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Current State of DIII-D Plasma Control System

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The DIII-D Plasma Control System (PCS) is a comprehensive software and hardware system used in real-time data acquisition and feedback control of numerous actuators on the DIII-D tokamak. It regulates hundreds of plasma characteristics including shape, position, divertor function, and core performance. The custom software developed at DIII-D provides an expandable platform from which new control algorithms can be incorporated. PCS has been expanding with the needs of the DIII-D research program, national, and international institutions that have adapted the PCS for use on their devices.
The DIII-D PCS group in collaboration with many national and international groups have been instrumental in steadily improving the effectiveness and capability of the system. Recent hardware improvements have been made to enhance real-time connectivity using a 40Gbit/s InfiniBand network, and to increase computational performance with additional real-time computing cores and a new GPU. Real-time data acquisition capabilities have also been enhanced through upgrades of PCS digitizers that double the acquisition rate and increase the range between signal source and digitizers. The range increase allows additions of signal sources from dispersed laboratories in the facility. New control capabilities have also been added, including machine protection algorithms (e.g. disabling ECH power in case of high plasma density) and more granular feedback of Neutral Beam control. A new GPU with 61,400 computing threads has been included in one of the PCS real-time nodes to run new Resistive Wall Mode feedback algorithms (Columbia University). Novel capabilities have been added, including the machine learning-based Disruption Predictor via Random Forest algorithm (MIT) and the ability to display real-time PCS signals beyond the control room.
In this paper, we will describe enhancements to PCS system, their motivations, results, and impact to enable the mission of the DIII-D program.
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