GENeric programming Interface for CAMeras

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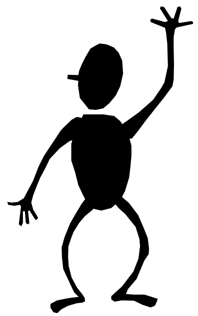
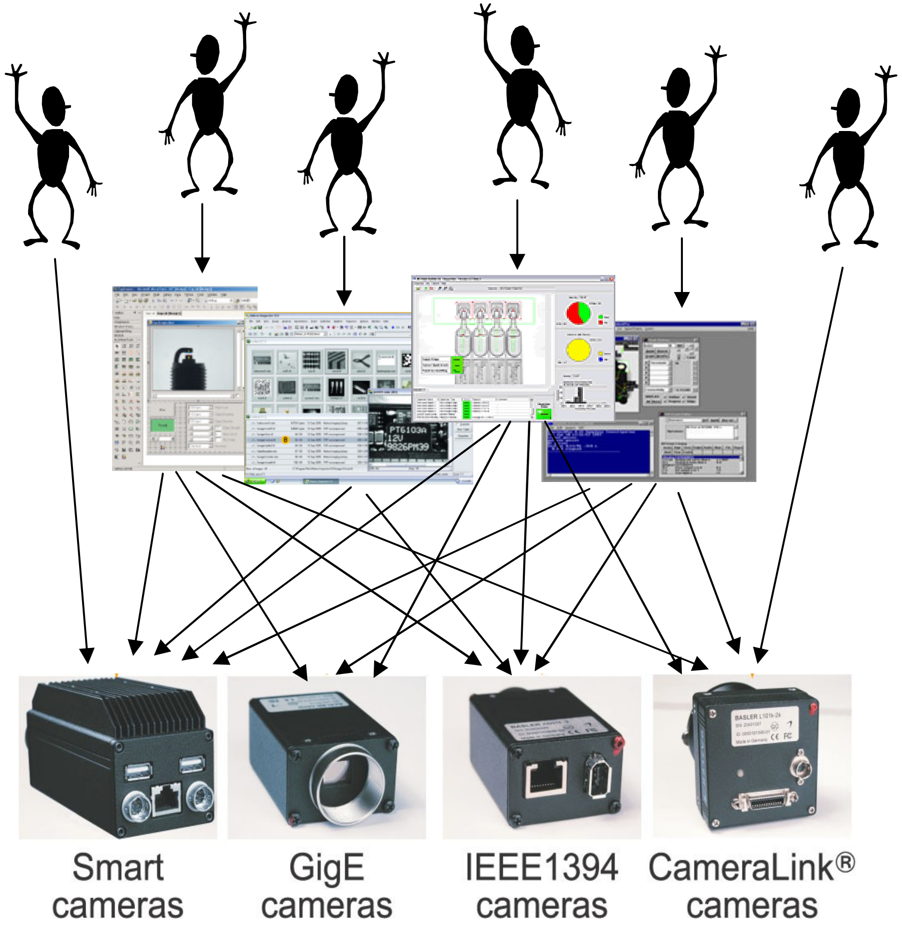
Version 2.8

Questions Answered in this Presentation

- Why GenICam Standard?
- How does it work?
- How is the standard committee organized?
- Who is driving GenICam?
- What is the status and the roadmap?
- How can you become part of GenICam?
- What are your benefits?



Situation Yesterday



Customers want to use…
- …any image processing library
- …any camera
- …any smart feature in the camera

Camera Vendors want to..
- …sell to every customer
- …supply their smart features

Library Vendors have to…
- …support all cameras
- …support all smart features

➔ **This is expensive**
➔ **This reduces time-to-market**
➔ **This prevents market growth**

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Situation Today

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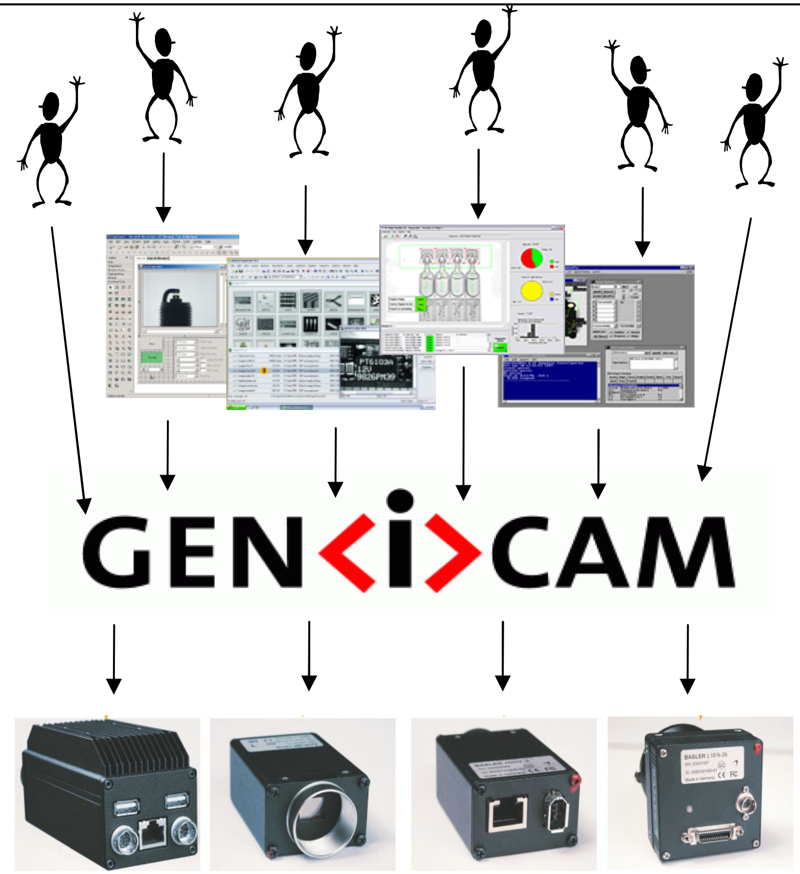

Smart cameras | GigE cameras | IEEE1394 cameras | CameraLink® cameras

GenICam can connect the Customer..

- …to all cameras
- …through all libraries
- …giving access to all smart features

GenICam can support…

- …any interface technology
- …products from any vendor
- …products with different register layout

GenICam is easy to integrate for…

- …customers
- …camera vendors
- …software library vendors
- …frame grabber / driver vendors

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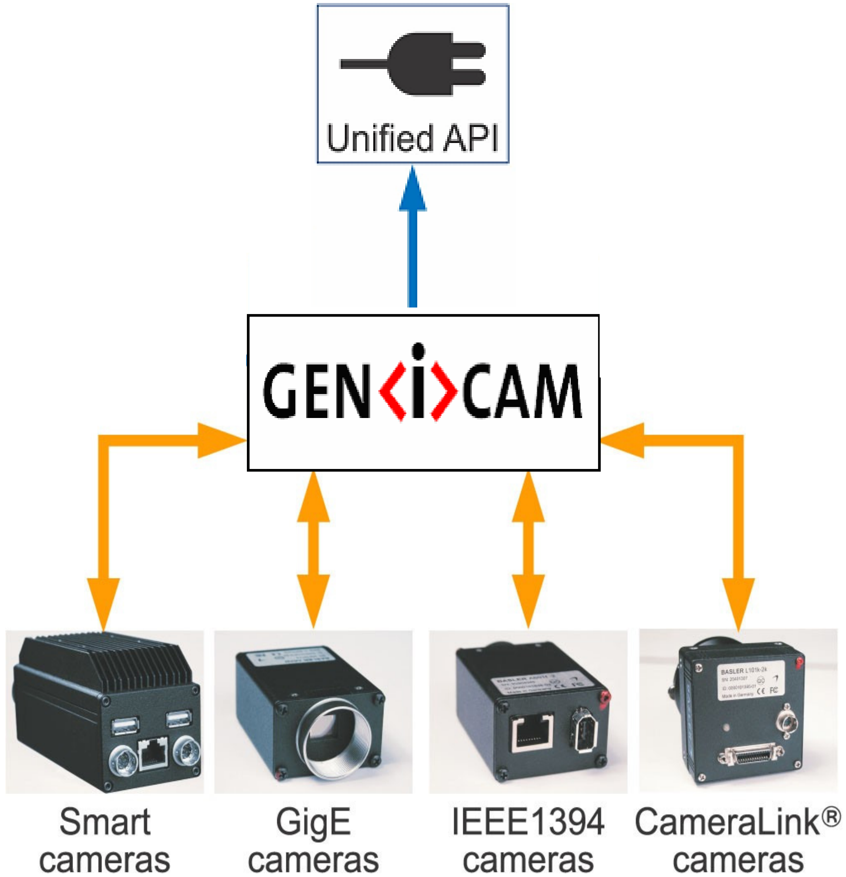
GenICam in an NutShell

➔ **GenICam provides a**
Unified Programming Interface
for machine vision cameras



GenICam Use Cases

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- Configuring the Camera
- Grabbing Images
- Providing a Graphical User Interface
- Delivering Events
- Transmitting Extra Image Data

Customer Viewpoint

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Configuring the Camera

Use Case

User API

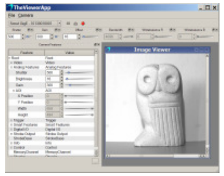
- C++ programming interface

```
if( IsWritable(Camera.Gain) )
     Gamera.Gain = 42;
```

- Provided by freely available GenICam reference implementation
- Other programming languages can be supported, e.g., .NET

Transport Layer API

- Read / Write Register
- Provided by driver vendors (small adapter required)
- Send / Receive ASCII Command extension under planning



User API

Set Gain = 42

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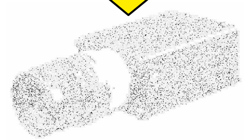
TL API

Write Register
Address, Len, Data

Transport Layer

Interface

1394, GigE Vision, Camera Link, etc.



Code Example

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```
// Create and open the driver (this part is driver specific)
CBcamPort Bcam;
Bcam.Open( DeviceName );

// Create the GenICam camera access object and bind to the driver
CDcam Camera;
Camera._LoadDLL();
Camera._Connect(&Bcam);

// Access different property types
Camera.ShutterRaw = 42;                       // integer
Camera.ShutterAbs = 47.11;                    // float
Camera.ContinuousShot = true;                 // boolean
Camera.OneShot();                             // command
Camera.PixelFormat = PixelFormat_Mono8;       // enumeration
Camera.PixelFormat = "Mono8";                 // enumeration (alternative)
Camera.FilePath = "OffsetShading";            // String
```

Precompiled camera access object

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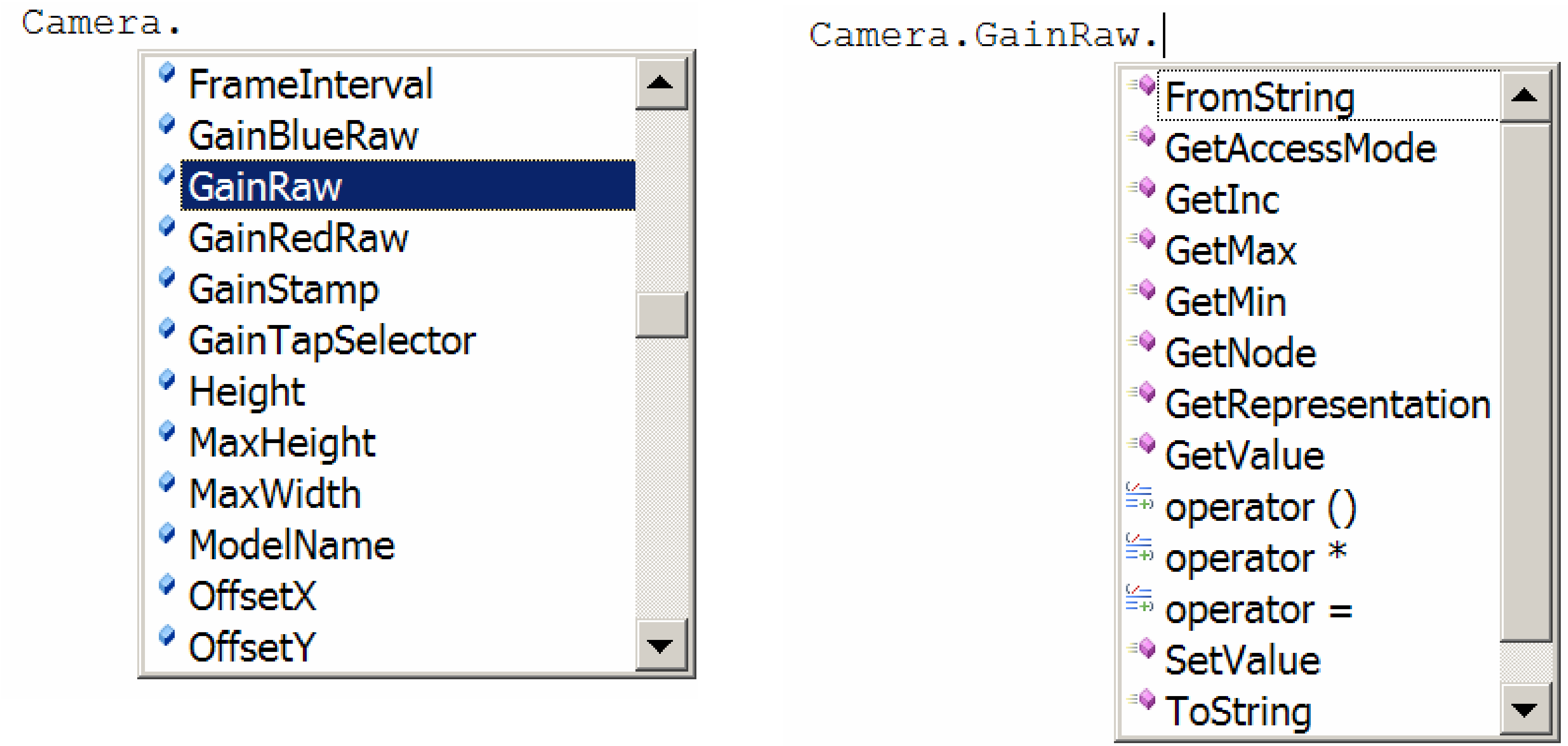
Intellisense Support



Code Example

```
// Get range information
int64_t Min = Camera.GainRaw.GetMin();
int64_t Max = Camera.GainRaw.GetMax();
int64_t Inc = Camera.GainRaw.GetInc();

// Convert to and from string
gcstring ShutterStr = Camera.ShutterAbs.ToString();
Camera.ShutterAbs.FromString( ShutterStr );

// write generic code
if( IsImplemented(Camera.GainRaw) )
{
    if( IsReadable(Camera.GainRaw) )
        cout << Camera.GainRaw.ToString();

    if( IsWritable(Camera.GainRaw) )
        Camera.GainRaw = Camera.GainRaw.GetMax();
}
```

Code Example

```
// Create and open the driver (this part is driver specific)
CBcamPort Bcam;
Bcam.Open( DeviceName );

// Create the GenICam camera access object and bind to the driver
CNodeMapRef Camera;
Camera._LoadXMLFromFile("c:\temp\MyCameraDescriptionFile.xml");
Camera._Connect(&Bcam);

// Access properties
CIntegerPtr ptrShutterRaw = Camera._GetNode("ShutterRaw");
if( IsWritable(ptrShutterRaw) )
{
    *ptrShutterRaw = 42;
    ptrShutterRaw->SetValue( ptrShutterRaw->GetMax() );
}

// More like, e.g. enumerating all features
```

XML camera description file

Grabbing Images

Use Case

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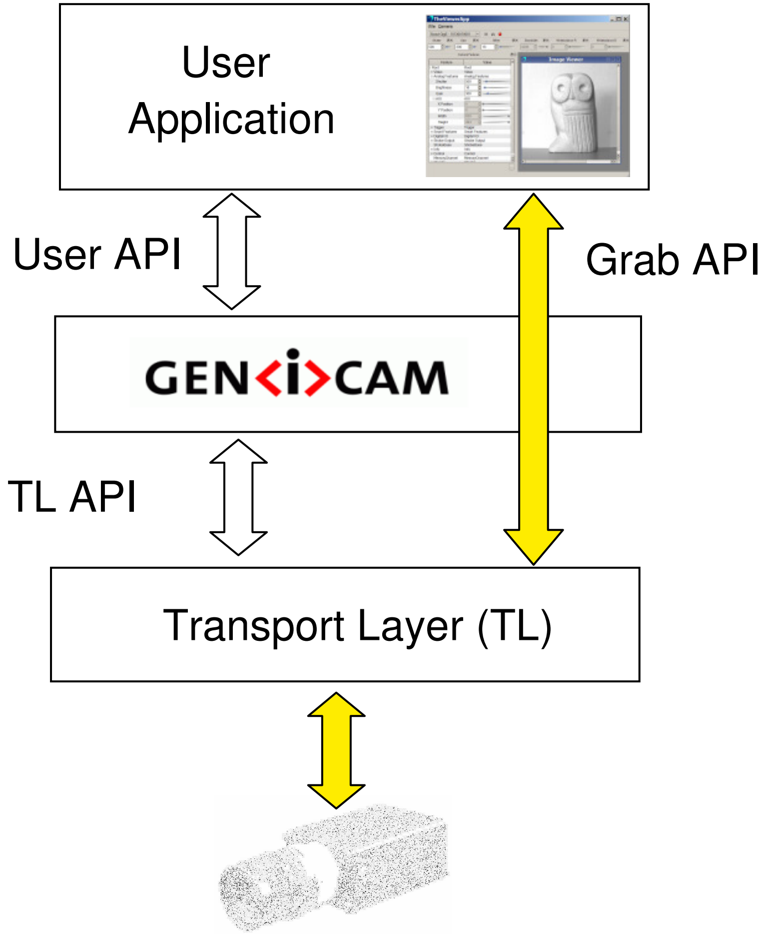
Grab API

- Abstract C++ programming interface
  - Get device names
  - Create camera access object
  - Configure camera
  - Queue buffers
  - Start acquisition
  - Wait for buffers
- Implemented by transport layer DLLs
- Provided by driver vendors (adapter required)
- GenICam provides services to
  - register transport layer DLLs
  - enumerate devices and
  - instantiate camera access objects



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Code Example

Preliminary!

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```
// Get the factory
pFactory = CFactory::CreateFactory();

// Get the first device
FirstDeviceName = pFactory->GetDeviceName(0);
pDevice         = pFactory->OpenDevice( FirstDeviceName );

// Get the default image stream (index=0)
pDevice->GetImageStream( 0, &pImageStream );

// Configure the camera
/// ...

// create and announce buffer
for (int i=0; i<3; i++)
{
    pImageBuffer[i] = malloc(BufferSize);
    pImageStream->AnnounceBuffer( pImageBuffer[i], BufferSize,
                                  NULL, &(BufferIds[i]));
}
```

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Code Example

Preliminary!

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```
// Start the DMA in the grabber
pImageStream->StartAcquisition(ACQ_START_FLAGS_NONE, 100);

// Start image transfer in the camera
Camera.ContinuousShot = true;

// enqueue the buffers
for (i=0; i<3; i++)
    pImageStream->QueueBufferByID(BufferIds[i]);

// run the grab loop
for (i=0; i < 20; i++)
{
    // Get a buffer from the output queue
    pImageStream->WaitForBuffer(1000, ACQ_WAIT_FLAGS_NONE, &Info, NULL);

    // Do something usefull with image data

    // Enqueue the buffer again
    pImageStream->QueueBufferByID(Info.m_iID);
}

// clean up
```

Providing a Graphical User Interface

Use Case

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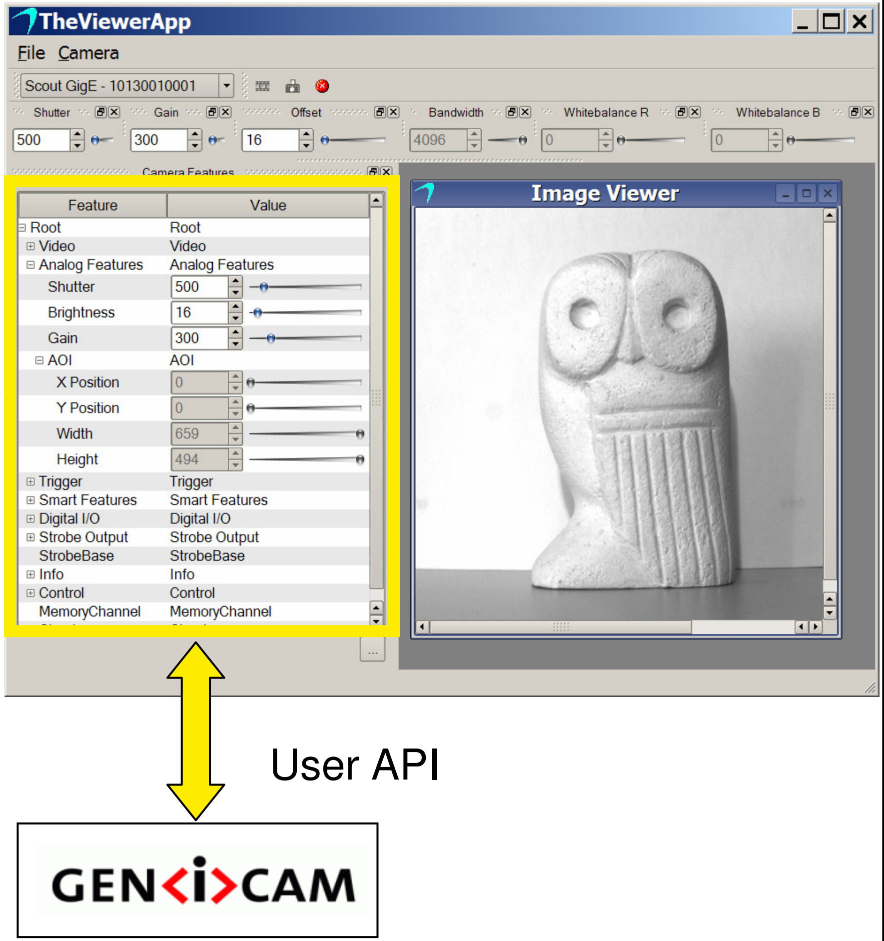
GUI support

- Feature tree
- Widgets support
  - **Slider** → value, min, max
  - **Drop-Down Box** → list of values
  - **Edit Control** → From/ToString
  - etc.
- Access mode information
  → RW, RO, WO, …
- Full model / view support
  → callback if a feature changes



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Delivering Events

Use Case

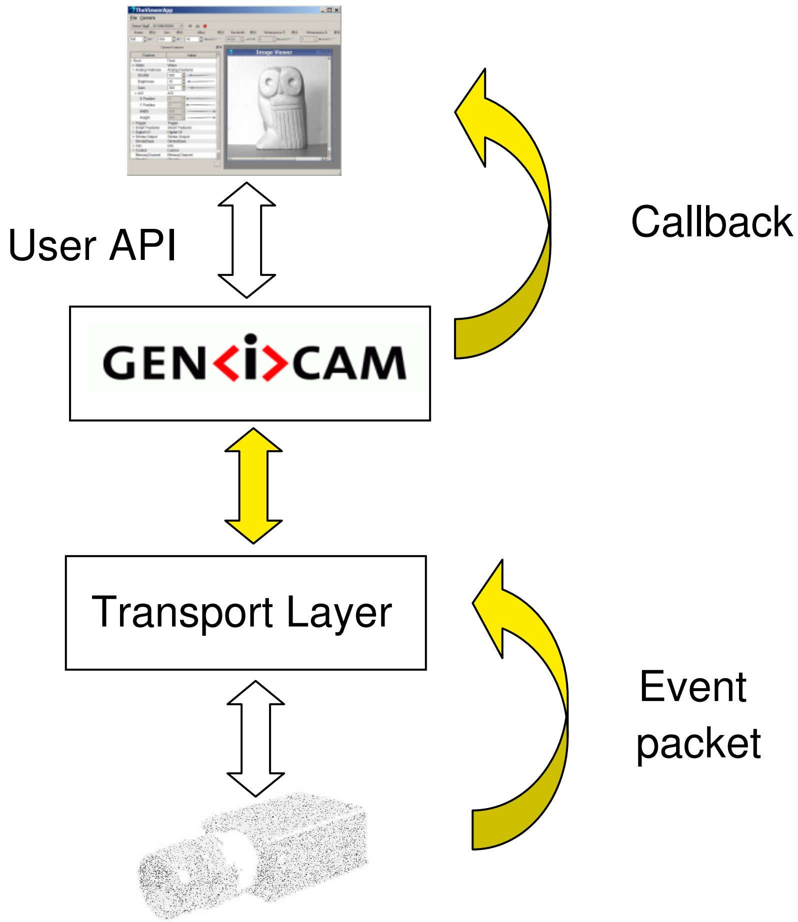
Asynchronous Callbacks

- Cameras can deliver event packets, e.g. when the exposure has finished
- Users can register a callback

```
void Callback( INode* pNode )
{ printf("Hi!"); }

Register( Camera.ExposureEnd,
      &Callback );
```

- Events are identified by an EventID
- If an event packet arrives GenICam fires a callback on all nodes with matching EventID
- Data coming with events is also delivered.



Code Example

User code

```
void OnInputEvent(INode* pNode)
{
    // react to input event
}

// Register a callback for changes on the InputLines
Register(Camera.PioInput, OnInputEvent);
```

Code within the transport layer adapter

```
// Create and connect the event adapter
CEventAdapterGEV EventAdapter( Camera._Ptr );

// Deliver GigE Vision event packets
OnGEVEventPacket(GVCP_EVENTDATA_REQUEST *pEventData)
{   // this will fire the appropriate callbacks
    EventAdapter.DeliverEventMessage( pEventData );
}
```

Transmitting Extra Image Data

Use Case

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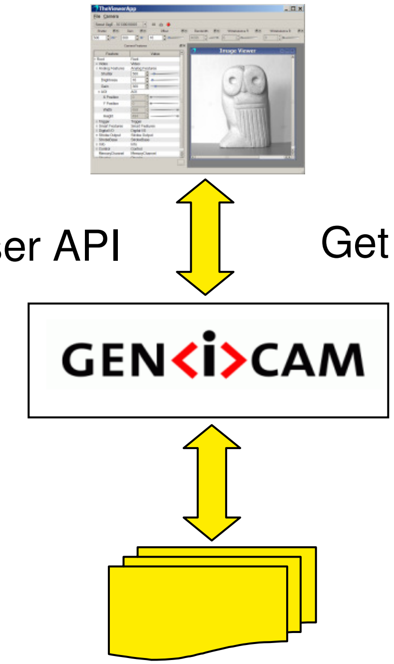
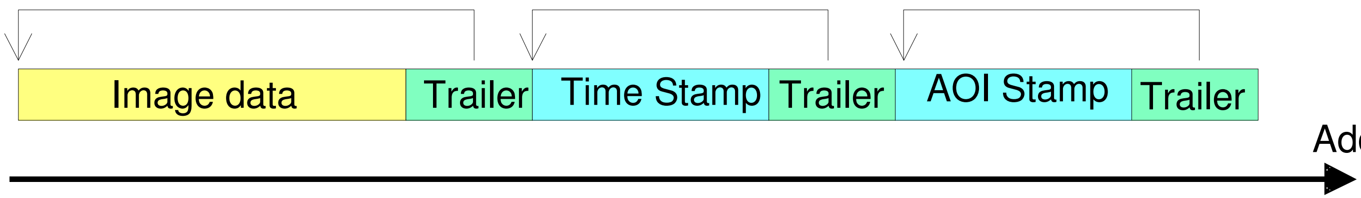
Chunked Data Stream

- Images can have chunks of additional data appended, e.g. a time stamp.
- GenICam makes this data accessible

```
if( IsReadable( Camera.TimeStamp ) )
     cout << Camera.TimeStamp();
```

- The transport layer “shows” each buffer to GenICam.
- GenICam interprets the chunks as read only registers identified by a ChunkID





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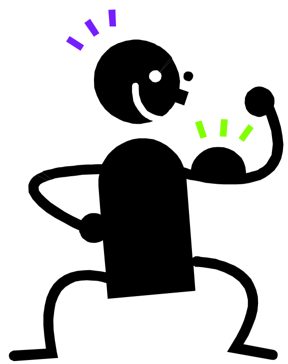
Code Example

```
// Create and connect the chunk adapter
CChunkAdapterGEV ChunkAdapter( Camera._Ptr );

GetNewBuffer( &pBuffer );

// Parse the buffer layout and connect to features
ChunkAdapter.AttachBuffer( pBuffer, BufferSize );

for(;;)
{
    // Retrieve time stamp from buffer
    if( IsReadable( Camera.FrameCounter )
        cout << Camera.FrameCounter.ToString();

    GetNewBuffer( &pBuffer );

    // update buffer assuming the same chunk layout
    ChunkAdapter.UpdateBuffer( pBuffer );
}
```

Making GenICam Compatible Products

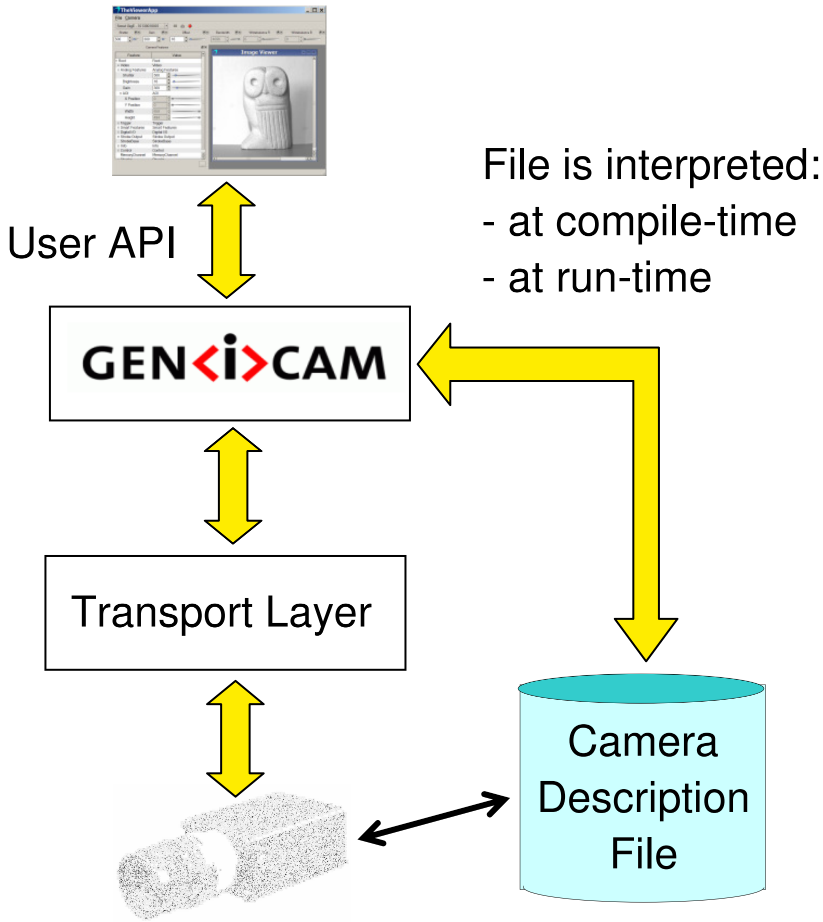
- Features
- Making Cameras Interchangeable
- Reference Implementation
- License Issues



Vendor Viewpoint

Camera Description File

- Describes how features (“Gain”) map to registers (or commands)
- XML format with a syntax defined in the GenICam standard
- Static use case : a code generator creates a camera specific C++ class at compile-time
- Dynamic use case : the program interprets the XML file at run-time
- Camera description files are provided by the camera vendor



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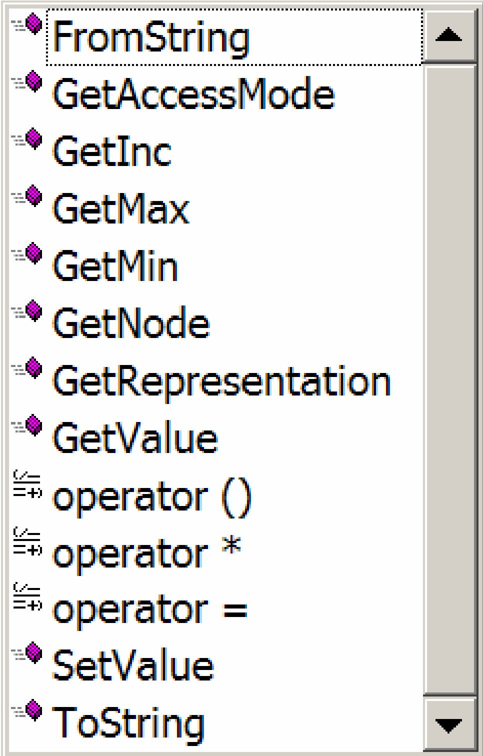
Feature Types

- Each feature has a type that is defined by an abstract interface
- Common types with associated controls are:
  - Integer, Float ⇔ slider
  - String ⇔ edit control
  - Enumeration ⇔ drop down box
  - Boolean ⇔ check box
- With GenICam camera vendors can use whatever feature names, types and behavior they like.
- As a consequence GenICam alone does not make cameras interchangeable!

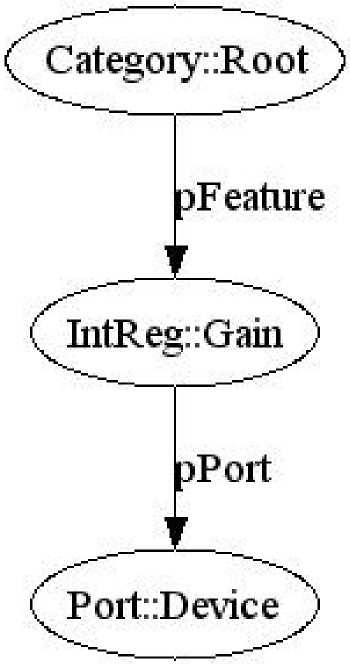
  ➔ **Standard Feature List** is required

Example: Integer interface

`Camera.Gain.`

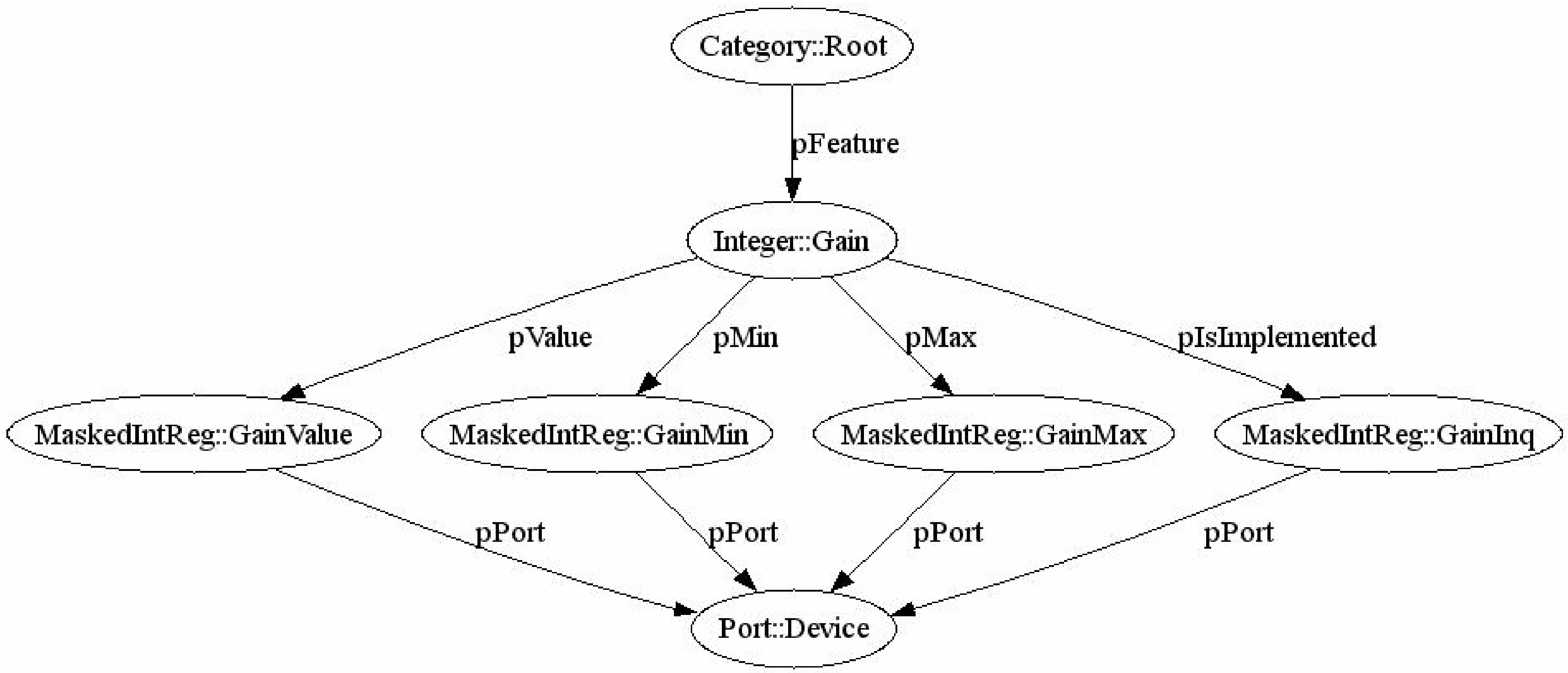


Camera Description File Example




```xml
<RegisterDescription ModelName="Example01" VendorName="Test"
   ../GenApiSchema_Version_1_0.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>
      <Endianess>BigEndian</Endianess>
   </IntReg>
   <Port Name="Device">
      <ToolTip> Port node giving access to the camera</ToolTip>
   </Port>
</RegisterDescription>
```

Feature Tree Example



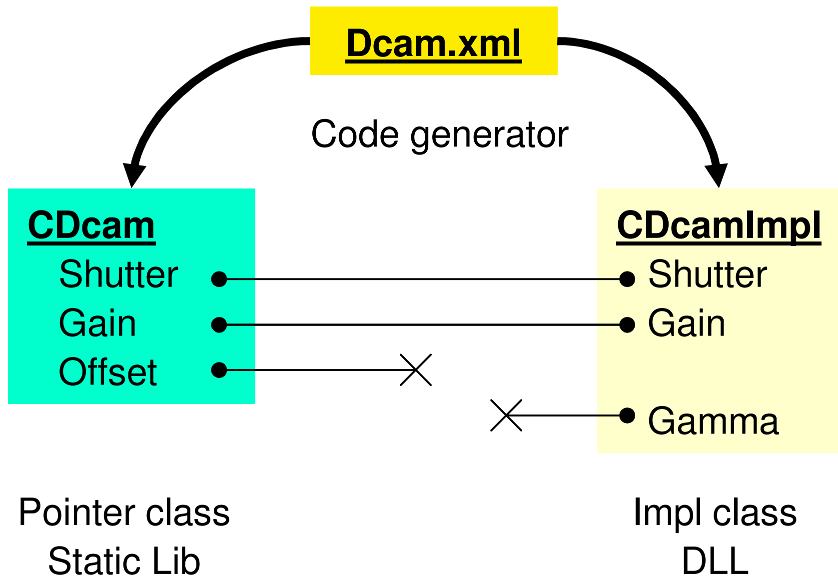
Pointer / Impl Class

Pointer class

- Static library
- From code generator

Impl class

- DLL
- Uses vtable pointers like COM
- Camera specific from code generator
- Generic XML file loader



- Node exists in pointer and impl

```
Camera.Shutter = 42;
```

- Node exists in pointer only

```
assert( !IsImplemented(Offset) );
```

- Node exists in impl only

```
CIntegerPtr ptrGamma;
ptrGamma = Camera.GetNode("Gamma");
*ptrGamma = 42;
```

Node Types Available

- **Basics**
  - ✓ Node
  - ✓ Category → feature tree
  - ✓ Port
- **Registers**
  - ✓ Register → hex edit
  - ✓ IntReg → slider
  - ✓ MaskedIntReg → slider
  - ✓ FloatReg → slider
  - ✓ StringReg → string edit
- **Mathematics**
  - ✓ SwissKnife → double mathematics
  - ✓ IntSwissKnife → int64 mathematics
  - ✓ Converter → bidirectional int64<>double
  - ✓ IntConverter → bidirectional int64<>int64
- **High Level Features**
  - ✓ Integer → slider
  - ✓ Enumeration → drop down box
  - ✓ Float → slider
  - ✓ Command → button
  - ✓ Boolean → check box
- **IIDC Support**
  - ✓ ConfRom → Base data
  - ✓ AdvFeature → IIDC specific
  - ✓ SmartFeature

Standard Feature List

For **GigE Vision** cameras a list of ~**180** standard features is provided.

- This list is organized along use cases:
  - Image size control
  - Acquisition and trigger controls
  - Digital IO
  - Analog Controls
  - …
- Only 7 features are mandatory, the others are just recommended

- The GigE Vision standard says

*…any GigE Vision device **MUST** provide an XML device description file compliant to the syntax of the GenApi module of GenICam™.*

For **1394 IIDC** cameras the same list of features can be used with only a few adaptations.

- A common XML file is still under construction

Standard and Reference Implementation (1/2)

GenICam Standard Document

- Describes how the camera description file is organized
- Describes feature types and their abstract interfaces

XML Schema File

- Defines the syntax of the camera description file
- XML editors can validate the syntax of camera description files using the schema

Standard Feature List

- Is not part of GenICam but the transport layer standards (GEV, IIDC)

Reference Implementation

- Is not part of the standard
- Can be used for commercial products
- C++ code in production quality
- Windows (MS Visual C++) and Linux*) (GNU) supported
- Is organized in modules. Each module can be used stand-alone
- Each module has a maintainer who ensures code integrity
- Automated tests are provided for each module to ensure stable code under maintenance

*) GenApi module only

Standard and Reference Implementation (2/2)

Main Modules

- **GenApi** : Configures the camera
  - ➔ Provides the configuration API
  - ➔ Provides the configuration GUI
  - ➔ Handles events & chunk buffers

- **GenTL** : Grabs images
  - ➔ Enumerates cameras
  - ➔ Creates camera access objects
  - ➔ Provides the grab API

License Issues

- **Run-time binaries**
  Required for:
  - using GenICam in an application
  - creating camera description files
  - creating TL adapters
  BSD-like license: everyone may use it at no cost but must not modify it

- **Source code access**
  For GenICam members only. The rules of the group must be obeyed which ensures that there is only one (well tested) version of GenICam available.

Software Quality

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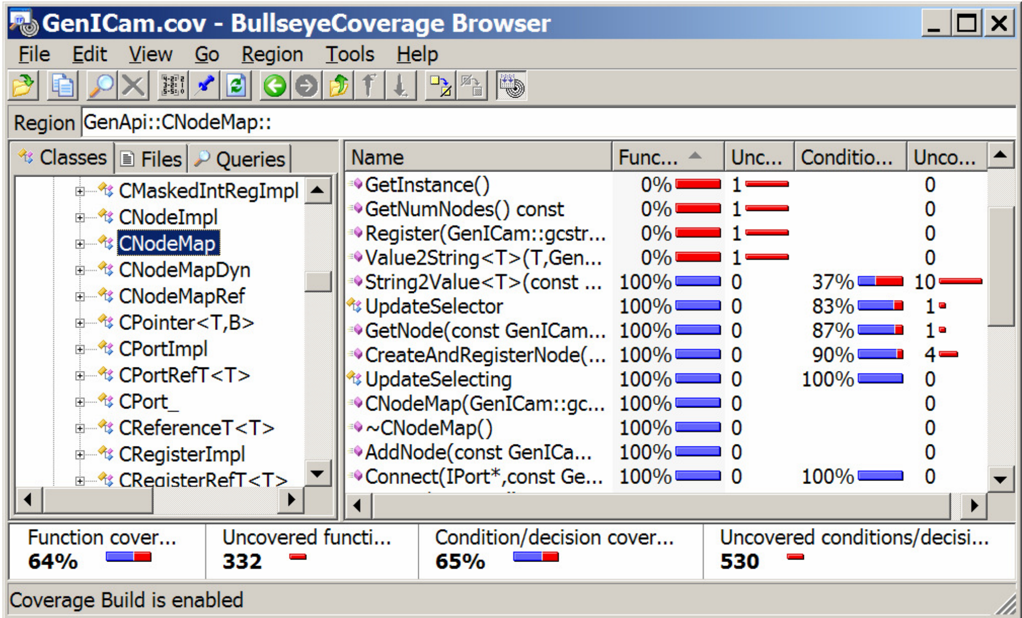
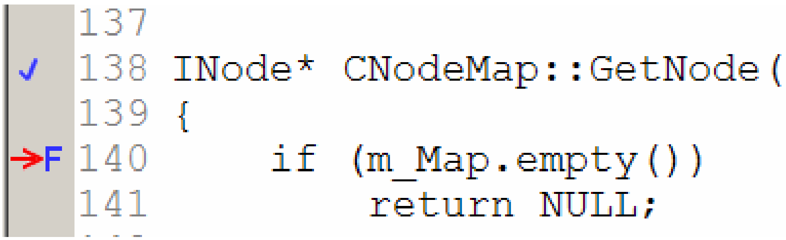
Regression Tests

- CppUnit based
- Coverage measurement
- **8** contributing companies
- **139** tests cases *)
- GenApi : **7.500 LOC** **)
- GenApiTest : **5.400 LOC** **)
- **97%** function coverage *)
- **91%** condition/decision coverage *)





*) version 1.0.0 **) LOC = lines of code (C++)

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Performance

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Test Environment

- Pentium 4 – 2.4 GHz
- Timer resolution = 0.28 µs
- Dummy Port read/write : t = 0.1 µs
- t = with / without caching

Accessing an Integer Register

- IntReg ⇔ Port
- SetValue : t = **2.1** / **3.2** µs
- GetValue : t = **0.2** / **3.1** µs

Delivering a GigE Vision EventData packet

- ← Integer ⇔ Port [E1]
  ← Integer ⇔ Port [E1]
  ← Integer [E2]
- 2 events, 3 callbacks : t = **3.9** µs

Scalar feature (Gain, Shutter etc.)

- Integer ⇔ MaskedIntReg(Value) ⇔ Port
  ⇔ MaskedIntReg(Max) ⇔ Port
  ⇔ MaskedIntReg(Min) ⇔ Port
  ⇔ MaskedIntReg(Inq) ⇔ Port
- SetValue : t = **8.3** / **18.6** µs; no verify t = **3.3** µs
- GetValue : t = **0.2** / **3.5** µs

IntSwissKnife computing X * Y + 12

- IntSwissKnife ⇔ Integer (X = const)
  ⇔ Integer (Y = const)
- GetValue : t = **0.2** / **5.6** µs

Delivering a GigE Vision chunk buffer

- ← Integer ⇔ Port1 [C1]
  Integer ⇔ Port1 [C1]
  Integer ⇔ Port2 [C2]
- 2 chunks, attach buffer, 1 callback : t = **3.3** µs
- 2 chunks, update buffer, 1 callback : t = **3.2** µs

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GenICam Organization

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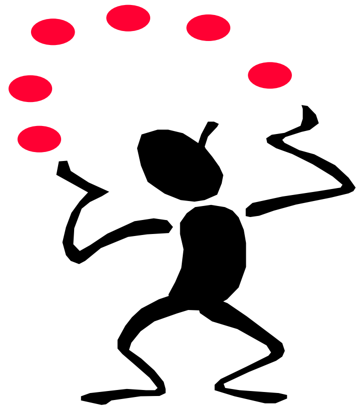
- Standard Committee
- Supporting Companies
- Status & Roadmap
- Benefits



Industry Viewpoint

VISION TECHNOLOGIES

GenICam Standard Committee

- GenICam is hosted by the European Machine Vision Association (EMVA)
- **Contributing members** are working(!) on the standard and the reference implementation. Only contributing members can **vote**.
- **Associated members** agree to the GenICam rules. They get full access to the source code and are placed on the mailing list but **cannot vote**.
- **Interested outsiders** get the GenICam run-time and the released standard documents
- You can **register** at www.genicam.org

no fees!

emva

Contributing Members
- currently 8 companies -

Associated Members
- currently 20 companies -

Interested Outsiders

*) as of b/o May 2006

GenICam Members

emva
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AccuSoft
Adimec
ALLIED Vision Technologies
BASLER VISION TECHNOLOGIES
COGNEX
COLOUR CONTROL
DALSA CORECO
A division of DALSA Corporation
DVC
EURESYS
e2v
e2v semiconductors
formerly ATMEL
FASTVISION
FLIR
GigaLinx
imagsa
i-solutions
JAI
Leutron Vision
Lumenera corporation
MATROX IMAGING
MIKROTRON
MontiVision Imaging Technologies
MVTec Software GmbH
NATIONAL INSTRUMENTS
Pleora Technologies
PROSILICA
SICK | IVP
STEMMER IMAGING
teli

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Status*) and Roadmap

GenApi Module

- Standard and reference implementation v1.0 are released and are available on www.genicam.org.
- The number of GenICam aware products is constantly growing. Among them are:
  - All GigE Vision compliant cameras
  - Many of the image procession software libraries
  - Some 1394 cameras

GenTL Module

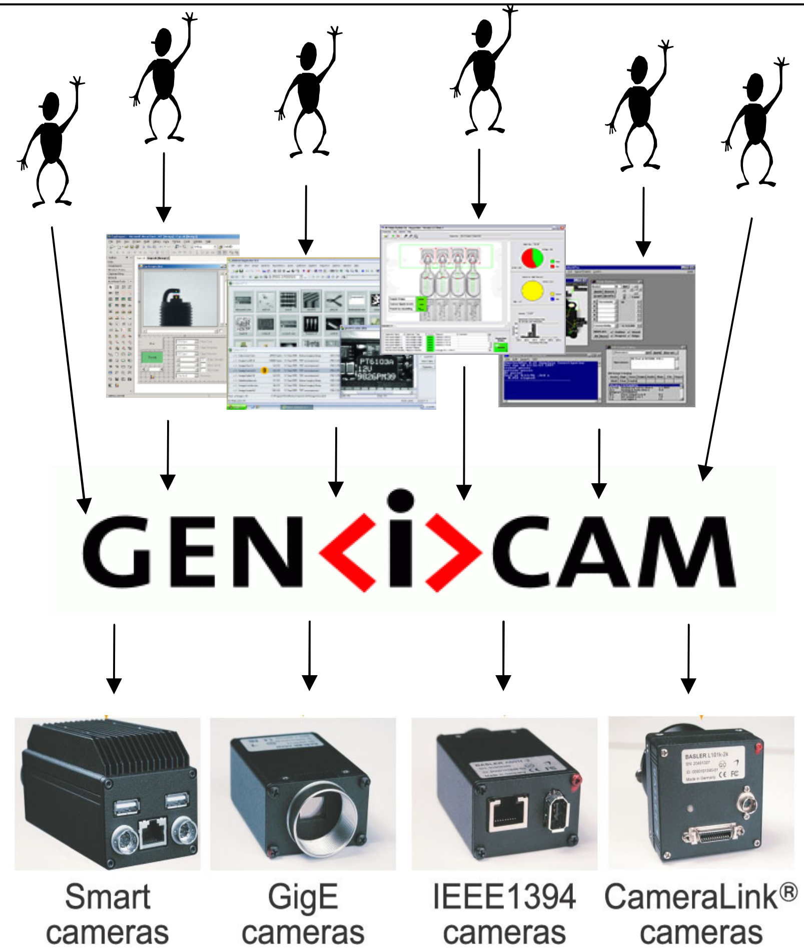
- Defined interfaces and working adapters for GigE Vision, 1394, and Camera Link
- Draft standard expected Q1 2007

Standard Feature List

- GigE Vision : v1.0 is released
- 1394 IIDC : under construction

*) cw36 / 2006

Benefits



Customers

- Combine
  → any camera with
  → any smart feature with
  → any software library
- Mix interface technologies and cameras from different vendors

Vendors

- Enlarge your market
- Reduce your cost
- Speed up time-to-market

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Thank you for your attention!

Contact me → friedrich.dierks@baslerweb.com

Get information → www.genicam.org