



# Johnny Tang

## **Brookhaven National Laboratory**

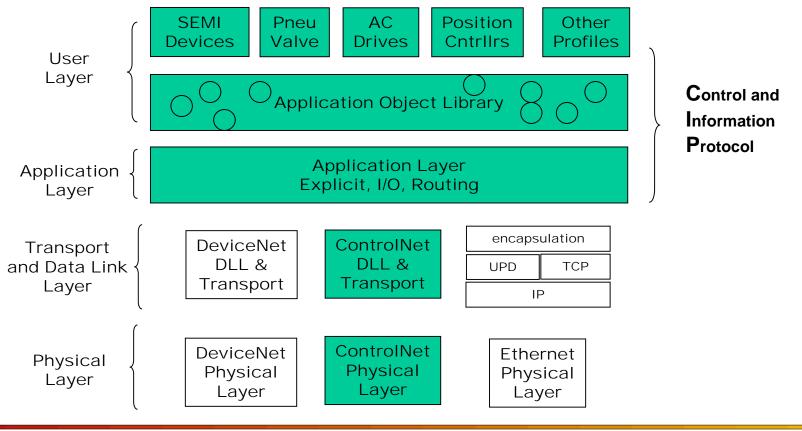
Subjects will be covered in this talk:

- 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. (<u>www.controlnet.org</u>) - an organization of Vendors (55+) and Users



Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000



SPALLATION NEUTRON

# **ControlNet Characteristics** – *the Media Access*



- 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-timecritical data transfers – priority scheme is necessary to accomplish this
  - Media Access Algorithms employed for the networks
    - DeviceNet uses <u>CSMA/NBA</u> (Carrier Sense Multiple Access w/Nondestructive Bitwise Arbitration)
    - ControlNet uses <u>CTDMA</u> (Concurrent Time Domain Multiple Access)
      - a time-slice algorithm which provides determinism and repeatability
    - Ethernet uses <u>CSMA/CD</u> (Carrier Sense Multiple Access w/Collision Detection)

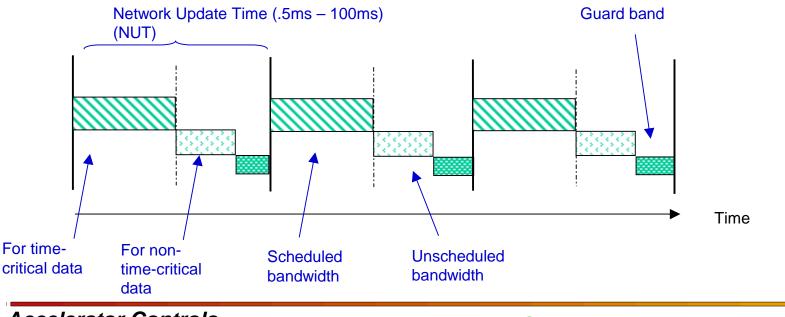


## **ControlNet Characteristics** – *CTDMA Definitions*



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"



Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000

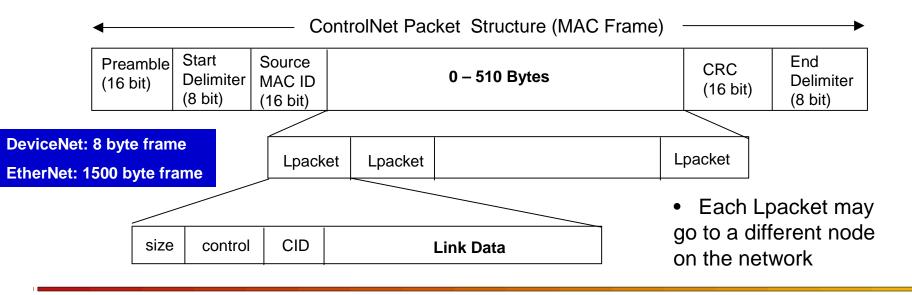


## **ControlNet Characteristics** – the data transfer method

Sased 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)



Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000



SPALLATION NEUT

## 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 o Simultaneous operation of 128 schedul E) and 128 unscheduled connections Simultaneous functionality of ControlNet F) 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 Köybes 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
  - o FPGA is software field upgradeable
- Network interface
  - o 2 BNC connectors
  - ControlNet redundany implemented in hardware on interface card
  - Standard Controlinet 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°)

### **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
  - o Registers: SD08(0), SA16
- Addressing:
  - Standard: 16 Kbytes on any 16 Kbyte boundary, or 512 Kbytes on any 512 Kbyte boundary
  - o Short: 32 bytes on any 32 byte boundary
- Interrupts:
  - o Software selected 1-7, or none
  - o Software set 8 bit status/ID register
  - o Release on acknowledge (ROAK)





## VME/ControlNet EPICS Support – Design & Issues



### Utilizing Shared RAM Application Interface for EPICS support module

O

C

12

30000

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	13	D	34000	File receive area
			2.2 SD Emulation ControlNet Interface	14	E	38000	File receive area
				15	F	3C000	File receive area
1	1	04000	RSLinx Interface	16	10	40000	Scheduled data area Rx
2	2	06000	Scheduled connection configuration object instances	17	11	44000	Scheduled data area Rx
3	3	0C000	Unscheduled connection/unconnected	18	12	48000	Scheduled data area Tx
3	°	00000	control blocks	19	13	4C000	Scheduled data area Tx
4	4	10000	CCO Parameter Data Area (used for variable length data in CONN_CNTRL blocks)	20	14	50000	Unscheduled message buffers
				21	15	54000	Unscheduled message buffers
5	5	14000	CCO Parameter Data Area (used for variable length data in CONN_CNTRL	22	16	58000	Unscheduled message buffers
				23	17	5C000	Unscheduled message buffers
-	-		blocks)	24 - end	-	-	Reserved
6	6	18000	Unscheduled Path Data Area				
7	7	1C000	Unscheduled Path Data Area	<ul> <li>Monitoring VME module status (page 0)</li> <li>Get scheduled connection configuration (page 2)</li> </ul>			
8	8	20000	File send area / PLC 5 file emulation				
9	9	24000	File send area/ PLC 5 file emulation				
10	A	28000	File send area/ PLC 5 file emulation				
11	В	2C000	File send area/ PLC 5 file emulation	1			
	-	_		-			

• Real-time I/O (page 16-19)



File receive area



# 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)

- <b>M</b>	
1	× 1

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

Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000



### VME/ControlNet EPICS Support — Address Mapping

1. Configure <app>.cnc One ControlNet connection can ControlNet be mapped to many SST tags Network with - The Maltievik Plateonic Configuration - E Constant i SET Consolius Scannet CnCfg.exe SST's <CnCfg> ALL IT? I Desirate 281, 17771 Information WHERE COST CHAVE Send · AE 1771 Specials Mode too1 TOWNE Setd All CheAllC Alloot AEI Drives AEI Faix Spec 15 and Floor changes FDVD Skt N Fex Digital Federater Controlled File: adapter 2051 and with being adverse to a <app>.bss All Redundance Produc Int They Analog (1794-E-400EDA Flav mechan ED/S Iverbook Medical ACCENT. The 21 Marchine 2 (117) at CMP 414, Final American EDC) Chanisis contribution in the start of All Changes 214 site 1771 changes ED/S) Seneral Purpose Atalog 3 <app>.tss etwinel Plur proble Direct Rot 13 1171 Chadal Photositive Controlled 1171 adapter ED15 Agreed Milertane, Harding & This is CNET hologi Laner Compone **Josting Controles** configuration file to be Vige ammodile Loope C And Parahaste downloaded onto SST This is ascii text file 5136-CN-VME that contains a list of module SST tags and their offset addresses in VME shared RAM Configuration Database antrolLogix TagNam 2. Add hardware 100 Table Sale 100 Contrast 1 addresses into EPICS database db2hw.exe <app>-temp.db template with JLAB's Fill up DTYP INP OUT fields <dh2hw>tool <app>.db

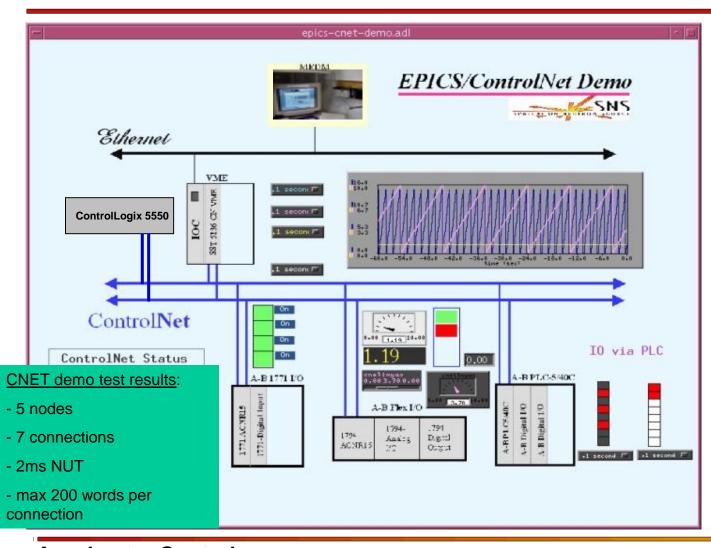
### Using VME ControlNet EPICS Support

Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000



SPALLATION NEUTRON

## VME/ControlNet EPICS Support - Product



Currently Tested hardware

- PLC5c
- ControlLogix 5550
- Flex IOs w/ 1794-ACNR15:

SPALLATION NEUTRON SOI

- 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





## VME/ControlNet EPICS Support - Product (2)



### http://www.sns.bnl.gov/epics/cnet

in [at year Aponton ]out year ar	
est	
daw si kiti nawa sasibili polopicalorea	<ul> <li>PGo Links *</li> </ul>
PICS VME/ControlNet Interface Module	EPICS <sup>÷</sup>
is page is the home of the EPICS VME/ControlNet interface module, which provides VME controller (IDC) the access of the Control an Bradley PLCS, ControlLogic, Silo, Flex (I/D modulet, 1771 I/D modulet ac well as some third party ControlNet Interfaced scane	
is web site gives access to the criet source code and documentation on the how to include and use it in your EPICS applications. bug reports to me.	Please emeril any comments, questions
ardware Supported	
ftware provided in the module can drive and has been tested with the following hardwares	
Motorola : WWE2200 Programmer's Guide and WWE2000 Processor Hodule Installation     SST (Wootheed Industries, Inc.): S124-CN-WE.     Allen-Bradley : PLCS and ControlLogic S558 with a ControlNet Science     Allen-Bradley : Flex ICs and 1771-Os with a ControlNet Adapter	
/here to Find it	
ou can download the software directly from the links in the table below:	
utule Version EPK's Release Filename	
Ede R3.13.1.1 (with VolVoria 5.3.1)(cret-9 tie tor gc	
Edb P3.13.3 (with YoWorks 5.4) cnet-0-6b.tar.gp	
ocumentation	Tig Local Internet

### Supported EPICS Record Types

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

Accelerator Controls EPICS Collaboration Meeting @ ORNL Nov 2000





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

