">XValue</pVariable>
  <pVariable Name="Y">YValue</pVariable>
  <Formula>X*Y</Formula>
</IntSwissKnife>

<Integer Name="XValue">
  <Value>42</Value>
</Integer>

<Integer Name="YValue">
  <Value>12</Value>
</Integer>

```

The *<Formula>* element contains a mathematical formula that can refer to variables defined by *<pVariable>* elements which point to an *Integer* node and have a *Name* attribute that defines the name of the variable inside the formula. The variable name must be upper case.

The Swiss knife used in the reference implementation is quite powerful. However, to simplify the task for people wanting to do their own implementation, the standard only allows a restricted set of mathematical operations. The following operations are supported by the standard:

()	brackets
+ - * /	addition, subtraction, multiplication, division
%	remainder
**	power
& ^ ~	bitwise and / or / xor / not
< > = > < <= >=	logical relations not equal / equal / greater / less / less of equal / greater or equal
&&	logical and / or
<< >>	shift left, shift right

Conditional operator:

```
<condition> ? <true expr.> : <false expr.>
```

Functions:

SGN, NEG,

Functions present only with the SwissKnife but not with the IntSwissKnife:

ATAN, COS, SIN, TAN, ABS, EXP, LN, LG, SQRT,
TRUNC, FLOOR, CEIL, ROUND(x, precision=0),
ASIN, ACOS, SGN, NEG, E, PI

When embedding formulas in XML files the problem arises that the characters `<`, `>`, and `&` cannot be used directly because they are part of the XML syntax. There are two possible solutions for that problem.

First you can escape these letters as follows:

<code><</code>	becomes	<code>&lt;</code>	(lt = less than)
<code>></code>	becomes	<code>&gt;</code>	(gt = greater than)
<code>&</code>	becomes	<code>&amp;</code>	(amp = ampersand)

As a result the formula `(x>0) && (x<10)` becomes

```
<formula>(x &gt; 0) &amp;&amp; (x &lt; 10)</formula>
```

Alternatively you can declare the whole formula as non-XML-text by bracketing it with `<![CDATA[and]]>`. The formula then becomes:

```
<formula><![CDATA[ (x>0) && (x<10) ]]>/formula>
```

The *SwissKnife* syntax has some extensions: You can use named constants using the *Constant* entry and named sub expressions using the *Expression* entry as shown in the following example. The sub expressions may not refer to other sub expressions.

```
<SwissKnife Name="Result">
  <pVariable Name="X">ValueX</pVariable>
  <pVariable Name="Y">ValueY</pVariable>
  <Constant Name="Two">2.0</Constant>
  <Expression Name="TwoX">2.0*X</Expression>
  <Formula> TwoX * Y + Two </Formula>
</SwissKnife>
```

In Addition you can access the minimum, maximum, and increment of a node by using the variable name extensions *.Min*, *.Max*, *.Inc*, and – for completeness – also *.Value*. In addition *.Entry.Name* is allowed which accesses the integer value of an *EnumEntry* described by *Name*. As an example the *SwissKnife* to find the middle of the [min, max] range would look like this:

```
<SwissKnife Name="MidRange">
  <pVariable Name="Gain.Max">Gain</pVariable>
  <pVariable Name="Gain.Min">Gain</pVariable>
  <Formula> (Gain.Max - Gain.Min) / 2 </Formula>
</SwissKnife>
```

In contrast to the *SwissKnife* the *Converter* works bi-directionally. It implements an *IFloat* interface, looks a bit like the *SwissKnife* but contains an additional `<pValue>` element which can point to an *IInteger* or *IFloat* interface. It has two formulas: the `<FormulaFrom>` describes how to convert a value **from** the `<pValue>` node to the use domain and the `<FormulaTo>` describes how to convert a user value **to** the `<pValue>` domain. The `<Slope>` entry indicates if the formula is monotonously *Increasing* or *Decreasing*, if it is *Varying* (in this case the full number range is used), or if the slope is determined in an *Automatic* way by

probing the function. The converter will also apply the *FormulaFrom* equation to all value of the `<ValidValueSet>`.

The following example shows a Converter which computes an absolute shutter value (a float) by multiplying a raw shutter value (an integer) with a time base (another integer).

```
<Converter Name="ShutterAbs">
  <pVariable Name="TIMEBASE">TimeBase</pVariable>
  <FormulaTo> FROM / TIMEBASE </FormulaTo>
  <FormulaFrom> TO * TIMEBASE </FormulaFrom>
  <pValue>ShutterRaw</pValue>
  <Slope>Increasing</Slope>
</Converter>

<Integer Name="ShutterRaw">
  <Value>2</Value>
</Integer>

<Integer Name="TimeBase">
  <Value>10</Value>
</Integer>
```

In this example, calling `ShutterAbs.GetValue` would return 20.0.

The *IntConverter* works like the Converter but implements an *IInteger* interface. The increment of an *IntConverter* is always 1.

The *Converter* has an additional element `<IsLinear>` which can be set to Yes or No indicating that the Converter's formula describes a linear relationship between TO and FROM. When set to Yes, the node exposed the converted increment of the node `<pValue>` node. When set to False, the node reports no increment.

2.8.14 ConfRom, TextDesc, and IntKey

The **DCAM** standard for 1394 cameras implements a Configuration ROM that is a tree-like data structure defined in the **IEEE 1212 standard**. Its main purpose in the context of a camera is to expose the model name, vendor name, the supported interface standard version, and the base address for the DCAM standard register block. Due to the special layout of an IEEE 1212 compliant Configuration ROM, a special *ConfROM* node has been introduced to give access to all of this information.

The following example searches for a unit directory with the unit ID given in the `<Unit>` element that describes a DCAM compliant camera. Inside this unit directory, three entries are picked and made available as sub-nodes. The `<IntKey>` *CommandRegBase* element will transform to a node with the *IInteger* interface reading the base address for the DCAM registers. The `<TextDesc>` *VendorName* and *ModelName* elements transform to nodes with the *IString* interface reading the vendor and the model name of the camera.⁷ The hex numbers in the elements are the respective **key values** that the entries are stored with in the unit directory.

⁷ Note that the strings inside the Configuration ROM are not required to be null-terminated; see IEEE 1212.

```

<Category Name="Root">
  <pFeature>CommandRegBase</pFeature>
  <pFeature>VendorName</pFeature>
  <pFeature>ModelName</pFeature>
</Category>

<ConfRom Name="ConfRom">
  <Unit>0x00A02D</Unit>
  <Address>0x400</Address>
  <pAddress>InitialNodeSpace</pAddress>
  <Length>0x400</Length>
  <pPort>Device</pPort>
  <IntKey Name="CommandRegBase">0x40</IntKey>
  <TextDesc Name="VendorName">0x81</TextDesc>
  <TextDesc Name="ModelName">0x82</TextDesc>
</ConfRom>

<Integer Name="InitialNodeSpace">
  <Value>0xFFFFF0000000</Value>
</Integer>

```

Note that a ConfROM node has *<Address>*, *<pAddress>*, *<IntSwissKnife>*, *<Length>*, and *<pPort>* elements that have the same meaning as with other *Registers* (see section 2.8.3).

The typical implementation will create separate nodes for the *<IntKey>* and the *<TextDesc>* elements that are given the name denoted in the respective entry's *Name* attribute, a *<p1212Parser>* element pointing to the ConfROM node and a *<Key>* element with the respective key values.

2.8.15 DcamLock and SmartFeature

Currently, most standard register layouts are fixed mechanisms, and methods are required to give access to custom features not defined in the standard. GenICam currently supports two access mechanisms.

The *DcamLock* node can retrieve the address of a smart feature exposed according to the DCAM advanced features mechanism. It inherits the elements and attributes from the *Register* node. The following example unlocks an advanced DCAM feature with a *<FeatureID>* element of 0x0030533B73C3 where 0x003053 is a vendor ID and 0x3B73C3 is a feature ID defined by that vendor. The value 0 in the *<Timeout>* element means that the feature will not unlock automatically.

```

<AdvFeatureLock Name="BaslerAdvFeatureLock">
  <FeatureID>0x0030533B73C3</FeatureID>
  <Timeout>0</Timeout>
  <Address>0xfffff2f00000</Address>
  <Length>8</Length>
  <AccessMode>RW</AccessMode>
  <pPort>Device</pPort>
</AdvFeatureLock>

```

The *SmartFeature* node can retrieve the address of a smart feature when it is given a global unique identifier (GUID) describing that feature in the `<FeatureID>` element. It also inherits the elements and attributes from the *Register* node. The following example retrieves the address of a smart feature with a GUID of {5590D58E-1B84-11D8-8447-00105A5BAE55}:

```
<SmartFeature Name="TimeStampAdr">
  <FeatureID>5590D58E - 1B84 - 11D8 - 8447 - 00105A5BAE55</FeatureID>
  <Address>0xfffff2f00010</Address>
  <pPort>Device</pPort>
</SmartFeature>
```

2.8.16 Port

The *Port* object is just a proxy that forwards Read and Write calls to the transport layer. Note, however, that the proxy has all of the properties of a *Node*. For example, it can be “not present.” This will tell all dependent nodes that the transport layer driver is currently not open and as a result, all dependent features will automatically also be “not present.” Another example would be the implementation of a user set loader. If a user set is loaded from flash ROM inside the camera, all features inside the node graph must be invalidated. This can be achieved by simply invalidating the Port node, which in turn can be automated using a `<pInvalidator>` linked to the *ReadUserSet* feature node.

If the transport layer is restricted to a maximal chunk length or needs special alignment, e.g., quadlet-wise, the transport layer implementation must emulate the IPort interface by breaking down calls longer than the maximum chunk length into multiple calls and must pad calls not fitting the necessary alignment. In order to support certain types of quadlet based interface the `<SwapEndianness>` element has been introduced: if it reads true the endianness of each quadlet must be swapped before exposing the data to GenICam via the IPort interface.

The *Port* node inherits the elements and attributes of the *Node* node. In addition, it can have a `<ChunkID>` element which is a hexadecimal number that identifies a chunk of data in a buffer. This chunk may be mapped to a virtual port that does not give access to a real device, but rather to the chunk of data residing in memory.

```
<Port Name="Device" Namespace="Standard">
  <ChunkID>4711</ChunkID>
</Port>
```

Instead of a `<ChunkId>` entry a `<pChunkID>` entry may be used to retrieve the *ChunkID* value from another node.

Chunk ports implement two int64 pseudo registers: The `CHUNK_BASE_ADDRESS_REGISTER` at the address of `INT64_MAX` indicates the memory address of the start of the chunk. The `CHUNK_LENGTH_REGISTER` at the address of `(INT64_MAX-15)` indicates the length of the chunk excluding the trailer.

Chunk ports can deal with negative addresses which will be interpreted as offset from the back of the chunk. If a register node is mapped to a chunk port and a chunk is present the method `GetAddress()` will always return the address from start of the chunk.

A chunk port can have an element `<CacheChunkData>` which can have the values Yes and No. If chunk data caching is enabled a copy of the chunk data is held even if the corresponding buffer is detached.

2.8.17 Group element

The `<Group>` element helps to make a large camera description file more readable. The element can be used to bundle blocks of nodes together as shown in the following example:

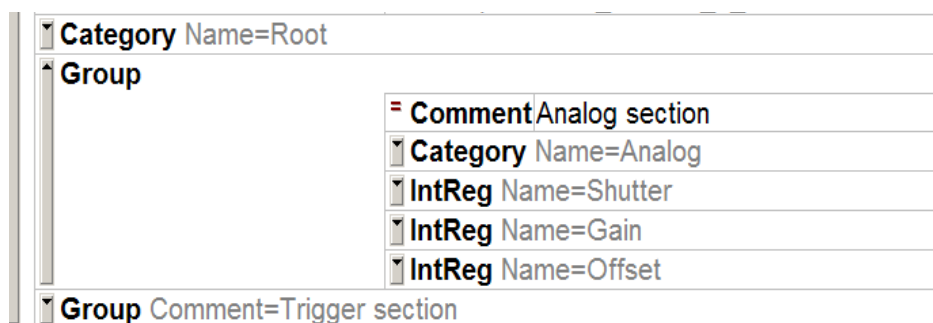
```
<Category Name="Root">
  <pFeature>Analog</pFeature>
  <pFeature>Trigger</pFeature>
</Category>

<Group Comment="Analog section">
  <Category Name="Analog">
    <pFeature>Shutter</pFeature>
    <pFeature>Gain</pFeature>
    <pFeature>Offset</pFeature>
  </Category>

  <IntReg Name="Shutter">
    <!-- more elements -->
  </IntReg>
  <IntReg Name="Gain">
    <!-- more elements -->
  </IntReg>
  <IntReg Name="Offset">
    <!-- more elements -->
  </IntReg>
</Group>

<Group Comment="Trigger section">
  <!-- more elements -->
</Group>
```

A typical XML editor will be able to hide the contents of a group as shown in the following screen shot:



The `<Group>` node has a *Comment* attribute, which is displayed by the editor when the group is folded away. Groups can be nested in any depth. They do not have any meaning with respect of the functionality of the camera. If the camera description file is interpreted, they are just stripped off.

2.9 Available Interfaces

This section uses a **pseudo code** notation to list the most important interfaces as introduced in section 2.3. An actual implementation can have more methods per interface, e.g., in parallel to a `SetValue(value)` method, an `operator=(value)` method might be implemented that maps directly to the `SetValue()` method. Also, the actual variable types may differ, e.g., for the pseudo code type string, the actual implementation might be `CString`, `std::string`, or something else.

A more thorough explanation is found in section 2.8.

2.9.1 Integer Interface

- `int64 GetValue()` – returns the value
- `void SetValue(int64)` – sets the value
- `int64 GetMin()` – returns the minimum
- `int64 GetMax()` – returns the maximum
- `EIncMode GetIncMode()` – returns the type of increment.
- `int64 GetInc()` – returns the increment if `GetIncMode` returns `fixedIncrement`
- `gcint64_autovector GetListOfValidValue()` returns a list of valid values if `GetIncMode` returns `listIncrement`
- `ERepresentation GetRepresentation()` – returns the representation as an enumeration
- `string GetUnit()` – returns the unit
- `void ImposeMin(int64)` – restricts the minimum
- `void ImposeMax(int64)` – restricts the maximum
- `IFloat *GetFloatAlias()` – returns a node with represents the same value in float type

2.9.2 IFloat Interface

- `double GetValue()` – returns the value
- `void SetValue(double)` – sets the value
- `double GetMin()` – returns the minimum
- `double GetMax()` – returns the maximum
- `EIncMode GetIncMode()` - returns the type of increment
- `int64 GetInc()` – returns the increment if `GetIncMode` returns `fixedIncrement`
- `gcdouble_autovector GetListOfValidValue()` returns a list of valid value if `GetIncMode` returns `listIncrement`
- `ERepresentation GetRepresentation()` – returns the representation as an enumeration
- `string GetUnit()` – returns the unit
- `EDisplayNotation GetDisplayNotation()` – determines how to display the float number

- **Int64 GetDisplayPrecision()** – determines the precision to display the float number with
- **Integer *GetIntAlias()** - returns a node with represents the same value in integer type
- **IEnumeration *GetEnumAlias()** - returns a node with represents the same value in enumeration type
- **void ImposeMin(int64)** – restricts the minimum
- **void ImposeMax(int64)** – restricts the maximum

2.9.3 IString Interface

- **string GetValue()** – returns the value
- **void SetValue(string)** – sets the value
- **int64 GetMaxLength()** – gets the maximum length of the string

2.9.4 IEnumeration Interface

- **int64 GetIntValue()** – returns the index value corresponding to the enumeration value
- **void SetIntValue(int64)** – sets the index value corresponding to the enumeration value
- **NodeList GetEntries()** – returns a list of pointers to the EnumEntry nodes of the enumeration
- **void GetSymbolics(StringList&)** – returns a list of valid enumeration values
- **IEnumEntry *GetEntryByName(string)** – gets the EnumEntry corresponding to the symbolic
- **IEnumEntry *GetEntry (int64)** – gets the EnumEntry corresponding to the integer value
- **IEnumEntry *GetCurrentEntry (int64)** – gets the currently active EnumEntry

2.9.5 ICommand Interface

- **void Execute()** – submits the command
- **boolean IsDone()** – returns true if the command has been executed; false as long as it still executes.

2.9.6 IBoolean Interface

- **boolean GetValue()** – returns the value
- **void SetValue(boolean)** – sets the value

2.9.7 IRegister Interface

- **void Get(uint8 *pBuffer, int64 Length)** – gets the register's content to a buffer
- **void Set(uint8 *pBuffer, int64 Length)** – sets the register's content from a buffer
- **int64 GetAddress()** – gets the register's address
- **int64 GetLength()** – gets the register's length in bytes

2.9.8 ICategory Interface

- NodeList **GetFeatures()** – returns a list of pointers to the feature nodes

2.9.9 IPort Interface

- void **Read**(uint8 *pBuffer, int64 Address, int64 Length) – reads an array of bytes located in the device at [Address, Address+Length]
- void **Write**(uint8 *pBuffer, int64 Address, int64 Length) – writes an array of bytes to the device at [Address, Address+Length]

2.9.10 ISelector Interface

- boolean **IsSelector()** – indicates if that node is a selector
- void **GetSelectedFeatures**(FeatureList_t &) – returns a list of pointers to the feature nodes which are selected by the current node.
- void **GetSelectingFeatures**(FeatureList_t &) – returns a list of pointers to the feature nodes which are selecting the the current node.
-

3 Appendix

3.1 Endianness of GigE Vision Cameras

Because the GigE Vision standard provides two different schemes for the register access (READMEM and READREG) and because this fact was frequent source of confusion among different GenICam implementations in past, this section clarifies, how GenICam endianness should be implemented by GigE Vision based products.

For historical purposes, it defines two different kinds of behavior, each targeting different GenICam schema version:

- Behavior of products using GenICam schema version 1.1 and higher - this is the "correct" behavior, allowing full flexibility and no extra limitations.
- Behavior of products using GenICam schema version 1.0 - "legacy" attitude maintained for backward compatibility with schema 1.0 based products. This attitude has several limitations (or undefined behavior), especially for the little endian cameras.

Cameras providing XML files for different schema versions (eg. 1.1 and 1.0) are possible; the two attitudes differ only on side of the XML file. The behavior of the camera firmware (how registers are accessed) is defined by the GigE Vision standard and is thus independent on the GenICam.

While the behavior of products using schema 1.1 and newer is normative (all devices and applications must fully respect it), the part treating schema 1.0 is just a recommendation of the typical expected behavior promising best interoperability (it cannot be normative, because schema 1.0 devices and applications were deployed prior creation of this document).

Note that the following discussion targets only the GigE Vision cameras, it has no effect on other transport technologies or other GenApi uses.

3.1.1 Behavior of products based on schema version 1.1 and newer

Cameras providing XML file based on schema version 1.1 or newer must implement endianness as follows:

- The <Endianness> tags of all registers have to correspond with the real endianness of the camera, corresponding with the endianness reported in the DeviceMode bootstrap register.
- The port's <SwapEndianness> tag must not be used.

It should also follow the requirements/recommendations listed in the GigE Vision specification (note that these are not mandatory requirements in the GigE Vision standard, just recommendations, but they become important when the camera is accessed through the GenICam interface):

- WRITEMEM should be implemented (if possible) when device is to be used through a GenICam interface.
- If READREG/WRITEREG is used to access strings, the camera must behave as if the string is composed of multiple 32-bit registers. This means that little endian camera must flip (reverse) each 4-character group, as expected. The same rules apply when accessing integers/floats of different size than 32-bit (particularly 64-bit and 16-bit ones).

Applications (libraries) supporting schema versions 1.1 or newer should check, whether the XML file is based on schema version 1.1 or newer. If so, it must implement the endianness as follows:

- When reading/writing the data of any size, it has free choice of the access method, READMEM/WRTMEM or READREG/WRITEREG, provided it follows the guidelines listed below. The READMEM/WRTMEM more naturally matches the GenApi data access model and is therefore recommended option, wherever suitable.
- When reading/writing the data using READMEM/WRTMEM (recommended option, particularly if WRTMEM is supported by the camera), the data must be passed "as is" to the GenApi.
- When READREG/WRITEREG has to be used for any reason (eg. because WRTMEM is not implemented by the camera), the transport layer (or other IPort implementation) has to revert the data back to the "camera order" before passing it to GenApi. This means no extra operation for big endian cameras. For little endian cameras it means to flip each 4-byte word read/written before passing it to GenApi, so that it works with the same data layout (camera's native byte order) as if READMEM/WRTMEM was used. Note that the application knows the camera order, which can be read from the DeviceMode bootstrap register.

3.1.2 Behavior of products based on schema version 1.0

Cameras providing XML file based on schema version 1.0 should implement endianness as follows to reach best possible compatibility (although for historical reasons slightly different implementations exist in the field):

- The <Endianness> tags of all registers have to be set to "BigEndian", regardless its actual endianness.
- String registers should always be bigger than 4 bytes (the Length attribute of the registers should be bigger than 4). Device specific (non-bootstrap) strings should be read-only, particularly on little endian cameras.
- All integer and float registers should be exactly 32-bit, particularly on little endian cameras.

Applications supporting schema version 1.0 (or applications supporting multiple schema versions, when working with cameras based on schema version 1.0) should behave as follows to reach best possible compatibility (although for historical reasons slightly different implementations exist in the field):

- When reading/writing a 4-byte data, it should assume it is a integer/float register and use READREG/WRITEREG. The READREG/WRITEREG data are always in network order and it should be passed as such to GenApi.
- When reading data longer than 4 bytes, it should assume it is a string register and use READMEM. Pass the data "as is" to GenApi.
- Writing data longer than 4 bytes should be considered as non-reliable for little endian cameras.

3.1.3 Passing the schema version to the IPort implementation

The register access happens in the IPort implementation (in the IPort's Read/Write functions), ie. in the "transport layer" software component. This component typically does not retrieve and parse the XML (this is task of a top-level client component). The IPort implementation

therefore needs to get notified about the schema version associated with the XML being used to access the camera.

If the two components are part of the same software package, the client can easily inform the IPort implementation about the schema version used.



If the two components are communicating through the GenTL interface (IPort implementation resides in GenTL Producer, XML retrieval and parsing in the GenTL Consumer), they need to cooperate according following rules:

- GenTL producers handling other than GigE Vision cameras don't need any specific considerations.
- GenTL producers (GenTL version 1.1 and newer) handling GigE Vision cameras must publish enumeration feature "DeviceEndiannessMechanism" in the XML file associated with the GenTL device module. This enumeration must provide two entries, "Standard" and "Legacy". When the consumer selects "Standard", the producer has to implement the GCReadPort/GCWritePort functions of the associated remote device port in the standard way corresponding with schema version 1.1. When the consumer selects "Legacy", the producer has to implement the GCReadPort/GCWritePort of the associated remote device port in the legacy way corresponding with schema version 1.0.
- GenTL consumers (GenTL version 1.1 and newer) accessing a GigE Vision device must instantiate a node map of the GenTL device module and set the DeviceEndiannessMechanism feature properly before any access (read/write) to the port of the remote device. The DeviceEndiannessMechanism feature must be set to "Standard" when the XML file used for the remote device is based on schema version 1.1 or newer. It has to be set to "Legacy" when the XML file is based on schema version 1.0.
- The enumeration feature DeviceEndiannessMechanism and corresponding rules will be standardized by the next GenTL standard version 1.1 (not yet released when publishing this document). GenTL 1.0 does not address this issue. However, GenTL 1.0 compliant producers and consumers willing to fully support little endian GigE Vision cameras are free to implement the same functionality.



3.2 Default values of optional Node elements and attributes

The table below contains all node elements and attributes which are an optional part of the available node types in the device XML file. These node elements or attributes needs a definition of its default value even if they are not present in the device XML file to ensure the same behavior in different GenApi implementations.

Node Type	Node Element / Attribute	Default value
Boolean	OffValue	0
	OnValue	1
	Streamable	No
Converter	DisplayNotation	Automatic
	DisplayPrecision	6
	IsLinear	No
	Representation	PureNumber
	Slope	Automatic
	Streamable	No
	Unit	Empty string
EnumEntry	IsSelfClearing	No
Enumeration	Streamable	No
Float	DisplayNotation	Automatic
	DisplayPrecision	6
	Inc	If not given the Float has no Inc
	Max	Largest double value
	Min	Smallest double value
	Representation	PureNumber
	Streamable	No
	Unit	Empty string
FloatReg	Cachable	WriteAround
	DisplayNotation	Automatic
	DisplayPrecision	6
	Representation	PureNumber
	Unit	Empty string
IntConverter	Representation	PureNumber
	Slope	Automatic
	Streamable	No
	Unit	Empty string
Integer	Inc	1
	Max	Largest integer value according to it's number representation
	Min	Smallest integer value according to it's number representation

		
Version 2.1.1	Standard	

	Representation	PureNumber
	Streamable	No
	Unit	Empty string
	ValidValueSet	All values between Min and Max with respect to Inc are valid
IntReg	Cachable	WriteTrough
	Representation	PureNumber
	Sign	Unsigned
	Streamable	No
	Unit	Empty string
IntSwissKnife	Representation	PureNumber
	Streamable	No
	Unit	Empty string
MaskedIntReg	Cachable	WriteTrough
	Representation	PureNumber
	Sign	Unsigned
	Streamable	No
	Unit	Empty string
NodeAttributeTemplate	NameSpace	Custom
	MergePriority	0
NodeElementTemplate	Description	Empty string
	DisplayName	The node's name
	DocuURL	Empty string
	IsDeprecated	No
	ImposedAccessMode	RW
	ToolTip	Empty string
	Visibility	Beginner
Port	CacheChunkData	No
	SwapEndianness	No
RegisterDescription	ToolTip	Empty string
RegisterElementTemplate	Cachable	WriteTrough
	Streamable	No
String	Streamable	No
StructEntry	Cachable	WriteTrough
	Description	Empty string
	DisplayName	Empty string

		
Version 2.1.1	Standard	

	DocuURL	Empty string
	ImposedAccessMode	RW
	IsDeprecated	No
	Representation	PureNumber
	Sign	Unsigned
	Streamable	No
	ToolTip	Empty string
	Visibility	Beginner
	Unit	Empty string
SwissKnife	DisplayNotation	Automatic
	DisplayPrecision	6
	Representation	PureNumber
	Streamable	No
	Unit	Empty string

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6 Index

—A—

access mode 12
 locked 13
 not available 13
 not implemented 13
 API
 camera 7
 transport layer 7
 arrays
 accessing 29
 multi-dimensional 30

—B—

Boolean 34
 OffValue 34
 OnValue 34
 pValue 35
 Value 35

—C—

camera description file 7
 Category 25
 pFeature 25
 Command 35
 CommandValue 35
 pCommandValue 35
 PollingTime 35
 pValue 35
 Value 35
 ConfROM 41
 TextDesc 41
 Unit 41
 ConfROMIntKey 41
 Converter 40
 FormulaFrom 40
 FormulaTo 40
 IsLinear 41
 pValue 40
 Slope 40

—D—

DcamLock 42
 FeatureID 42
 Timeout 42

—E—

EnumEntry 36
 IsSelfClearing 37
 NumericValue 37

Symbolic 37
 Value 37

Enumeration 36
 EnumEntry 36
 PollingTime 37
 pSelected 37
 pValue 36
 Value 36

example

area of interest
 computing the maximum values 18
 coupled with Binning 19
 simple 17
 basic structure of a camera description
 file 8
 category tree 25
 Gamma feature being implemented or
 not 16
 look-up table (LUT) 29
 reading and writing a value 11
 struct 28
 trigger polarity being temporary not
 available 13

—F—

feature node 26
 Float 35
 DisplayNotation 35
 DisplayPrecision 36
 Max 35
 Min 35
 pIndex 36
 pMax 35
 pMin 35
 pValue 35
 pValueDefault 36
 pValueIndexed 36
 Representation 35
 Unit 35
 Value 35
 ValueDefault 36
 ValueIndexed 36

FloatReg 36

Endianness 36

—G—

GenApi module 7

- Group element 44
 - Comment attribute 44
- I**—
- IBoolean interface 32, 34, 46
- ICategory interface 25, 47
- ICommand interface 35, 46
- IEnumeration interface 36, 46
- IFloat interface 35, 45
- IInteger interface 30, 45, 46
- IInteger Interface 45
- implementation node 26
- indirect addressing 28
- IntConverter see Converter
- Integer 32
 - Inc 32
 - Max 32
 - Min 32
 - pInc 32
 - pIndex 33
 - pMax 32
 - pMin 32
 - pSelected 33
 - pValue 32
 - pValueCopy 32
 - pValueDefault 33
 - pValueIndexed 33
 - Representation 33
 - Unit 33
 - Value 32
 - ValueDefault 33
 - ValueIndexed 33
- IntKey 42
 - Key 42
 - p1212Parser 42
- IntReg 30
 - Endianness 31
 - pSelected 33
 - Sign 31
- IntSwissKnife see SwissKnife
- IPort Interface 47
- IRegister interface 27
- IRegister Interface 46
- ISelector interface 30, 47
- IString interface 38, 46
- M**—
- MaskedIntReg 31
 - Bit 31
- LSB 31
- MSB 31
- pSelected 33
- N**—
- Node 22
 - Description 24
 - DisplayName 24
 - DocuURL 25
 - EventID 24
 - ExposeStatic 24
 - Extension 24
 - ImposedAccessMode 24
 - IsDepecated 25
 - MergePriority 23
 - Name 23
 - Namespace 23
 - pAlias 24
 - pBlockPolling* 24
 - pCastAlias 25
 - pError 25
 - pInvalidator 28
 - pIsAvailable 24
 - pIsImplemented 24
 - pIsLocked 24
 - pSelected 30
 - Streamable 25
 - ToolTip 24
 - Visibility 24
- P**—
- Port 43
 - CacheChunkData 44
 - ChunkID 43
 - pChunkID 43
 - SwapEndianness 43
- R**—
- reference implementation 8
- Register 27
 - AccessMode 27
 - Address 27
 - Cacheable 27
 - IntSwissKnife 27
 - Length 27
 - pAddress 27
 - pIndex 27, 28
 - pLength 27
 - PollingTime 27
 - pPort 27

RegisterDescription 20

MajorVersion 21

MinorVersion 21

ModelName 20

schemaLocation 21

SchemaMajorVersion 21

SchemaMinorVersion 21

SchemaSubMinorVersion 21

StandardNameSpace 20

SubMinorVersion 21

ToolTip 20

VendorName 20

VersionGuid 22

—S—

SmartFeature 43

FeatureID 43

String 38

StringReg 38

StructReg 33

Comment 34

StructEntry 34

SwissKnife 38

Constant 40

Expression 40

Formula 39

mathematical operations 39

pVariable 39

—T—

TextDesc 42

Key 42

p1212Parser 42

—X—

XML schema 10