Designing GENIUS Version 2 to Model Inter-Facility Relationships

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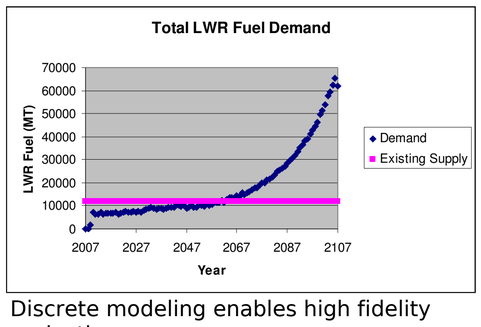
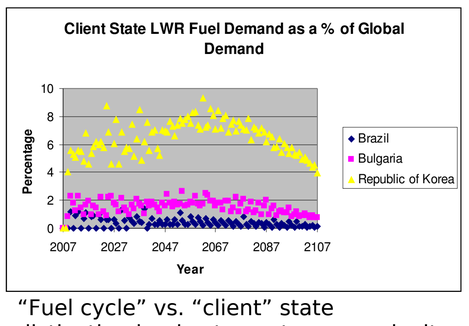
About GENIUS

GENIUS (Global Evaluation of Nuclear Infrastructure Utilization Scenarios) is the top-level code in the SINEMA nuclear fuel cycle modeling framework. It will provide **"quantitative dynamic assessment" of worldwide nuclear materials management, energy production, energy cost, environmental impact, and proliferation resistance.**

Its design specification requires **discrete modeling of materials and fuel cycle facilities as well as capability for optimization and uncertainty analyses**.[1] GENIUS Version 1 was developed at Idaho National Laboratory by Chris Juchau and Mary Lou Dunzik-Gougar (with optimization and uncertainty support from Paul Turinsky, Hany Abdel-Khalik, and Tracy Stover at North Carolina State University). The code is nearly complete, and it has generated baseline results for two GNEP-type scenarios.[2]



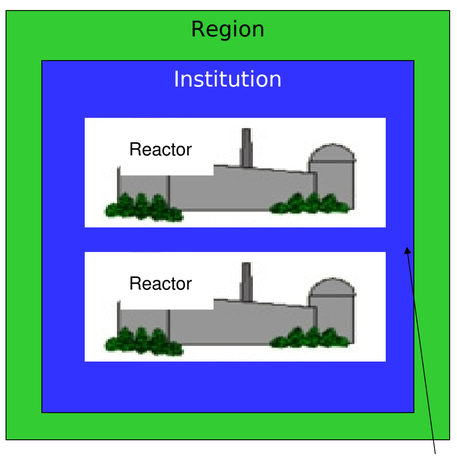
Discrete modeling enables high fidelity projections.

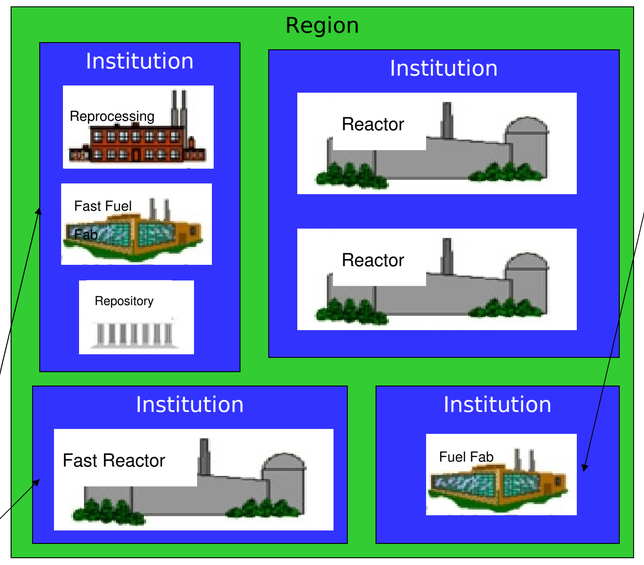


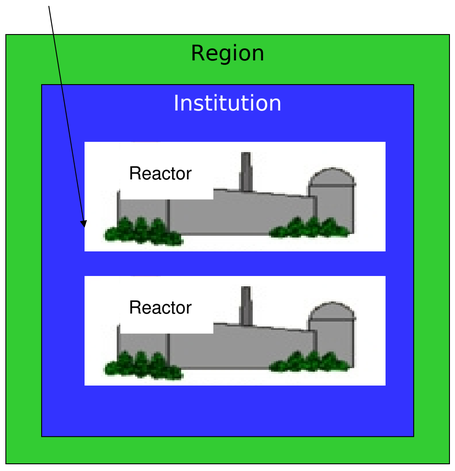
"Fuel cycle" vs. "client" state distinction begins to capture complexity of GNEP-type fuel cycles.

Discrete Facility Data Model

A manager and supporting objects drive the simulation itself and communicate with regions, institutions, and facilities as needed.







Institutions represent companies and government entities. Each may own one or more facilities.

There are one or more reactors to meet the nuclear energy demand in each region. Fuel cycle states (center) also contain other fuel cycle facilities.

GENIUS Version 2 features a discrete facility data model similar to that of GENIUSv1, with two revisions. First, the concept of an institution has been introduced to allow realistic financial and "relational" modeling. The institutions in each global region each own one or more facilities; thus, the model ties economic performance to regional, institutional, and facility-specific parameters.

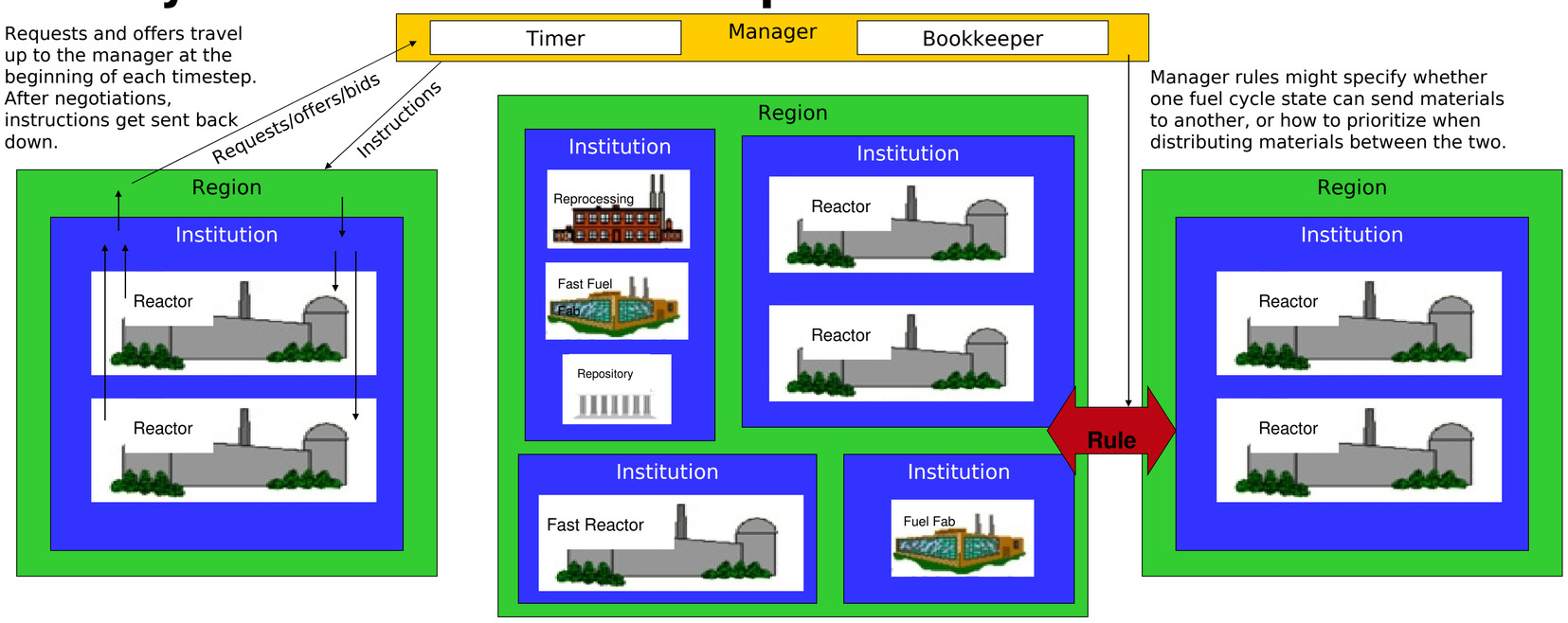
Second, the quanta of material tracked in GENIUSv2 has been made smaller (v1 tracked fuel batches, v2 will track individual fuel assemblies and similarly sized quanta of waste and raw materials). Thus, each individual material object will know both its isotopic history and its path through the various facilities in the simulation.

Inter-Facility Communication/Cooperation Model

Each simulation object communicates with the object directly above and below it in the hierarchy. Offers, bids, and requests from the facilities get passed up to the manager at the beginning of each timestep. The manager uses rules to clear all the requests and sends instructions back down the hierarchy accordingly.

This process simulates real-life bidding and negotiation. Thus, the manager's rules enforce physical, economic, and political constraints. For example, a rule may require that requests be filled from within a particular institution or region, if possible, or it may allow transfer of materials between some regions but not others.

Requests and offers travel up to the manager at the beginning of each timestep. After negotiations, instructions get sent back down.

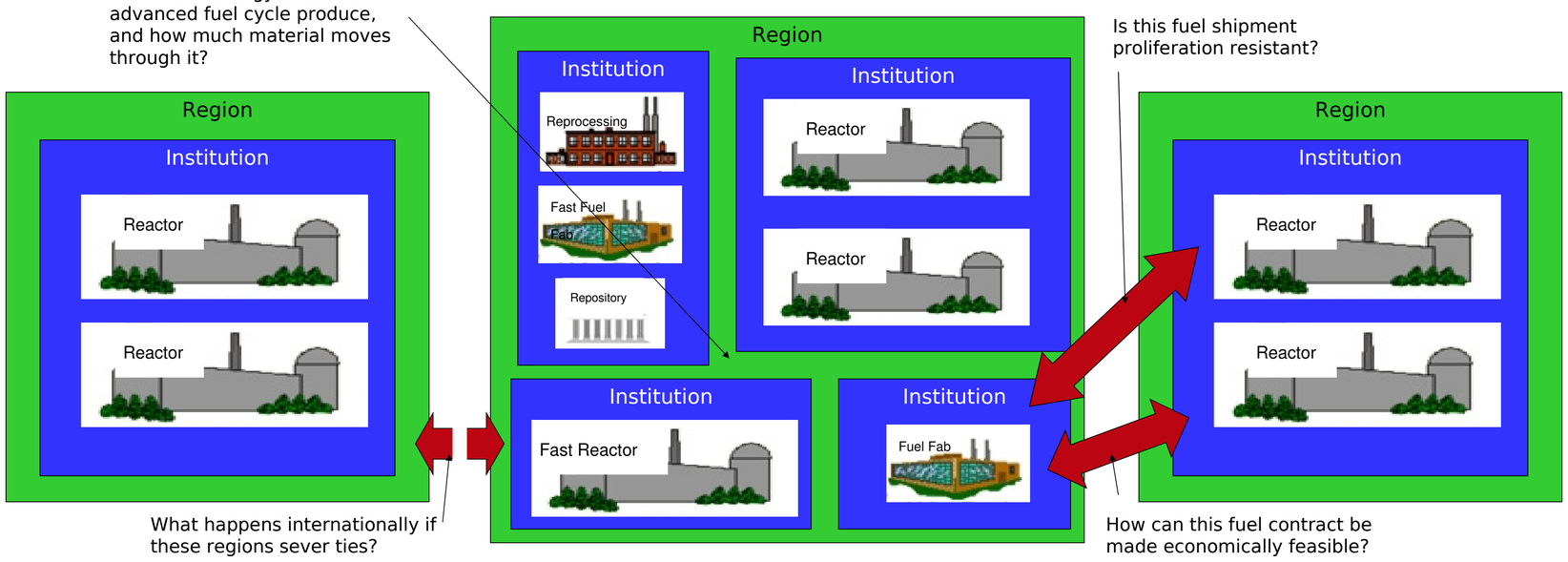


Manager rules might specify whether one fuel cycle state can send materials to another, or how to prioritize when distributing materials between the two.

Supported Analyses

How much energy does this advanced fuel cycle produce, and how much material moves through it?

Is this fuel shipment proliferation resistant?



What happens internationally if these regions sever ties?

How can this fuel contract be made economically feasible?

GENIUSv2 will support a rich variety of analyses beyond projections of global capacity and demand:

- The bidding/negotiation capability will shed light on the kinds of financial incentives necessary to encourage a GNEP-type international fuel services market.
- The modeling of regional relationships will give insight into fuel cycle robustness in the face of political or economic turmoil between regions.
- Improved materials tracking abilities will allow investigation of proliferation resistance of necessary shipments within and between cooperating regions.

1. Juchau, C. & Dunzik Gougar, M. L. (2006). "A Review of Nuclear Fuel Cycle Systems Codes." Accessed 13 February 2007 from SINEMA Web site: http://thesinema.org/
2. Dunzik-Gougar, M.L, et al. (2007). "Global Evaluation of Nuclear Infrastructure Utilization Scenarios (GENIUS)." International Conference on Future Nuclear Systems, GLOBAL '07.