A REDUNDANT EPICS CONTROL SYSTEM BASED ON PROFINET

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Abstract

This paper will demonstrate a redundant EPICS control system based on PROFIENT. The control system consists of 4 levels: EPICS IOC, PROFINET IO controller, the PROFINET media and the PROFINET IO device. Redundancy at each level is independent of redundancy at each other level in order to achieve highest flexibility. The implementation and performance of each level will be described in this paper.

ARCHITECTURE

EPICS IOC

- **VMware FT is chosen to achieve hot standby for the EPICS IOC.**
- **VMware FT provides continuous availability for VMs by creating and maintaining a Secondary VM that is identical to, and continuously available to replace, the Primary VM in the event of a failover situation.**
- **The Primary and Secondary VMs continuously exchange heartbeats. This allows the virtual machine pair to monitor the status of one another to ensure that Fault Tolerance is continually maintained.**

PROFINET IO controller

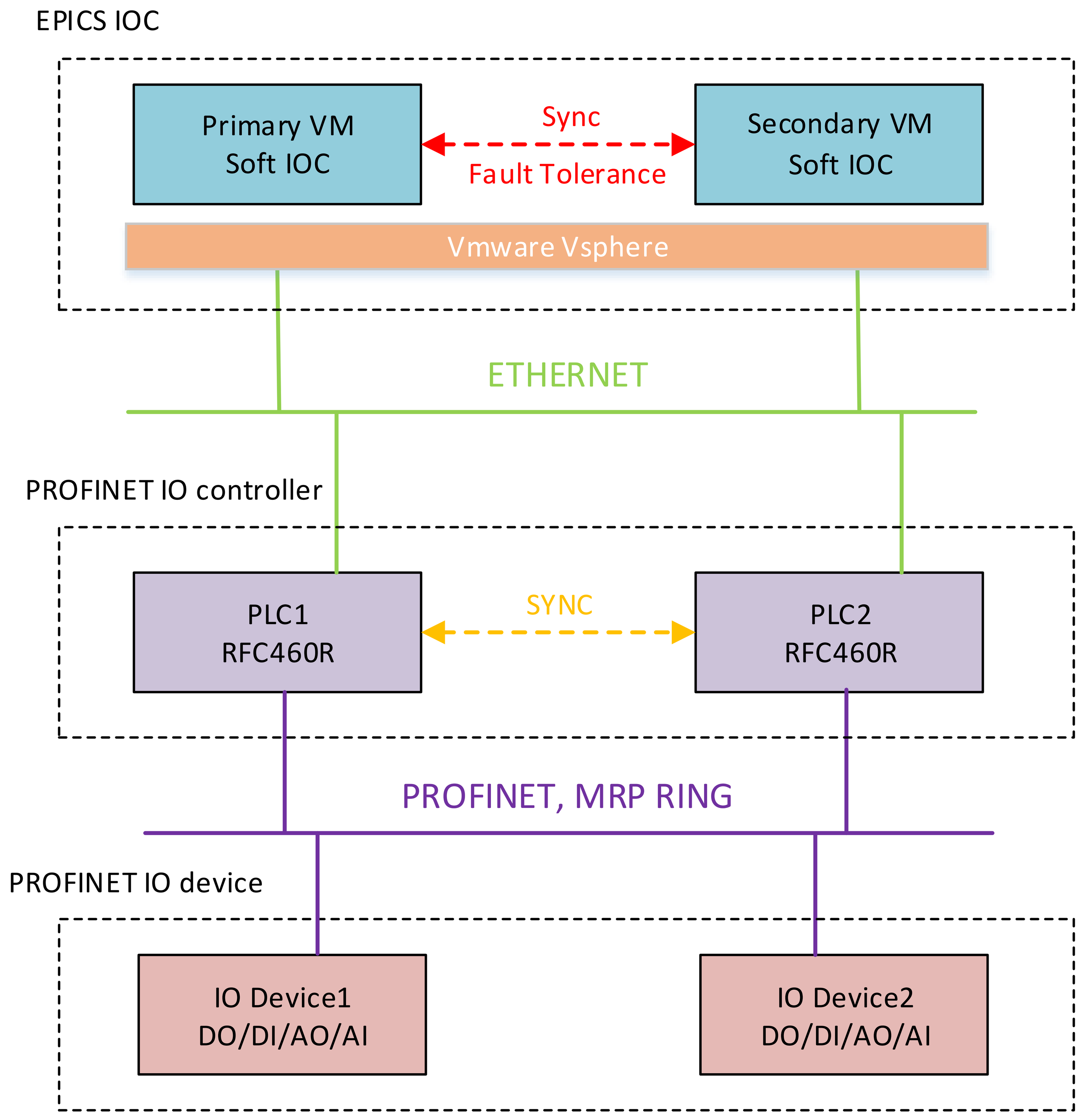
- **The redundant pair consists of two synchronized RFC 460R PLCs connected via fiber optics. The built-in fiber optic interface is used for synchronization and adjustment between the connected devices.**
- **During initial startup redundancy type FIRST must be assigned to one of RFC 460R PLCs and redundancy type SECOND to the other.**

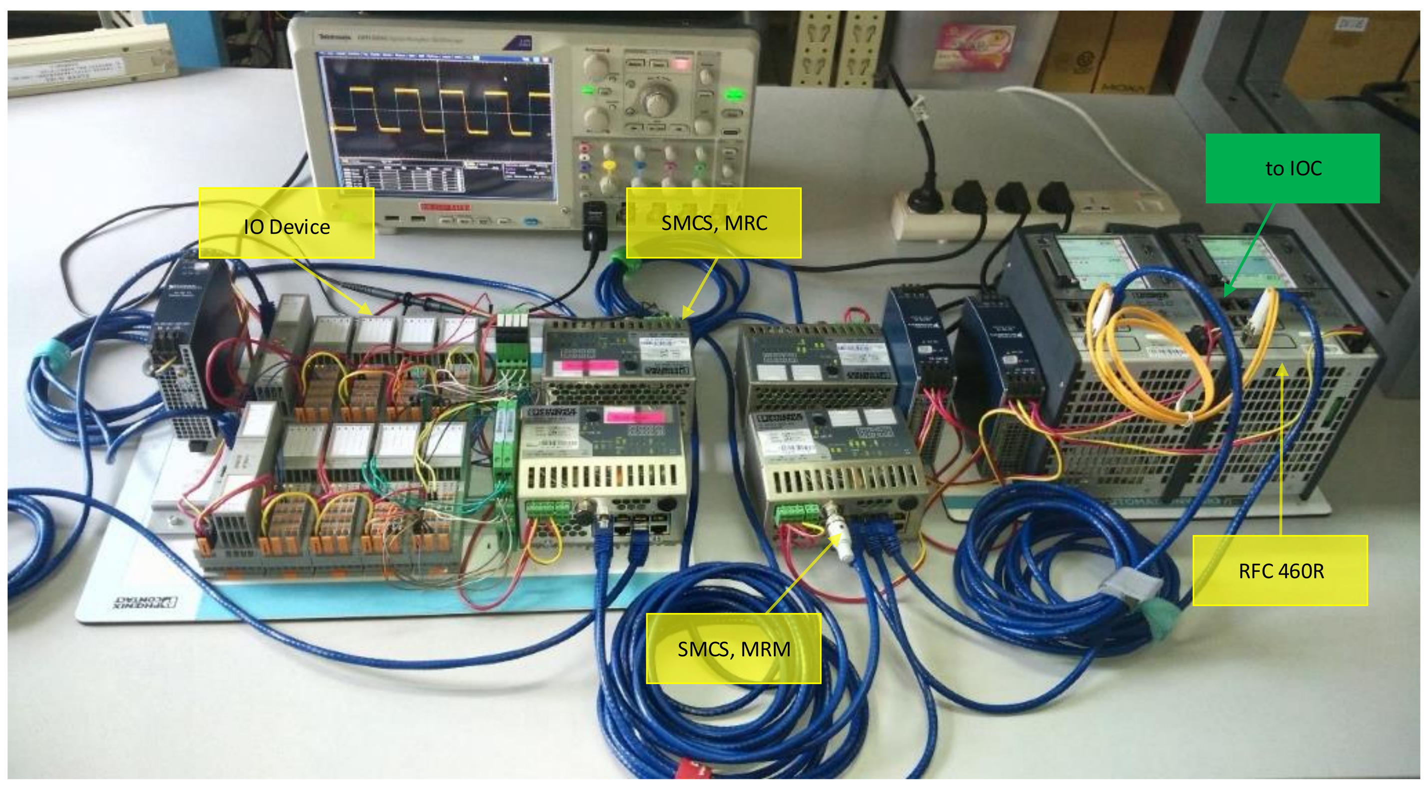
PROFINET media

- **The Media Redundancy Protocol (MRP) is used to realize the redundantly of PROFINET. MRP is a self-recovery media redundancy protocols based on physical ring topological network architecture, designed for the fault of single switch or single switch link in ring network.**

PROFINET IO device

- **The redundant pair of PROFINET IO devices consists of two PROFINET IO stations, one is primary station and the other one is backup station. The wiring for the AO, AI, DO, DI modules installed on the PROFINET IO stations is redundant.**





PROTOTYPE SYSTEM AND TEST

EPICS IOC

- **In order to investigate the availability of the softIOCs running on the VMs with FT, An ao record is created, and it outputs a triangle waveform with 100ms step.**
- **The EPICS extensions Striptool and EPCIS command camonitor are used to monitor the value of the ao record.**

PROFINET IO controller

- **There are 9 switch-over ways for the redundant pair of the RFC 460R PLCs. We test all 9 switch-over ways.**
- **Generally the control process is implemented in the PLC. A triangular wave is produced in order to simulate the control process, and Fig. 5 shows the switch-over with the 3rd way "link down at the PROFINET controller interface".**
- **The switchover time in Figure 5 is too short to observe changes from oscilloscope. Thus we use the packet analyzer Wireshark to capture the communication frames between the PLCs and PROFINET IO Devices. The switch-over time can be analyzed from the captured frames, Table 1 is the test results, the average switch-over time is 6.229 ms, the longest switch-over time is 7.078 ms.**

PROFINET Media

- **The recovery time is a very important parameter for a MRP ring. We also use Wireshark to capture the communication frames between the switches and analyze the recovery time. Table 2 is the test results, the average recovery time is 69.338 ms, the longest recovery time is 87.778 ms.**

PERFORMANCE

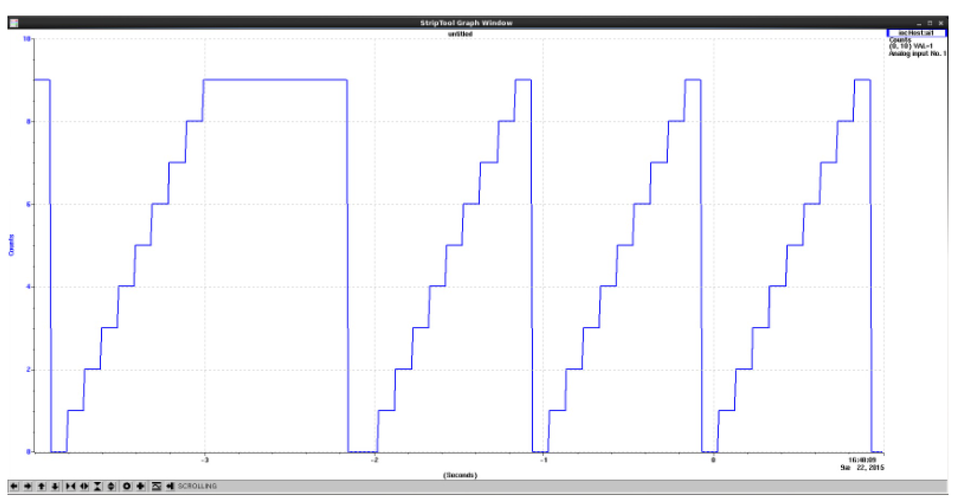


Figure 3: Switch-over of the softIOC monitored by Strip-tool

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iocHost:ai1                   2015-09-22 16:48:06.251241 7 HIGH MINOR
iocHost:ai1                   2015-09-22 16:48:06.351407 8 HIHI MAJOR
iocHost:ai1                   2015-09-22 16:48:06.451520 9 HIHI MAJOR
iocHost:ai1                   2015-09-22 16:48:07.260921 0 LOLO MAJOR
iocHost:ai1                   2015-09-22 16:48:07.447481 1 LOLO MAJOR
```

Figure 4: Switch-over of the softIOC monitored by camon-itor

Figure 5: Switch-over of the PLC monitored by the oscillo-scope

Table 1: PLC Switch-Over Time Test

Number	1	2	3	4	5
Time(ms)	6.964	4.571	6.986	6.953	6.969
Number	6	7	8	9	10
Time(ms)	6.962	6.984	7.078	6.984	2.542

Table 2: MRP Ring Recovery Time Test

Number	1	2	3	4	5
Time(ms)	67.694	78.618	71.138	73.192	87.778
Number	6	7	8	9	10
Time(ms)	56.787	64.676	59.751	72.223	61.518

CONCLUSION

We set up the prototype system by integrating the commercial solution into EPICS environment. The prototype system consists of 4 levels: the EPICS IOC, the PROFINET IO controller, the PROFINET media and the PROFINET IO device. Redundancy at each level is independent of redundancy at each other level. This means each level can have different redundancy configurations. Beside its flexibility, the prototype system is also easy to implement, and the switch-over performance is good enough to adapt to the most control processes of the big scientific facility.