Fusion Engineering and Design 128 (2018) 95–100

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

Preliminary implementation of the real-time data sharing system based on RFM for EAST

C.C. Li[a,b], Z.S. Ji[a,*], F. Wang[a], Q.P. Yuan[a], S. Li[a]

[a] Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China
[b] University of Science and Technology of China, Hefei 230026, China

ARTICLE INFO

Keywords:
Data sharing system
Real-time
Data acquisition
PCS
Diagnostic data

ABSTRACT

For EAST experiments, the plasma control system (PCS) needs a lot of diagnostic data produced by the distributed subsystems of EAST to meet the requirements of steady-state plasma control. But due to the factors of different sampling frequencies of the subsystems and the signal distortion caused by long distance transmission, it's difficult for the PCS alone to acquire all the diagnostic data in each control cycle. So the real-time data sharing system is designed to solve the problem of real-time data transmission between the PCS and the subsystems so as to realize data sharing among the distributed EAST systems.

In consideration of the required transfer speed and data volume, a "multiple networks" structure composed of a reflective memory (RFM) network and a Gigabit Ethernet network is used to build this system. To work with this multi-network structure, Red Hat MRG Realtime (Messaging, RealTime, and Grid) operating system (OS) is adopted, as it can provide deterministic response time. This system is responsible for transferring the diagnostic data collected by the data acquisition (DAQ) systems of the various distributed subsystems to the PCS and data server. The PCS receives the data through the RFM network in each PCS control cycle (defined as 100 microseconds) while the data server receives the data through the Ethernet network in every time-slice (defined in the DAQ program). All the relevant diagnostic data are to be available to the PCS through the data sharing system, though the PCS has the ability to choose some specified data according to its own needs during the plasma control. Likely, the above advantages for the PCS also apply for any EAST subsystems connected to the RFM network. In this paper, the details of the real-time data sharing system are described and the future work is also discussed.

1. Introduction

The experimental advanced superconducting tokamak (EAST) is composed of many diverse sub-systems, which are located in different electromagnetic environments and separated by varying distances from each other [1]. Among these subsystems, the PCS plays an important role in the EAST experiments.

The EAST PCS is a mini, Linux-based cluster with one host node and three real-time computing nodes [2], which are collected through a local real-time Myrinet Network [3] for real-time data exchange. The host computer is also connected to an Ethernet switch, through which experimental data and discharge parameters are transmitted before and after a discharge [4,5]. Fig. 1 shows a sketch of the current EAST PCS and peripheral systems [6]. It can be seen in the figure that the data from the data input system needs to be collected by the PCS during the control cycle; the collected data is only a small amount of the total EAST diagnostic data that is produced by all of the different subsystems. From a theoretical point of view, the PCS needs more diagnostic data to better control and maintain the plasma in a high performance steady-state. However, due to the different sampling frequencies of the subsystems, the mutual interference from the various signals, and the attenuation caused by long distance transmission, it's difficult for the PCS to acquire all the diagnostic data by itself in each control cycle. Moreover, the diagnostic data collected by the DAQ machines of the EAST subsystems distributed in different places aren't accessible by the PCS or other subsystems.

To solve the above problems, the real-time data sharing system is designed based on the "multiple network" structure as the central principle. This system will be able to deliver acquisition data in real-time to other subsystems connected to the RFM network, especially the PCS − to achieve better plasma control [7]. Section 2 describes the hardware architecture of this system and the upgrade of both the network and the DAQ machines. In Section 3, the details of the software design are presented. Section 4 describes the construction of a test

* Corresponding author at : Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China.
E-mail addresses: licc@ipp.ac.cn (C.C. Li), jizh@ipp.ac.cn (Z.S. Ji).

https://doi.org/10.1016/j.fusengdes.2018.01.044
Received 23 June 2017; Received in revised form 1 December 2017; Accepted 17 January 2018
Available online 06 February 2018

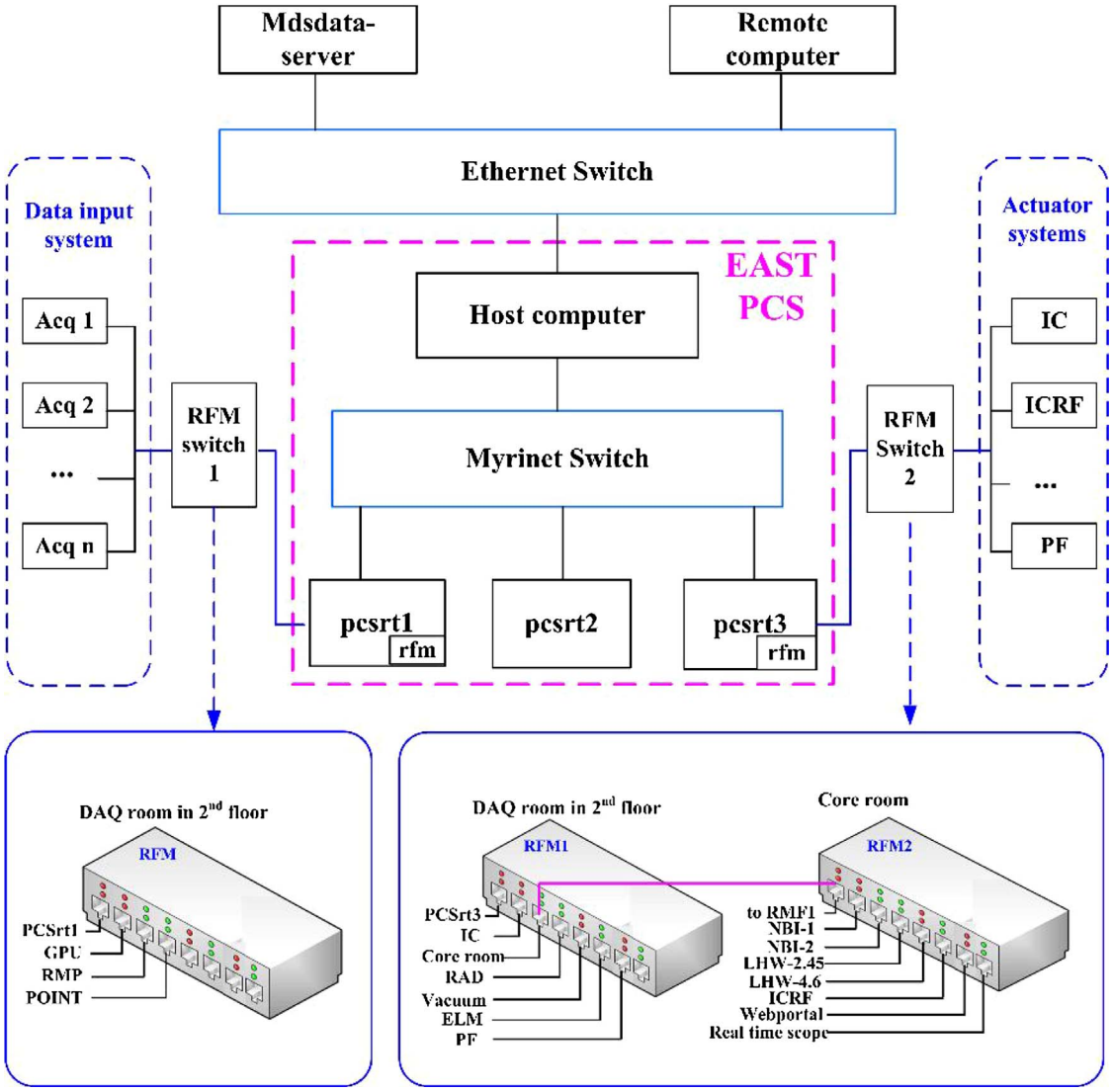

Fig. 1. A sketch of the current EAST plasma control system and peripheral systems.

platform and preliminary results. The conclusions are given in Section 5.

2. Hardware architecture

To maximize cost-efficiency, the real-time data sharing system is designed and developed by remodeling the current hardware and software in use on the existing systems. Fig. 2 illustrates the hardware structure of this system. The system is composed of the RFM network, Ethernet network, the distributed DAQ machines of the EAST subsystems and PCS. The architecture of the PCS is described in the introduction; the DAQ machines all have nearly identical components, utilizing the same series of motherboard with PXI (PCI eXtensions for Instrumentation) bus and quad-core processors. The main modules contained in each DAQ machine are as follow:

(a) Digital input − receives the external trigger or clock for synchronization.
(b) Analog input and output − acquires the diagnostic data and sends the commands from the PCS to the various subsystems, respectively.
(c) Two RFM boards − real-time data communication.
(d) A fast processor with MRG Realtime OS − real-time processing.

The overall function of this system can be sub-divided into four parts: data collection, transmission, analysis and storage. The DAQ machines are responsible for collecting and transferring all the diagnostic data to different subsystems and the data server for analysis and storage respectively. So the question about data communication needs to be discussed. The RFM network and Gigabit Ethernet network are deployed in the real-time data sharing system to meet the requirements of both transfer speed and data volume.

2.1. RFM network

Because the collected data needs to be transferred to the PCS and other subsystems, not just in real-time, but as fast as possible, the RFM network was chosen; we also have various experimental experience with it already. A reflective memory network is a special type of shared memory system which enables multiple, separate computers to share a common set of data [8]. It is the best choice in terms of transfer speed for distributed systems when compared with many standard networks such as Ethernet, ATM, and other customized communication hardware [9,10]. To better meet the requirements of the EAST experiments, the RFM network will be an upgrade to the existing network, and it will consist of two independent real-time networks. RFM network#1 transfers the diagnostic data produced by the subsystems and other