Comparative Analysis of Discovered Models for Processing Unit 1 (PU1)

Experimental Report

December 22, 2025

1 Introduction

This report presents the Petri net models discovered for Processing Unit 1 (PU1) of the Automated Manufacturing System. The component's logic involves an entry event (a), followed by a parameter check (b) and a drilling operation (c). The pair $b \rightarrow c$ may repeat multiple times until the condition is met, ending with event d.

Therefore, the expected behavior is a cycle involving events b and c, bounded by start event a and end event d.

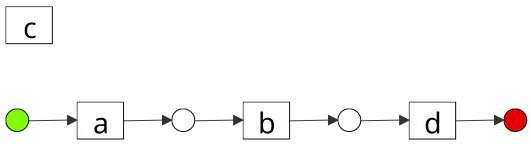
2 Discovered Models

2.1 Alpha Miner Family

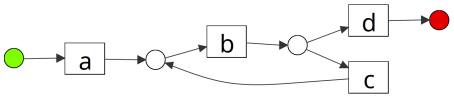
Figure 1 displays the results from the Alpha Miner variants.

Observation: The algorithms performed differently regarding the cyclic behavior:

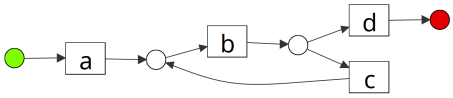
- The standard **Alpha Miner** (Fig. 1a) left event c disconnected. In practice, this represents an **always-enabled transition** that neither produces nor consumes tokens. This results in **overgeneralization**: while it does not prevent perfect fitness (since c can be replayed at any moment), it represents a modeling failure as c respects no execution order.
- **Alpha+** and **Alpha++** (Figs. 1b and 1c) correctly identified the loop structure $b \leftrightarrow c$ without using silent transitions, yielding results comparable to the Inductive Miner.
- **Alpha$** (Fig. 1d) also captured the loop but introduced a **silent transition** (black transition) in the path to event c, adding unnecessary complexity.



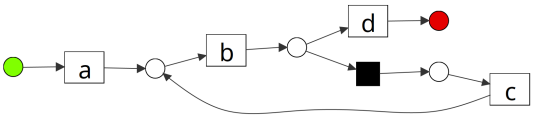
(a) Alpha Miner (Disconnected 'c')



(b) Alpha+ Miner (Clean Loop)



(c) Alpha++ Miner (Clean Loop)



(d) Alpha$ Miner (Silent Transition)

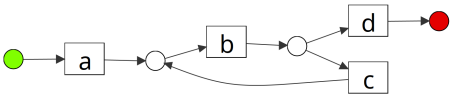
Figure 1: Models discovered by the Alpha Miner family for PU1.

2.2 Heuristic and Inductive Approaches

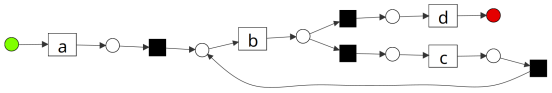
Figure 2 shows algorithms capable of handling noise and loops more robustly.

Observation:

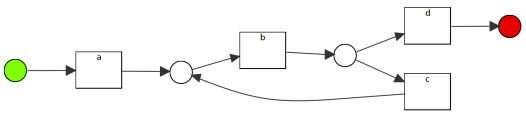
- The **Inductive Miner** (Fig. 2a) produced a clean, block-structured model for the loop.
- The **Heuristics Miner** (Fig. 2b), while capturing the correct flow, relied on **silent transitions** (black boxes) to model the routing logic required to connect the Causal Net structure to the Petri net formalism.
- **Fodina** (Fig. 2c) generated a precise model. It successfully mapped the routing logic directly onto the visible events, using an explicit XOR-split after event b to choose between looping (c) or finishing (d).



(a) Inductive Miner (Clean Loop)



(b) Heuristics Miner (Silent Transitions)



(c) Fodina (Direct Routing)

Figure 2: Comparison of Inductive, Heuristics, and Fodina miners.

2.3 Optimization-based Approaches (ILP)

Figure 3 presents the result for the ILP Miner.

Observation: The **ILP Miner** successfully discovered a structure similar to Alpha, Alpha+, Alpha++, Inductive Miner and Fodina, correctly modeling the loop.

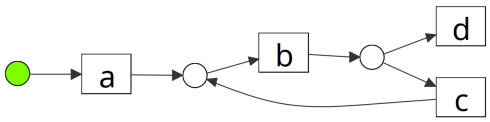


Figure 3: ILP Miner result.

3 Computational Constraints and Hybrid ILP

For this experiment, the **Hybrid ILP Miner** was also evaluated. However, no model was produced.

The mining task could not be completed due to a lack of computational resources. The experimental setup utilized a workstation with an **Intel(R) Core(TM) i7-10700 CPU @ 2.90GHz octa-core 16 threads, 16 GB of RAM, and an NVMe 256GB**. Despite these specifications, the state-space calculation required by the Hybrid ILP algorithm for the PU1 log exceeded the available memory/processing time limits, resulting in a failure to return a Petri net model.