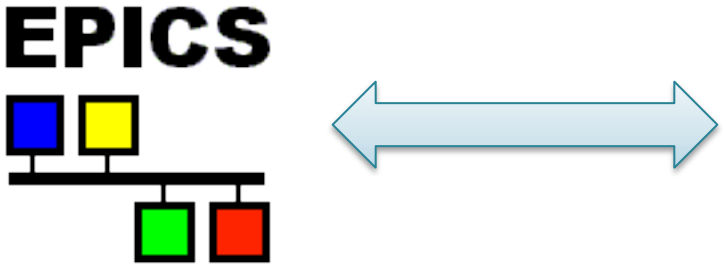
# EPICS EtherIP Driver






EtherNet/IP

**Kay Kasemir**

kasemirk@ornl.gov

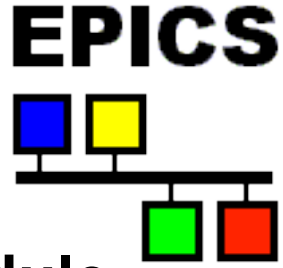
**Sept. 2014**

# EtherNet/IP ?

- **Industrial Protocol, a.k.a.**
  - **ControlNet-over-Ethernet**
  - **TCP encapsulation of CIP (Control & Information Protocol)**
- **Open DeviceNet Vendor Association (ODVA)**

**Routing, messages, objects, services, data types**

# EPICS “ether-ip” Support




## EtherNet/IP spec:

- ✓ Connect & read serial number of ENET module

## Allen Bradley 1756-RM005A-EN-E.pdf:

- ✓ Read & write PLC tags

## EPICS support:

- ✓ IOC records read/write

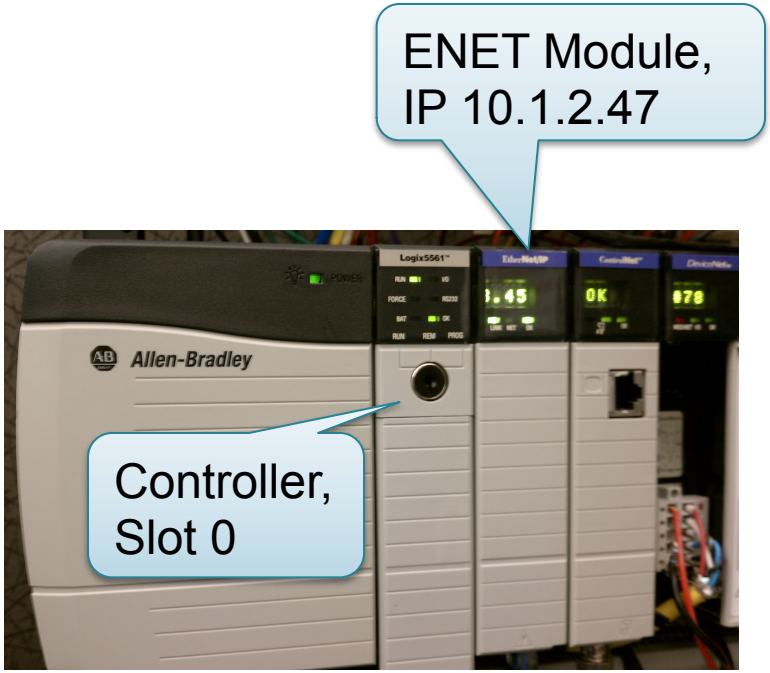
# History, Status

- Developed ~2000 for SNS
  - Key to its operation: Vacuum, cryo, water, …
  - Now used by many EPICS sites
- Convenient
  - Compared to serial, ControlNet, …:
    No special interface hardware nor wiring
  - Can read/write any tag on the PLC, no “publish”
  - “Fast enough”
- Supports AllenBradley ControlLogix, CompactLogix

# PLC Requirements

- **ENET Module**
  - **Know the IP address**
  - **Know the CPU slot number**

    **One PLC could have multiple controllers!**
- **Tags**
  - **Know tag names**
  - **"Controller" level, not! private to program**
  - **No need to "produce"**




Program Tags - MainProgram

Scope: MainProgram  Show: Show All  Sort: Tag Nam

| Tag Name | Alias For | Base Tag | Type |
|---|---|---|---|
| north_tank_mix | | | BOOL |
| north_tank_pressure | | | REAL |
| north_tank_temp | | | REAL |
| +-one_shots | | | DINT |
| +-recipe | | | TANK[3] |
| +-recipe_number | | | DINT |
| replace_bit | | | BOOL |
| +-running_hours | | | COUNTER |
| +-running_seconds | | | TIMER |
| start | | | BOOL |
| stop | | | BOOL |

Monitor Tags | Edit Tags

# EPICS Records

## Input Records (ai, bi, mbbi, mbbiDirect,  stringin)

```
field(DTYP, "EtherIP")
field(INP,  "@my_plc name_of_tag")
field(SCAN, "1 second”)
```

## Output Records (ao, bo, mbbo, mbboDirect)

```
field(DTYP, "EtherIP")
field(OUT,  "@my_plc name_of_tag")
```

# PLC Data Type ⇔ Record Type

REAL, INT, DINT ⇔ ai, ao (REAL?VAL:RVAL)

INT, DINT, BOOL[] ⇔ bi, bo, mbb*

BOOL ⇔ bi, bo

For arrays, access one element:

```
field(INP,"@my_plc my_array[42]")
```

For structures, access one element:

```
field(INP,"@my_plc gadget.ps.voltage")
```

# Starting the IOC: Development

**Type this on one line:**

```
eipIoc
   -p my_plc=10.1.2.47
   -m "P=MyPrefix,N=2"
   -d example.db
```

'softIoc' with EtherIP built in

`-p "name=ip,slot"`
Define PLC name for "@my_plc" in INP/OUT links,
IP address, optional CPU slot

`-m "macro=value"`
Define database macros

`-d path/to/some.db`
Load database

# Starting the IOC: Production Setup

## Add driver to ‘makeBaseApp’ type IOC:

configure/RELEASE:

```
ETHER_IP=/path/to/share/ether_ip
```

yourApp/src/Makefile:

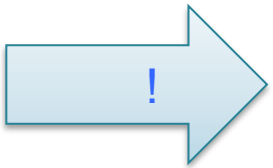
```
your_DBD += ether_ip.dbd
your_LIBS += ether_ip
```

iocBoot/iocYours/st.cmd:

```
drvEtherIP_init()
drvEtherIP_define_PLC("my_plc", "10.1.2.47", 0)
dbLoadRecords(…
```

# Arrays, Aliases

- Arrays are MUCH more effective
  - Read scalar REAL tag: 8ms
  - Read REAL[40]: 8ms
  - Read BOOL[352]: 8ms
  - Read 352 separate BOOL tags: ~352 * 8 ms
- Records with INP or OUT that access
  - INP="@plc my_array[2]"
  - INP="@plc my_array[39]"
  - → Driver reads my_array[0..39]




1. Arrange data in array tags
2. Configure INP/OUT to use array elements
3. May use alias tags within PLC logic

# Driver Combines Tags used by Records

## Records

1. INP “@plc1 arrayA[2]”, SCAN “2 second”
2. INP “@plc1 arrayA[3]”, SCAN “2 second”
3. INP “@plc1 arrayB[13]”, SCAN “1 second”
4. INP “@plc2 arrayA[2]”, SCAN “2 second”

## Driver

1. “plc”
   - Handle “arrayA[0-3]” every 2 seconds
   - Handle “arrayB[0-13]” every 1 second
2. “plc2”
   - Handle “arrayA[0-2]” every 2 seconds

# Reading, Writing, Scanning

## Records

1. INP “@plc array[2]”, SCAN “2 second”
2. INP “@plc array[3]”, SCAN “1 second”
3. INP “@plc array[13]”, SCAN “I/O Intr”
4. OUT “@plc array[5]”, SCAN “Passive”

## Driver

“array[0-13]” read every 1 second

1. Reads most recent value[2] every 2 seconds
2. .. [3] every 1 second, data may be 0.999 sec old
3. Processes whenever value [13] changes
4. Reads (though *output!*) when value [5] changes. When processed, updates value [5], marks whole tag for writing. Driver will then once *write* instead of read.

# Scan Flag “ S <seconds>”

## Records

1. INP “@plc array[2]”, SCAN “2 second”
2. INP “@plc array[3]”, SCAN “1 second”
3. INP “@plc array[13]”, SCAN “I/O Intr”
4. OUT “@plc array[5]”, SCAN “Passive”

## Driver

Uses the “fastest” SCAN of any record related to a tag.

Records 2 & 3 should add “@plc array[..] S 1” to provide suggested scan period, otherwise warning

```
“cannot decode SCAN field, no scan flag given”
```

# Elementary “ E” Flag

## Records

1. INP “@plc array[190]”
2. OUT “@plc array[191]”

## Driver

1. Reads array[0..191], but we may only use [190], [191]
   ➔
   “@plc array[190] E“ causes transfer of just that array element
2. Writes all of [0..191] even if just 191 was changed, *writing* elements which we otherwise wanted to *read*
   a) Use separate arrays for “writing” and “reading”
   b) Add “ E” to write just that element, not whole array

# Bitfiddly Stuff

**Internally, DINT and BOOL[32] look similar.**

**Driver assumes bit for binary records.**

`"some_tag[40]"`

a) **ai, ao:**
   **Element 40 of a REAL, INT, DINT array**

b) **bi, bo, mbb*:**
   **Bit 40 of a BOOL array,**
   **or**
   **bit 40 of a DINT array, i.e. bit 8 of DINT[1]**

   **To force [i] to be the $i^{th}$ array element:**
   `"some_tag[1] B 8"`

# Diagnosis on IOC

- **Set records' `TPRO` field**
  - **Show when tag is read/written by that record**
- **`drvEtherIP_dump`**
  - **Dumps all tags and their value**
- **`drvEtherIP_report` *`level`***
  - **Dumps info about each plc, period list, tag**
  - **Level 0..10**
- **`EIP_verbosity(7)`, `EIP_verbosity(10)`**
  - **Show warnings or details of protocol**

# The Elusive Buffer Limit

## Driver combines several reads and writes for tags into one network transfer until either the request or the response reaches `EIP_buffer_limit`

**How large? About 500 bytes, details hairy**

**Set too large**

→ PLC error "Buffer too small, partial data only"

**Set too small**

→ Inefficient, can't combine many tags

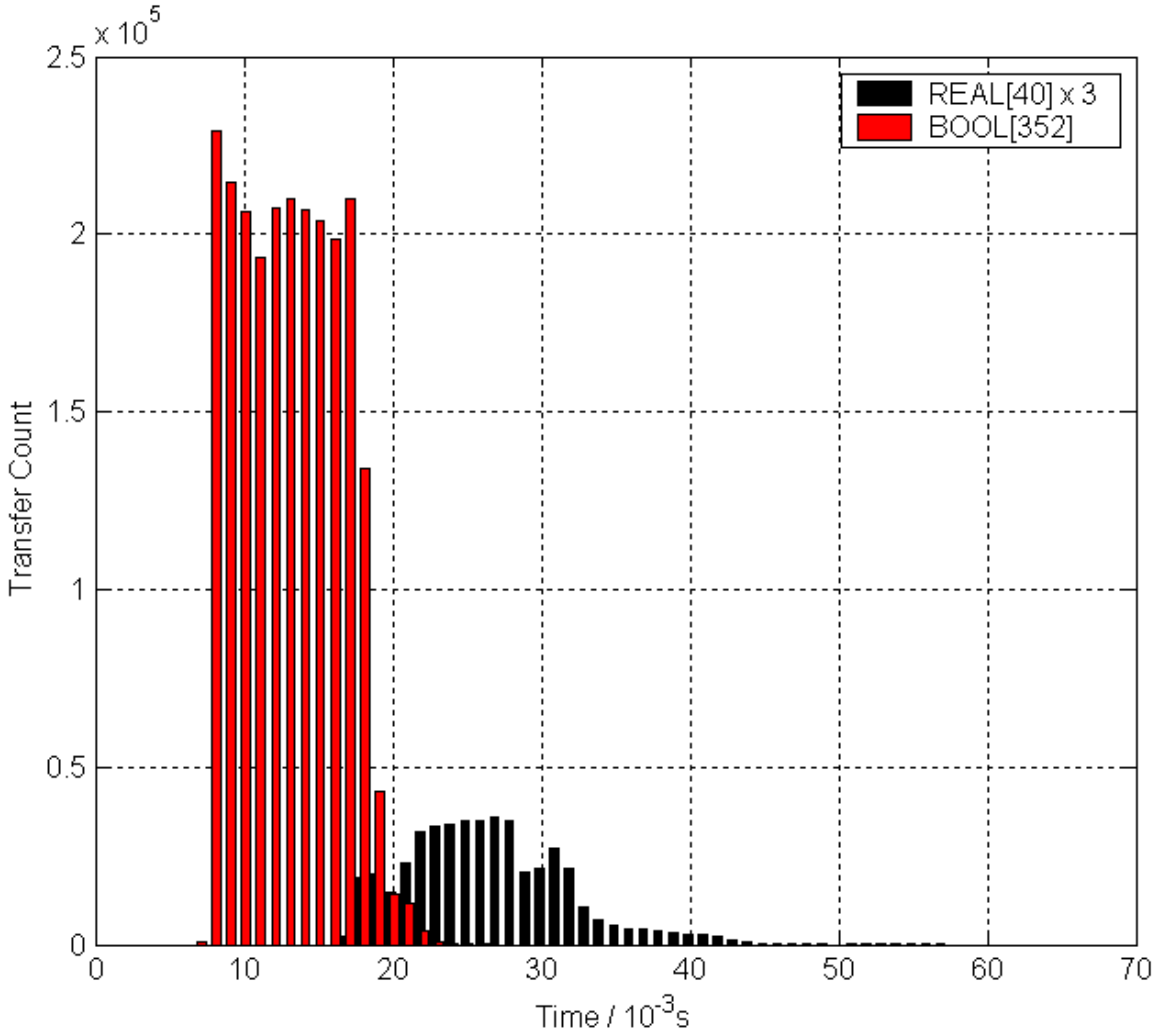
**Set way too small**

→Can't read a single REAL[40] array, driver error "Tag 'xyz' exceeds buffer limit of .. Bytes"

## Don't mess with the default EIP_buffer_limit.

## Keep arrays to REAL/DINT/INT[40] and BOOL[400]. Driver will then combine several of those in one transfer.

# Transfer Time Histogram




**352 BI @ 10Hz, 3 x REAL[40] @ 2 Hz**

# Summary

- Arrange PLC data in arrays
  - Separate ones for read, write
  - Maybe 40 elements per array (400 for BOOL)
- Point records' INP/OUT to those array tags
- Done