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Introduction to the Channel Access Client Library

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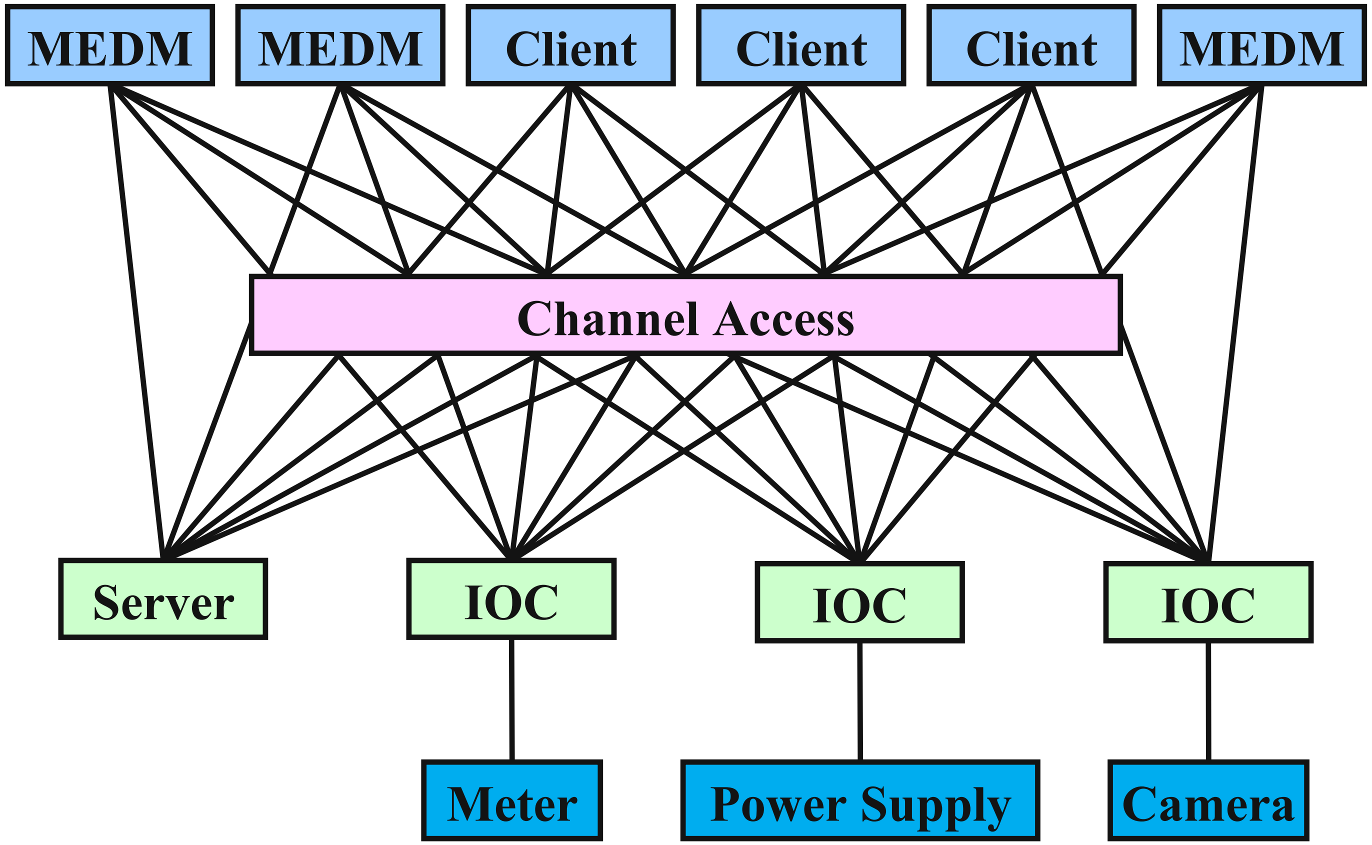
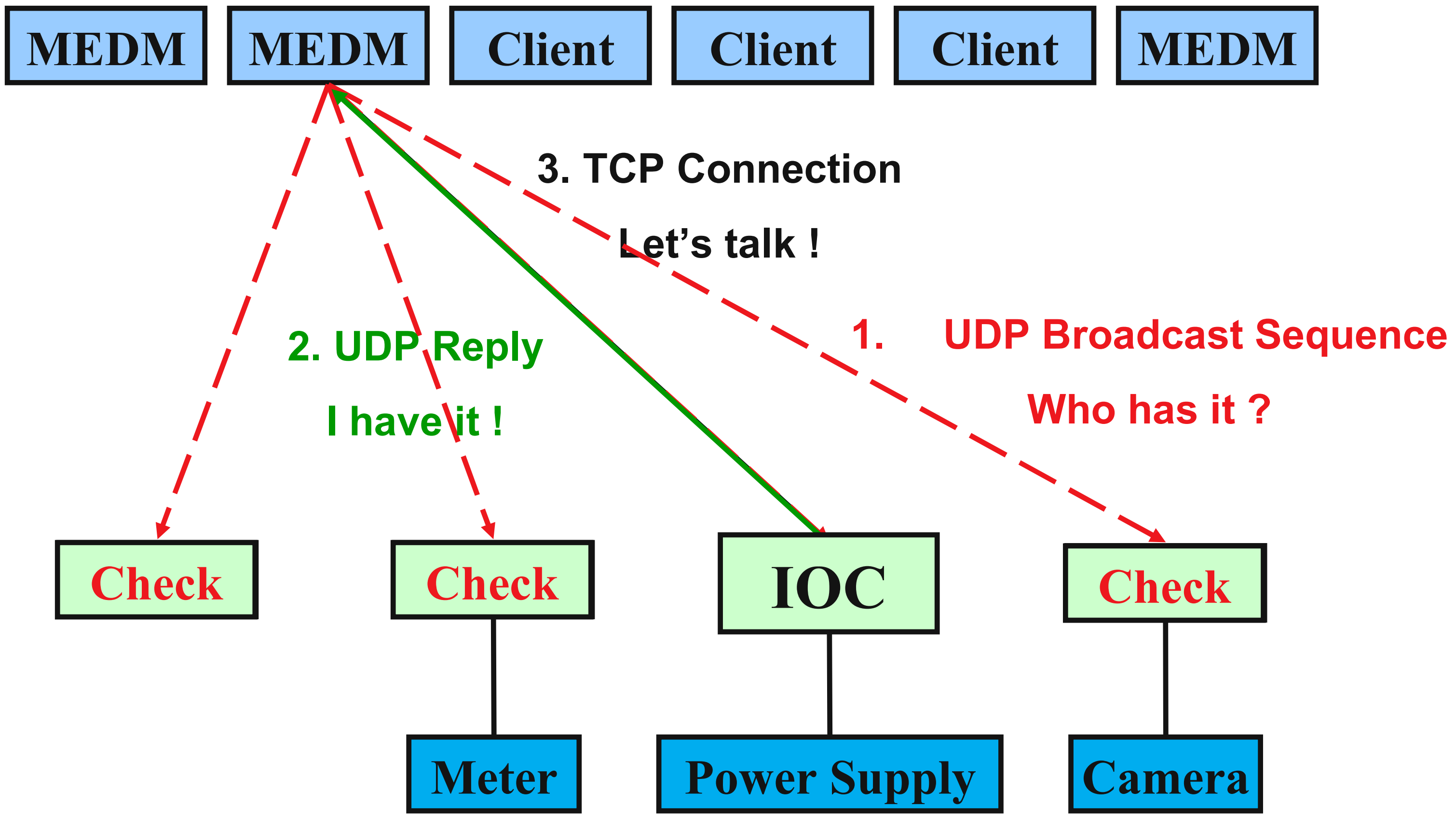
Channel Access Reference Manual

- The place to go for more information
- Found in the EPICS web pages
  - http://www.aps.anl.gov/epics/index.php
  - Look under Documents
  - Also under Base, then a specific version of Base

EPICS Overview

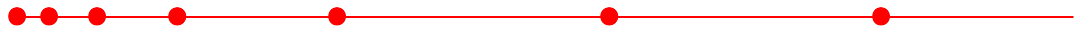


Search and Connect Procedure



Search Request

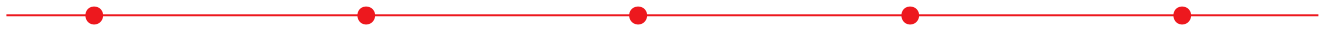
- A search request consists of a sequence of UDP packets
  - Only goes to EPICS_CA_ADDR_LIST
  - Starts with a small interval (30 ms), that doubles each time
  - Until it gets larger than 5 s, then it stays at 5 s
  - Stops after 100 packets or when it gets a response
  - Never tries again until it sees a beacon anomaly or creates a new PV
  - Total time is about 8 minutes to do all 100



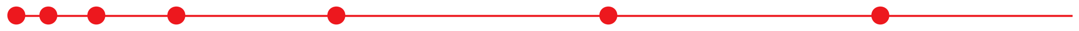
- Servers have to do an Exist Test for each packet
- Usually connects on the first packet or the first few
- Non-existent PVs cause a lot of traffic
  - Try to eliminate them

Beacons

- A Beacon is a UDP broadcast packet sent by a Server
- When it is healthy, each Server broadcasts a UDP beacon at regular intervals (like a heartbeat)
  - EPICS_CA_BEACON_PERIOD, 15 s by default



- When it is coming up, each Server broadcasts a startup sequence of UDP beacons
  - Starts with a small interval (25 ms, 75 ms for VxWorks)
  - Interval doubles each time
  - Until it gets larger than 15 s, then it stays at 15 s
    - *Takes about 10 beacons and 40 s to get to steady state*



- Clients monitor the beacons
  - Determine connection status, whether to reissue searches

Virtual Circuit Disconnect

- 3.13 and early 3.14
  - Hang-up message or no response from server for 30 sec.
  - If not a hang-up, then client sends “Are you there” query
  - If no response for 5 sec, TCP connection is closed
  - MEDM screens go white
  - Clients reissue search requests
- 3.14.5 and later
  - Hang-up message from server
  - TCP connection is closed
  - MEDM screens go white
  - Clients reissue search requests

Virtual Circuit Unresponsive

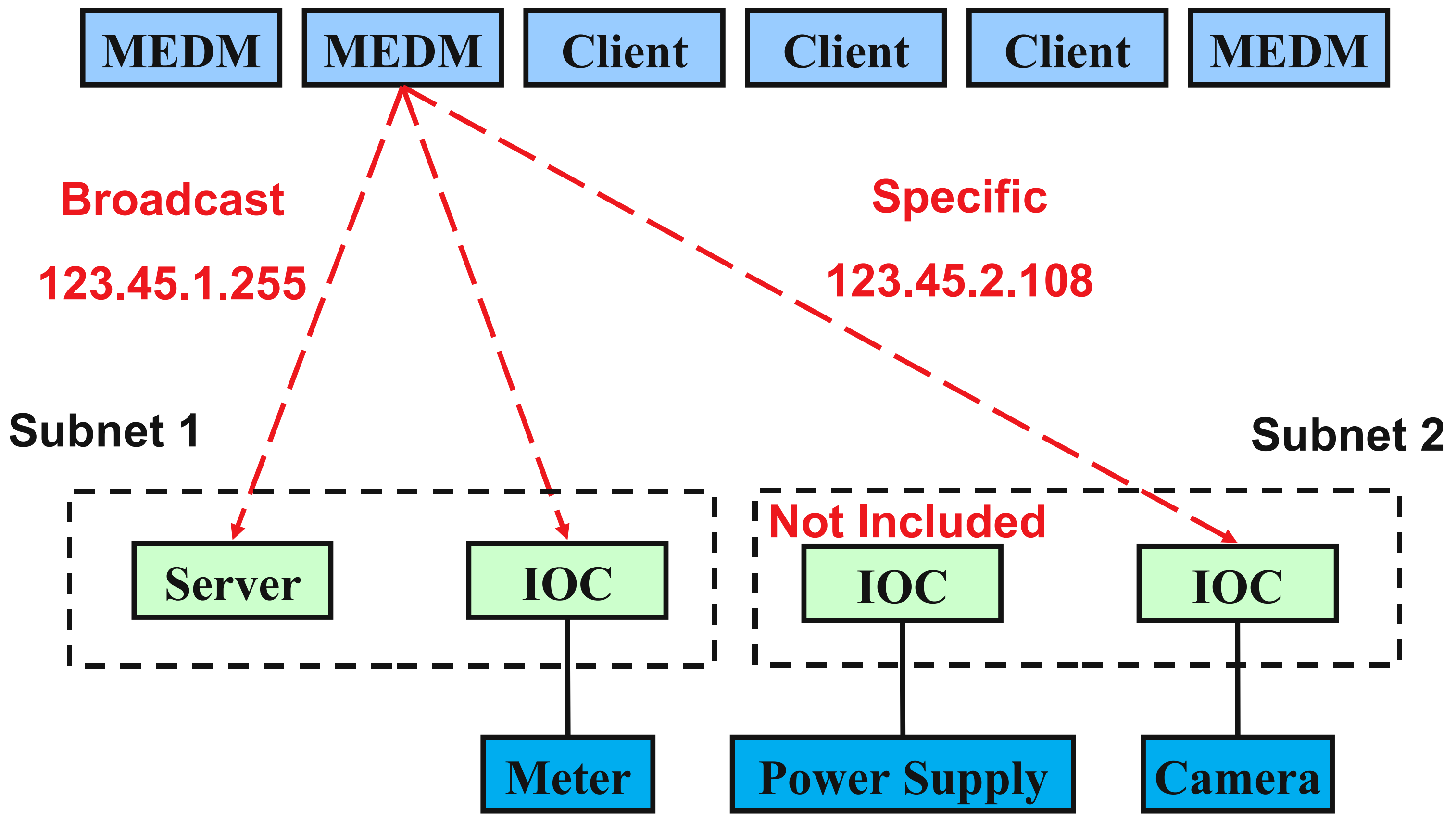
- 3.14.5 and later
  - No response from server for 30 sec.
  - Client then sends “Are you there” query
  - If no response for 5 sec, TCP connection is not closed
    - *For several hours, at least*
  - MEDM screens go white
  - Clients do not reissue search requests
    - *Helps with network storms*

  - Clients that do not call ca_poll frequently get a virtual circuit disconnect even though the server may be OK
    - *Clients written for 3.13 but using 3.14 may have a problem*
    - *May be changed in future versions*

Important Environment Variables

- EPICS_CA_ADDR_LIST
  - Determines where to search
  - Is a list (separated by spaces)
    - *“123.45.1.255 123.45.2.14 123.45.2.108”*
  - Default is broadcast addresses of all interfaces on the host
    - *Works when servers are on same subnet as Clients*
  - Broadcast address
    - *Goes to all servers on a subnet*
    - *Example: 123.45.1.255*
    - *Use ifconfig –a on UNIX to find it (or ask an administrator)*
- EPICS_CA_AUTO_ADDR_LIST
  - YES: Include default addresses above in searches
  - NO: Do not search on default addresses
  - If you set EPICS_CA_ADDR_LIST, usually set this to NO

EPICS_CA_ADDR_LIST



Other Environment Variables

- CA Client

EPICS_CA_ADDR_LIST
EPICS_CA_AUTO_ADDR_LIST
EPICS_CA_CONN_TMO
EPICS_CA_BEACON_PERIOD
EPICS_CA_REPEATER_PORT
EPICS_CA_SERVER_PORT
EPICS_CA_MAX_ARRAY_BYTES
EPICS_TS_MIN_WEST

- CA Server

EPICS_CAS_SERVER_PORT
EPICS_CAS_AUTO_BEACON_ADDR_LIST
EPICS_CAS_BEACON_ADDR_LIST
EPICS_CAS_BEACON_PERIOD
EPICS_CAS_BEACON_PORT
EPICS_CAS_INTF_ADDR_LIST
EPICS_CAS_IGNORE_ADDR_LIST

- See the Channel Access Reference Manual for more information

Channel Access

- The main CA client interface is the "C" library that comes with EPICS base
  - Internally uses C++, but API is pure C.
- Almost all other CA client interfaces use that C library
  - Exception: New pure Java JAC

Basic Procedure for a Channel Access Client

- Initialize Channel Access
  - ca_task_initialize or ca_context_create
- Search
  - ca_search_and_connect or ca_create_channel
- Do get or put
  - ca_get or ca_put
- Monitor
  - ca_add_event or ca_create_subscription
- Give Channel Access a chance to work
  - ca_poll, ca_pend_io, ca_pend_event
- Clear a channel
  - ca_clear_channel
- Close Channel Access
  - ca_task_exit or ca_context_destroy

makeBaseApp.pl

- Includes a template for basic CA client in C:
  - Start with this:
    ```
    makeBaseApp.pl -t caClient cacApp
    make
    ```
  - Result:
    ```
    bin/linux-x86/caExample <some PV>
    bin/linux-x86/caMonitor <file with PV list>
    ```
  - Then read the sources, compare with the reference manual, and edit/extend to suit your needs.

makeBaseApp's caExample.c

- Minimal CA client program.
  - Fixed timeout, waits until data arrives.
  - Requests everything as 'DBR_DOUBLE'.
    - *… which results in values of C-type 'double'.*
    - *See db_access.h header file for all the DBR_… constants and the resulting C types or structures.*
    - *In addition to the basic DBR_<type> requests, it is possible to request packaged attributes like DBR_CTRL_<type> to get { value, units, limits, …} in one request.*

Excerpt from db_access.h

```
/* values returned for each field type
&
 *      DBR_DOUBLE      returns a double precision floating point number
&
 *      DBR_CTRL_DOUBLE returns a control double structure (dbr_ctrl_double)
 */
&
/* structure for a control double field */
struct dbr_ctrl_double{
        dbr_short_t     status;                 /* status of value */
        dbr_short_t     severity;               /* severity of alarm */
        dbr_short_t     precision;              /* number of decimal places */
        dbr_short_t     RISC_pad0;              /* RISC alignment */
        char            units[MAX_UNITS_SIZE];  /* units of value */
        dbr_double_t    upper_disp_limit;       /* upper limit of graph */
        dbr_double_t    lower_disp_limit;       /* lower limit of graph */
        dbr_double_t    upper_alarm_limit;
        dbr_double_t    upper_warning_limit;
        dbr_double_t    lower_warning_limit;
        dbr_double_t    lower_alarm_limit;
        dbr_double_t    upper_ctrl_limit;       /* upper control limit */
        dbr_double_t    lower_ctrl_limit;       /* lower control limit */
        dbr_double_t    value;                  /* current value */
};
```

makeBaseApp's caMonitor.c

- Better CA client program.
  - Registers callbacks to get notified when connected ot disconnected
  - Subscribes to value updates instead of waiting.
  - … but still uses the same data type (DBR_STRING) for everything.

Ideal CA client?

- Use callbacks for everything
  - no idle 'wait', no fixed time outs.
- Upon connection, check the channel's *native* type (int, double, string, …)
  - to limit the type conversion burden on the IOC.
- … request the matching DBR_CTRL_<type> *once*
  - to get the full channel detail (units, limits, …).
- … and then subscribe to DBR_TIME_<type> to get updates of only time/status/value
  - so now we always stay informed, yet limit the network traffic.
  - *Only subscribe once*, not with each connection, because CA client library will automatically re-activate subscriptions!
- This is what EDM, archiver, … do.
  - Quirk: They don't learn about online changes of channel limits, units, ….
    Doing that via a subscription means more network traffic, and CA doesn't send designated events for 'meta information changed'.

Side Note: SNL just to get CAC help

- This piece of SNL handles all the connection management and data type handling:

```
double value;
assign value to "fred";
monitor value;
```

- Extend into a basic 'camonitor':

```
evflag changed;
sync value changed;

ss monitor_pv
{
   state check
   {
       when (efTestAndClear(changed))
       {
           printf("Value is now %g\n", value);
       } state check
   }
}
```

Quick Hacks, Scripts

- In many cases, one can get by just fine by invoking the command-line 'caget' from within bash/perl/python/php.
- Especially if you only need to read/write one value of a PV, not a subscription!
- There are more elaborate CAC bindings available for perl/python/php
  - But that means you have to find, build and later maintain these!
  - A basic p* script is portable, but you'd have to install the CAC-for-p* binding separately for Linux, Win32, MacOS…

Perl Example

```
use English;

# Get the current value of a PV
# Argumment: PV name
# Result: current value
sub caget($)
{
    my ($pv) = @ARG;
    open(F, "caget -t $pv |") or die "Cannot run 'caget'\n";
    $result=<F>;
    close(F);
    chomp($result);
    return $result;
}

# Do stuff with PVs
$fred = caget("fred");
$jane = caget("jane");
$sum = $fred + $jane;
printf("Sum: %g\n", $sum);
```

Matlab 'MCA' Extension (Works with Octave as well)

- Same setup & maintenance issue as for p/p/p!
  - … but may be worth it, since Matlab adds tremendous number crunching and graphing.
- Initial setup
  - Get MCA sources (see links on APS EPICS web)
  - Read the README, spend quality time with MEX.
- Assume that's done by somebody else
  - You are in the SNS control room
  - 'caget' from EPICS base works
  - Matlab works (try "matlab -nojvm -nodesktop")
- Do this once:

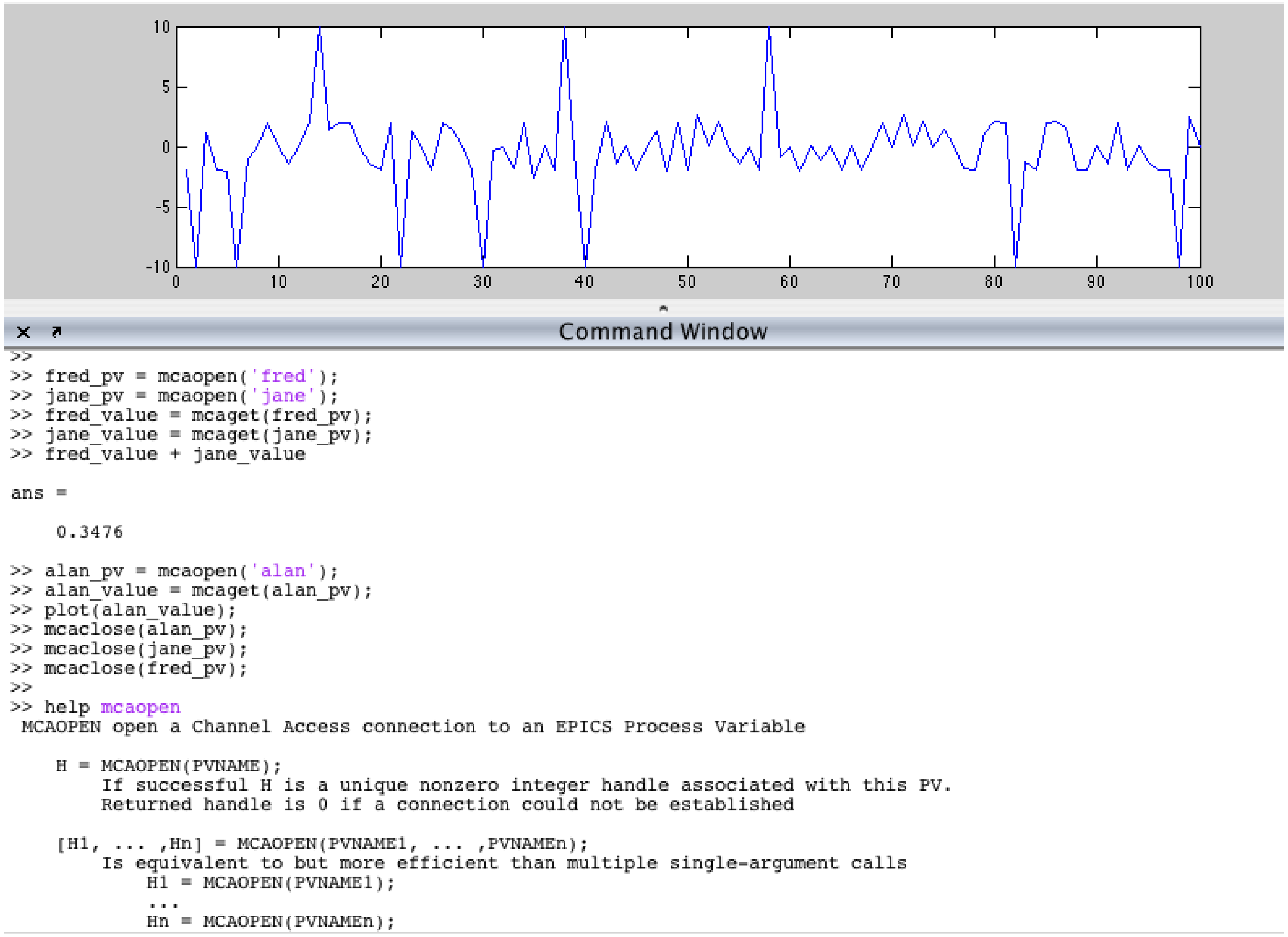
```
cd $EPICS_EXTENSIONS/src/mca
source setup.matlab
```

  - … and from now on, Matlab should include MCA support

MCA Notes

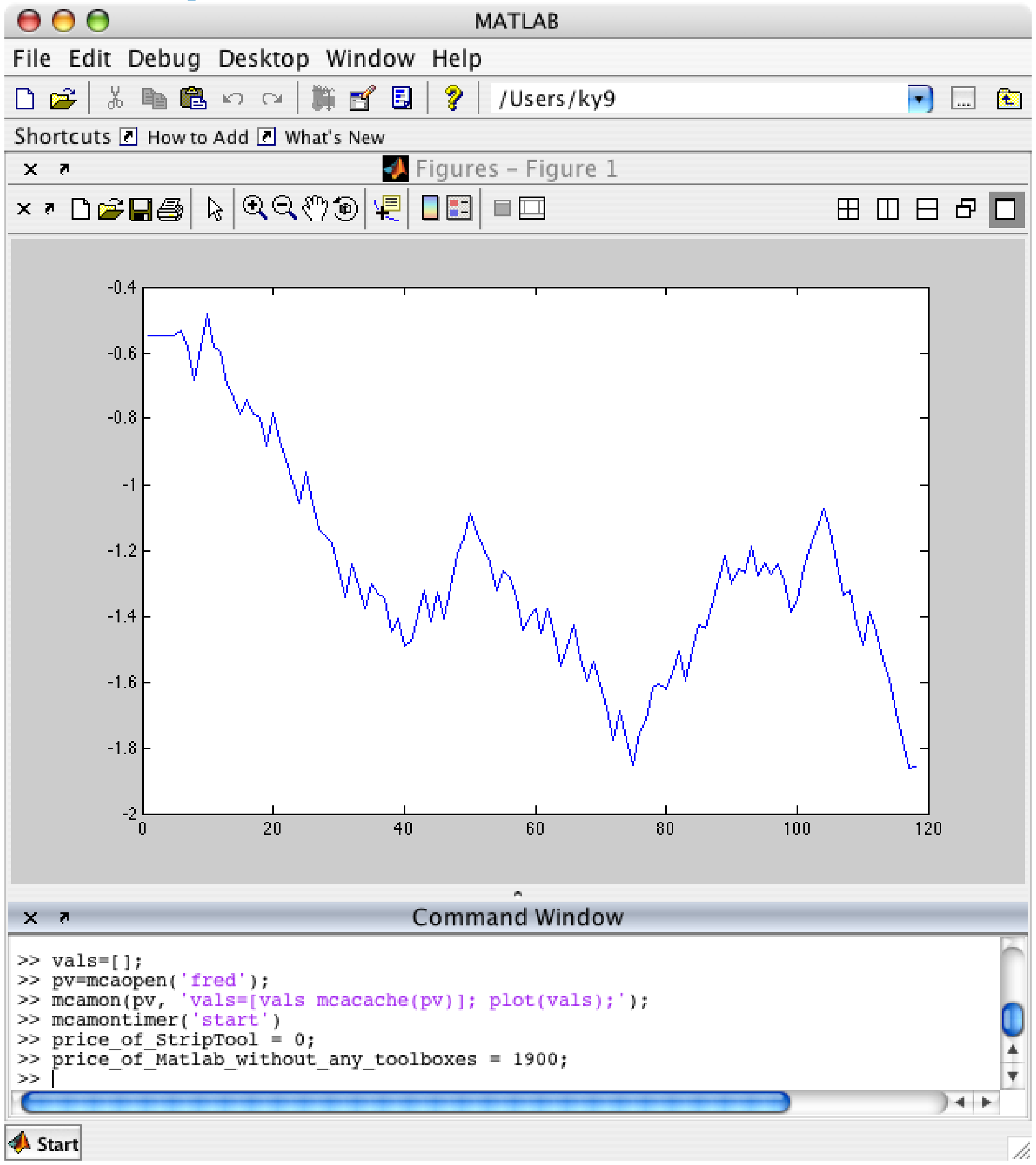
- Basically, it's a chain of
  - pv = mcaopen('some_pv_name');
  - value = mcaget(pv);
  - mcaput(pv, new_value);
  - mcaclose(pv);
- Your pv is 'connected' from ..open to ..close
  - When getting more than one sample, staying connected is much more efficient than repeated calls to 'caget'.
- Try 'mca<tab>' command-line completion to get a list of all the mca… commands
- Run 'help mcaopen' etc. to get help

Matlab/MCA Examples



```
>>
>> fred_pv = mcaopen('fred');
>> jane_pv = mcaopen('jane');
>> fred_value = mcaget(fred_pv);
>> jane_value = mcaget(jane_pv);
>> fred_value + jane_value

ans =

    0.3476

>> alan_pv = mcaopen('alan');
>> alan_value = mcaget(alan_pv);
>> plot(alan_value);
>> mcaclose(alan_pv);
>> mcaclose(jane_pv);
>> mcaclose(fred_pv);
>>
>> help mcaopen
 MCAOPEN open a Channel Access connection to an EPICS Process Variable

    H = MCAOPEN(PVNAME);
        If successful H is a unique nonzero integer handle associated with this PV.
        Returned handle is 0 if a connection could not be established

    [H1, ... ,Hn] = MCAOPEN(PVNAME1, ... ,PVNAMEn);
        Is equivalent to but more efficient than multiple single-argument calls
            H1 = MCAOPEN(PVNAME1);
            ...
            Hn = MCAOPEN(PVNAMEn);
```

MCA Value Subscription


MATLAB
File Edit Debug Desktop Window Help
/Users/ky9
Shortcuts How to Add What's New
Figures - Figure 1
Command Window
Start

```
>> vals=[];
>> pv=mcaopen('fred');
>> mcamon(pv, 'vals=[vals mcacache(pv)]; plot(vals);');
>> mcamontimer('start')
>> price_of_StripTool = 0;
>> price_of_Matlab_without_any_toolboxes = 1900;
>>
```

Java

- There is actually a JNI and a pure Java binding.
  - Only difference in initialization, then same API.
  - Usage very much like C interface, "real programming" as opposed to Matlab, but in a more forgiving Java VM.
- See Docs/Java CA example.

Acknowledgements

- Channel Access on every level in detail:
  - Jeff Hill (LANL)
- makeBaseApp.pl
  - Ralph Lange (BESSY) and others
- MCA
  - Andrei Terebilo (SLAC) is the original author,
  - Carl Lionberger maintained it for a while (then SNS)
- Java CA
  - Eric Boucher is the original author (then APS),
  - Matej Sekoranja maintains it;
    he added the pure java version (Cosylab)