Demonstration of Demand Driven Deployment Capabilities in Cyclus

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ABSTRACT

Nuclear Fuel Cycle (NFC) simulation scenarios are constrained objective functions. The objectives are systemic demands such as "1% power growth", while an example of a constraint is the availability of new nuclear technology. To add ease in setting up nuclear fuel cycle simulations, NFC simulators should bring demand responsive deployment decisions into the dynamics of the simulation logic [1]. While automated power production deployment is common in most fuel cycle simulators, automated deployment of supportive fuel cycle facilities is non-existent. Instead, the user must detail the deployment timeline of all supporting facilities or have infinite capacity support facilities. Thus, a next generation NFC simulator should predictively and automatically deploy fuel cycle facilities to meet user defined power demand. This paper discusses demonstration of a new solution, `d3ploy`, enabling demand driven deployment in Cyclus.

Cyclus is an agent-based nuclear fuel cycle simulation framework [2]. Each entity (i.e. Region, Institution, or Facility) in the fuel cycle is modeled as an agent. Institution agents are responsible for deploying and decommissioning facility agents and can represent a legal operating organization such as a utility, government, etc [2].

The Demand-Driven Cycamore Archetypes project (NEUP-FY16-10512) aims to develop Cyclus's demand-driven deployment capabilities. This capability is developed in the form of a Cyclus Institution agent that deploys facilities to meet the front-end and back-end fuel cycle demands based on a user-defined commodity demand. Its goal is to meet supply for any commodity while minimizing oversupply. This demand-driven deployment capability is referred to as `d3ploy`.

At each time step, `d3ploy` predicts demand and supply of each commodity for the following time step. Then, `d3ploy` deploys facilities to meet predicted demand. Three interchangeable algorithm types govern demand and supply predictions: non-optimizing, time series forecasting, and deterministic optimizing.

We compared the prediction algorithms with fuel cycle scenarios in which the demand driving commodity, its demand curve, and the combination of facilities in the scenario are varied. Specifics about the prediction algorithms are discussed in [3]. We demonstrated deployment capabilities in `d3ploy` for scenarios requiring front-end facility deployment, back-end facility deployment, closed fuel cycle deployment, and transition scenario deployment. Each scenario was run with each prediction algorithm, and the results were compared based on the number of time steps in which demand exceeds supply and the χ^2 goodness of fit test. These comparisons demonstrated that the non-optimizing methods effectively predicted appropriate facility deployment for supplying the driving commodity. These comparisons also demonstrated that the time series forecasting and deterministic algorithms effectively predicted appropriate facility deployment for supplying front-end and back-end commodities. The full paper will compare these prediction algorithms quantitatively, determine the advantages and disadvantages of each, and provide recommendations for which algorithm is desirable for use in modeling transition scenarios. Demonstration of how `d3ploy` improves the analysis of transition scenarios is discussed in [4].

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