Abstract

Nuclear power plants traditionally rely on well-trained operators to regulate dynamic operations, but nuclear plant workforces do not currently scale with plant output. However, advanced reactors, to include small modular reactors, have improved passive safety features, which can reduce frequency and consequences of abnormal conditions that cause core damage. The requirement for human operators is significantly reduced at these facilities, enabling the conversion of the human operator into reliable and verifiable autonomous processes. An autonomous machine benefits plant operations in two ways: fewer human operators and continuous monitoring of all plant process sensors. Abnormal conditions can be identified more rapidly, increasing the available response time to correct these situations, minimizing the probability of reactor downtime, and reducing operational costs. A system that uses discrete event systems (DES), modelled as finite state automata (FSA), to track and execute state changes leaves nothing to chance and is the more reliable operator. Demonstrating a controller's ability to execute and monitor a reactor startup operation is a first step towards autonomous control and is integral to new reactor deployment. A simple supervisory control system using FSA was successfully demonstrated using the Massachusetts Institute of Technology Research Reactor systems and procedures. This robust proof of concept establishes the foundation of this modelling approach and can be scaled to incorporate comprehensive plant models. This supervisory control system facilitates a smooth transition from operator aids to fully autonomous operation and lays the groundwork for its implementation in advanced reactor plant designs.