

EPICS VME/ControlNet Interface



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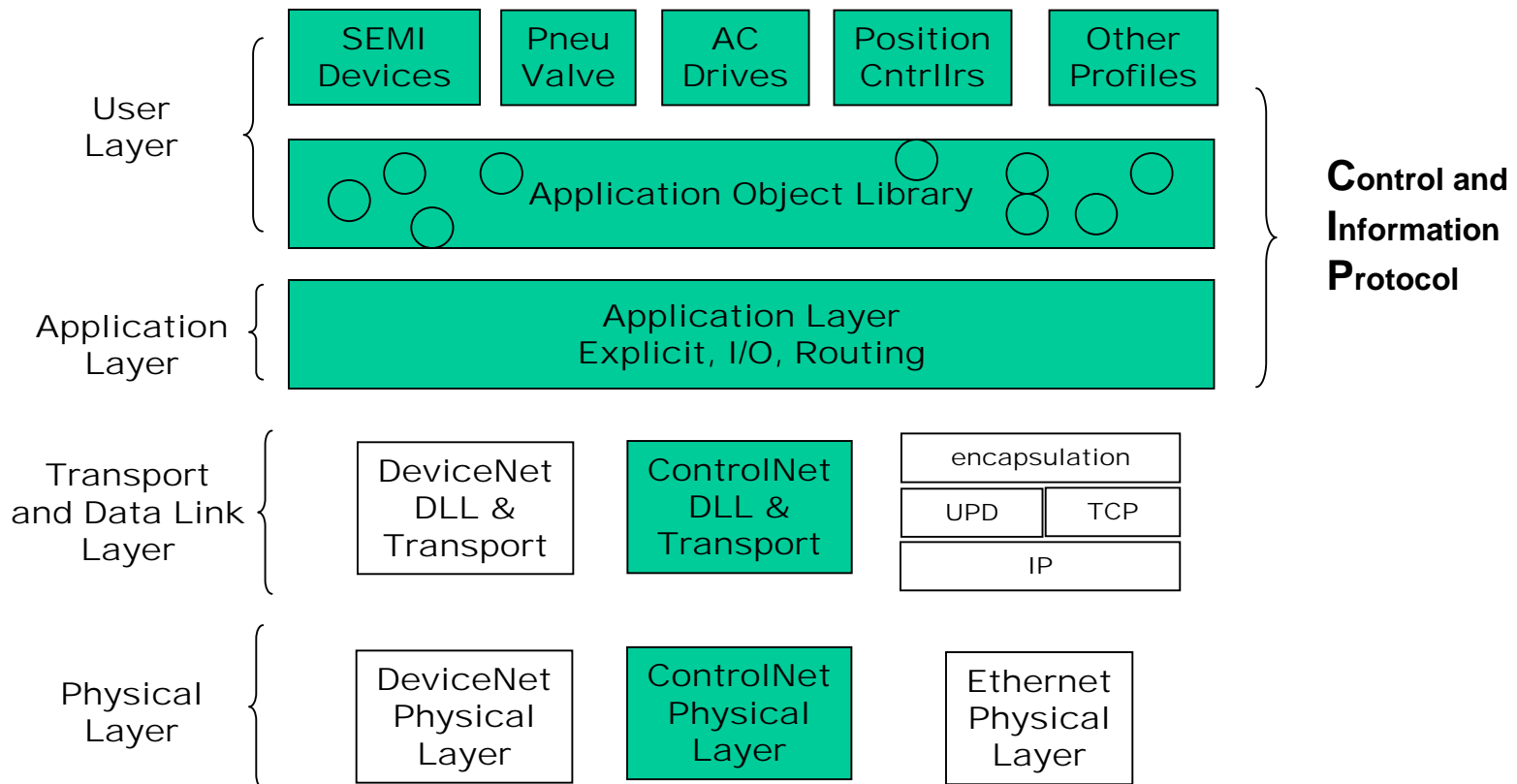
Subjects will be covered in this talk:

- ControlNet characteristics
- VME/ControlNet interface module features
- EPICS ControlNet support software
- The benefits to EPICS users

ControlNet Characteristics – *the protocol*



An open network for real-time control applications, represented by ControlNet International, Ltd. (www.controlnet.org) - an organization of Vendors (55+) and Users



ControlNet Characteristics – *the Media Access method*

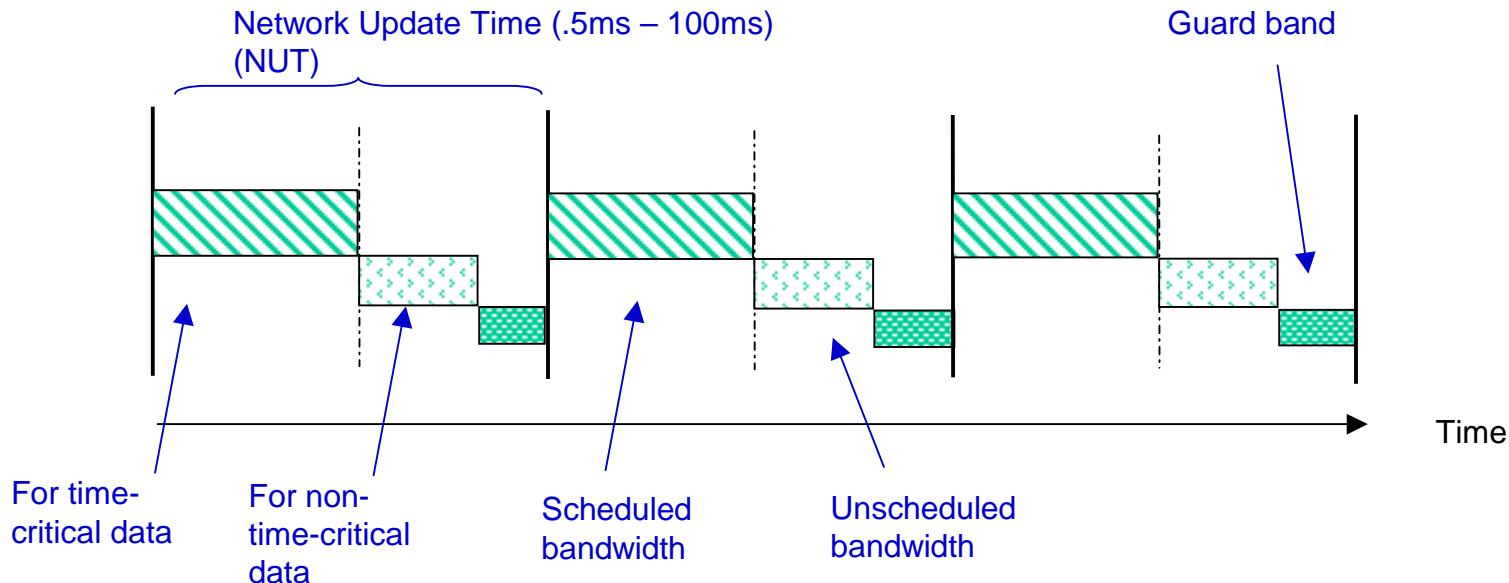


- Determinism and Repeatability guaranteed by the media access algorithm
 - There are two types of data moved on most control system
 - time-critical : real-time control data updates, peer to peer I/O interlocking
 - non-time-critical : connection establishment, peer to peer explicit messaging
 - It's desirable that real time control I/O is not impacted by the non-time-critical data transfers – priority scheme is necessary to accomplish this
 - Media Access Algorithms employed for the networks
 - DeviceNet uses **CSMA/NBA** (Carrier Sense Multiple Access w/Nondestructive Bitwise Arbitration)
 - ControlNet uses **CTDMA** (Concurrent Time Domain Multiple Access)
a time-slice algorithm which provides determinism and repeatability
 - Ethernet uses **CSMA/CD** (Carrier Sense Multiple Access w/Collision Detection)

ControlNet Characteristics – CTDMA Definitions



- Concurrent Time Domain Multiple Access (CTDMA)
 - Bandwidth is allocated based on the time critical nature of the data to be transmitted (Priority)
 - A time slice algorithm to ensure each node has one opportunity per NUT to “talk”

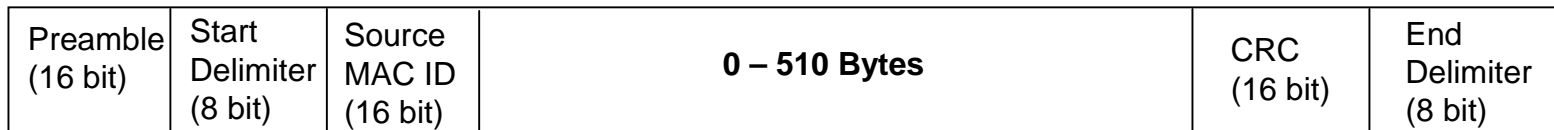


ControlNet Characteristics — *the data transfer method*

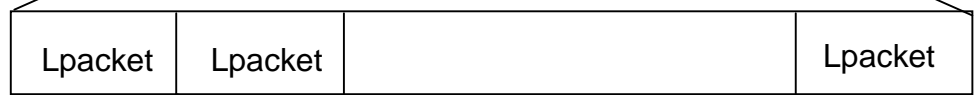


- Based on Producer / Consumer Model (*NOT source/destination model*)
 - A Producer is a sender of data
 - Producers transmit data (Lpackets) on the wire
 - A Consumer is a receiver of data
 - Any and all interested consumers can pick a particular Lpacket off the wire by filtering on the Identifier (CID)

ControlNet Packet Structure (MAC Frame)



DeviceNet: 8 byte frame
Ethernet: 1500 byte frame



- Each Lpacket may go to a different node on the network

VME/ControlNet Interface Module – features

ControlNet VME Interface Card

Part Number: 5136-CN-VME

The SST ControlNet card connects your VME bus computer to ControlNet.



Applications

- Scan ControlNet I/O
- Exchange data with other PLCs and devices over ControlNet
- Embedded PLCs/computers

Features

- **High performance**
 - 32-bit 1960 RISC CPU
 - Simultaneous operation of 128 scheduled and 128 unscheduled connections
 - Simultaneous functionality of ControlNet messaging, scanner and adapter

Hardware Specifications

- Intel i960 32-bit RISC 30 Mhz processor
- 1 Mbyte local 32-bit RAM
- 512 Kbytes of shared 16-bit RAM
- 512 Kbytes of 16-bit Flash memory
- Serial configuration port
- LAN Controller (no ControlNet ASICs used) is implemented in a field programmable gate array (FPGA)
 - FPGA executes all protocol activity, including scanning I/O, without intervention from 1960 processor
 - FPGA is software field upgradeable
- Network interface
 - 2 BNC connectors
 - ControlNet redundancy implemented in hardware on interface card
 - Standard ControlNet LEDs for each channel
- 5136-SD-VME DH+ Emulation
 - Supports standard PCCC messaging
- Power requirements: 400 mA @ 5 V
- Operational temperature: 0 to 50C (32 to 122° F)
- Storage temperature: -25 to 70C (-13 to 158° F)

VME Specifications

- Size: double height (6U), single width card using P1 connector compatible with ANSI/IEEE 1014
- Capabilities:
 - Memory: SD16, SD08 (E0), SD24
 - Byte ordering is software selectable
 - Registers: SD08(0), SA16
- Addressing:
 - Standard: 16 Kbytes on any 16 Kbyte boundary, or 512 Kbytes on any 512 Kbyte boundary
 - Short: 32 bytes on any 32 byte boundary
- Interrupts:
 - Software selected 1-7, or none
 - Software set 8 bit status/ID register
 - Release on acknowledge (ROAK)

VME/ControlNet EPICS Support – Design & Issues



Utilizing Shared RAM Application Interface for EPICS support module

Page Number (decimal)	Page Number (hex)	Offset (hex)	Description	Page Number (decimal)	Page Number (hex)	Offset (hex)	Description
0	0	00000	Main User Interface - Refer to section 2.2 SD Emulation ControlNet Interface	13	D	34000	File receive area
1	1	04000	RSLinx Interface	14	E	38000	File receive area
2	2	08000	Scheduled connection configuration object instances	15	F	3C000	File receive area
3	3	0C000	Unscheduled connection/unconnected control blocks	16	10	40000	Scheduled data area Rx
4	4	10000	CCO Parameter Data Area (used for variable length data in CONN_CNTRL blocks)	17	11	44000	Scheduled data area Rx
5	5	14000	CCO Parameter Data Area (used for variable length data in CONN_CNTRL blocks)	18	12	48000	Scheduled data area Tx
6	6	18000	Unscheduled Path Data Area	19	13	4C000	Scheduled data area Tx
7	7	1C000	Unscheduled Path Data Area	20	14	50000	Unscheduled message buffers
8	8	20000	File send area / PLC 5 file emulation	21	15	54000	Unscheduled message buffers
9	9	24000	File send area / PLC 5 file emulation	22	16	58000	Unscheduled message buffers
10	A	28000	File send area / PLC 5 file emulation	23	17	5C000	Unscheduled message buffers
11	B	2C000	File send area / PLC 5 file emulation	24 - end	-	-	Reserved
12	C	30000	File receive area				

- Monitoring VME module status (page 0)
- Get scheduled connection configuration (page 2)
- Real-time I/O (page 16-19)

VME/ControlNet EPICS Support – *Design & Issues (2)*



Endian Issues

- Power PC processors and VMEbus are inherently big-endian, while the ControlNet is inherently little-endian
- The module supports 2 bytes correction which takes care of most of IO modules today, while the driver takes care of up and low word swap for longs or floats for ControlLogix processors (4 bytes)

Contention Issues

- Both IOC and VME ControlNet Scanner may access same location of the RAM at one time
- Interlocking RAM access will hurt the performance (it can be an option for some applications)
- IOC twice consecutive reading verification is used to avoid contention.

IOC bump less reboot or VME power reset Issues

- sending triggers to VME ControlNet module on IOC init: *disable connections, set to scan and run mode, restore data in shared RAM, enable connections*
- configure remote I/O modules “hold data when lost communication and in program mode

VME/ControlNet EPICS Support – Design & Issues (3)



● EPICS record address and management Issues

- When number of records in an application goes up to hundreds or even few thousands, tools are needed to help EPICS record hardware address management which could impact on the reliability and the flexibility of a control system
- It's not practical to map one record to one connection since the number of connections for a scanner is limited. It is not efficient way to utilize the bandwidth.
- Mapping a group of records to one connection requires record-to-RAM-offset mapping.
- SST ControlNet configuration tool produces record-to-RAM-offset map which can be imported into a configuration database. A tool, like JLAB's "db2hw", can be used to fill up DTYP, INP and OUT fields of an application database template by querying the configuration database

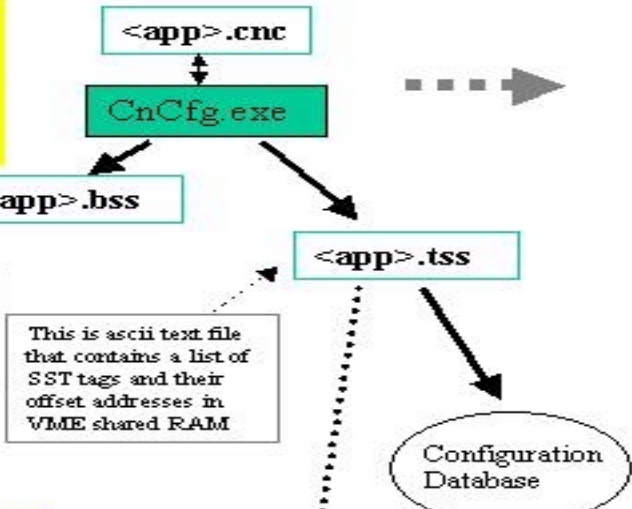
Devices	Connections
1756-CNB/CNBR	64 bi-directional
1756-ENET	16 bi-directional
1756-DNB	2 bi-directional
5136-CN-VME	128 scheduled / 128 unscheduled

VME/ControlNet EPICS Support – Address Mapping

Using VME ControlNet EPICS Support

1. Configure ControlNet Network with SST's <CnCfg> tool

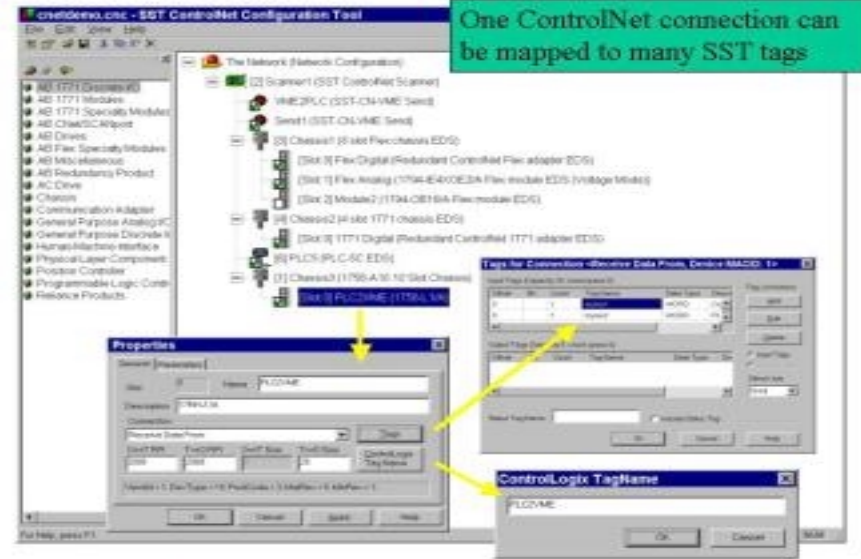
This is CNET configuration file to be downloaded onto SST 5136-CN-VME module



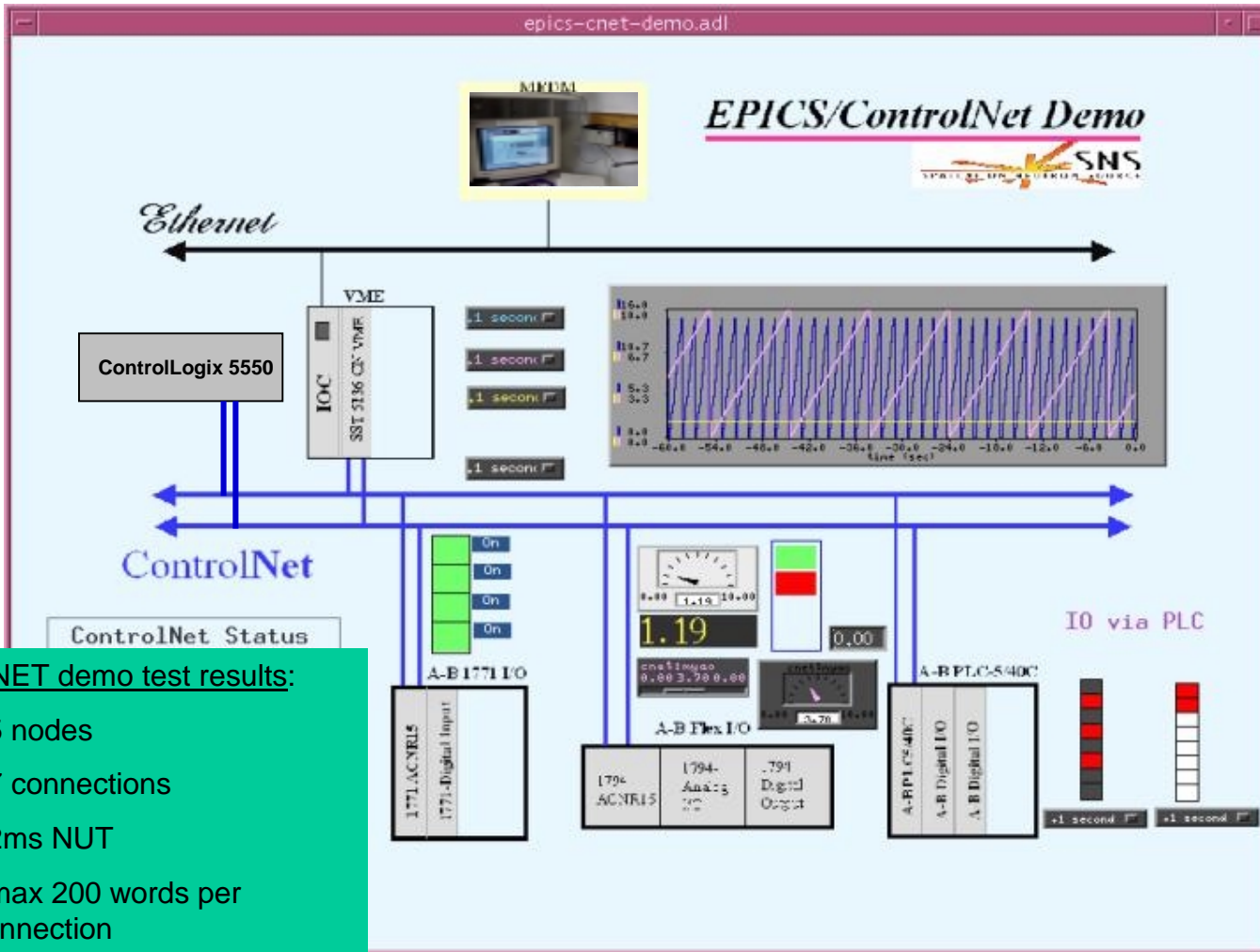
This is ascii text file that contains a list of SST tags and their offset addresses in VME shared RAM

2. Add hardware addresses into EPICS database template with JLAB's <db2hw> tool

Fill up DTYP INP OUT fields



VME/ControlNet EPICS Support – Product



Currently Tested hardware

- PLC5c
- ControlLogix 5550
- Flex IOs w/ 1794-ACNR15:
 - 1794-Analog
 - 1794-Digital
- 1771-IOs w/ 1771-ACNR15:
 - 1771-Digital
- with Power PC 2300 IOC
- with EPICS 3.13.3 & Tornado II
- with EPICS 3.13.1.1 & Tornado I

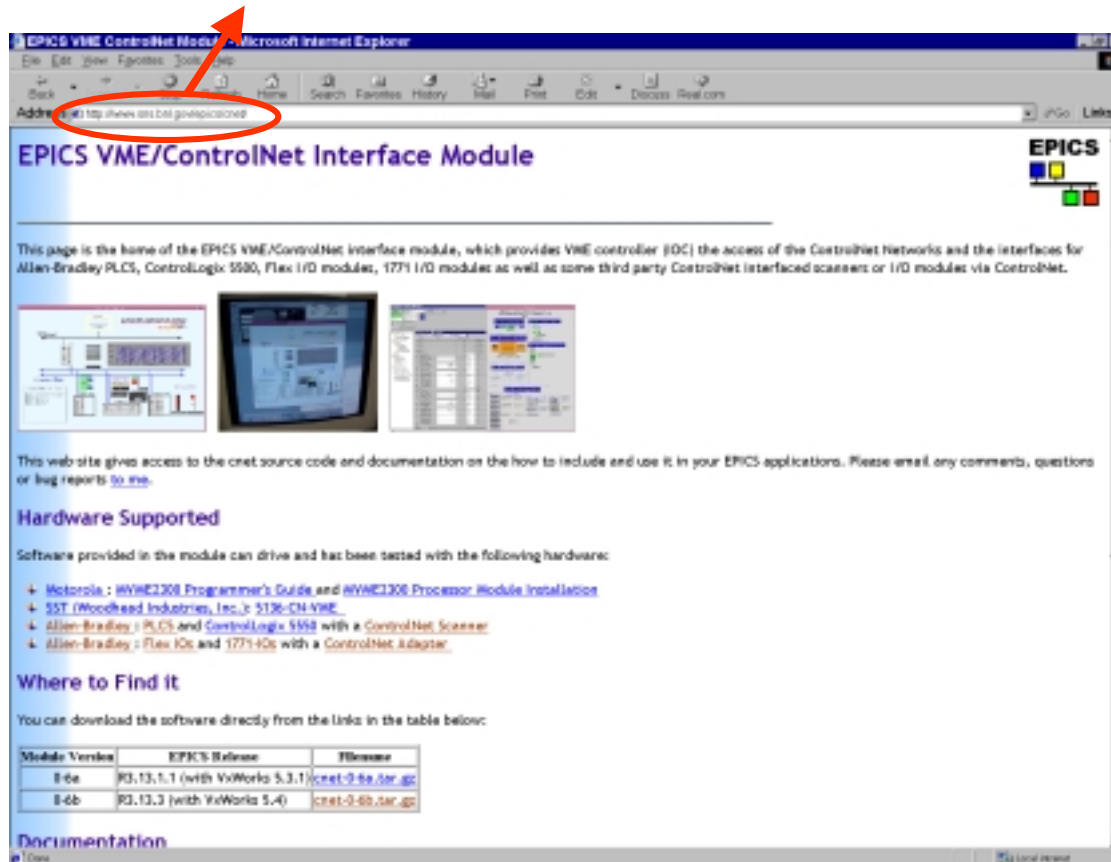
CNET demo test results:

- 5 nodes
- 7 connections
- 2ms NUT
- max 200 words per connection

VME/ControlNet EPICS Support — Product (2)



<http://www.sns.bnl.gov/epics/cnet>



Supported EPICS Record Types

- Ai
- Ao
- Bi
- Bo
- Longin
- Longout
- MbbiDirect
- MbboDirect
- Waveform (TBA)

VME/ControlNet EPICS Support – *Conclusions*



Benefits to EPICS users:

With the EPICS VME/ControlNet interface support module,

- A VME IOC is now able to engage a real-time application via an open, real-time industrial network
- A VME IOC is now able to perform peer-to-peer interlocking at 2ms deterministic rate
- A VME IOC is now able to remotely scan FLEX IO or 1771-IO modules via ControlNet with a faster rate as an alternative option
- A VME IOC is now able to communicate with PLC5 or ControlLogix5550 with at least 200 words data block at 2ms update rate