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 the constraints are availability of new nuclear technology. To effectively simulate a nuclear fuel cycle, NFC simulators must bring demand responsive deployment decisions into the dynamics of the simulation logic [1]. Thus, a NFC simulator should have the capability to deploy supporting fuel cycle facilities to meet a user-defined commodity demand. In most fuel cycle simulators, automated deployment of supportive fuel cycle facilities is non-existent. Instead, the user has to detail the deployment timeline of all supporting facilities or have infinite capacity support facilities. This shortcoming exists in the fuel cycle simulator, 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. Each facility agent operates in an institution agent, where the institution agent is responsible for deployment and decommissioning facility agents. The institution agent represents a legal operating organization such as a utility, government, etc [2].

The Demand-Driven Cycamore Archetype 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 and back-end demands of the fuel cycle based on a user-defined commodity demand. Its goal is to minimize the time where demand exceeds supply for any commodity. The demand-driven deployment capabilities is referred to as d3ploy.

At each time step, demand and supply for each commodity is predicted for the following time step. Based on the prediction, facilities will be deployed to meet predicted demand. The demand and supply predictions are governed by four types of algorithms: non-optimizing, time series forecasting, deterministic optimizing and machine learning. The choice of which prediction algorithm to use is a user-input.

The prediction algorithms are compared using numerical experiments. The numerical experiments are in the form of fuel cycle scenarios where the demand driving commodity, its demand curve and the combination of facilities in the scenario are varied. The results of the numerical experiments are compared based on number of time steps where demand exceeds supply, residuals and chi goodness of fit test. The non-optimizing methods were effective for predicting the driving commodity. Whereas, the time series forecasting, deterministic and machine learning algorithms were more effective for predicting derived demand for front and back deployment.

To evaluate d3ploy's capability in Cyclus, transition scenarios are simulated using Cyclus with and without it. The use of d3ploy automates the deployment of supporting facilities and thus, improves the ease of setting up transition scenarios. Users of the Cyclus code can now run fuel cycle and transition scenarios simply by defining a driving commodity and its demand curve.

REFERENCES

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