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Adapting DCS real time framework for WEST plasma control

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ABSTRACT

In December 2016, the experimental Tokamak WEST (W -for Tungsten- Environment in Steady state Tokamak) has produced its first plasma using its new Plasma Control System (PCS) based on the AUG RT framework DCS (Discharge Control System) and adapted to the specific needs of WEST. Now, WEST project's development phase ends and a first operational version is routinely used for experimental purpose.

1. Introduction

The project, started in 2013, has consisted in transforming the Tore Supra tokamak into an X point divertor device to test tungsten plasma facing component in an ITER-relevant environment. To operate this new machine, the Tore Supra control system had to use a segment (which is characterized by a set of references/parameters, used control/diagnostic schemes and exception policies and represents a plasma phase) approach (unlike a monotonic time line description) to manage and control the plasma. As the Real-time (RT) control framework of AUG (ASDEX Upgrade) called DCS (Discharge Control System) integrates a native handling of the events [1–3], it has been adapted and integrated in the WEST control infrastructure [4–6] (cf. Fig. 1). DCS was also selected because of the ease of implementing interfaces with different communications systems, three in our case in order to be compatible with the WEST specificities: real time network, timing system and pulse sequence [6].

This paper describes in the first section, the way used to connect DCS to the Timing System network, allowing it to exchange discrete events (i.e. trigger diagnostic high frequency acquisitions) and share global clock.

In the second section, we explain how we enable data sharing between DCS and WEST acquisition units during the real-time phase without modifying core codes, neither in DCS nor in the West acquisition library and client.

We will show then how DCS was integrated through the Acquisition network into the pulse sequence manager which handles the different phases of the operation (plasma phase, between shots…). Plasma control mechanism will be shown in the Section 4. To finish, we will present results we achieved after connecting all the WEST networks.

2. Timing system interface

The West Timing System plays an important part in the correct scheduling (cf. Fig. 2) of the pulse. This custom developed network [7] embeds two main functions. The first one is the distribution of time to all the control system; it is by far the main feature of this strategic network. Its purpose is to synchronize all the subsystems in the right order and in due time. The second one is the management of the time events. The timing system network is also used to trigger specific requests on some subsystems (ex: trigger fast data acquisition process of a diagnostic, pellet injection…) and to send/receive specific event notifications (ex: Plasma stop request).

As mentioned before, DCS is a real time framework in which several processes, called Application Processes (AP), can run in sequence. The APs are all synchronized by a generic cycle master connected to the timing system through a time adapter plugin. The reception and the sending of timing events are done by a specific AP called ChronoPCIAP. The two processes need to communicate with the Timing System PCI board. However, this board was not designed to be interrupted in a parallel way (i.e. by several processes at the same time cycle). Therefore, a dedicated application "pollonchrono" has been developed to interface DCS with the timing system hardware (cf. Fig. 3). "Pollonchrono" reads in an infinite loop the current time and the time events and writes them in a fast access memory. Pollonchrono is also capable of reading from the fast access memory in order to forward any

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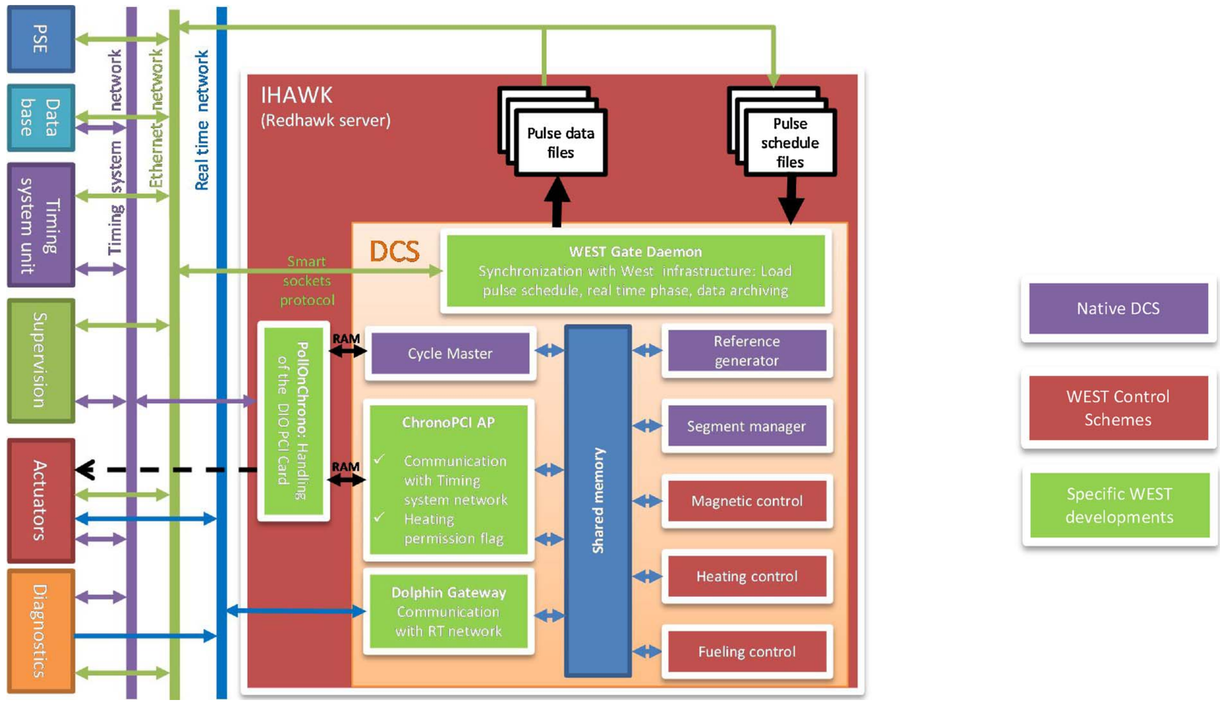

Fig. 1. New interfaces has been developped (shown in green) in DCS. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

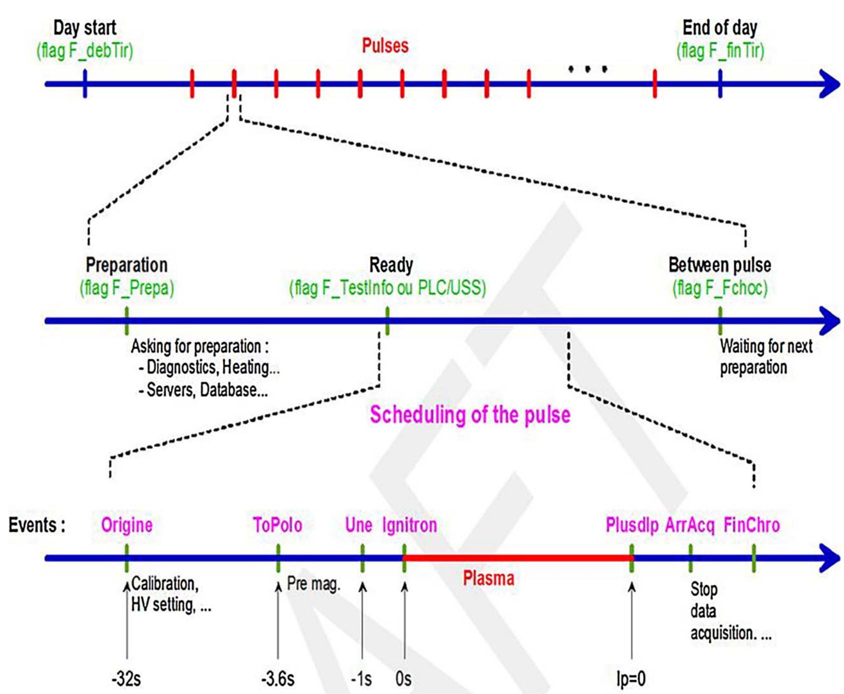

Fig. 2. A bespoke timing is used to manage pulse and to trigger action during pulse.

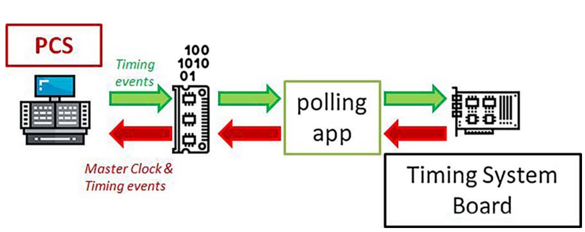

Fig. 3. Polling app makes PCS independent of the materials.

time events that were produced by the DCS.

The cycle master checks that all the AP cycles are within the time cycle without overrun. Otherwise, an alarm leads to the end of the RT phase. It uses a TimeAdapter plugin and expects hardware support for access to experiment time (uint64_t, in nanoseconds) and for a wakeup function for each time cycle. From a generic time adapter, a WEST version has been specialized to read the time given by the Pollonchrono process.

The reference generator produces a dedicated signal (code) for the time events, following the pre-defined waveform of the current

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