Diversion Detection in Cyclus Archetpyes

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Objectives

- Timely detection of diversion relies on the identification of signatures and observables for unique facilities.
- Create high-fidelity diversion algorithms.
- Determine optimum detector and inspection locations in pyroprocessing facilities using the Cyclus framework.
- Adapt this work to be applicable to a wide range of nuclear fuel cycle facilities in Cyclus
- Characterize required detection sensitivities and corresponding false positive rates.

Background

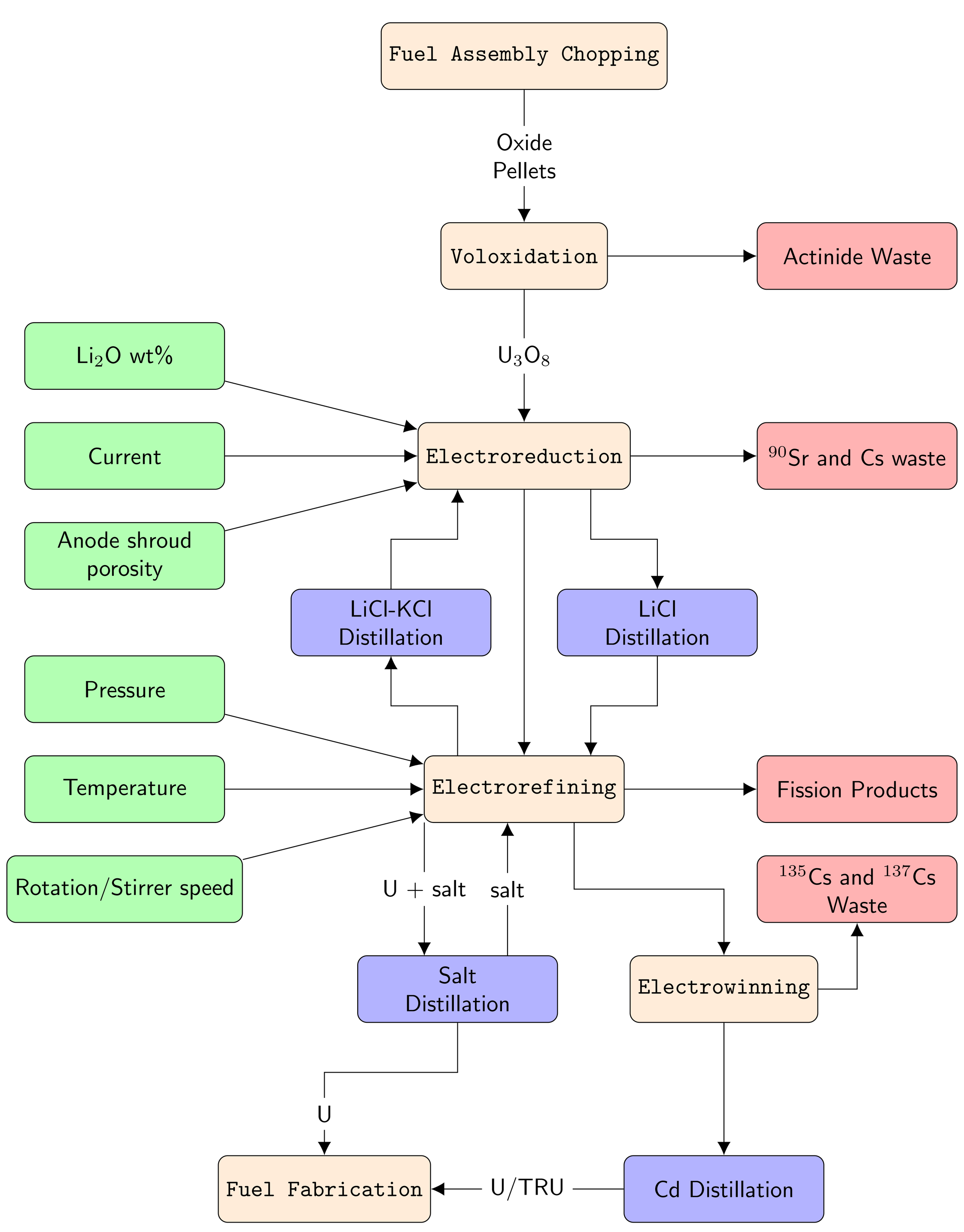

Figure: Archetpye design of the Pyre facility [2].

Facility Simulation

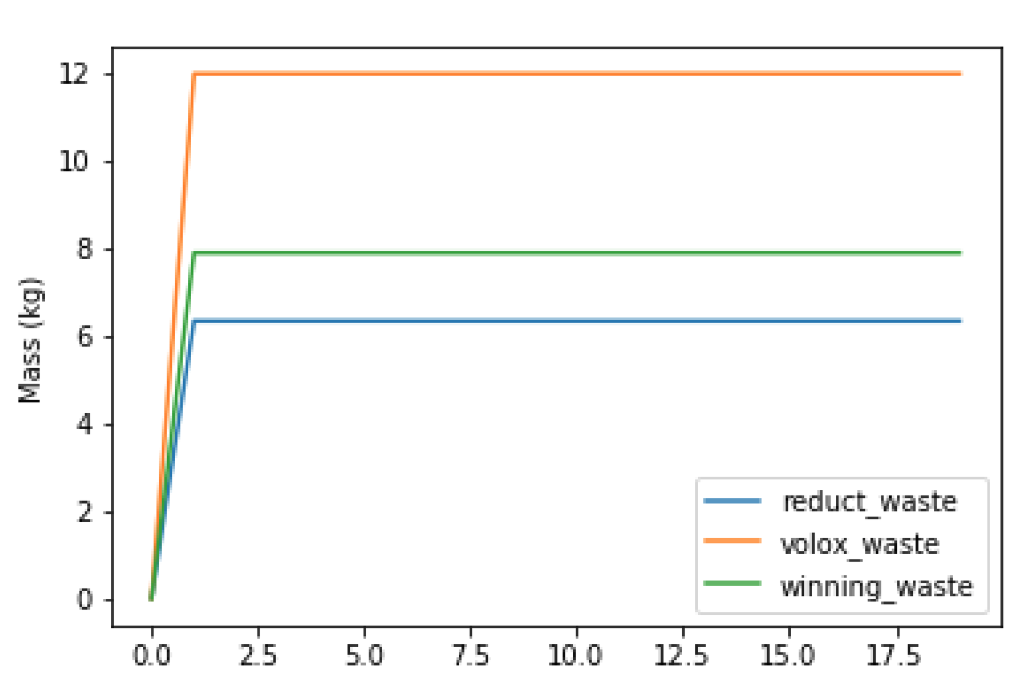

Figure: Example material transactions every time step.

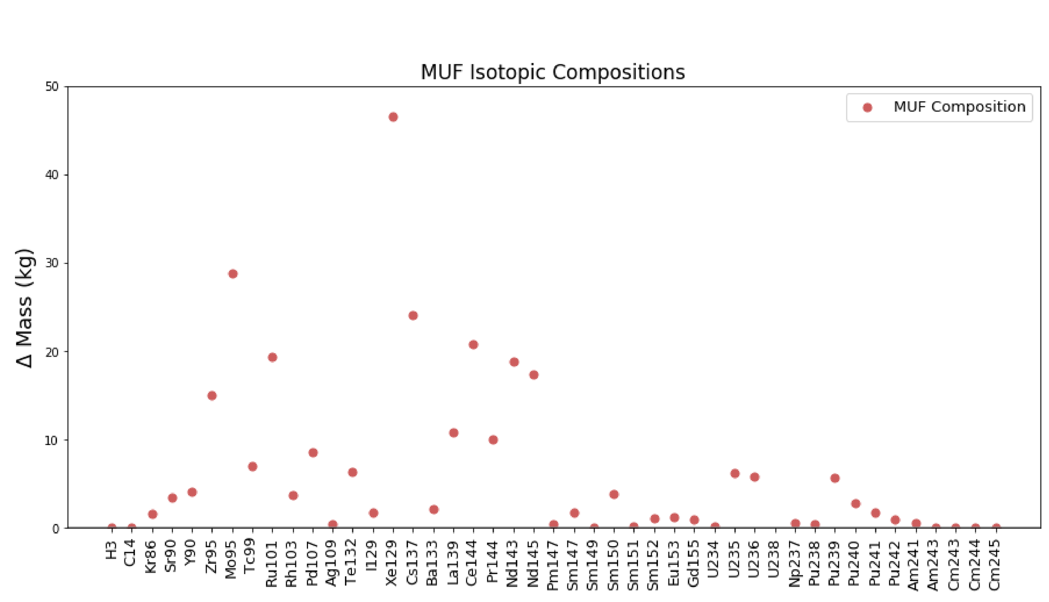

Figure: The isotopic breakdown of material transactions in the facility.

Material Diversion

Material diversion occurs in two different modes: **nefarious** or **operator**.

- **Nefarious Diversion** imagines diversion by a single bad actor with facility access.
- **Operator Diversion** imagines undeclared production.
- Either can be achieved by increasing plant throughput and siphoning off material excess for unsanctioned weapons production.

Nefarious Diversion

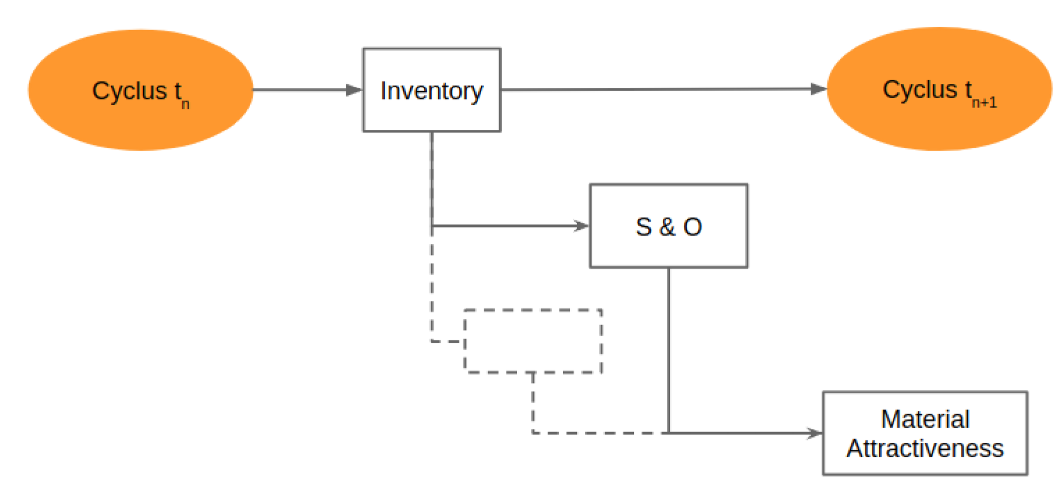

Figure: Illustration of nefarious diversion of Cyclus inventory.

Operator Diversion

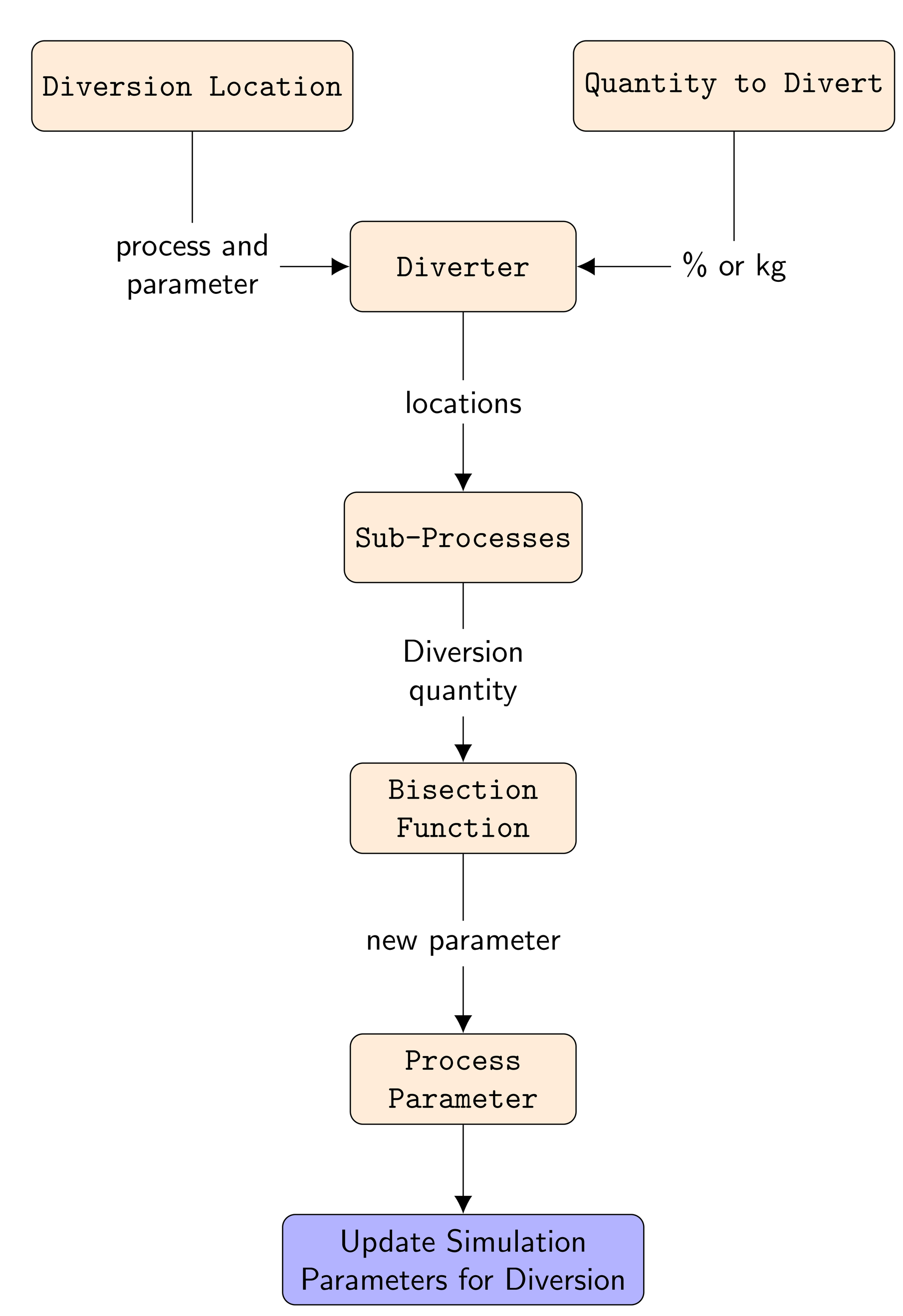

Figure: Procedure for generating operator diversion values inside a simulation.

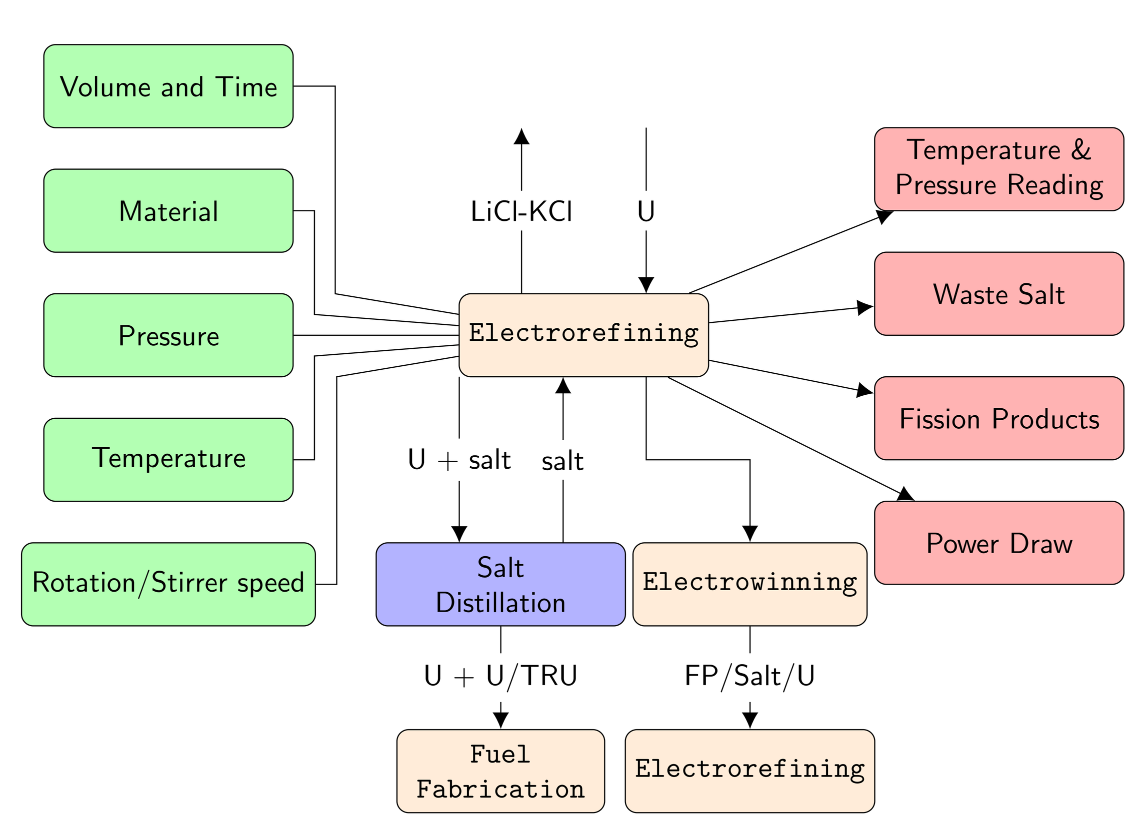

Figure: Example material balance used over a sub-process for diversion detection [4].

Diversion Detection

To maintain customization of the archetype a CUMUFR (cumulative sum of MUF residuals) algorithm is used. This approach has the benefit of not requiring a known mean value, however, time is required for the statistic before being able to accurately detect material diversion.

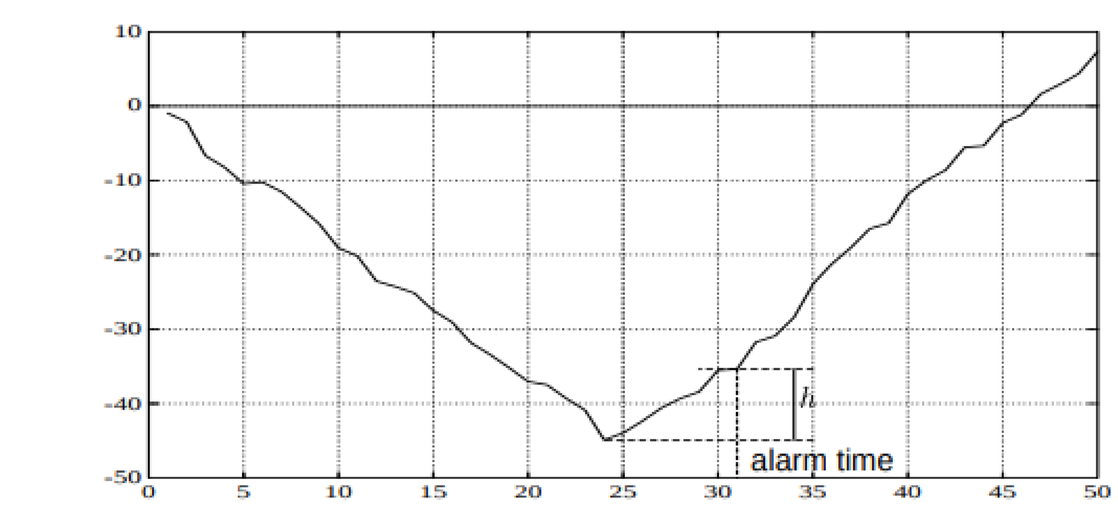

Figure: Cumulative sum method being used to detect a change in material flow [1].

Accomplishments

- Created a highly customizable pyroprocessing facility within Cyclus.
- Performed a variety of "standard operation" simulations without diversion.
- Developed a method to handle multiple diversion modes and improve reproducibility.

Future Work

- Sensitivity analysis of diversion methods.
- Compare Cyclus output for various facility configurations.
- Assess capability of using Cyclus as online detection.

In addition to completing the diversion detection module for pyroprocessing, the goal is to expand this to be accessible to other Cyclus archetypes as well [3]. Other capabilities to be added include accounting for a variety of diversion times, currently the algorithm is capable of routine and set times for diversion.

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