Programming EPICS with PERL

Mohan Ramanathan
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Outline

- History
- Quick Overview of Perl
- EPICS Overview
- Channel Access (EZCA)
- Perl interface to EZCA
- Perl Applications
- Current and Future
- Conclusions
- Acknowledgments

History

- **Perl is an easy language for WEB programming (CGI)**
  - Needed an easy to program , yet powerful language to write code to interface to CA, SDDS and for writing CGI interface
- **Object oriented**
- **Easy to interface to other languages like C, C++, java etc..**
- **Preexisting objects modules are available in abundance**
  http://www.cpan.org
- **Perl is free!**
- **Great support and free!**

History

- **Why Perl?**
  - Back in 1995/96 was looking for a language to use for various applications
  - C was too cumbersome
  - Needed a quick and easy to use, yet a powerful language
  - Tcl/Tk was used at APS but was not properly suited for the applications I was interested in (mainly WEB interface)
  - Easy to learn !!
  - Perl has simple constructs and looks similar to C
  - Numerous modules available in CPAN for graphics and GUI
  - pTK was already available for Perl in 1996
  - Interpreter based language means no compilation
  - Full programs can be generated easily with Perl
- **Perl EZCA module was born in 1996**

Quick Overview of Perl

- **A high-level interpreted programming language**
- **Modern programming language**
  - Data Structures
  - Control Structures
  - Regular Expressions
  - Object Oriented
- **Perl handles both strings and numbers elegantly**
  - Excellent for manipulation of both strings and numbers
  - Most string and arithmetic operators are similar to C
  - All operators and most functions work on scalar or array data of any type
- **Multi-platform support**
  - Unix, Linux, Windows, etc..

Quick Overview of Perl

- **Data types**
  - Scalars need no assignment. Internally all scalars are assigned to double. However for users it takes the form of the data it holds
  - Arrays can be multi-dimensional. However internally it is only one dimension
- **Variable Names**
  - All scalars start with $
  - All arrays start with @
  - All hash reference start with %

- **Has special variables and arrays like $_, @_, @ARGV, %ENV, etc..**
- **User has a choice of (not) using special cryptic variables !!**
- **Memory allocation is dynamic – will use up all memory when needed !**

Quick Overview of Perl - Operators

- **Binary and String Operators**

```
$a = 123; $b = 456;
$c = 3;
print $a + $b;     # prints 579          (addition)
print $a . $b;     # prints 123456       (concatenation)
print $a x $c;     # prints 123123123    (repeat)
```

- **Logical Operators**

```
$a && $b           # $a if $a is false, $b otherwise
! $a               # True if $a is not true
```

- **Numeric and String Comparison Operators**

```
$a == $b           # True if $a is equal to $b  (numeric)
$a  eq $b          # True if $a is equal to $b  (string)
```

- **File Test Operators**

```
-e $a              # True if file named in $a exists
```


Quick Overview of Perl - Control

- **if and unless statements**

```
if ($level < 0) {
     print "Level is below Zero \n";
}
print "City is not New York \n" unless ($city eq "New York");
```

- **while and until statements**

```
while ($level < 100) {
     $level++;
     print "level value is $level\n";
}
until ($level == 0) {
     $level--;
     print "level value is $level\n";
}
```

Quick Overview of Perl - Control

- for statements

```
for ($level =0; $level <100; $level++) {
    print "level value is $level\n";
}
```

- foreach statements

```
foreach $user (@users) {
    print "$user is ok\n";
}
```

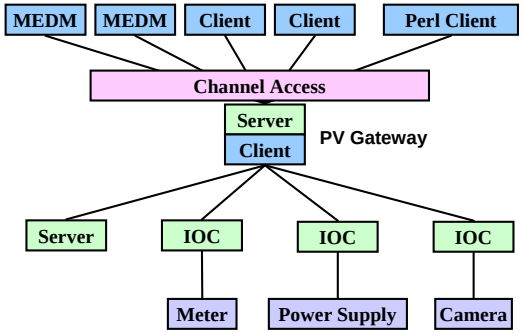
- next

```
foreach $user (@users) {
    next unless ($user eq "jack");
}
```

- last

```
foreach $user (@users) {
    last if ($user eq "jack");
}
```


EPICS Overview



Channel Access (EZCA)

EPICS extension for "E-Z (Easy) Channel Access"

- EZCA provides a simplified interface to Channel Access, which is useful for some C programs which do not need all the capabilities of the full API
- Don't need to handle chids, just use PV name strings – hash table
- Synchronous APIs - applications don't have to handle callbacks
- Has only 25 routines to handle synchronous groups, individual requests and easy error handling

Perl Interface to EZCA

Description

- EZCA.pm is a Perl interface to EPICS EZCA library
- The routine names are based on EZCA nomenclature
- Each routine name in EZCA has an equivalent in Perl module
- All the commands are similar to what is used in EZCA
- Data types as described in EZCA (ezcatype) are used
  - *ezcaByte*
  - *ezcaString*
  - *ezcaShort*
  - *ezcaLong*
  - *ezcaFloat*
  - *ezcaDouble*

Perl Interface to EZCA

Return Codes

- **Most function calls return status codes indicating the success/failure of the call**
- **Following are the return codes**
  - *EZCA_OK*
  - *EZCA_INVALIDARG*
  - *EZCA_FAILEDMALLOC*
  - *EZCA_CAFAILURE*
  - *EZCA_UDFREG*
  - *EZCA_NOTCONNECTED*
  - *EZCA_NOTIMELYRESPONSE*
  - *EZCA_INGROUP*
  - *EZCA_NOTINGROUP*

Perl Interface to EZCA

Work in Progress

- **Most functions with the exception of the Group function have been implemented and tested**
  - 21 of the 25 functions are working
- **All functions involving arrays have a limitation of 2000 elements**
- **In the case of PV Put at this time only one element is possible**

Perl Interface to EZCA

Main Functions

- `@data = EZCA::Get($pvname,"ezcatype",$no_elem)`

  Retrieves values from *$pvname* and the data type is specified as *ezcatype*

  The return status code is stored in *$data[0]* and the retrieved values are in the rest of the array starting at elements *$data[1]*

  At this time the no of elements *$no_elem* is limited to 2000

- `$status = EZCA::Put($pvname,"ezcatype",$no_elem,$data)`

  Write values into *$pvname*.

  The value is send in *$data* and the data type is specified as *ezcatype*.

  The return status code is *$status*

  At this time the no of elements *$no_elem* is limited to 1

- `EZCA::GetStatus($pvname,$tstamp,$tnstamp,$status,$severity)`

  Retrieves various information about the said *$pvname*.

  The time in seconds is in *$tstamp* and in nanoseconds is in *$tnstamp*.

  The *$status* and *$severity* returns status and the severity of the process variable

Perl Interface to EZCA

Associated Functions

- `$status = EZCA::GetNelem($pvname,$nelem)`

  The number of elements in the *$pvname* is returned in *$nelem*.

- `$status = EZCA::GetPrecision($pvname,$prec)`

  The precision for the *$pvname* is returned in *$prec*.

- `$status = EZCA::GetUnits($pvname,$unit)`

  This returns the Engineering Unit field of the *$pvname* in *$unit.*

- `$status = EZCA::GetControlLimits($pvname, $low, $high)`

  Retrieve the Control Limits values in *$low* and *$high*.

- `$status = EZCA::GetGraphicLimits($pvname, $low, $high)`

  Retrieve the Graphics Limits values in *$low* and *$high*.

Perl Interface to EZCA

Monitors

- `$status = EZCA::SetMonitor($pvname,"ezcatype")`
  Used to set a monitor on the *$pvname*.
- `$status = EZCA::ClearMonitor($pvname,"ezcatype")`
  Used to clear any monitors placed on the *$pvname*.
- `$mon = EZCA::NewMonitorValue($pvname,"ezcatype")`
  Use this function to poll for new values on a previously set monitor.
  A non zero return value in *$mon* indicates a new value since the last time the value was read via a Get
- `$status = EZCA::Delay($seconds)`
  Use to introduce delays between calls.
  The time *$seconds* is in seconds. Fractional time are allowed.

Perl Interface to EZCA

Error Handling

- `EZCA::AutoErrorMessageOn()`
  Turn ON the EZCA error messages to be printed on the *stdout*.
- `EZCA::AutoErrorMessageOff()`
  Turn OFF the EZCA error messages to be printed on the *stdout*.
- `EZCA::Perror($prefix)`
  Use this to optionally add a prefix message to the EZCA error message.
- `EZCA::GetErrorString(NULL, $stringBuff)`
  Retrieve the EZCA error message in the *$stringBuff* instead of *stdout*.
- `EZCA::Free($stringBuff)`
  Use this to free up the *$stringBuff* used in the above call.

Perl Interface to EZCA

Tuning EZCA

- `$seconds = EZCA::GetTimeout()`
  Retrieve the current CA timeout value in seconds
- `$number = EZCA::GetRetryCount()`
  Retrieve the current CA number of retries.
- `$status = EZCA::SetTimeout($seconds)`
  Set the current CA timeout value in seconds. *$status* is the return status
- `$status = EZCA::SetRetryCount($number)`
  Set the CA number of retries. *$status* is the return status

Perl Applications

Use EZCA and GD modules to generate images every minute for WEB

```
#!/usr/bin/perl
#################################################################
#        Program to retrieve the data from EPICS and generate
#        png files of Storage ring history.
#################################################################
use Time::CTime;          # load Time module for manipulating time
use EZCA;                 # load EZCA module
use GD;                   # load GD graphics module
use File::Copy;           # load File handling modules

$ENV{'EPICS_CA_AUTO_ADDR_LIST'} = 'NO';
$ENV{'EPICS_CA_ADDR_LIST'} = "164.54.188.65"; #environment for Rhea gateway

$epoch = 631152000;       # this is the difference between EPOCHS

$nfont  = "/usr/openwin/lib/X11/fonts/TrueType/Arial.ttf";
$bfont  = "/usr/openwin/lib/X11/fonts/TrueType/Arial-Bold.ttf";
$bifont = "/usr/openwin/lib/X11/fonts/TrueType/Arial-BoldItalic.ttf";

$smallfile = "/Public/aod/blops/plots/smallStatusPlot.png";
$tempfile = "/Public/aod/blops/plots/statusPlot.png";
$pdajpgfile = "/Public/aod/blops/plots/tinyStatusPlot.jpg";
```

For PV Gateway

Perl Applications

Use EZCA and GD modules to generate images every minute for WEB

```
EZCA::AutoErrorMessageOff();      # Turn off error messages to STDOUT
EZCA::SetTimeout(0.01);           # Fine Tune EZCA
EZCA::SetRetryCount(10);          # Fine tune EZCA
#  setup monitor to trigger whenever this changes....
$val = EZCA::SetMonitor("S:SRdateCP","ezcaLong");
$val = EZCA::NewMonitorValue("S:SRdateCP","ezcaLong");
@pvvalues = EZCA::Get("S:SRdateCP","ezcaLong",1440);
EZCA::Delay(2.0);                 #  Wait 2.0 seconds
# wait for the monitor to trigger action. happens every minute.
while(1) {
    $status = EZCA::NewMonitorValue("S:SRdateCP","ezcaLong");
    if ($status) {
        &getPV;                   # to retrieve the PVs
        &generateImage;           #  generate the Images
        &generateHtml;            # generate the Html file
    }
    EZCA::Delay(5.0);             # Wait 5.0 seconds before polling
}
exit;
```

Important! Performance Issue

Need to poll this only

Perl Applications

Use EZCA and GD modules to generate images every minute for WEB

```
sub getPV {
# get the current status of storage ring ...
    @pvvalues = EZCA::Get("S:IOC:timeOfDayForm1SI","ezcaString",1);
    $lastUpdate =$pvvalues[1];
    @pvvalues = EZCA::Get("XFD:srCurrent","ezcaFloat",1);
     $current = sprintf("%6.1f mA", $pvvalues[1]);
    @pvvalues = EZCA::Get("XFD:FillNumber","ezcaShort",1);
    $fill_no= sprintf ("%4d", $pvvalues[1]);
# get the time and current 24 hr data arrays ...
    @timearray = EZCA::Get("S:SRdateCP","ezcaShort",1440);
    shift @timearray;
    @userarray = EZCA::Get("S:UserOpsCurrent","ezcaFloat",1440);
    shift @userarray;
# Find the time from the last data point and adjust for epoch ...
    $curtime = $timearray[$#timearray]+$epoch;
    $curhour = strftime("%H",localtime($curtime));
    $curmin = strftime("%M",localtime($curtime));
```

Difference between EPICS & UNIX EPOCHS

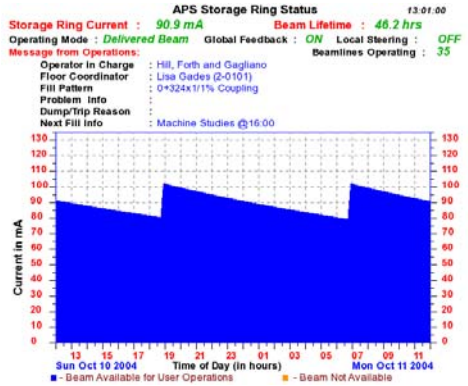
Perl Applications

Use EZCA and GD modules to generate images every minute for WEB

```
sub generateImage {
# Initiallize the size of the image...
    $timage = new GD::Image (360, 340);

# Allocate colors ...
    $twhite = $timage->colorAllocate (255,255,255);
    $tgreen = $timage->colorAllocate (0,170,0);
    $tblue = $timage->colorAllocate (0,0,255);

# Define the origin of the plot (0,0) of the image is the top left corner
    @torigin = (40,290);

# Generate the heading  for the plot ..
    $timage ->stringTTF ($tblack,$bfont,10,0, 190,49,"Active Beamlines :");

# Generate the heading  for the plot ..
    open (IMGFILE, ">$tempfile");
    print IMGFILE $timage->png;
    close IMGFILE;
```


Perl Applications

Use EZCA and GD modules to generate images every minute for WEB



Perl Applications

Example of writing to an EPICS process variable …

```
#!/usr/bin/perl
##########################################################################
#       Program to scan the Undulator from Closed gap to Open gap
#       and collect the encoder values at fixed gaps.
##########################################################################

use Time::CTime;          # Module needed to format time is fancy formats
use EZCA;                 # Loads the EZCA.pm module
use English;              # this is to use $UID instead of $<
use Sys::Hostname;        # to get access to system variables
        .
        .
while ( abs($gap-$cgap) > 0.020 ) {
        $status = 1;
        until ($status == 0) {
        $status = EZCA::Put("ID$sector:ScanGap","ezcaFloat",1,$gap);
        EZCA::Delay(0.05);
        }
```

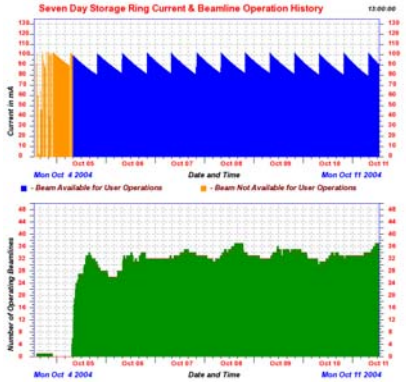

Perl Applications

Example of a program using SDDS and GD module

```
#!/usr/bin/perl
##########################################################################
#   Program to read the data files and generate a large gif file
#  of Storage ring history for the past 7 days.
##########################################################################

$dir = "/home/helios/XFDOPS/monitoring/shutter";
$tempfile = "/home/helios/xfdsys/monitoring/tempfiles/weektemp.sdds";
$pngfile2 = "/net/epics/Public/aod/blops/plots/WeekHistory.png";

use Time::CTime;
use SDDS;
use File::Copy;
use GD;

#  get the current time and the time 7 days ago ....
#  then get it nearest 0, 15, 30 or 45 minute interval.

$curtime = time;

$curmin = strftime("%M",localtime($curtime));
$cursec = strftime("%S",localtime($curtime));
```

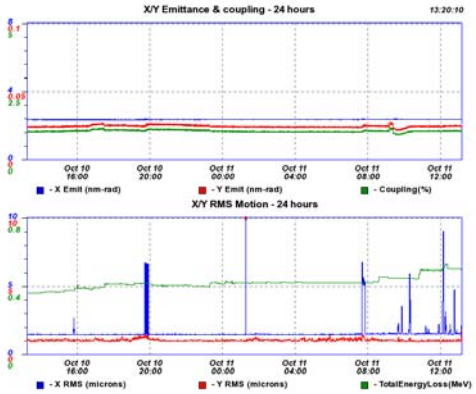

Perl Applications

Use SDDS and GD modules to generate this image for WEB



Perl Applications

Use SDDS and GD modules to generate this image for WEB



Current and Future

- In use for over 8 years by numerous people in APS and others. Easy to develop quick applications.
- With the CA and other available Perl modules it is possible to create complex applications for the EPICS environment.
- Needs additional work in Linux port (bug fixes)
- Needs to be ported and tested with EPICS R3.14
- Built and test in Windows environment
- Interface directly to portable CA instead of EZCA

Conclusions

How to get the Software

- Documentation available
  http://www.aps.anl.gov/aod/people/mohan/EZCA/EZCA.html
- Installation packages for Solaris and Linux
- Source code available
- Requires EPICS libraries
- The software is available as gzipped tarfiles
  http://www.aps.anl.gov/aod/people/mohan/EZCA/solEZCA.tar.gz
  http://www.aps.anl.gov/aod/people/mohan/EZCA/linuxEZCA.tar.gz
- For building it standalone, some of the EPICS include files and libraries are provided. These were build on Sun Solaris and Linux platforms

Acknowledgements

- Karl Glazebrook the developer of PGPERL, the perl interface to PGPLOT for the help in dealing with arrays.
- Marty Kraimer for his help during the development days.

Final Note

What is PERL?

Practical Extraction and Report Language

OR

Pathologically Eclectic Rubbish Lister