Initial Thoughts on MICE RF Controls

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Outline

I Assumptions

II Unknown

III Framework

IV State Machine Description

V Initial Thoughts on RF State Machine

VI Conclusions

History

All too often, control systems (in MICE) are built as an afterthought.

Assumptions

- *Darsbury Lab (DL) will build control system*
  - *Infrastructure*
  - *Facilities*
  - *Instrumentation*
- *Hardware is protected*
  - *Interlocks*
  - *Fail safes*
- *What is left?*
  - *User interface*
  - *Alarms*
  - *Archiving*

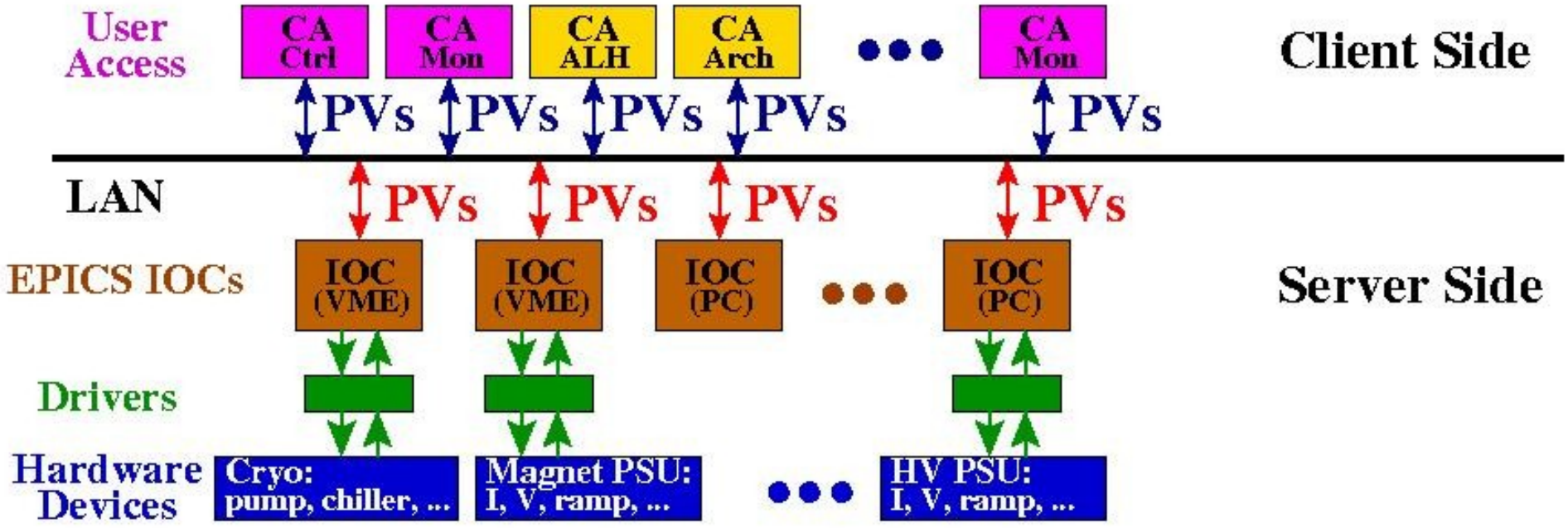
Unknown

- *What is the C&M Hardware?*
  - *Standard Darsbury Lab C&M?*
  - *PLC based?*
  - *Hybrid?*
- *Need to define requisite parameters*
  - *Parameters for each phase of operation*
  - *Starting from the beginning*
- *Identify differences between MTA and MICE needs*
  - *Instrumentation*
  - *Infrastructure*

Framework: EPICS

Experimental **P**hysics & **I**ndustrial **C**ontrol **S**ystems

- **HW+Drivers connect to IOCs** (Input/Output Controllers)
- **IOCs create PVs** (process variables) **to represent params**
- **PVs are further described with native fields**
- **PVs available on LAN to other IOCs or clients**



MICE State Machines

EPICS state notation language employed:

Define equipment operational states:

- For each state:
  - define parameters of interest
    - define transitions out of state
    - set alarm limits
    - set archiving features
    - define critical variables

check for software interlocks; e.g. quench
check for errors
check for transition

All parameters come from configuration database – ensures correct settings

State Machine Requirements

Must enumerate the states and provide for each state:

1)Description of state
2)Transition into state
3)PVs of interest
4)Alarm limits for PVs
5)Archiving features for PVs
6)AutoSMS (auto dialer) flag
7)Hardware interlocks*
8)Software “interlocks” (enables)

- Required for each state
- Stored in a database

State Machine: SS Example

Spectrometer Solenoid Magnets:

1)Offline
2)Pumping: establish insulating vacuum
3)Pumped_Warm: insulating vacuum established
4)Pre_Cooling: N_2 pre-cooling (T>100K)
5)Cooling: cryo-coolers lower shield/cold mass T
6)LHe_Filling: add liquid He
7)Cold_Ready: cold and stable
8)Ramping: applying current
9)Powered: stable operation
10)Quenched: quench detected
11)Error: error requires operator intervention
12)Testing: interlocks disabled for manual testing

Successfully used in training/mapping SS magnets

SS1 Example

Load these to data base

PV Name	Description	Measured Low	Measured High	ALARM LoLo	ALARM Low	ALARM High	ALARM HiHi	Units	ARCHIVER mode	ARCHIVER frequency (s)	ARCHIVER deadband	AutoSMS	Transition description	Transition value
MICE-SS1-VAC-01:PGMAX	insulating vacuum			1.0E-10	1.0E-09	2.0E-03	2.0E-02	torr	monitor	300	1.0E-08	TRUE	N/A	1.0E+00
MICE-SS1-SD-01:RDGK	Top of HTS lead E1 side			0.0	-1.0	120.0	125.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-02:RDGK	Rad Shield near vertical copper plates			0.0	-1.0	213.0	218.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-03:RDGK	CC5 Cu Plate			0.0	-1.0	187.0	192.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-04:RDGK	Rad Shield near MC end upper support			0.0	-1.0	225.0	230.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-05:RDGK	CC2 Cu Plate			0.0	-1.0	217.0	222.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-06:RDGK	Rad Shield			0.0	-1.0	221.0	226.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-10:RDGK	CC1 Stage 1			0.0	-1.0	184.0	189.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-11:RDGK	CC2 Stage 1			0.0	-1.0	200.0	205.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-12:RDGK	CC3 Stage 1			0.0	-1.0	212.0	217.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-13:RDGK	CC4 Stage 1			0.0	-1.0	218.0	223.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-14:RDGK	Cold Head single stage strap			0.0	-1.0	69.0	74.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-15:RDGK	CC5 Stage 1			0.0	-1.0	237.0	242.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-16:RDGK	CC1 Cu Plate			0.0	-1.0	235.0	240.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-19:RDGK	Rad Shield			0.0	-1.0	228.0	233.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-20:RDGK	CM Support EC end lower support			0.0	-1.0	236.0	241.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-23:RDGK	Rad Shield inside bore matching coil end			0.0	-1.0	400.0	400.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-24:RDGK	CM Support matching coil end upper support			0.0	-1.0	242.0	247.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-25:RDGK	Centre of of Radiation bore at bottom			0.0	-1.0	233.0	238.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-26:RDGK	Bottom of outer cylinder of Radiation shield			0.0	-1.0	225.0	230.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-SD-27:RDGK	On the single stage cooler head surface			0.0	-1.0	81.0	85.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-01:RDGK	Cold Mass bottom by M1			0.0	-1.0	105.0	110.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-02:RDGK	Cold Mass top by E2			0.0	-1.0	105.0	110.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-03:RDGK	CC3 Cu Plate			0.0	-1.0	218.0	223.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-04:RDGK	CC4 Cu Plate			0.0	-1.0	203.0	208.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-05:RDGK	CC1 Stage 2			0.0	-1.0	179.0	184.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-06:RDGK	CC2 Stage 2			0.0	-1.0	207.0	212.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-07:RDGK	CC3 Stage 2			0.0	-1.0	219.0	224.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-08:RDGK	CC4 Stage 2			0.0	-1.0	227.0	232.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-09:RDGK	CC5 Stage 2			0.0	-1.0	242.0	247.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-10:RDGK	Cold Mass bottom of LTS leads			0.0	-1.0	200.0	205.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-11:RDGK	Line fill line heater			0.0	-1.0	100.0	105.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-12:RDGK	Cold Mass bottom heater			0.0	-1.0	100.0	105.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CX-13:RDGK	Top of HTS lead E2 side			0.0	-1.0	129.0	134.0	K	scan	300		FALSE	N/A	0.0
MICE-SS1-CC-01:STA	Cryo Compressor 1: status			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-02:STA	Cryo Compressor 2: status			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-03:STA	Cryo Compressor 3: status			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-04:STA	Cryo Compressor 4: status			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-05:STA	Cryo Compressor 5: status			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-01:ALM	Cryo Compressor 1: OR of alarm states			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-02:ALM	Cryo Compressor 2: OR of alarm states			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-03:ALM	Cryo Compressor 3: OR of alarm states			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-04:ALM	Cryo Compressor 4: OR of alarm states			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-CC-05:ALM	Cryo Compressor 5: OR of alarm states			0.0	-1.0	0.5	0.0	-	monitor	60.0	0.0	TRUE	N/A	0.0
MICE-SS1-PG-01:RP	vent line pressure from ADC			1.05	1.10	1.80	2.00	bar	monitor	1.0	0.02	FALSE	N/A	0.0
MICE-SS1-PG-01:ALM	sum of alarm states			0.0	-1.0	0.5	0.0		monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PG-01:ERR	communication error codes								monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PG-02:RP	fill line pressure from ADC			1.05	1.10	1.80	2.00	bar	monitor	1.0	0.02	FALSE	N/A	0.0
MICE-SS1-PG-02:ALM	sum of alarm states			0.0	-1.0	0.5	0.0		monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-PG-02:ERR	communication error codes								monitor	1.0	0.00	FALSE	N/A	0.0
MICE-SS1-HET-01:SSS	Cold mass heater			0.0	-1.0	0.5	1.0	-	monitor	1.0	0.0	TRUE	N/A	0.0
MICE-SS1-HET-02:SSS	fill line heater			0.0	-1.0	0.5	1.0	-	monitor	1.0	0.0	TRUE	N/A	0.0
MICE-SS1-LEVEL-01:BLEV	LHe level			0.0	-1.0	100.0	100.0	%	scan	5.0	0.0	FALSE	Level>85%	85.0
MICE-SS1-HLS-01:SSS	LHe level switch			-1.0	-1.0	2.0	2.0		monitor	10.0	0.0	FALSE	N/A	0.0
MICE-SS1-LEVEL-01:BLEV	LHe level overflow			0.0	-1.0	10.0	20.0	%	scan	10.0	0.0	FALSE	N/A	0.0

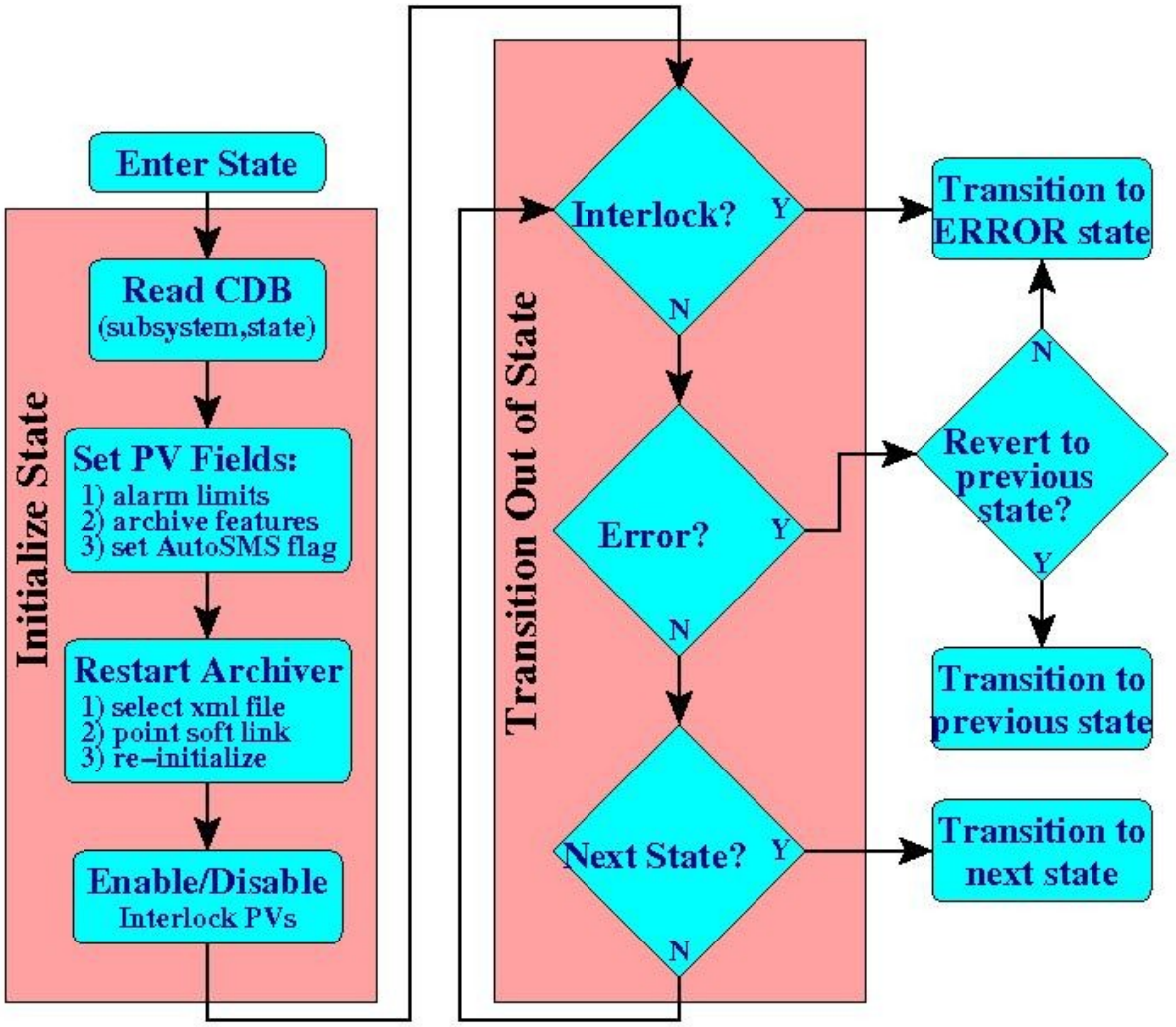
State Machine Algorithm

For each subsystem & state, the algorithm:

- **Transitions:**
- **manual**
- **automatic**

States can be:

- **static**
- **dynamic**



RF State Machine Initial Thoughts

1 Offline
- Continuously monitor pneumatic valves

2 Enabled
- Enable/Disable + RF to: Cavity or Dummy Load

3 Initialize (transition)
- Heat filaments
- Monitor: Vacuum, air, water

4 Standby
- May have “extended standby” – filaments remain on

5 Ready
- PSU and LLRF turned on

6 On
- DCs, V & I for biases and grids, PSUs, …

7 Testing

Conclusions

- *Only beginning*
- *Looking for synergies between MuCool and MICE*
- *Starting from the beginning – contribute early on*
- *Will use State Machine model to develop RF C&M*
- *Much to be done!!!*

This time, the MICE RF C&M won't be built as an afterthought