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Decision logic in ASDEX Upgrade real time control system

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One of the key requirements for large tokamak operation is a reliable handling of off-normal states such as failures in some subsystems and their combination, not all necessarily known a priori. Handling these issues requires advanced and flexible algorithms for decision logic to ensure a reliable, while still scalable system.

Our work focuses on the tokamak ASDEX Upgrade. The ASDEX Upgrade control system DCS already applies diverse decision algorithms for achieving strategic, system-wide goals as well as for implementing defence in depth in individual control functions. Beyond a certain number of states and complexity the current algorithms become hardly maintainable and scalable. In this contribution, we therefore propose the use of Behaviour Trees (BT) as the backbone for the decision logic to cope with the complexity and the experimental character of the control system for tokamaks.

BT are widely and successfully established in robotics and the game industry for the design of complex behaviours in real time. They possess several advantages over traditional methods such as hierarchical finite state machines (HFSM). As BT essentially operate state-less, they avoid the need of defining consistent state transitions between the many nested and concurrent sub-states of a plasma control system. This characteristic endows the BT with a great flexibility, high modularity and ease to maintain and extend.

In our contribution, we will show the usage of the BT in two examples. Firstly, it demonstrates how a BT can be used to define the current experimental goal by selecting the corresponding segment in the ASDEX Upgrade pulse schedule. Secondly, it shows the real time selection of the most convenient diagnostic sources for the real time density evaluation in presence of multiple diagnostics failures and diverse plasma states appearing at AUG.

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