ASYN/StreamDevice Support Frameworks

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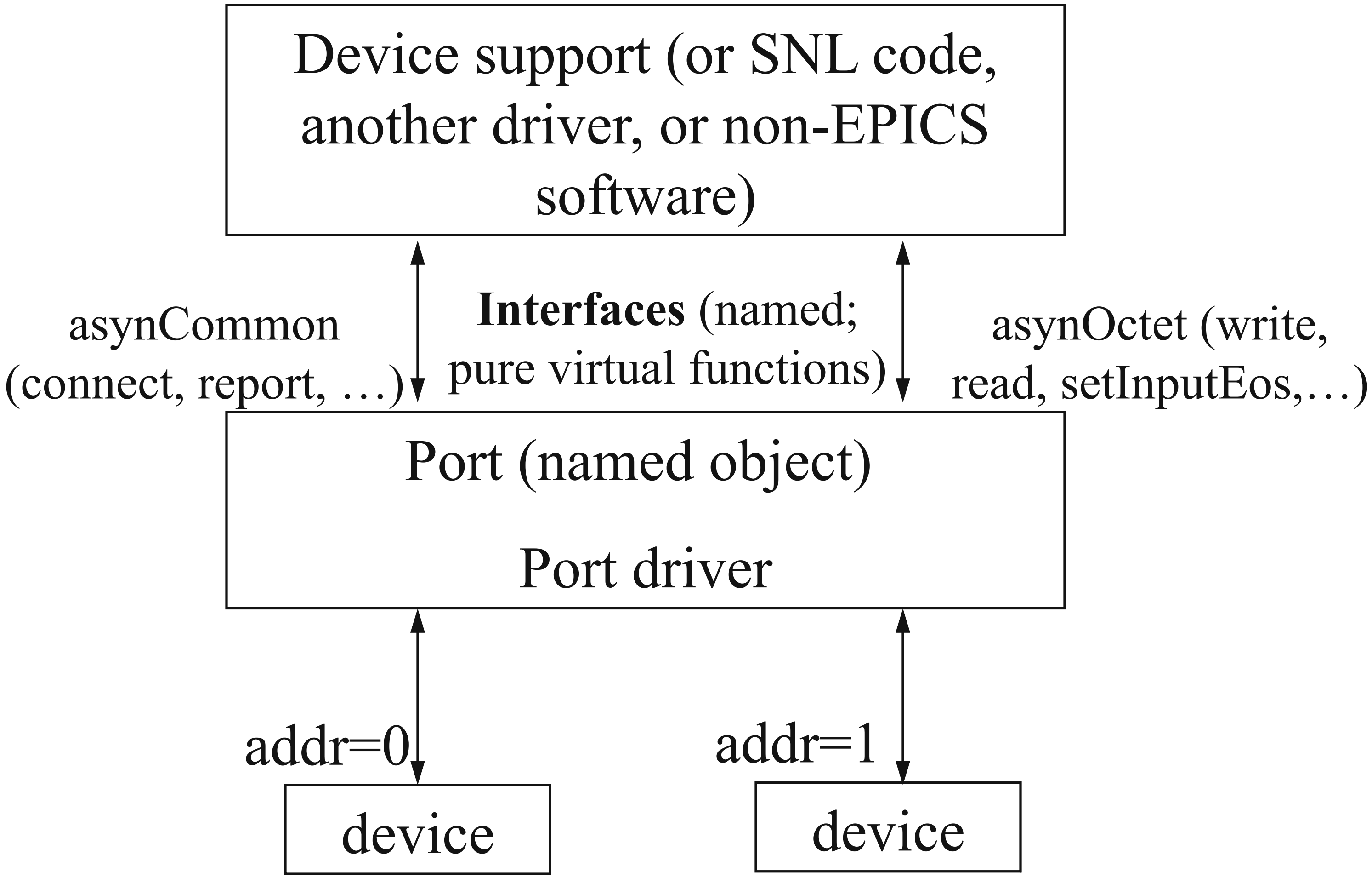
ASYN

- What is it?
- What does it do?
- How does it do it?
- How do I use it?

What is it?

Asynchronous Driver Support is a general purpose facility for interfacing device specific code to low level communication drivers

asyn Architecture



Device support (or SNL code, another driver, or non-EPICS software)

asynCommon (connect, report, …)

Interfaces (named; pure virtual functions)

asynOctet (write, read, setInputEos,…)

Port (named object)

Port driver

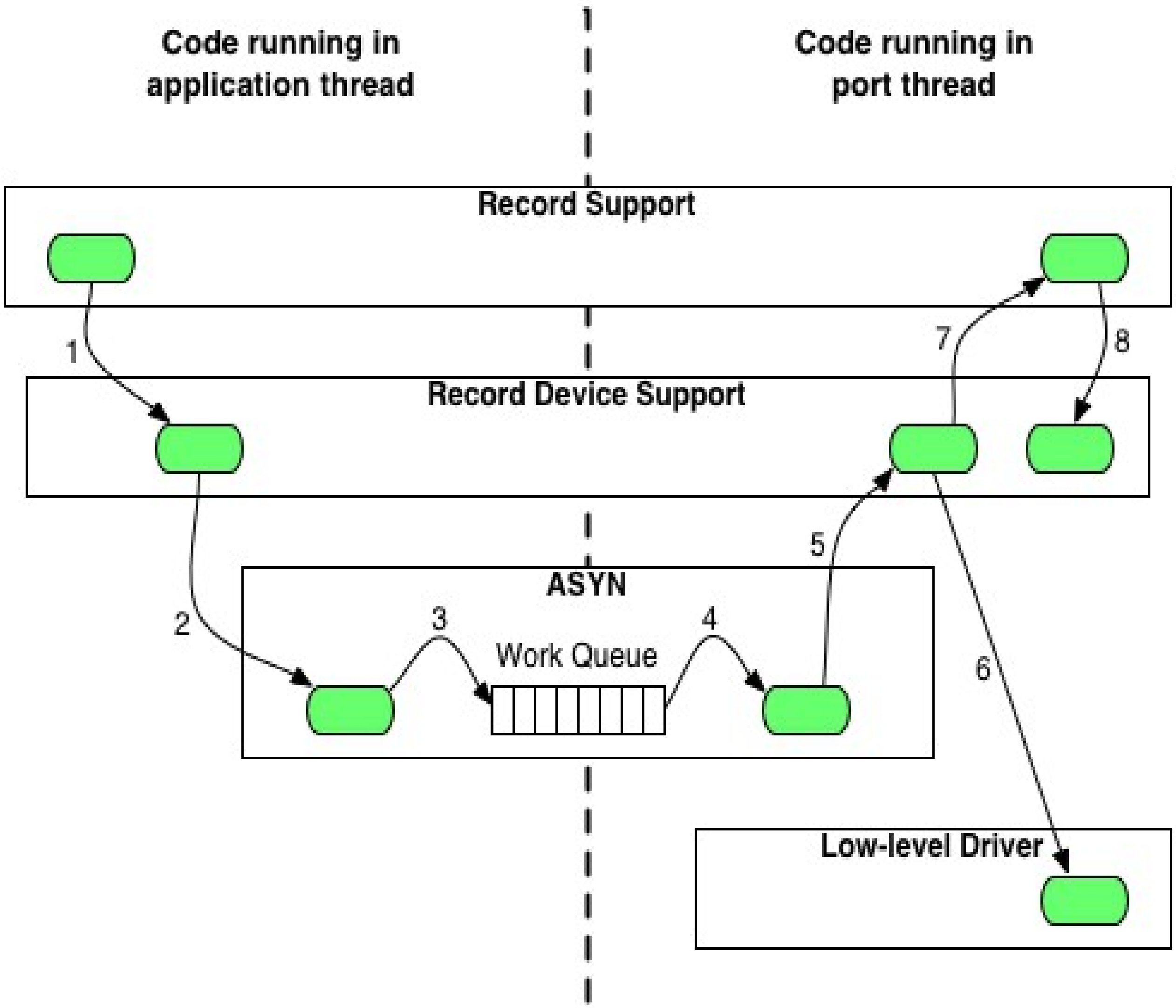
addr=0

addr=1

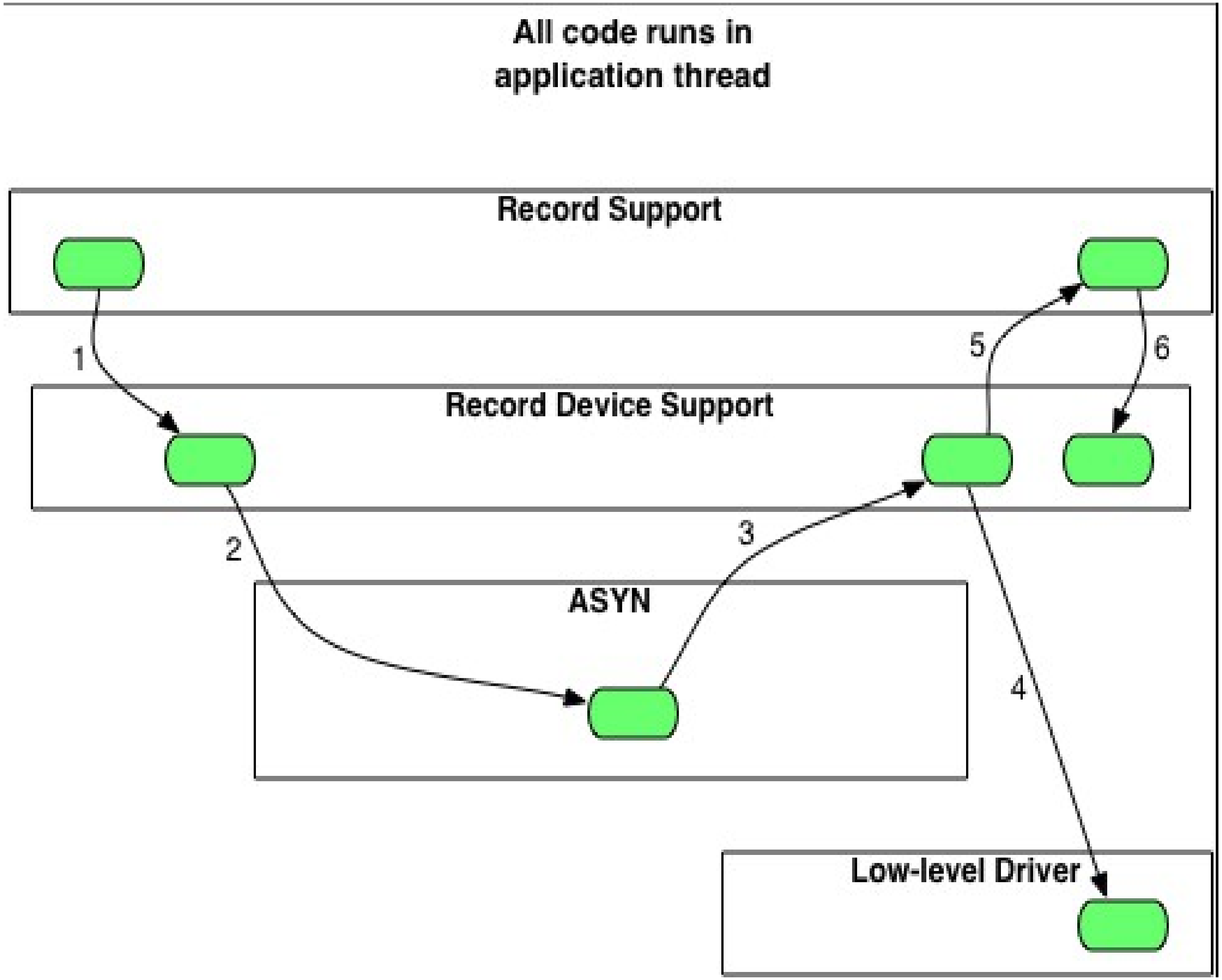
device

device

Control flow – asynchronous driver



Control flow – synchronous driver



ASYN Components – asynManager

- Provides thread for each communication interface
  - All driver code executes in the context of this thread
- Provides connection management
  - Driver code reports connect/disconnect events
- Queues requests for work
  - Nonblocking – can be called by scan tasks
  - User-supplied callback code run in worker-thread context makes calls to driver
  - Driver code executes in a single-threaded synchronous environment
- Handles registration
  - Low level drivers register themselves
  - Can ‘interpose’ processing layers

ASYN Components – asynCommon

- A group of methods provided by all drivers:
  - Report
  - Connect
  - Disconnect
  - Set option
  - Get option
    - Options are defined by low-level drivers
    - e.g., serial port rate, parity, stop bits, handshaking

ASYN Components – asynOctet

- Driver or interposed processing layer
- Methods provided in addition to those of asynCommon:
  - Read
  - Write
  - Set end-of-string character(s)
  - Get end-of-string character(s)
- All that's needed for serial ports, 'telnet-style' TCP/IP devices, USB-TMC.
- The single-threaded synchronous environment makes driver development much easier
  - No fussing with mutexes
  - No need to set up I/O worker threads

ASYN Components – asynGpib

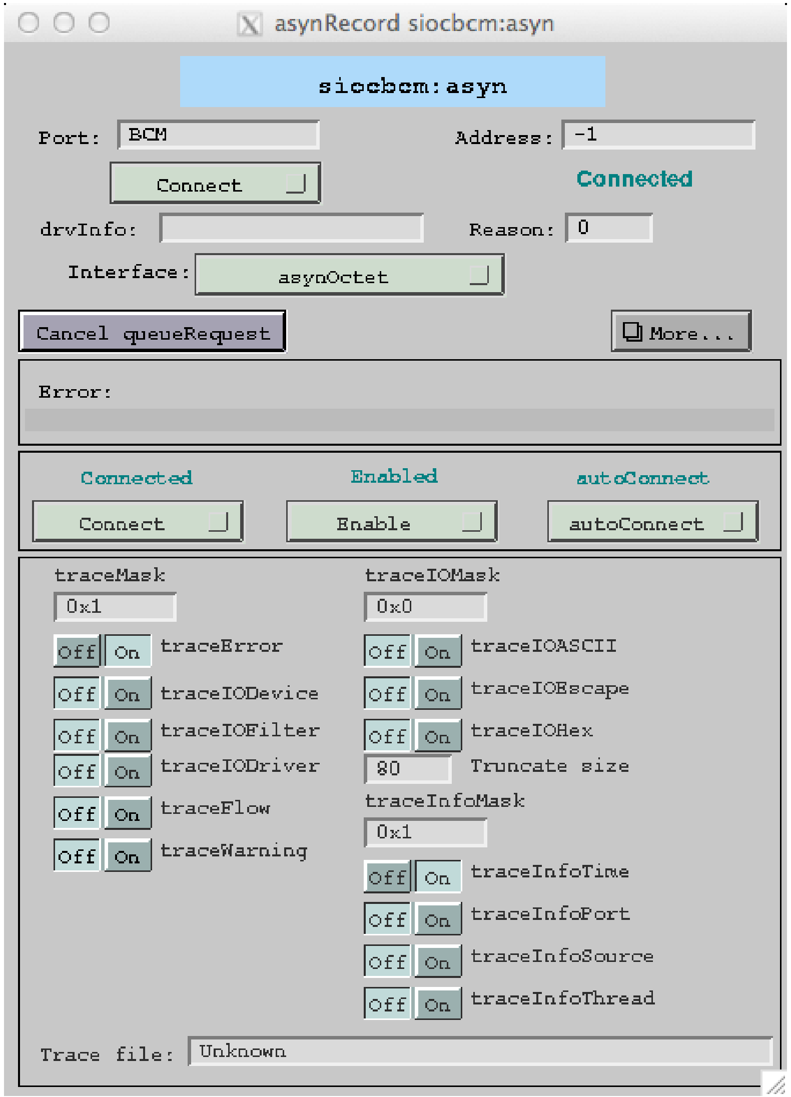
- Methods provided in addition to those of asynOctet:
  - Send addressed command string to device
  - Send universal command string
  - Pulse IFC line
  - Set state of REN line
  - Report state of SRQ line
  - Begin/end serial poll operation
- Interface includes asynCommon and asynOctet methods
  - Device support that uses read/write requests can use asynOctet drivers. Single device support source works with serial or GPIB.

ASYN Components – asynRecord

- Diagnostics
  - Set device support and driver diagnostic message masks
  - No more ad-hoc ‘debug’ variables!
- General-purpose I/O
  - Replaces synApps serial record and GPIB record
- Provides much of the old ‘GI’ functionality
  - Type in command, view reply
  - Works with **all** asyn drivers
- A single record instance provides access to all devices in IOC

asynRecord

- EPICS record that provides access to most features of asyn, including standard I/O interfaces
- Applications:
  - Control tracing (debugging)
  - Connection management
  - Perform interactive I/O
- Very useful for testing, debugging, and actual I/O in many cases
- **If your IOC uses ASYN it should provide at least one asynRecord to give clients control of diagnostic messages!**



asynRecord siocbcm:asyn

siocbcm:asyn

Port: BCM   Address: -1

Connected

drvInfo: Reason: 0

Interface: asynOctet

Error:

Connected   Enabled   autoConnect

traceMask: 0x1

traceIOMask: 0x0

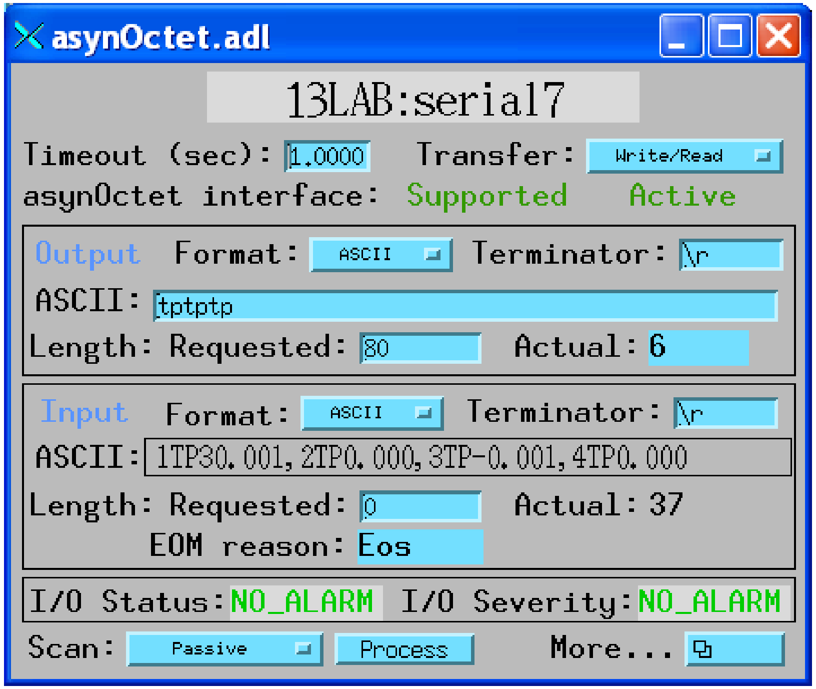
Truncate size: 80

traceInfoMask: 0x1

Trace file: Unknown

asynRecord – asynOctet devices

Interactive I/O to serial device



asynOctet.adl

13LAB:serial7

Timeout (sec): 1.0000 Transfer: Write/Read

asynOctet interface: Supported Active

Output Format: ASCII Terminator: \r

ASCII: tptptp

Length: Requested: 80 Actual: 6

Input Format: ASCII Terminator: \r

ASCII: 1TP30.001,2TP0.000,3TP-0.001,4TP0.000

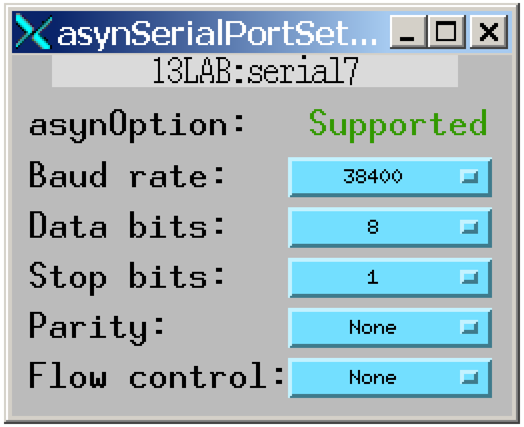
Length: Requested: 0 Actual: 37

EOM reason: Eos

I/O Status: NO_ALARM I/O Severity: NO_ALARM

Scan: Passive Process More...

Configure serial port parameters



asynSerialPortSet...

13LAB:serial7

asynOption: Supported

Baud rate: 38400

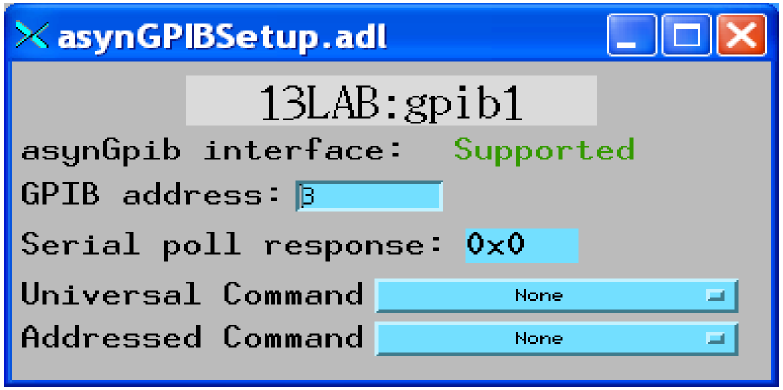
Data bits: 8

Stop bits: 1

Parity: None

Flow control: None

Perform GPIB-specific operations



asynGPIBSetup.adl

13LAB:gpib1

asynGpib interface: Supported

GPIB address: 3

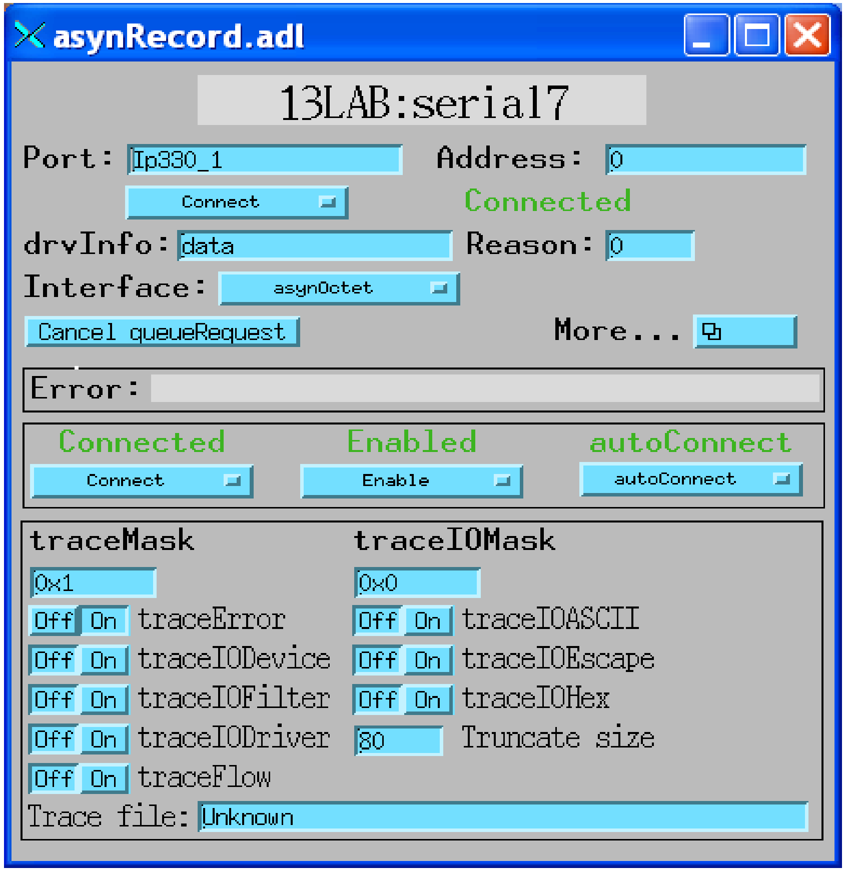
Serial poll response: 0x0

Universal Command None

Addressed Command None

asynRecord – register devices

Same asynRecord, change to ADC port



asynRecord.adl

13LAB:serial7

Port: Ip330_1 Address: 0

Connected

drvInfo: data Reason: 0

Interface: asynOctet

Error:

Connected Enabled autoConnect

traceMask: 0x1

traceIOMask: 0x0

Off On traceError

Off On traceIODevice

Off On traceIOFilter

Off On traceIODriver

Off On traceFlow

Off On traceIOASCII

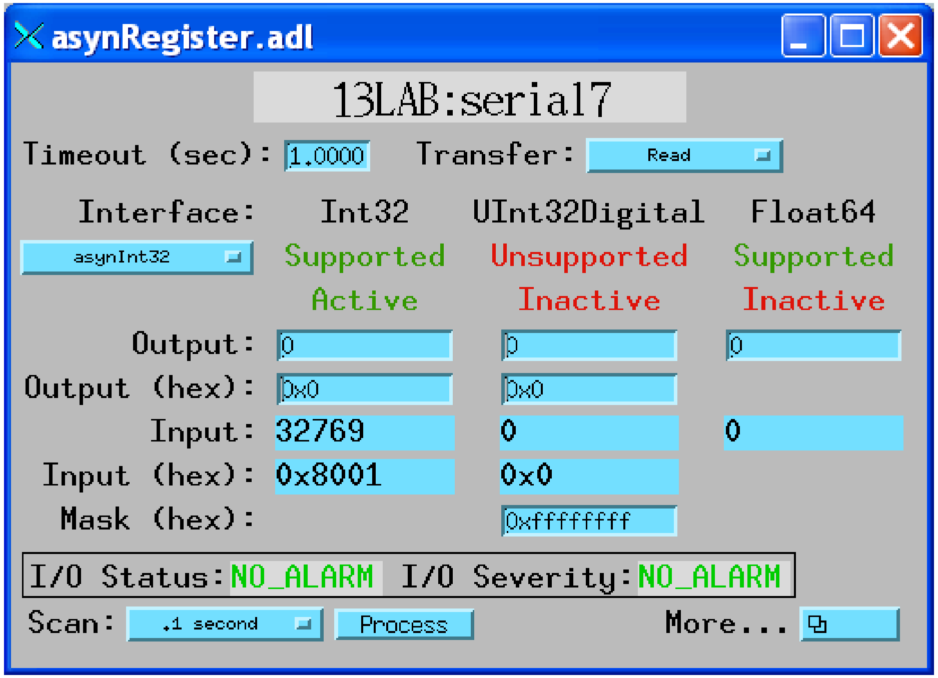
Off On traceIOEscape

Off On traceIOHex

80 Truncate size

Trace file: Unknown

Read ADC at 10Hz with asynInt32 interface



asynRegister.adl

13LAB:serial7

Timeout (sec): 1.0000 Transfer: Read

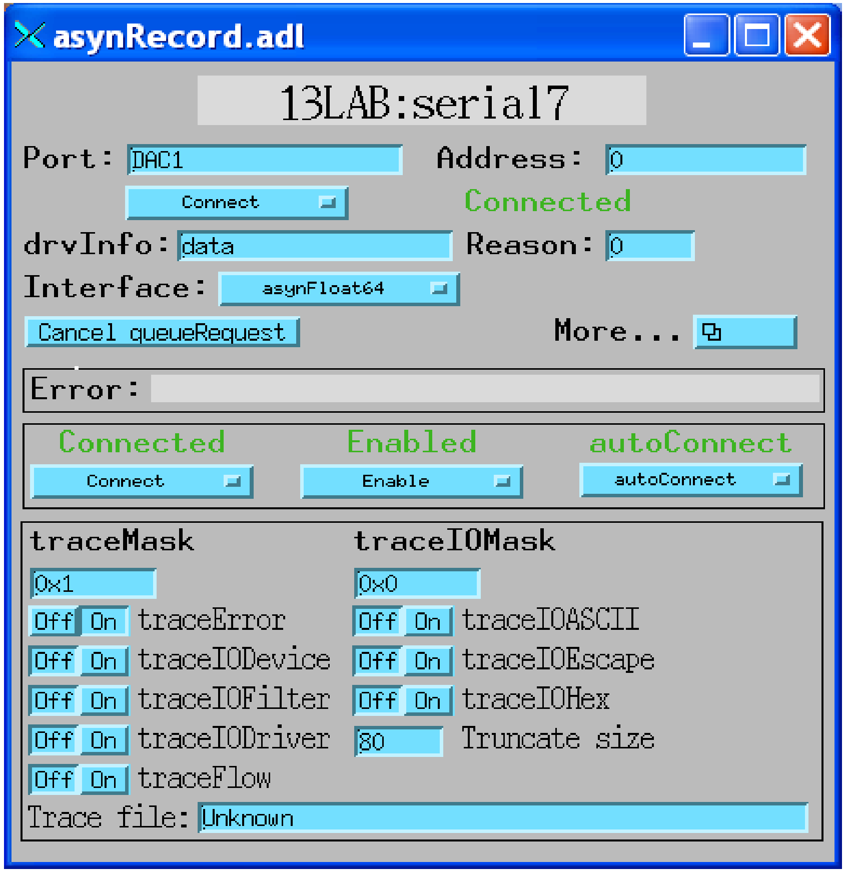
Interface:	Int32	UInt32Digital	Float64
asynInt32	Supported	Unsupported	Supported
	Active	Inactive	Inactive
Output:	0	0	0
Output (hex):	0x0	0x0	
Input:	32769	0	0
Input (hex):	0x8001	0x0	
Mask (hex):		0xffffffff	

I/O Status: NO_ALARM I/O Severity: NO_ALARM

Scan: .1 second

asynRecord – register devices

Same asynRecord, change to DAC port



asynRecord.adl

13LAB:serial7

Port: DAC1 Address: 0

Connect Connected

drvInfo: data Reason: 0

Interface: asynFloat64

Cancel queueRequest More...

Error:

Connected Enabled autoConnect

Connect Enable autoConnect

traceMask traceIOMask

0x1 0x0

Off On traceError Off On traceIOASCII

Off On traceIODevice Off On traceIOEscape

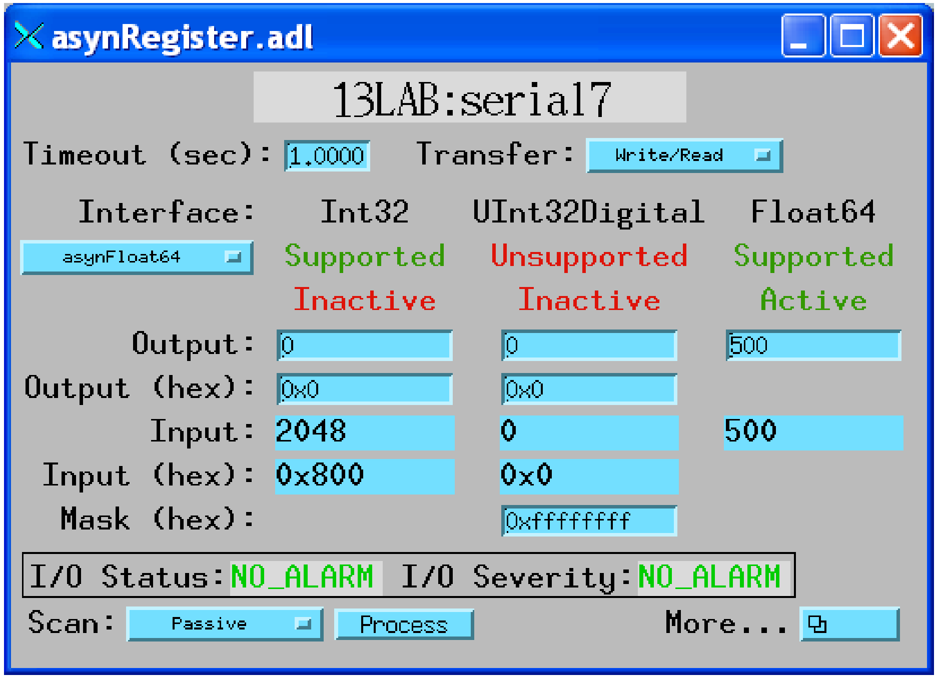
Off On traceIOFilter Off On traceIOHex

Off On traceIODriver 80 Truncate size

Off On traceFlow

Trace file: Unknown

Write DAC with asynFloat64 interface



asynRegister.adl

13LAB:serial7

Timeout (sec): 1.0000 Transfer: Write/Read

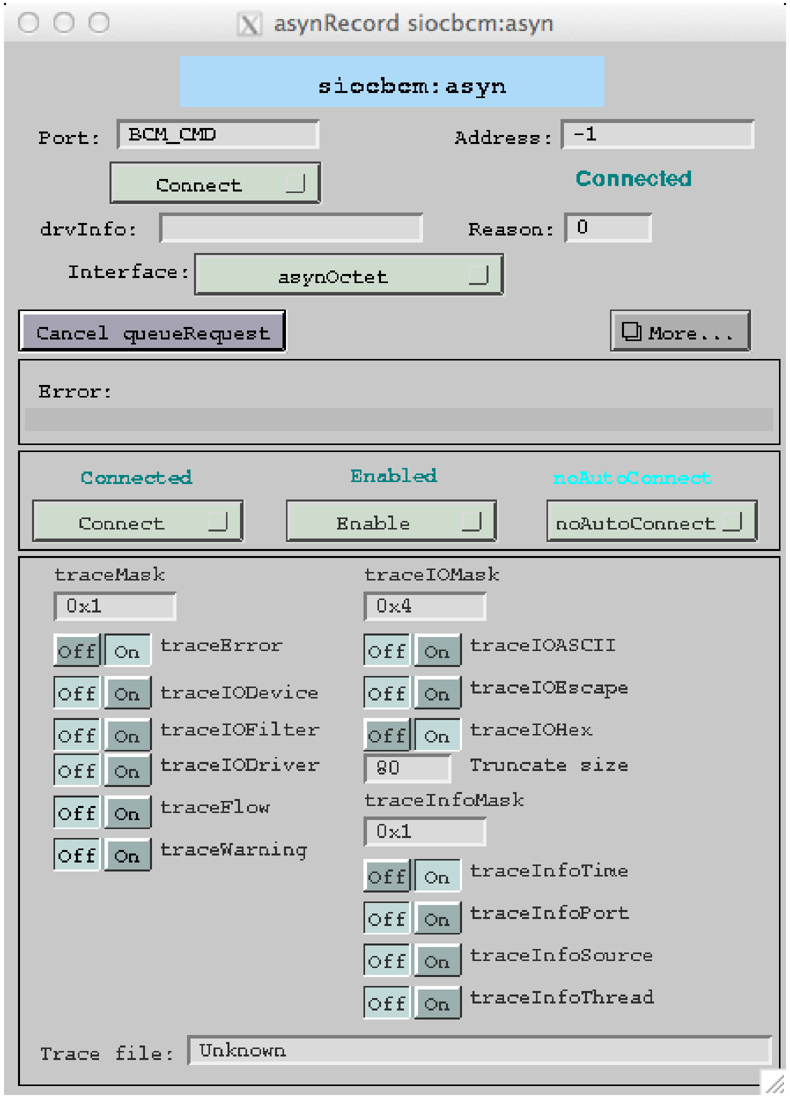
Interface:	Int32	UInt32Digital	Float64
asynFloat64	Supported	Unsupported	Supported
	Inactive	Inactive	Active
Output:	0	0	500
Output (hex):	0x0	0x0	
Input:	2048	0	500
Input (hex):	0x800	0x0	
Mask (hex):		0xffffffff	

I/O Status: NO_ALARM I/O Severity: NO_ALARM

Scan: Passive Process More...

Tracing and Debugging

- Standard mechanism for printing diagnostic messages in device support and drivers
- Messages written using EPICS logging facility, can be sent to stdout, stderr, or to a file
- Device support and drivers call:
  - asynPrint(pasynUser, reason, format, ...)
  - asynPrintIO(pasynUser, reason, buffer, len, format, ...)
  - Reason:
    - ASYN_TRACE_ERROR
    - ASYN_TRACEIO_DEVICE
    - ASYN_TRACEIO_FILTER
    - ASYN_TRACEIO_DRIVER
    - ASYN_TRACE_FLOW
    - ASYN_TRACE_WARNING
- Tracing is enabled/disabled for (port/addr)
- Trace messages can be turned on/off from iocsh, vxWorks shell, and from CA clients such as EDM via asynRecord
- asynOctet I/O from shell



asynRecord siocbcm:asyn

siocbcm:asyn

Port: BCM_CMD

Address: -1

Connected

drvInfo:

Reason: 0

Interface: asynOctet

Error:

Connected

Enabled

noAutoConnect

traceMask: 0x1

traceIOMask: 0x4

80 Truncate size

traceInfoMask: 0x1

Trace file: Unknown

Typical source file arrangement

- Instrument support is placed in

```
.../modules/instrument/<instrumentname>/Rx.y/
```

- Each `<instrumentname>/Rx.y/` directory contains at least

```
Makefile
configure/
<InstrumentName>Sup/
documentation/
License
```

Script to make this a little easier

- `mkdir /…/modules/instrument/`*`myinst`*`/head`
- `cd /…/modules/instrument/`*`myinst`*`/head`
- *`/<path to ASYN support mopdule>`*`/bin/`*`<arch>`*`/makeSupport.pl -t streamSCPI `*`myinst`*

```
Makefile
configure/...
myinstSup/
   Makefile devmyinst.db devmyinst.proto
documentation/
  devmyinst.html
```

- A few changes to the latter 3 files and you’re done!
- Notice that there are no C or C++ files.
  - Running `make` just copies the `.db` and `.proto` files to the support module top-level `db/` directory.

Introduction to Stream Device

- Generic EPICS device support for devices with “byte stream” communication.
  - RS-232 (Local serial port or LAN/Serial adapter)
  - TCP/IP
  - VXI-11
  - GPIB (Local interface or LAN/GPIB adapter)
  - USB-TMC (Test and Measurement Class)
- A single stream device module can serve to communicate using any of the above communication mechanisms.

Introduction to Stream Device

- Command/reply messages:
  - *IDN?
  - SET:VOLT 1.2
  - Non-ASCII ‘strings’ too
- Command generation and reply parsing configured by ***protocols***
- Formatting and interpretation handled with ***format converters***
  - Similar to C printf/scanf format strings
  - Custom converters too, but not easy

Stream Device ***Protocols***

- Defined in *protocol files*
- Plain ASCII text file
- No compiling – IOC reads and interprets protocol file(s) at startup
- Protocols are linear
  - No looping
  - No conditionals
  - Rudimentary exception handlers
- A single entry can read/write multiple fields in one or many records
- Output records can be initialized from instrument at IOC startup
  - With one big caveat – instrument must be on and communicating at IOC startup

StreamDevice EPICS Database

```
record(bo, "$(P)$(R)CLS") {
    field(DESC, "SCPI Clear status")
    field(DTYP, "stream")
    field(OUT,  "@devmyInst.proto cmd(*CLS) $(PORT) $(A)")
}
record(longin, "$(P)$(R)GetSTB") {
    field(DESC, "SCPI get status byte")
    field(DTYP, "stream")
    field(INP,  "@devmyInst.proto getD(*STB) $(PORT) $(A)")
}
```

- DTYP=stream
- INP/OUT fields specify protocol file name, protocol entry (with optional arguments), ASYN port and address.
- Address can be any value (typically 0) for single-address interfaces.

StreamDevice Protocol File

```
cmd {
    out "\$1";
}
getD {
    out "\$1?";
    in "%d";
}
```

- Protocol entries contain statements to produce output and request input
- C-style escape sequence can be used ('\r', '\n', '\033', '\e')
- Format converters are similar to those used by C printf/scanf
    - By default the VAL or RVAL field is used as the data source/destination
    - Can refer to any field, even in another record

StreamDevice Additional Records

DTYP ≠ stream for protocol entry additional records:

```
record(stringin, "$(P)$(R)Serial")
{
    field(DESC, "Serial number")
    field(DTYP, "Soft Channel")
}
record(ai, "$(P)$(R)VP5")
{
    field(DESC, "+5V supply")
    field(DTYP, "Raw Soft Channel")
    field(EGU,  "V")
    field(PREC, "3")
    field(LINR, "SLOPE")
    field(ESLO, "1e-3")
…
record(longin, "$(P)$(R)Temp1")
{
    field(DESC, "Sensor 1 temperature")
    field(DTYP, "Soft Channel")
```

StreamDevice Protocol File

Protocol entries can be long – Use multiple lines and string concatentation to improve readability

```
query {
    out "Q";
    in ":"
       "SN=%(\$1Serial.VAL)39[^,],"
       "UN=%(\$1Name.VAL)39[^,],"
       "IP=%*[^,],"
       "V3=%d,"
       "V5=%(\$1VP5.RVAL)d,"
       "V+12=%(\$1VP12.RVAL)d,"
       "V-12=%(\$1VM12.RVAL)d,"
       "T1=%(\$1Temp1.VAL)d,"
       …
       "POH=%(\$1HoursOn.VAL)g,"
       "MAXTMP=%(\$1MaxTemp.VAL)g;"
}
```

Notice the use of the width field – guard against buffer overruns!

StreamDevice Protocol File – Terminators

- Terminators can be set globally or per entry.
- Some interfaces can handle only a single character. If device replies with '\r\n' then specify `InTerminator='\n'` and ignore the '\r' in the reply.

```
InTerminator = "\n";
OutTerminator = "\r";
```

StreamDevice Protocol File – Initial Readback

- Useful to set initial value of output records to match the value presently in the instrument.
- @init ‘exception handler’
- Often the same as the corresponding readback prototype entry

```
getF {
    out "\$1?";
    in "%f";
}
setF {
    @init { out "\$1?"; in "%f"; }
    out "\$1 %f";
}


record(ao, "$(P)$(R)IntegrationTime")
{
    field(DESC,"Reading integration time")
    field(DTYP,"stream")
    field(OUT, "@devKeithley6487.proto setF(NPLC) $(PORT) $(A)")
```

Adding StreamDevice/ASYN instrument support to an application

- This is easy because the instrument support developers always follow all the guidelines – right?
- Most of these steps apply to pretty much any support module, not just StreamDevice/ASYN instruments.

Make some changes to configure/RELEASE

- Edit the configure/RELEASE file created by makeBaseApp.pl
- Confirm that the EPICS_BASE path is correct
- Add entries for the instruments and ASYN:

```
DAWN_RUSH =/usr/local/epics/R3.14.12/modules/instrument/DawnRuSH/R1-0
ASYN      =/usr/local/epics/R3.14.12/modules/soft/asyn/asynR4-21
EPICS_BASE=/home/EPICS/base
```

Modify the application Makefile

```
xxx_DBD += base.dbd
xxx_DBD += stream.dbd
xxx_DBD += drvAsynIPPort.dbd
   (and/or drvAsynSerialPort.dbd, drvAsynUSBTMC.dbd, etc.)
xxx_DBD += asyn.dbd

xxx_LIBS += stream asyn
```

Modify the application database Makefile

Copy the instrument support database and prototype files to the application <top>/db/ directory:

```
DB_INSTALLS += $(DAWN_RUSH)/db/devDawnRuSH.db
DB_INSTALLS += $(DAWN_RUSH)/db/devDawnRuSH.proto
```

Modify the application startup script

```
epicsEnvSet("CRATE_ADDRESS","$(CRATE_ADDRESS=crateapex01:23)")
```

(above line is optional, but makes it easy to override for testing)

```
epicsEnvSet("STREAM_PROTOCOL_PATH","${TOP}/db")
```

```
drvAsynIPPortConfigure("CR0","$(CRATE_ADDRESS) TCP",0,0,0)
```

```
dbLoadRecords("db/devDawnRuSH.db","P=apexCrate:,R=1:,PORT=CR0")
```

- P,R – PV name prefixes – PV names are (P)(R)name
- PORT– ASYN port name from corresponding dev*xxx*Configure command

Lab Session
Control ‘network-attached device’

- Host *www.xxx.yyy.zzz* – TCP Port 24742
- '\n' command terminator, '\r\n' reply terminator
- *IDN?
  - Returns device identification string (up to 100 characters)
- LOAD?
  - Returns three floating-point numbers separated by spaces (1, 5, 15 minute load average)
- ON?
  - Returns OFF/ON (0/1) status
- VOLTS?
  - Returns most recent voltage setting
- CURR?
  - Returns current readback (±11A)

Lab Session
Control ‘network-attached device’

- ON [*0*, *1*]
  - Turns supply OFF/ON (0/1)
- VOLTS *x.xxxx*
  - Sets voltage (±10V range)