Time Stamp Synchronization of PEFP Distributed Control Systems

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1. Introduction

Proton Engineering Frontier Project (PEFP) [1] proton linac consists of several types of control systems, such as soft Input Output Controllers (IOC) and embedded IOC based on Experimental Physics Industrial Control System (EPICS) [2] for each subsection of PEFP facility. One of the important factors is that IOC's time clock is synchronized. The synchronized time and timestamp can be achieved with Network Time Protocol (NTP) and EPICS timestamp record without timing hardware. The requirement of the time accuracy of IOCs is less than 1 second. The main objective of this study is to configure a master clock and produce Process Variable (PV) timestamps using local CPU time synchronized from the master clock. The distributed control systems are attached on PEFP control network as shown Fig. 1.

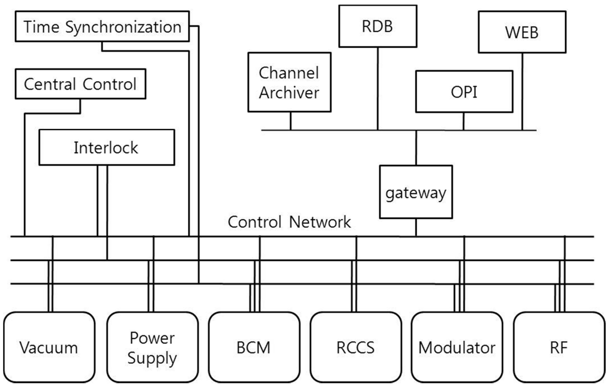

Fig. 1. Schematic layout of network-attached IOC

2. Soft-Time Implementation

All IOCs should have time clock synchronized from master clock or NTP server. The timestamp of PVs that could be produced in IOCs must be transmitted to operator interface and alarm viewer. It is important to record the time sync history and keep the time sync. That is because many IOCs on control subnet cannot be rebooted before a machine shutdown.

2.1 Time Sync Requirement

The time accuracy in IOCs should be less than 1 second. The accurate time should be able to be delivered by a NTP server and GPS time outside the control network subnet and timing hardware, and so on.

2.2 Time Salve IOC

The time master could be placed with three kinds of structure under the reliability and safety as follows.

- NTP server

The IOC has same and correct time when NTP-server is alive. But if NTP server or gateway fail or is not alive at IOC boot time, there is no time synchronization any more. The NTP based time sync is presented in Fig. 2.

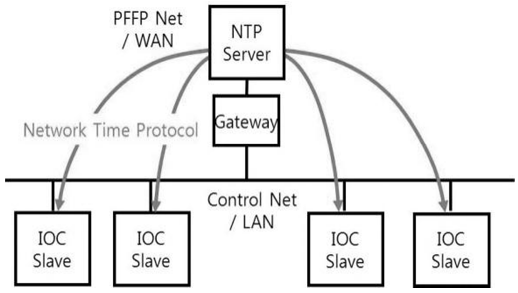

Fig. 2. Time synchronization using NTP server

- Master clock without NTP server

The IOC is synchronized with a master clock inside the control subnet without a NTP as shown in Fig. 3. In this case, the IOC clock could drift with a master clock.

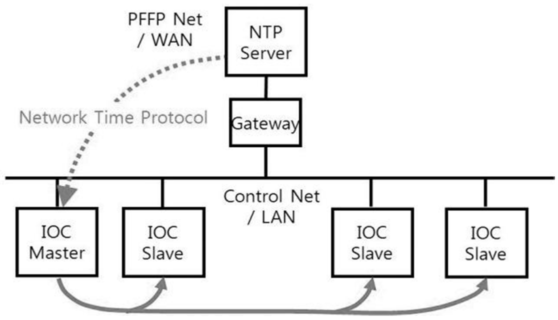

Fig. 3. Time master without NTP server

- NTP server and master clock

As the most stable configuration as shown in Fig. 4, the timing slaves are able to select time information from master clock and NTP server. Also the master clock can be synchronized with NTP server. If the NTP server fails, the timing slaves keep time sync using master clock instead of NTP server.

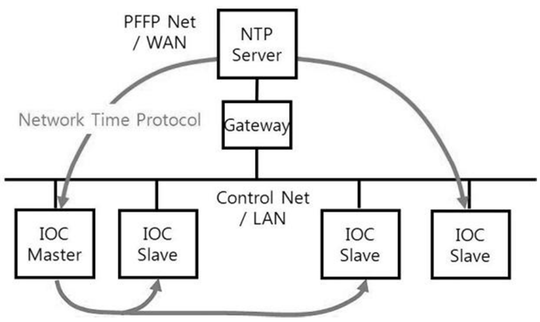

Fig. 4. Time sync using NTP server and master clock

3. Synchronized Timestamp

3.1 Concept

The soft channel device uses local CPU time on timestamps synchronized with soft time sync. If any timing hardware could be adapted for a time device support, it is possible to produce timestamps from the timing hardware. In order to produce timestamp without time support hardware, EPICS timestamp record is added in local IOCs and a central timestamp server to read each linked time through Time Stamp Event Link (TSEL) of record field. The soft timestamp device support and timestamp record are configured.

3.2 Soft timestamp device support and record

The soft timestamp device is a device support to import timestamp of other record. EPICS records have a field recording the timestamp when record is processed [3]. But the field permission is DBF_NOACCESS that EPCIS client library cannot access. The field can be accessed by record processing or run-time db access. The soft timestamp device support reads time between different records using DBF_INLINK type of time stamp link. The timestamp record shown in Fig. 5 takes charge of field configuration and a role of processing for soft-Device registration. The Time Stamp Type (TST) field has 12 kinds of expression type. Table 1 presents field and type of timestamp record.

```
menu(timestampTST) {
choice(timestampTST_YY_MM_DD_HH_MM_SS,"YY/MM/DD HH:MM:SS")
choice(timestampTST_MM_DD_YY_HH_MM_SS,"MM/DD/YY HH:MM:SS")
choice(timestampTST_MM_DD_HH_MM_SS_YY,"Mon DD HH:MM:SS YY")
choice(timestampTST_MM_DD_HH_MM_SS,"Mon DD HH:MM:SS")
choice(timestampTST_HH_MM_SS,"HH:MM:SS")
choice(timestampTST_HH_MM,"HH:MM")
choice(timestampTST_DD_MM_YY_HH_MM_SS,"DD/MM/YY HH:MM:SS")
choice(timestampTST_DD_MM_HH_MM_SS_YY,"DD Mon HH:MM:SS YY")
choice(timestampTST_VMS,"DD-Mon-YYYY HH:MM:SS")
choice(timestampTST_MM_DD_YYYY,"Mon DD, YYYY HH:MM:SS.ns")
choice(timestampTST_MM_DD_YY,"MM/DD/YY HH:MM:SS.ns")
choice(timestampTST_YYYY_MM_DD_HH_MM_SS, "YYYY/MM/DD HH:MM:SS.ns")
}
recordtype(timestamp) {
        include "dbCommon.dbd"
        field(INP, DBF_INLINK) {
                prompt("Input Specification")
                promptgroup(GUI_INPUTS)
                interest(1)
        }
        field(VAL,DBF_STRING) {
                prompt("Current Value")
                asl(ASL0)
                pp(TRUE)
                size(40)
        }
        field(OVAL,DBF_STRING) {
                prompt("Previous Value")
                special(SPC_NOMOD)
                interest(3)
                size(40)
        }
        field(RVAL,DBF_ULONG) {
                prompt("Current Raw Value")
                pp(TRUE)
        }
        field(TST,DBF_MENU) {
                prompt("Time Stamp Type")
                promptgroup(GUI_INPUTS)
                interest(2)
                menu(timestampTST)
        }
}
```

Fig. 5. Field and type of timestamp record

Table I: Expression type of timestamp record

TST	VAL
YY/MM/DD HH:MM:SS	2004/07/20 15:20:01
MM/DD/YY HH:MM:SS	07/20/2004 15:20:27
Mon DD HH:MM:SS YY	JUL 20 15:21:02 2004
Mon DD HH:MM:SS	JUL 20 15:21:30
HH:MM:SS	15:22:10
HH:MM	15:22
DD/MM/YY HH:MM:SS	20/07/2004 15:22:52
DD Mon HH:MM:SS YY	20 JUL 15:23:24 2004
DD-Mon-YYYY HH:MM:SS	20-JUL-2004 15:23:44
Mon DD, YYYY HH:MM:SS.ns	JUL 20, 2004 15:24:08.9048290
MM/DD/YY HH:MM:SS.ns	07/20/2004 15:24:33.672549000
YYYY/MM/DD HH:MM:SS.ns	2004/07/20 15:25:16.242448000

The timestamp record can be installed in local IOCs or a central timestamp server. Fig. 6 presents the local IOCs that include timestamp record and the central timestamp server that is connected with PVs of the local IOCs.

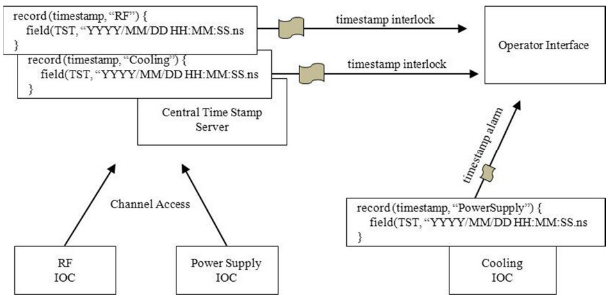

Fig. 6. Transmission of timestamp record from local IOCs and a central timesamp server

4. Conclusion

The IOC keeps system time within less than 1 second with soft time sync using NTP server and master clock in parallel. The local IOCs can produce PV's timestamp without time delay by transmission between event time and read time of operation parameters. As a result, the alarm and interlock signal of control systems can present the seamless timestamp of control PVs to the linac operators. In future, the infrastructure for time sync will be configured using NTP or GPS time device.

5. Acknowledgements

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Reference

[1] Y. S. Cho, H. M. Choi, S. H. Jan, I. S. Hong, J. H. Jang, H. S. Kim, K. Y. Kim, Y. H. Kim, H. J. Kwon, K. T. Seol, and Y.G. Song, Test Result of the PEFP 20-MeV Proton Accelerator, EPAC 2006, p. 1609.
[2] Martin R. Kraimer: "EPICS IOC Application Developer's Guide", APS/ANL, 1998
[3] Philip Stanley, Janet Anderson, Marty Kraimer: "EPICS Record Reference Manual "