Signaling with cpNode

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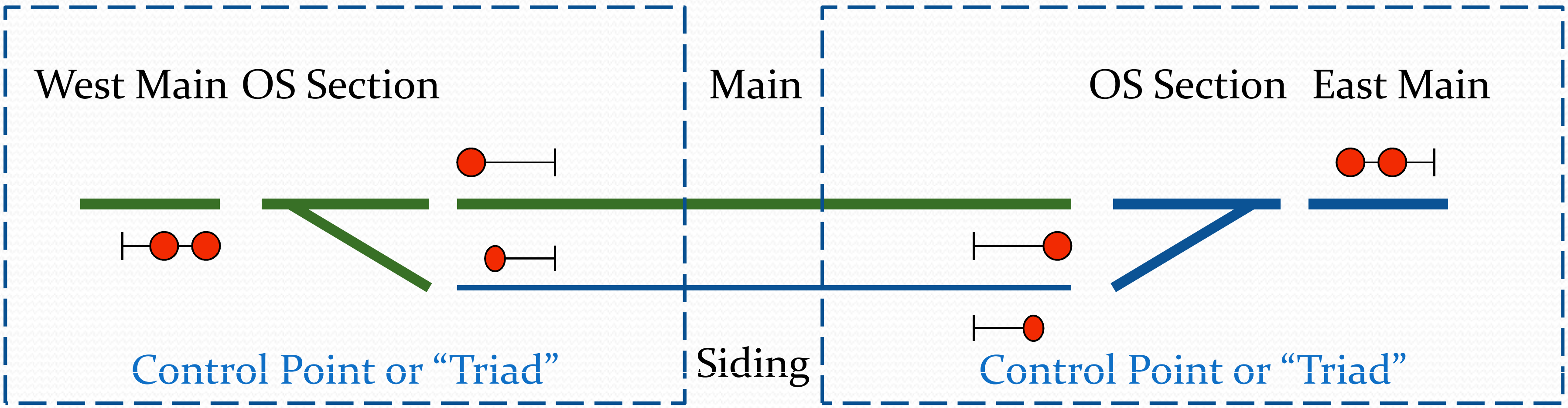
Assumptions:

- This clinic is focused on implementing a signaling system using cpNodes, CMRInet and JMRI
- You know what you want to model
- You are generally familiar with principles of Railroad Signaling
- You know something about JMRI or CATS and will be using a computer to control signaling on your railroad
- Hard CTC machines can be done easily with cpNode but we recommend going to the considerable effort and expense of a hard panel only after the design is proven on a “glass” panel

Agenda

- Control Point Layout
- Establishing blocks & detection
- Fascia switches/control panels
- Switch motor control
- CMRI configuration in JMRI
- CMRInet Configuration and Topology
- Configuration examples and worksheets

Control Point layout - 1

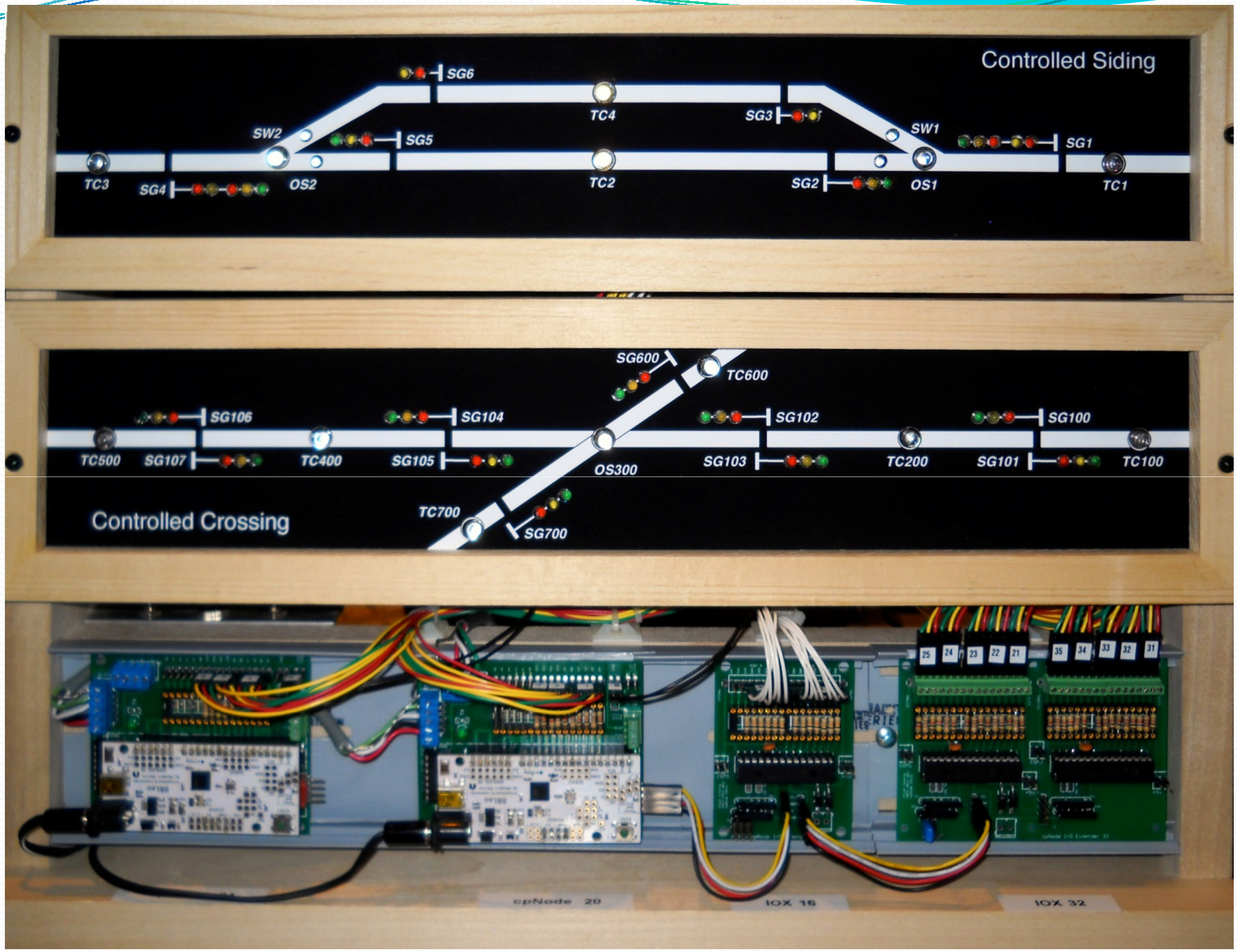


Whole Siding (30 i/o)

- Inputs: (8)
  - 6 Detection Blocks
  - 2 Fascia switches
- Outputs: (22)
  - 2 double high signals (@ 5 = 10)
  - 2 high signals (@3 = 6)
  - 2 low signals = (@2 = 4)
  - 2 switch motor lines (@1 = 2)

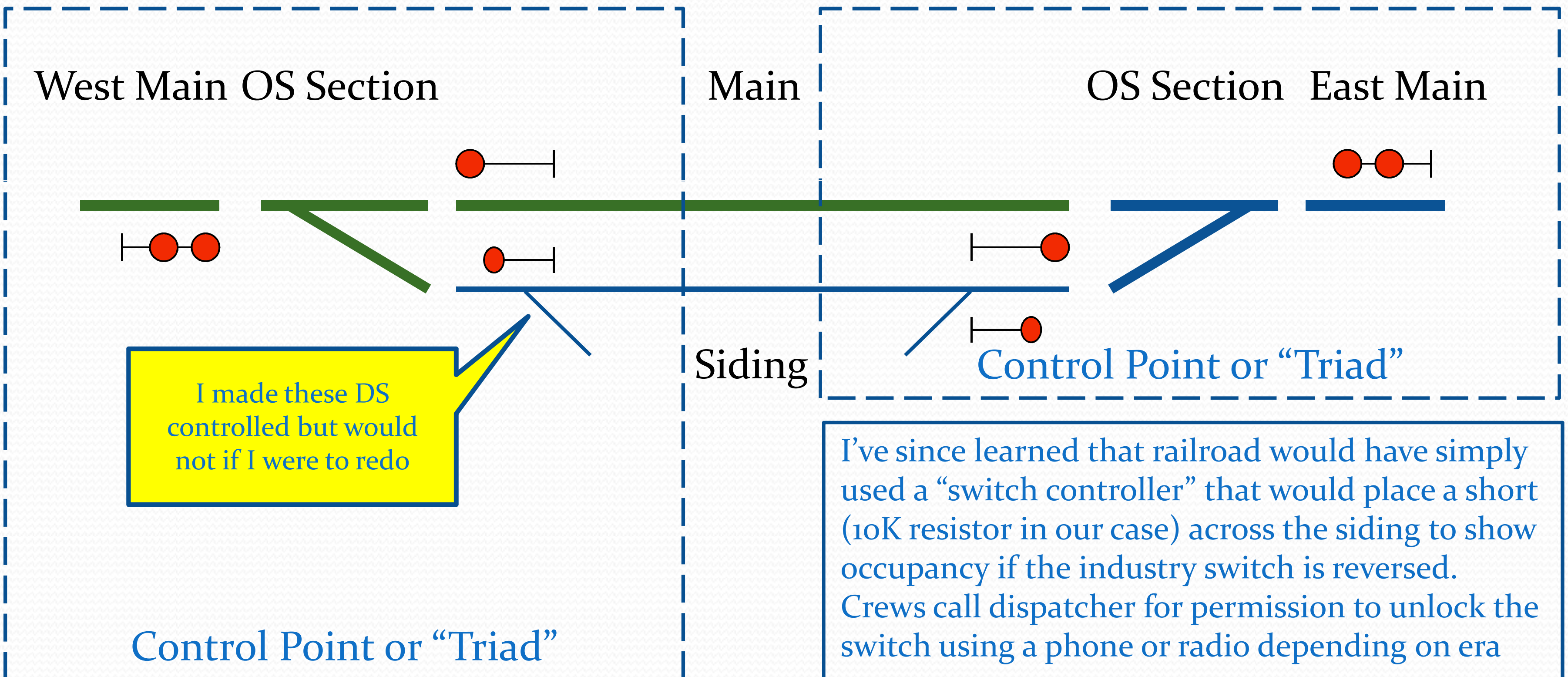
Control Point (15 i/o)

- Inputs: (4)
  - 3 Detection Blocks
  - 1 Fascia switch
- Outputs: (11)
  - 1 double high signal (@5)
  - 1 high signal (@3)
  - 1 low signal = (@2)
  - 1 switch motor line (@1)


Controlled Siding
SG6
TC4
SG3
SW1
SG1
SW2
SG5
TC3
SG4
OS2
TC2
SG2
OS1
TC1
SG600
TC600
SG106
SG104
SG102
SG100
TC500
SG107
TC400
SG105
OS300
SG103
TC200
SG101
TC100
Controlled Crossing
TC700
SG700
cpNode 20
IOX 16
IOX 32

Control Point layout - 2

- Siding with industry switches
- Switching signal – no change in hardware
- Possible locks? – add an input or do locally



I've since learned that railroad would have simply used a "switch controller" that would place a short (10K resistor in our case) across the siding to show occupancy if the industry switch is reversed. Crews call dispatcher for permission to unlock the switch using a phone or radio depending on era

Control Point layout - 3

- cpNode per control point
  - Each cpNode has 16 i/o lines and can be expanded to a total of 144 in groups 16 or 32 (IOX 16/32)
  - A standard control point requires 15 lines, or a single cpNode.
- cpNode per Siding
  - A simple siding requires 30 lines and can be implemented with a cpNode and a single IOX16
- cpNode per Interlocking
  - More complicated control points – such as interlockings – may be achieved by adding more i/o to the node. At 144 lines of i/o, a fully expanded cpNode can handle almost any interlocking used on a model railroad

Disclaimer: Chuck and Seth's secret plan for *world domination*:

- We want to offer the cpNode with a standard sketch that does ABS/APB with local switch control when no "code line" is present
- All "vital logic" is on the node (just like the prototype)
- When CMRInet "Code Line" is active the vital logic will accept commands from the CTC machine and execute them IF and ONLY IF the vital logic concludes it is safe to do so.
- John Plocher has done some work on a subset of the ATCS commands used by real CTC machines on real Code Lines.
- This is an additional reason for using the node per control point approach

Powering Signals -1

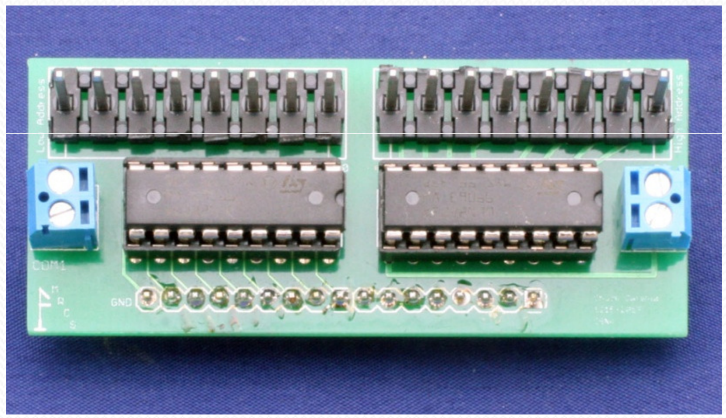
- We assume you are using modern 3-LED signals that will operate from the local 5 volt supply. A modern LED will light acceptably at 5-10mA current, so a whole siding with 20 heads, assuming all LEDs came on at startup, will draw 200mA.
- 200mA for LEDs can be supplied by the onboard regulator of the BB-Leo (Arduino) on the cpNode. If you need more current, consider an external 5 V supply and be sure to tie the ground side back to the cpNode ground. We like 3 LED common anode signals (such as those from BLMA) but common cathode and two LED signals may be used.

Color	Resistor to give 10mA @ 5V	Watts
Green	270 ohm	1/8 or greater
Yellow	220 ohm	1/8 or greater
Red	330 ohm	1/8 or greater
Lunar	6,000 ohm	1/8 or greater

- These values yield a pleasing balance of colors, but YMMV as 20% of males have some degree of diminished color vision. Pads for limiting resistors are provided on cpNode and IOX16/32.

Powering Signals -2

If you need to drive loads with higher voltage or if you need to exceed 25mA per line or a total of more than 160mA per device, use our CSNK, which can sink up to 500mA at 60V. The CSNK must be connected to an IOX16 and all supply grounds must tied together. CSNK ensures compatibility with older 12 systems and high current devices such as incandescent lamps.



Distance – the LEDs are driven by DC levels, so the limiting factor is resistance of the wire. We use 24 ga CAT5 cable (each one supports 2 heads) with a resistance of ~ 275 ohms per loop mile. Typical limiting resistor values at 5V are 220-330 Ohms, so keeping the wire at 10% of the resistance yields a limit of about 600ft: unlikely to be an issue on a model railroad

Blocks

- Each block (main, siding, OS, some auxiliary track such as staging) must be detected. Blocks are typically 1.25 – 2.0 train lengths except for OS sections and interlockings
  - Current Detectors
    - Best overall performance
    - More expensive: $6 -$18 per block
    - Require resistor wheel sets on each car for best performance
  - Optical Detectors
    - Good for point detection – some prefer them for OS sections
    - Less expensive: $3-$20 per detector but may need more than one
    - May be sensitive to ambient light and require some fiddling to get calibrated
    - Good for stopping blocks, impingement detectors

Detector types

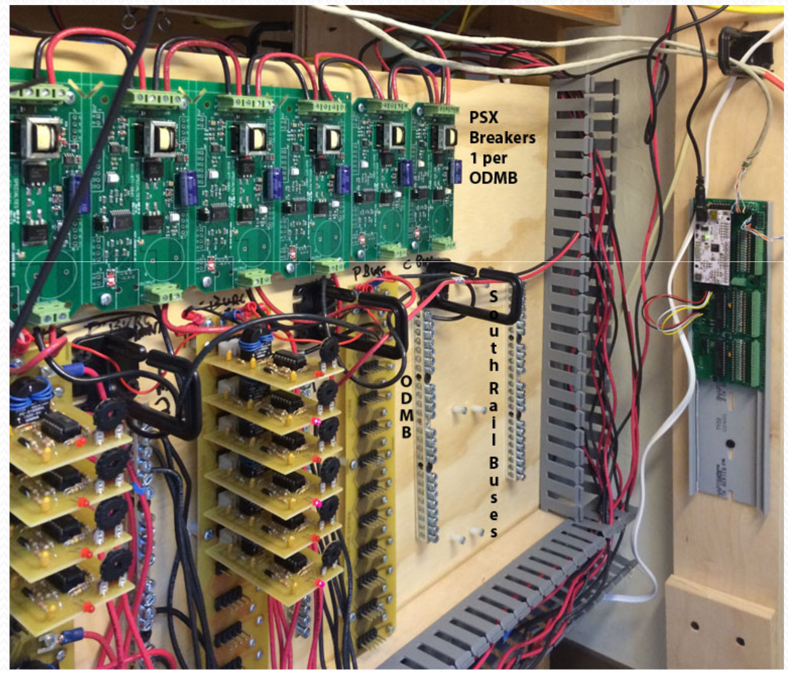
- Current sensing –
  - DCCOD (Chubb/JLC/SLIQ) $17 per
  - RR-Cirkits BOD-8 $ 6.25 in 8s
  - cpOD (future MRCS offer in Alpha Testing now)
  - Others – we like the transformer type
- Optical –
  - Paisley - $3 in 8s
  - IRDOT – From Heathcote (UK) $17 per
  - Boulder Creek Nightscope $20 per
  - Asian Cheapies - $1- $3 per

Current Detector Plans -1

Two approaches but you can mix and match:

Centralized –

- we co-located a cpNode and IOX32 with power distribution for a client. He has a power distribution panel on each wall of a 50’ x 15’ room. Each wall has about 48 blocks. (48 i/o and 48 detectors)
- Favors larger motherboards such as Chubb’s ODMB with DCCOD or cpOD(M) or RR-Cirkits BOD-8
- Longer 12 Ga runs from panel to the blocks. Runs should be limited to about 50’

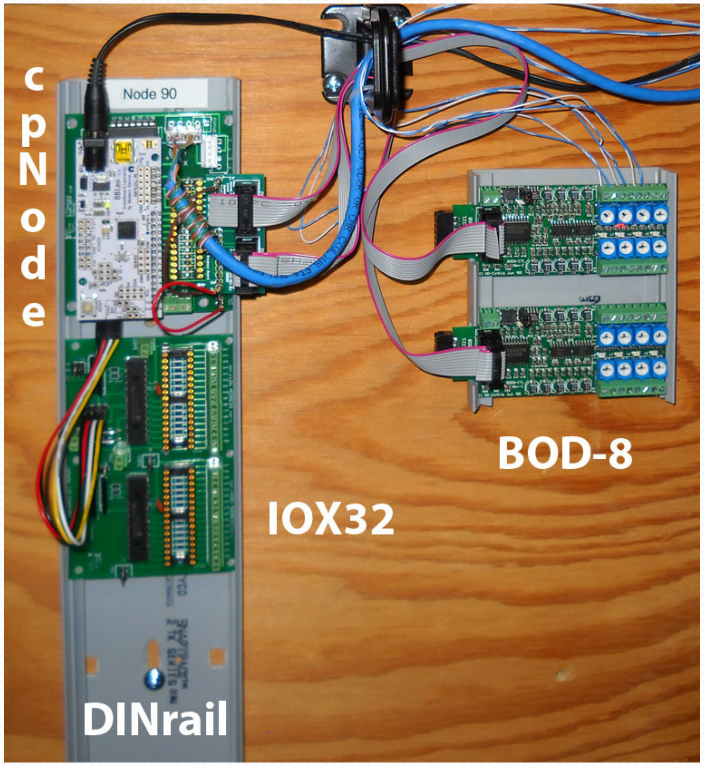


South Wall Power Panel
at Ted Stephens’ OL&K: Open tomorrow AM

Current Detector Plans -2

Distributed

- Distributed detectors with the control point. For control points with 3 blocks we like cpOD(M) on an ODX4 motherboard, for a siding per node model either two ODX4s or a BOD-8 (a couple of detector segments won't be used) will work well. You can use individual detectors wired into the feeders (cpOD)
- An advantage is that our forthcoming SafeTrak feature will allow the node to perform basic ABS functionality without a host computer if the detectors are connected locally



Node 90 at Walt Schedler's Shasta Division – under Dunsmuir

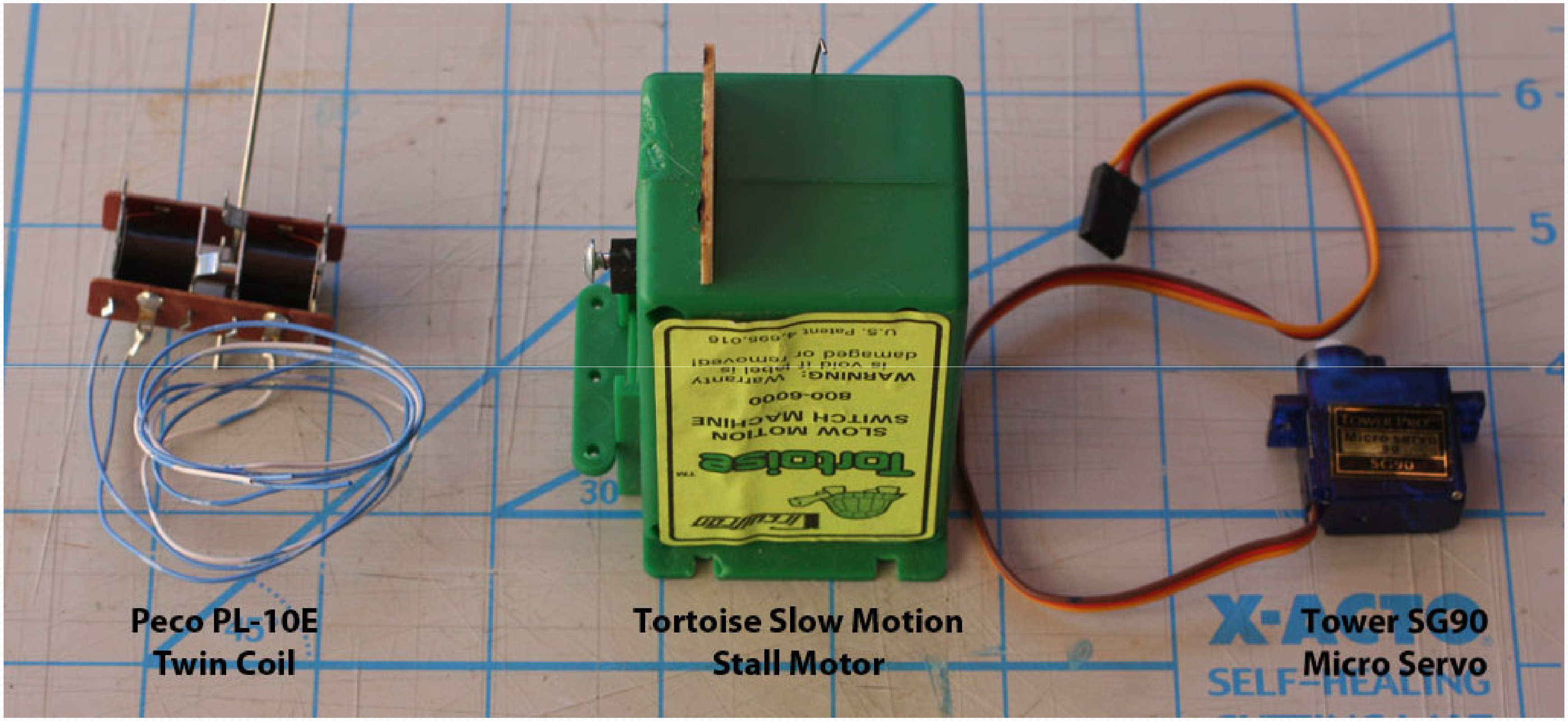
Detectors: to Motherboard or….

Some current detectors plug into motherboards, others have you install the coils on the feeder

- Motherboards:
  - Let you do the power wiring once and you can swap detectors in and out for trouble shooting
  - Motherboards can be centralized for easier adjustment and to see local occupancy lights
  - Add cost and connections (points of failure)
  - Chubb style motherboards (for DCCOD and cpOD(M)) come in 12 (ODMB) and 4 position (ODX4)
  - Detector outputs are logic levels and don't change quickly so you can use the 600' limit above although shorter is better. If remoting the "tombstone" transformers try to keep them to 25' from the main detector

We like motherboards!

Switch Machines - 1

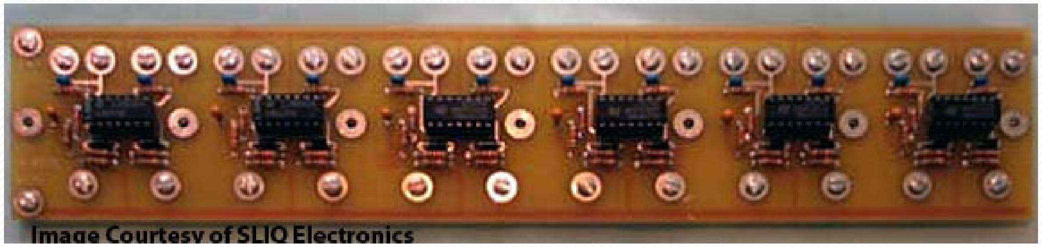


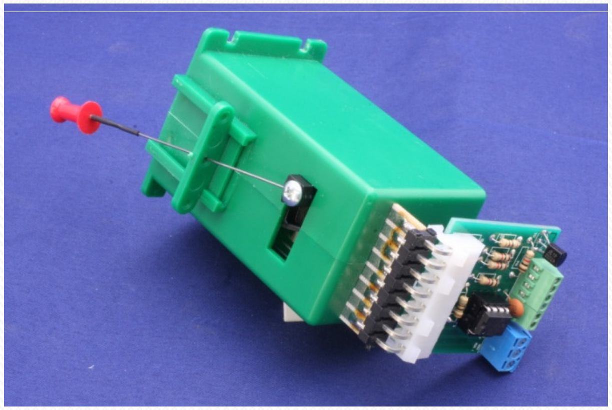
Switch Machines - 2

	Stall Motor	Servo	Twin Coil
Market Position	Most common	Challenger	Less popular but still used: Kato, Atlas
Power	12V @ 20mA, constant	5V @ 150mA while moving	12V @ .5A pulse, must turn off
Controller	SMC12, RSMC, SMD-8	Tam Valley, Arduino (Sketches on Arduino)	SCSD-8, SM1, SM2
Distance from controller	600’	40’	As short as possible
Pressure on points	Constant	Can be constant or momentary	Momentary
Frog Polarity Switch	Included in Tortoise	External relay or Micro Switch	External Relay
Street price including controller and frog switch	$21	$12 (using an Arduino controller)	$25

Switch Controls 3 – Stall Motor

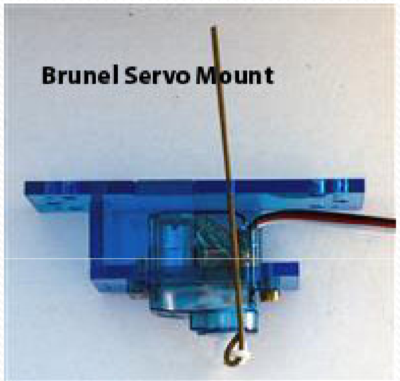
- Stall Motor:
  - SMC-12
  - RSMC
    - Free standing
    - Stuff option for one RSMC on cpNode

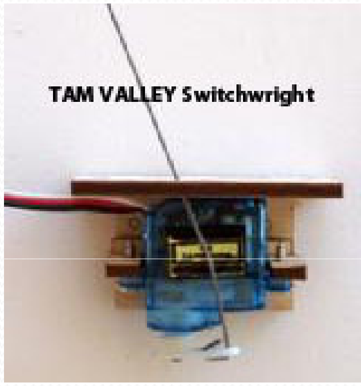




Switch Controls 4 - Servo

- TAM Valley
- Various Arduini Sketches including Charlie Bedard, use any handy Arduino
- Write your own Sketch that combines node and servo timing and use cpNode hardware
- Physical:
  - TAM Valley servo mount
  - Brunel servo mount
  - Others out there





- Servos do not have internal contacts to switch frog polarity so you'll need an external relay (TV) or a micro switch mounted on the bracket (Brunel) or a frog juicer if you want to switch frog polarity (recommended)
- Servos draw about 150mA while moving, so for most applications you'll want an external 5V supply (ground side tied to logic ground)

Fascia/Panel Controls

Use any type of switch you like – I like Rick Fortin's slide switch recessed behind the fascia – doesn't snag or break off. Keeps the fascia clean.

- Switch can be wired directly to cpNode input but requires that computer be on.
- Local panel to provide local control when no computer, Dennis Drury designed a switch panel using an RSMC that looks for a 5V line from the computer power supply, 5V isn't present, the switch panel is in local control. We should be offering this as a "community" product shortly
- "Safetrack" local sketch in absence of CMRI "Code Line"
- Usually one input line per Control Point, but a second line can be used for a switch lock. The lock can also be wired in series with the switch so the switch can't get to the input unless the lock is unlocked (with Dispatcher permission)

CMRInet Configuration

- Old-School: configure as a SUSIC with 24 line DIN and DOUT boards. If you only need 16 inputs, configure a DIN and just use 17-24. This approach also works if you want to use QBASIC or VBASIC
- Use standard JMRI or QBASIC or VBASIC configuration tools

CMRInet – C/MRI Communication Protocol

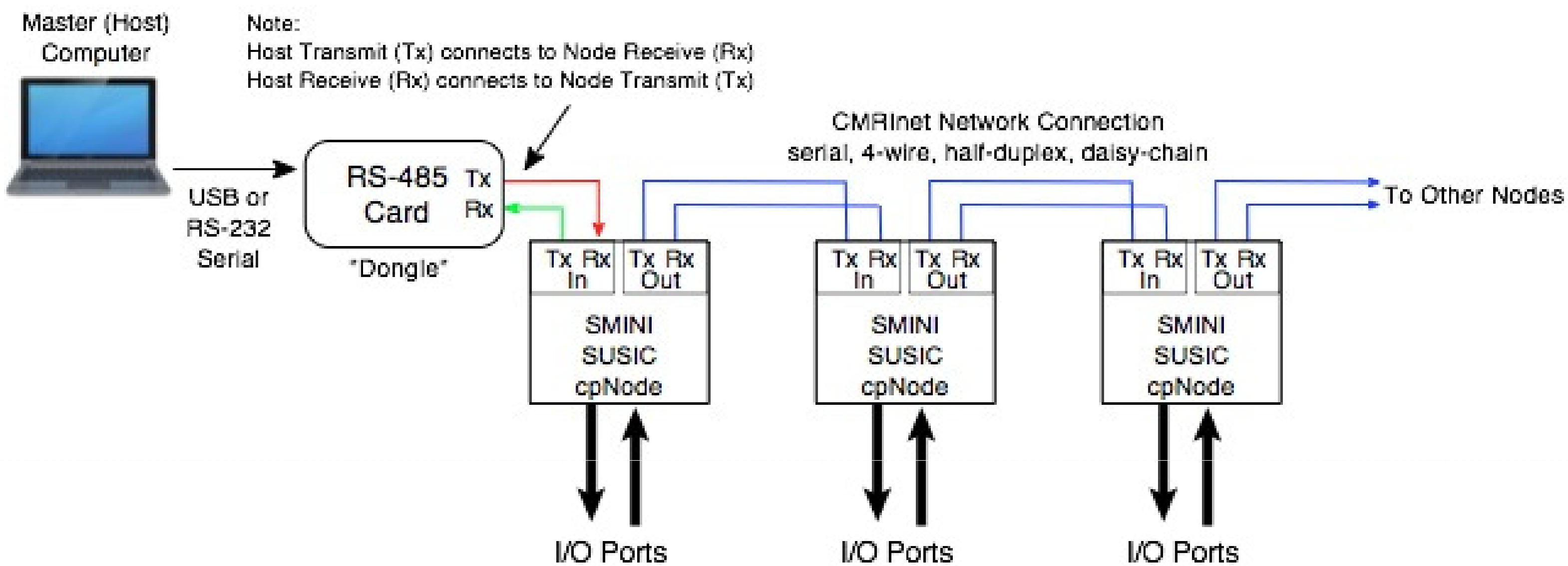
- Designed by Bruce Chubb in 1985 to be a simple, easy to implement, serial data messaging system.
- Robust, industrial grade network technology for moving data between a host (master) and node (slave) in a connected network.
- CMRInet specification submitted to the NMRA Layout Control Specification (LCS) Repository as LCS-9.10.
- NMRA - CMRI Special Interest Group (SIG) established 2015.

C/MRI 30! Celebrating the 30th anniversary of C/MRI at NMRA Portland.

CMRInet Topology

- Bruce Chubb assumed the network started at the host computer and worked linearly out to the furthest node, his RS232/485 converter includes a terminator at the computer and the user would terminate at the far end.
- RS485 does not allow branches (not to say that modelers don't cheat <g>), so best practice is to have a single CMRInet snaking around your layout with no taps or branches
- Install a terminator at the far end.
- More modern practice is to use an RS-485 USB dongle at the computer, use a terminator at the computer as well as the far end. This is standard RS-485. The Computer does not have to be at one end, but if not, ensure that ends (only) are terminated.
- We recommend CAT5 or better data cable rather than shielded 2 pair as the performance is comparable, the price is lower and you don't need to worry about shielding (which is best left to experts)

CMRInet Connection



The serial communication connection to all C/MRI network nodes is through a four-wire cable. One pair of wires is for transmission, the other pair for receive.   The network is defined as half-duplex, RS-422/485, Master/Slave.

The connection from the control computer (Host) to the C/MRI network is through an interface device which converts USB or RS-232 signals to RS-422/RS-485.

Nodes in a C/MRI network are connected daisy chain fashion, node to node.

CMRInet Timing

- Most Classic CMRI installations have a few large nodes and run at 9600 bps. Each node requires about 30mS to respond so a 10 node system had a poll cycle time of about 300mS (or 3 polls per second). This is plenty fast for our purposes.
- We recommend running faster, 28,800 or greater, to keep the poll cycle in the 300mS range with a larger number of nodes. The bus will run as fast as 115K.
- There is no problem with mixing and matching cpNode and classic nodes as long as they are set to the same speed – the classic nodes can also work at 115K

Proposed JMRI Updates to Support cpNodes

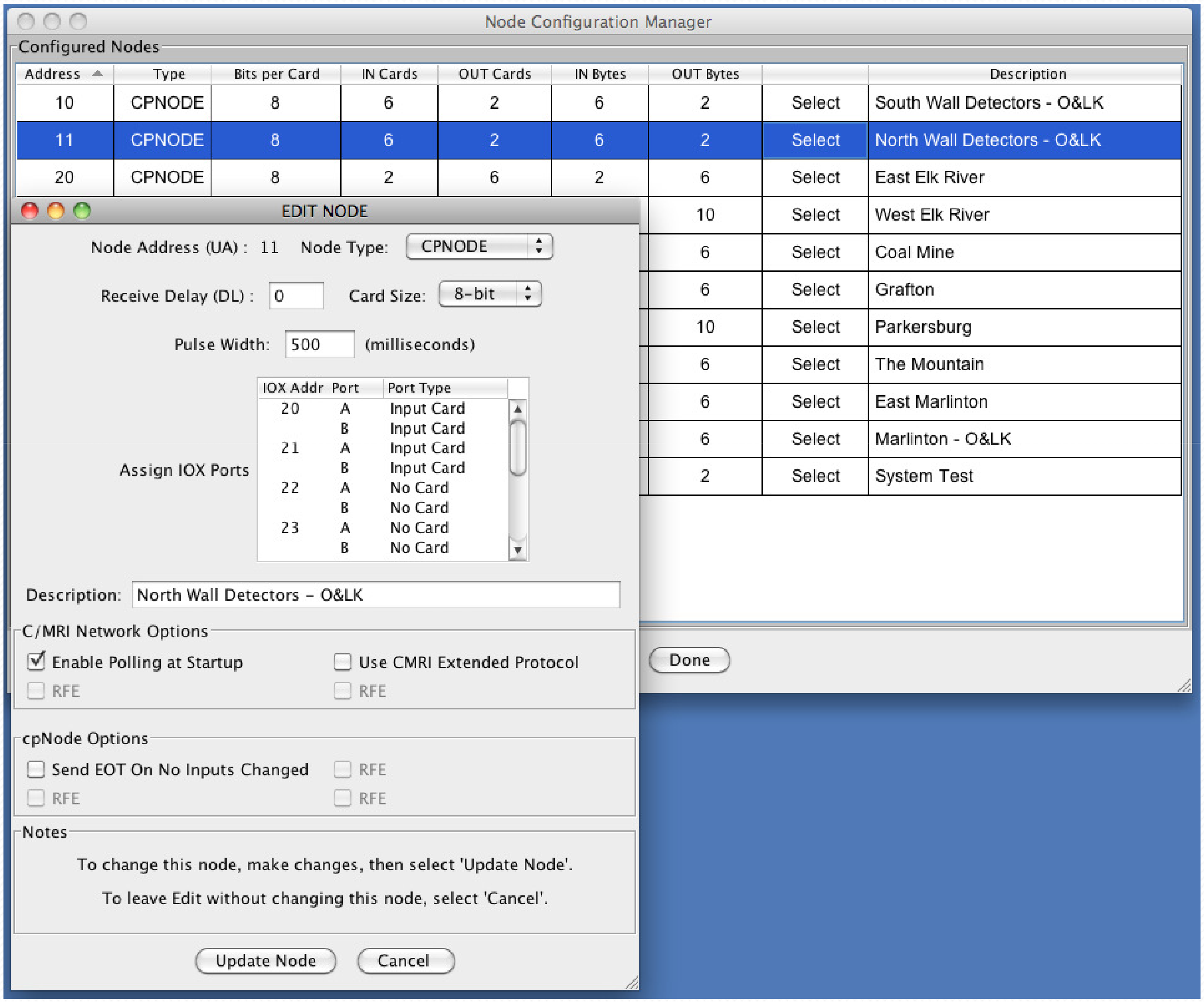
Node Configuration Manager

Configured Nodes

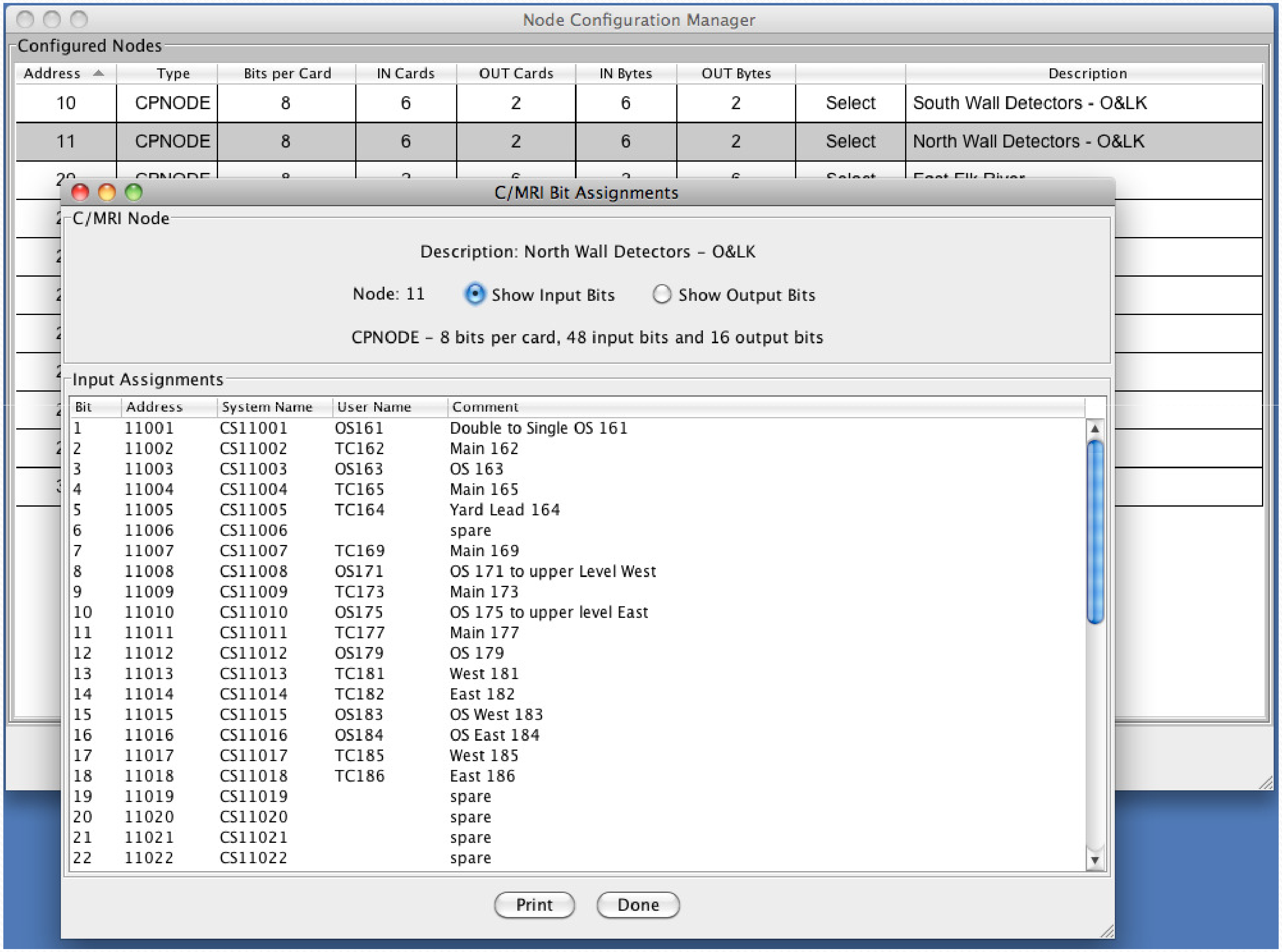
Address	Type	Bits per Card	IN Cards	OUT Cards	IN Bytes	OUT Bytes		Description
10	CPNODE	8	6	2	6	2	Select	South Wall Detectors - O&LK
11	CPNODE	8	6	2	6	2	Select	North Wall Detectors - O&LK
20	CPNODE	8	2	6	2	6	Select	East Elk River
21	CPNODE	8	2	10	2	10	Select	West Elk River
22	CPNODE	8	2	6	2	6	Select	Coal Mine
23	CPNODE	8	2	6	2	6	Select	Grafton
24	CPNODE	8	2	10	2	10	Select	Parkersburg
25	CPNODE	8	2	6	2	6	Select	The Mountain
26	CPNODE	8	2	6	2	6	Select	East Marlinton
27	CPNODE	8	2	6	2	6	Select	Marlinton - O&LK
30	CPNODE	8	2	2	2	2	Select	System Test

Add Print Done

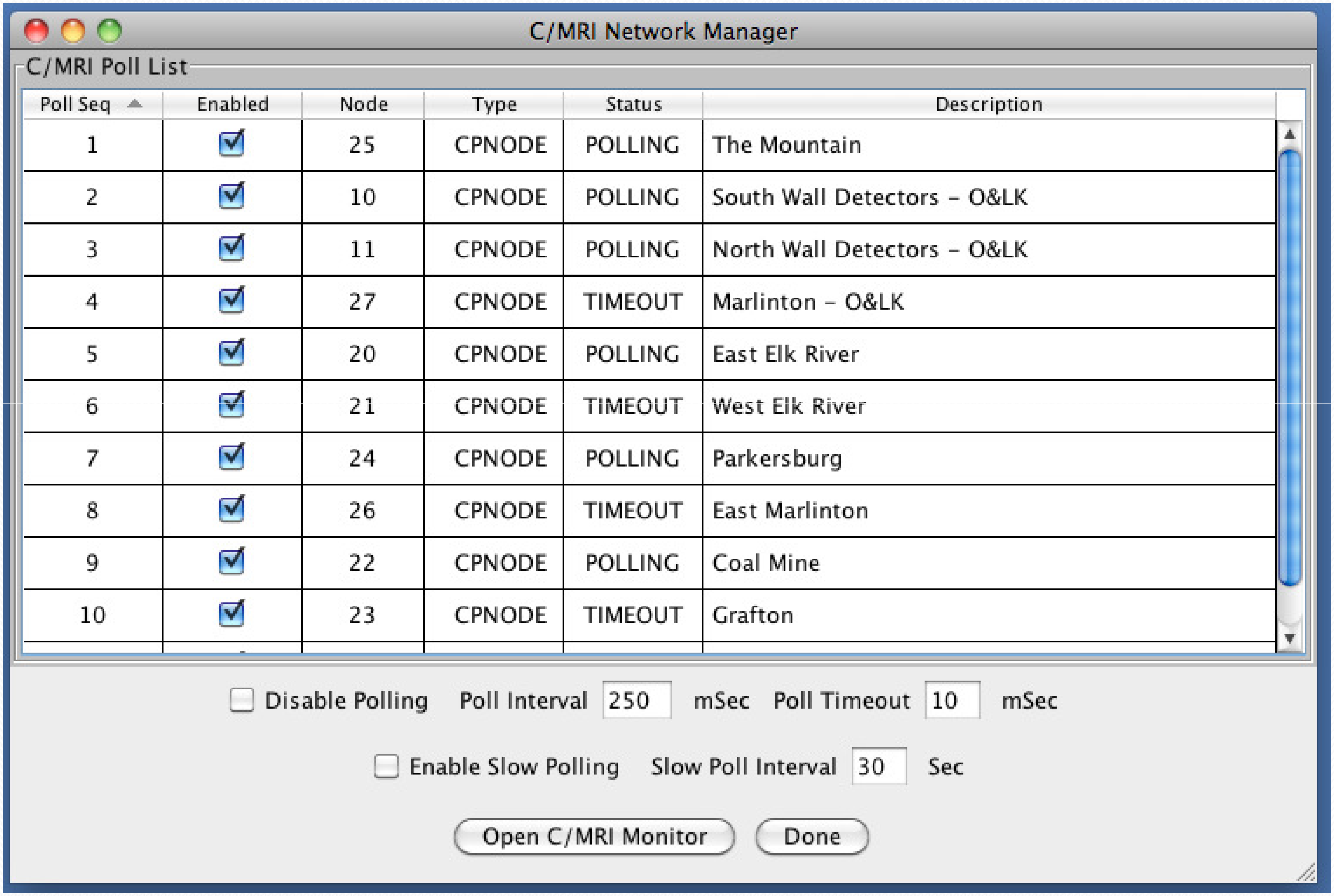
Proposed JMRI Updates to Support cpNodes



Proposed JMRI Updates to Support cpNodes



Proposed JMRI Updates to Support cpNodes

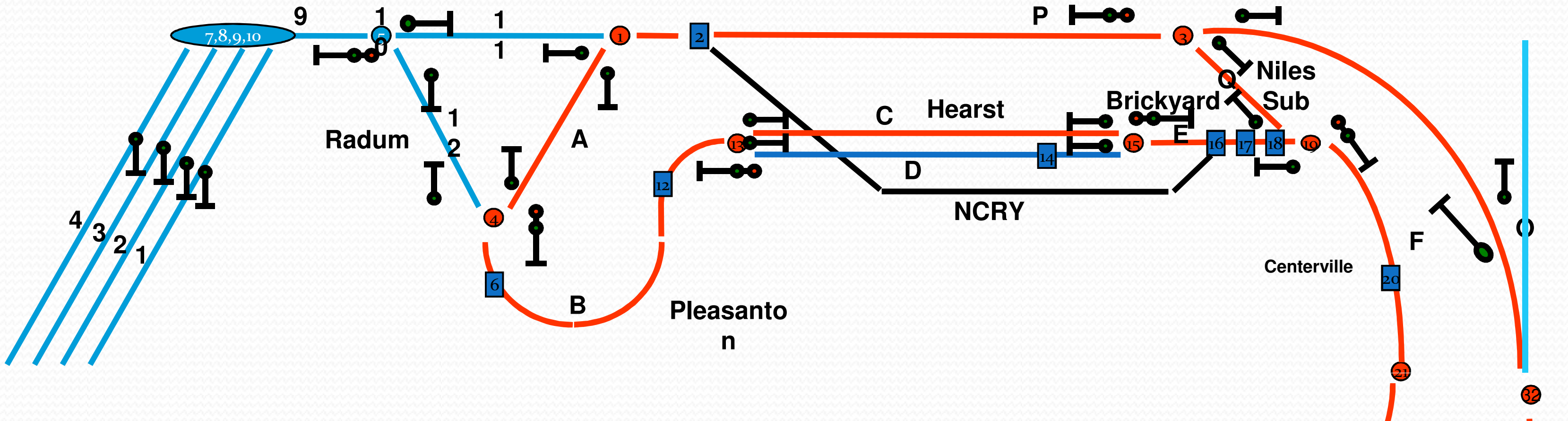


Poll Seq	Enabled	Node	Type	Status	Description
1	☑	25	CPNODE	POLLING	The Mountain
2	☑	10	CPNODE	POLLING	South Wall Detectors – O&LK
3	☑	11	CPNODE	POLLING	North Wall Detectors – O&LK
4	☑	27	CPNODE	TIMEOUT	Marlinton – O&LK
5	☑	20	CPNODE	POLLING	East Elk River
6	☑	21	CPNODE	TIMEOUT	West Elk River
7	☑	24	CPNODE	POLLING	Parkersburg
8	☑	26	CPNODE	TIMEOUT	East Marlinton
9	☑	22	CPNODE	POLLING	Coal Mine
10	☑	23	CPNODE	TIMEOUT	Grafton

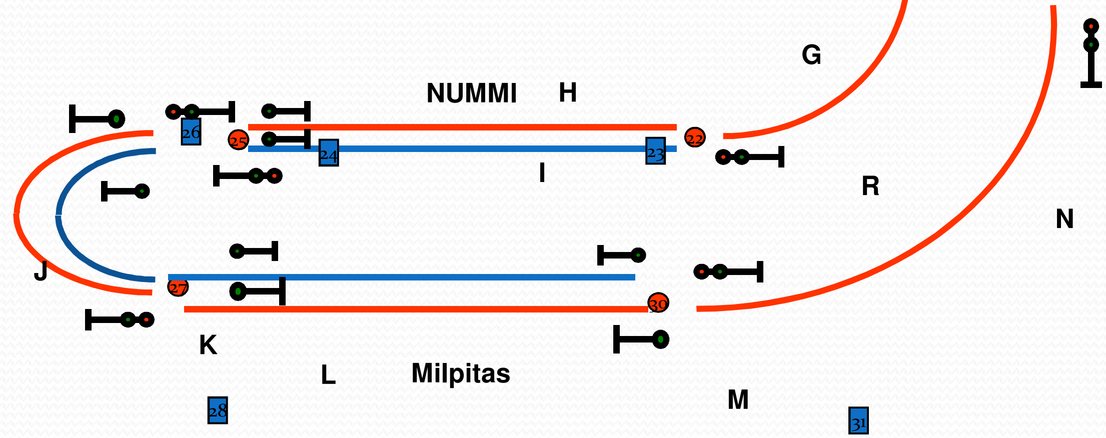
Use My Layout as an Example

- Main line ~ 100'
- Switches
  - 12 mainline switches (dispatcher controlled)
  - 6 controlled switches connecting to sidings
  - 6 industry spurs connect to the main
- Signals – All high signals are BLMA US&S H2 Searchlights
  - 14 (but 3 not visible so they have repeaters only) double head
  - 14 (but 3 not visible so they have repeaters only) single head high
  - 10 (but 2 not visible so it they have repeaters only) Low
  - 10 dwarf (some used in place of low signals in yards, industry areas)
- 3 Sidings, 1 Wye, crossover in the middle of the loop
- Blocks (35):
  - 12 OS (main line switches)
  - 3 main with sidings
  - 3 sidings, 1 main in cross over, 3 Wye sections, 4 staging
  - 10 Main line

My Track Plan



All Blocks are about a standard
Train (~ 10') long except
Pleasanton and the hidden
Back track, so not much point
In intermediate signals



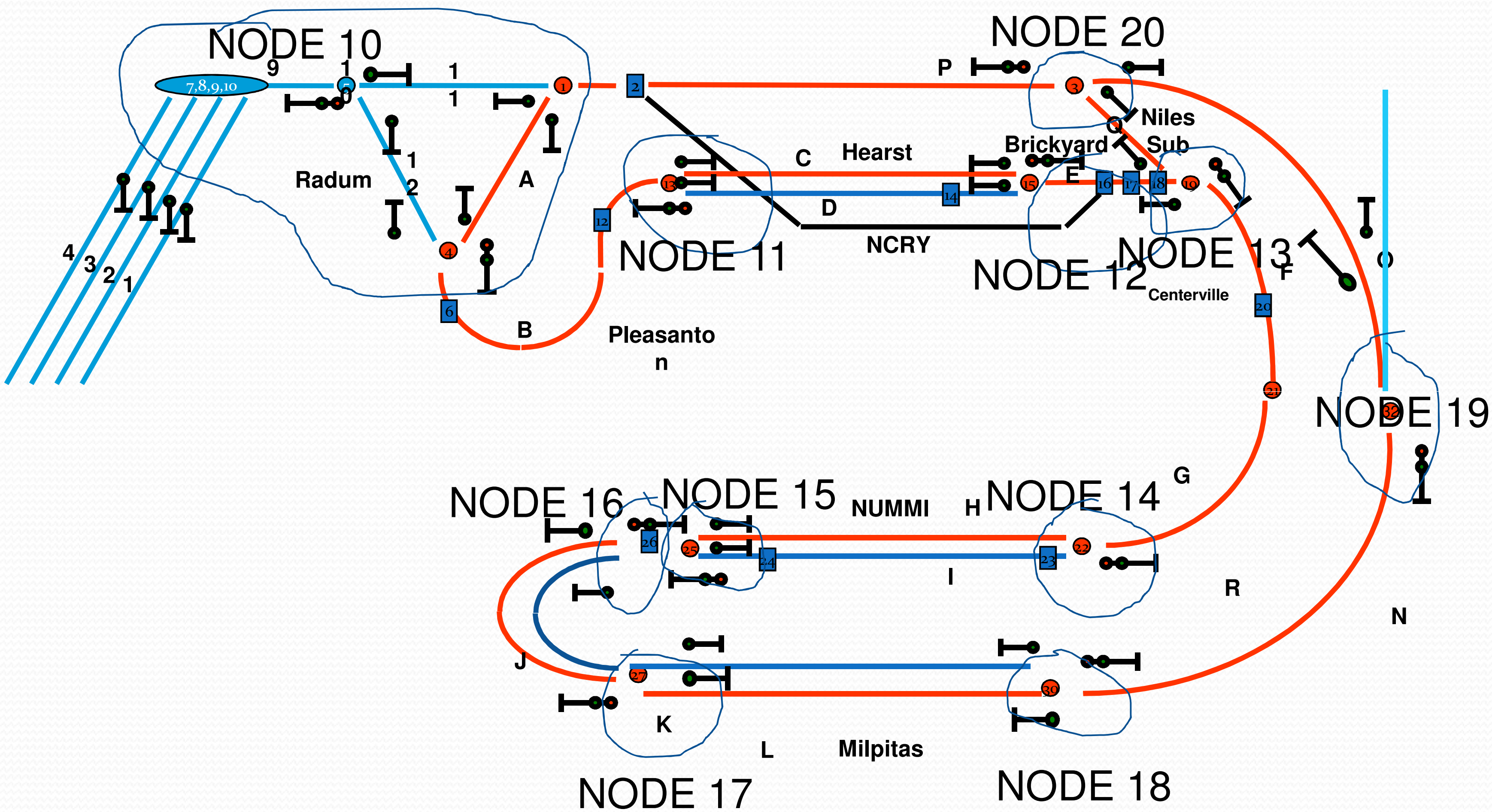
OS section
Spur switch,
controlled

Staging
Main
Pass
uncontrolled

Layout example

- UP (ex-WP) used western 3 block route signaling, note the real WP did not "bond" the sidings so the most favorable indication into the siding was approach
- 3 sidings + staging
- 2 of the sidings are connected to industry tracks or a yard
- No intermediate signals (uncommon in the prototype but very common in the model world)

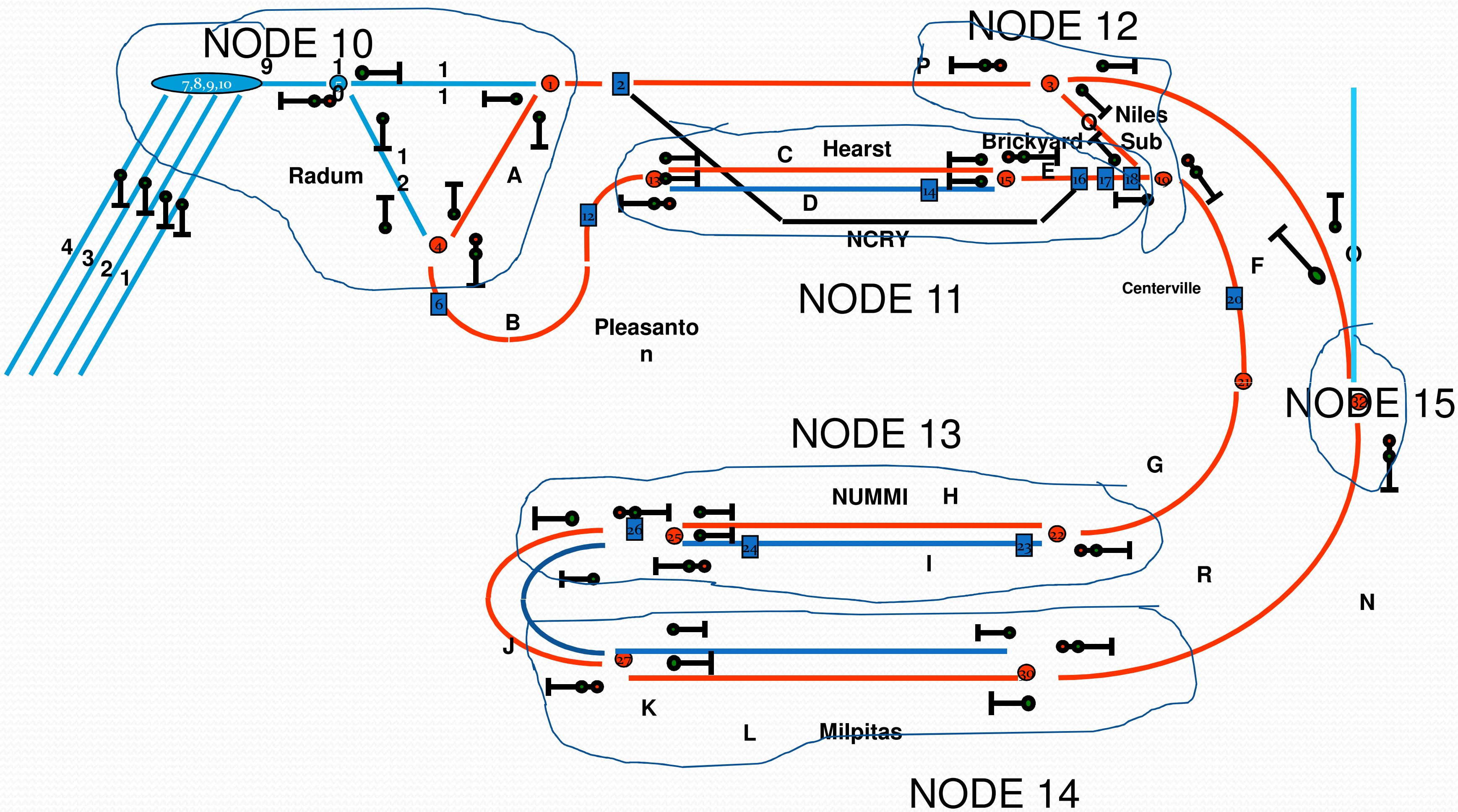
Example – control point per node



Bill of Materials: cpNode per Control Point

			Inputs		Outputs		total i/o	cpNode	IOX16	cpOD(M)	ODX4	RSMC	Dongle
Node		Milepost	fascia	Blocks	Switch	Signal Lines							
10	Staging + Wye	F044	7	10	7	40	64	1	3	10	3	6	
11	E Hearst	F039	1	3	1	10	15	1	0	3	1	0	
12	W Hearst	F038	1	3	1	10	15	1	0	3	1	0	
13	Niles JCT	F030	1	3	1	11	16	1	0	3	1	0	
14	E NUMMI	M004	1	2	1	10	14	1	0	2	1	0	
15	W NUMMI	M005	1	2	1	10	14	1	0	2	1	0	
16	Yard Lead	M009	1	3	1	8	13	1	0	3	1	0	
17	E Milpitas	M010	2	2	2	11	17	1	1	2	1	1	
18	W Milpitas	M012	1	3	1	9	14	1	0	3	1	0	
19	Diridon	M019	1	3	1	8	13	1	0	3	1	0	
20	Niles Back	NI010	1	2	1	12	16	1	0	2	1	0	
	Computer												1
	needed							11	4	36	13	7	1
	10% Sparing							2	1	4	1	1	1
	total order						**211**	**13**	**5**	**40**	**14**	**8**	**2**

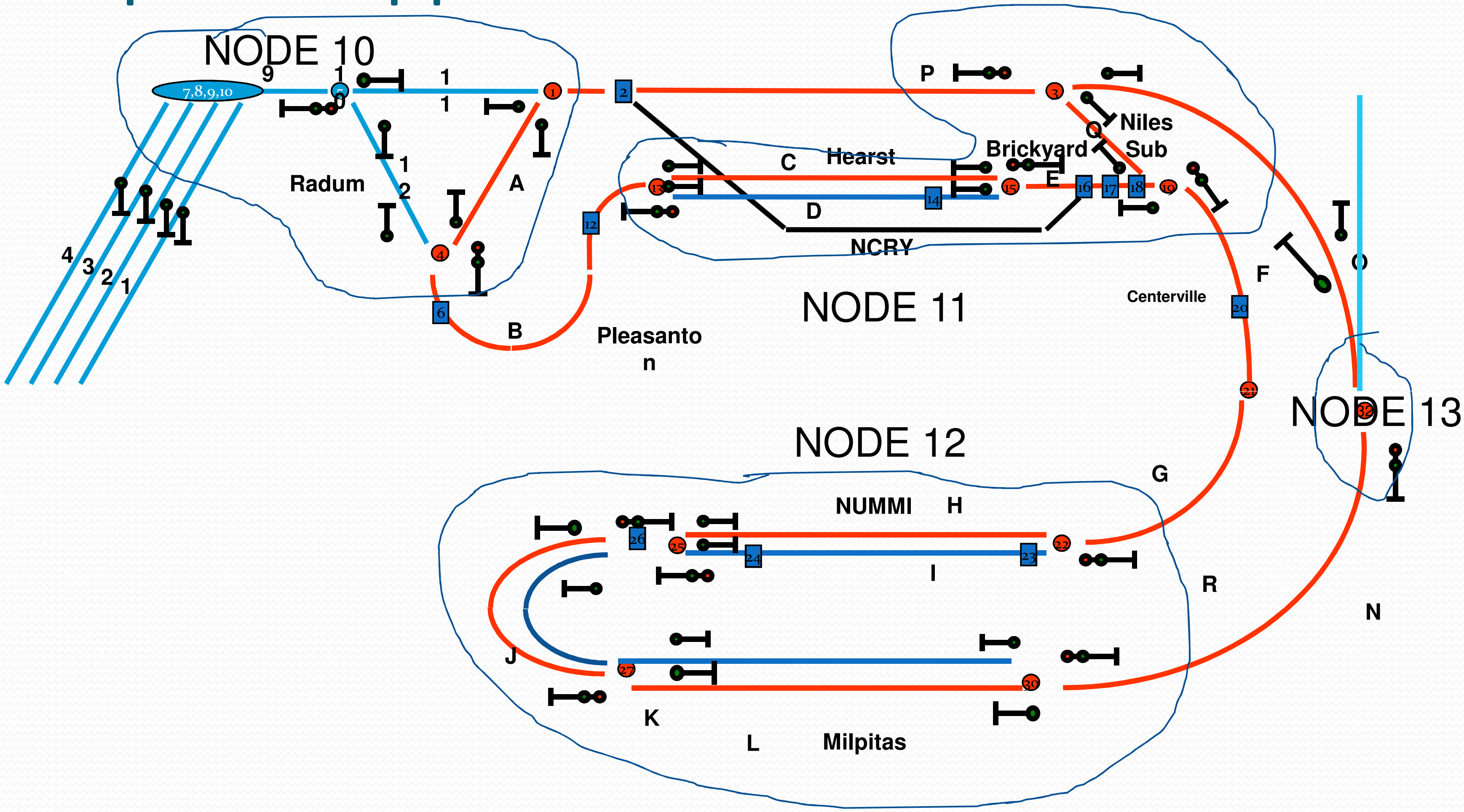
Examples - Full siding work sheet



Bill of Material: cpNode per Siding

				Inputs		Outputs		total i/o	cpNode	IOX16	cpOD(M)	ODX4	RSMC	Dongle
Node		Milepost		fascia	Blocks	Switch	Signal Lines							
10	Staging + Wye	F044	F043	7	10	7	40	64	1	3	10	3	6	
11	Hearst	F039	F038	2	6	2	20	30	1	1	6	2	1	
12	Niles Cutoff	F030	NI010	2	5	2	23	32	1	1	5	2	1	
13	E NUMMI	M004	M005	3	7	3	28	41	1	2	7	2	2	
14	E Milpitas	M010		3	5	3	20	31	1	1	5	2	2	
15	Diridon	M019		1	3	1	8	13	1	0	3	1	0	
	Computer													1
	needed								6	8	36	12	12	1
	10% Sparing								1	1	4	1	2	1
	total order								**7**	**9**	**40**	**13**	**14**	**2**

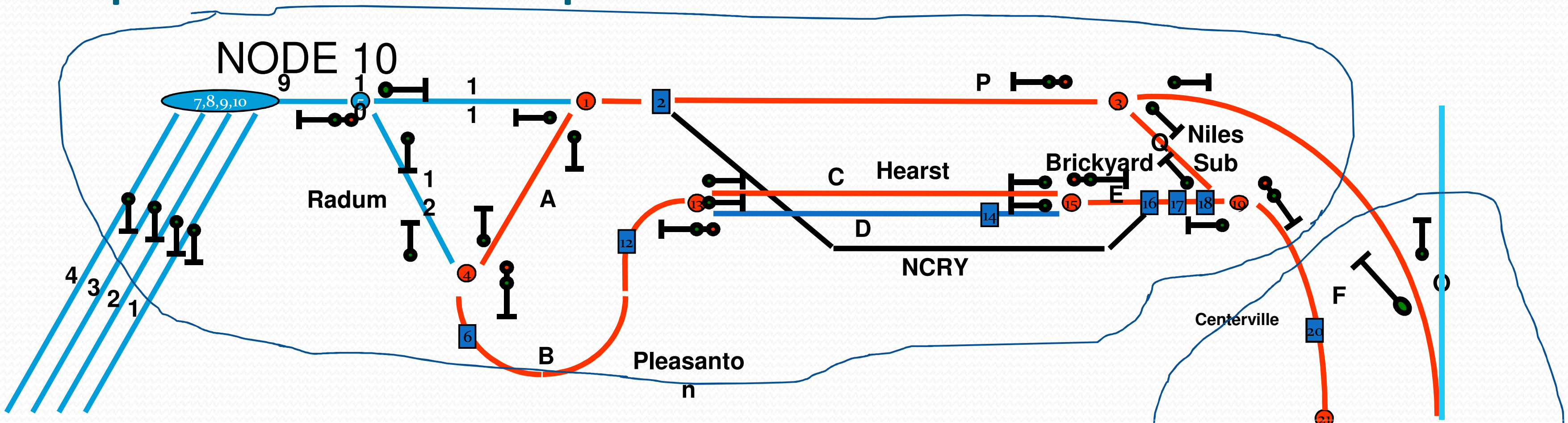
Example – “Opportunistic Clusters”

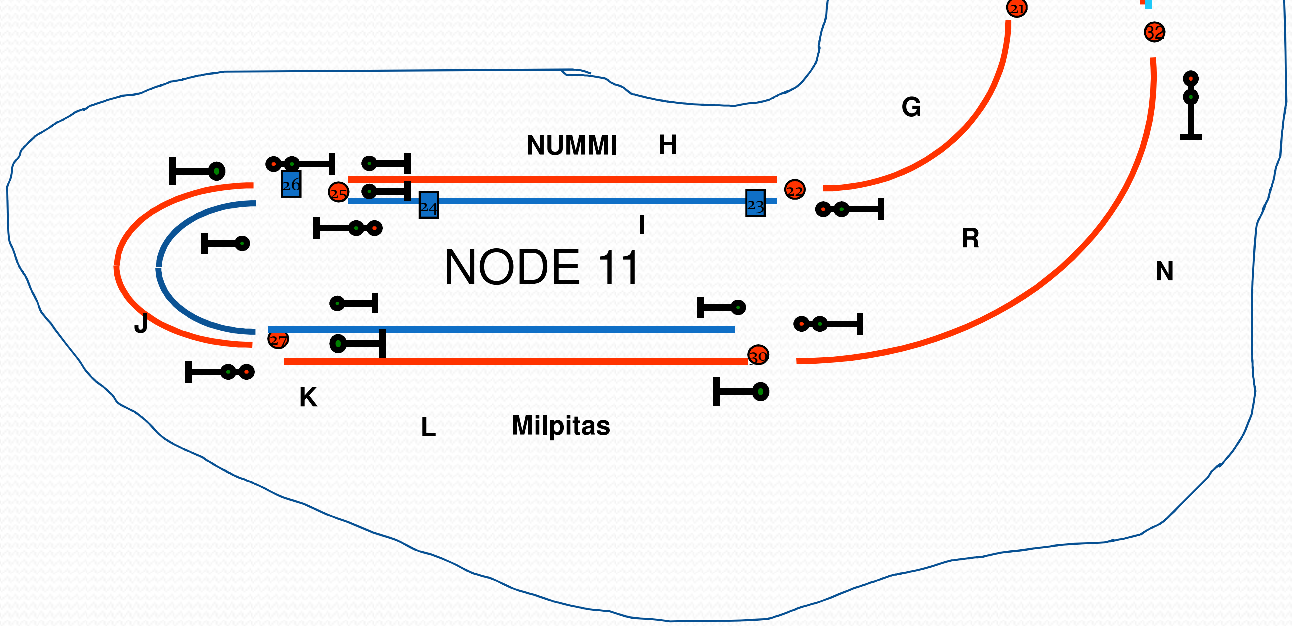


Bill of Materials: Opportunistic Clusters

				Inputs		Outputs		total i/o	cpNode	IOX16	cpOD(M)	ODX4	RSMC	Dongle
Node		Milepost		fascia	Blocks	Switch	Signal Lines							
10	Staging + Wye	F044	F043	7	10	7	40	64	1	3	10	3	6	
11	Hearst	F039	NI010	4	11	4	20	62	1	3	11	3	3	
13	E NUMMI	M004	M005	6	12	6	48	72	1	4	12	3	5	
13	Diridon	M019		1	3	1	8	13	1	0	3	1	0	
	Computer													1
	needed								4	10	36	10	14	1
	10% Sparing								1	1	4	1	2	1
	total order							**211**	**5**	**11**	**40**	**11**	**16**	**2**

Example – SMINI Replacement





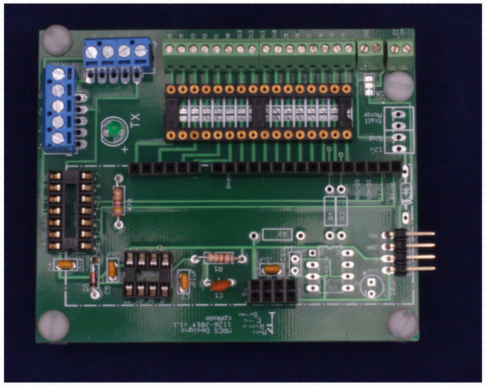
Layout actually has
3 SMINI under Radum,
2 under Milpitas and an
Intelligent (cpNode)
Control panel for Diridon

I'm open tomorrow
8:00 AM – 11:00 AM
Come see it!

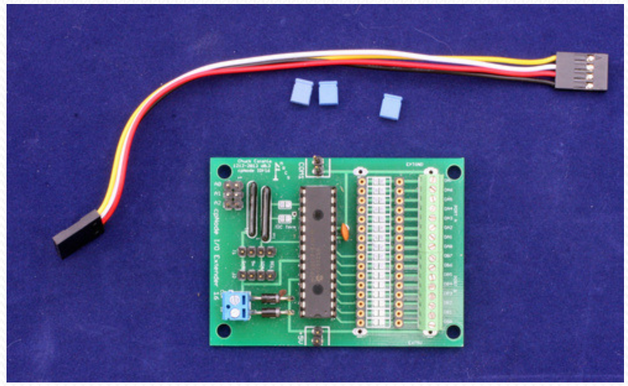
Bill of Materials:
SMINI Replacement

				Inputs		Outputs		total i/o	cpNode	IOX16	cpOD(M)	ODX4	RSMC	Dongle
Node		Milepost		fascia	Blocks	Switch	Signal Lines							
10	Radum Side	F044	NI010	11	21	11	84	126	1	7	21	6	10	
11	Milpitas Side	M004	M005	7	15	7	56	85	1	5	15	4	6	
	Computer													1
	needed								2	12	36	10	16	1
	10% Sparing								1	2	4	1	2	1
	total order							**211**	**3**	**14**	**40**	**11**	**18**	**2**

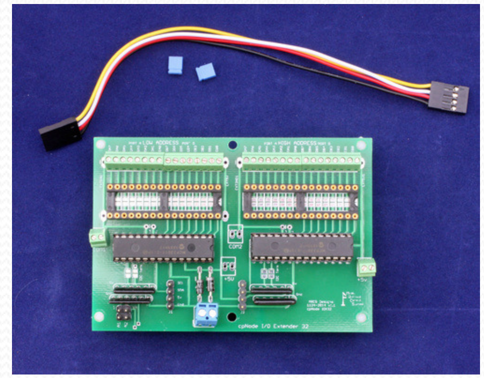
Appendix – the cpNode family



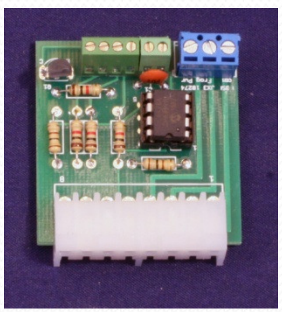
cpNode



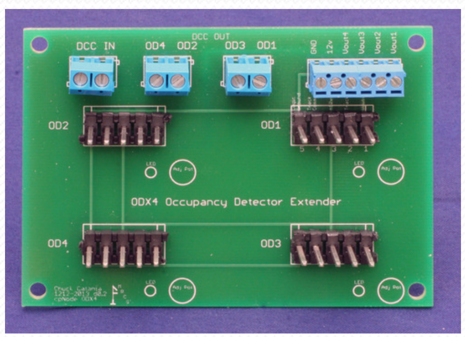
IOX16



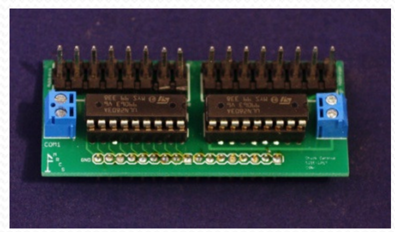
IOX32



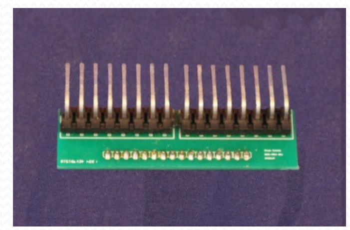
RSMC



ODX4



CSNK



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References:

- Our (MRCS) website http://www.modelrailroadcontrolsystems.com/
- Bruce Chubb's excellent manuals at http://www.jlcenterprises.net/Products.htm#Manual
- Texas Instruments RS485 Application Note http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCcQFjAB&url=http%3A%2F%2Fwww.ti.com%2Flit%2Fan%2Fslla272b%2Fslla272b.pdf&ei=UCFQVcCgIMWz0QTF80HQDQ&usg=AFQjCNGfNyOdKHc1uZHfxBvNlognOeiCog&sig2=PlID20JIA4kyFDee1J-leA&bvm=bv
- Other Vendors – see our resource section: http://www.modelrailroadcontrolsystems.com/information/