House Reconfiguration Problem (HRP)

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Problem Statement

The House Reconfiguration Problem (Gerhard et. al. 2011) is an abstract version of (re)configuration problems occurring in practice. This problem is studied within the broader context of reconfiguration problems in combinatorial optimization and artificial intelligence. The reconfiguration problem seeks a path between two given answer sets, such that each intermediate step is also a valid answer set. The goal is to determine whether one answer set can be transformed into another through a series of small changes. An optimal reconfiguration must satisfy various constraints. If the legacy configuration is empty, a reconfiguration problem in this sense degenerates to a configuration problem (HCP).

The specific problem at hand involves finding an optimal reconfiguration of a house which consists of sets of things, cabinets, and rooms owned by individuals, each of which needs to be assigned properly while respecting various constraints. The goal is to find the optimal placement of things in cabinets, cabinets in rooms, and the assignment of rooms to specific individuals, while ensuring that capacity and ownership constraints are met. For instance, cabinets have limits on the number of things they can store, and only high cabinets can accommodate long items, which must also fit within rooms with limited space.

The challenge in solving the House Reconfiguration Problem lies in making changes to the legacy configuration in a cost-effective manner. Each modification, such as reusing or resizing existing cabinets, creating new cabinets or rooms, or reallocating items, incurs specific costs that must be minimized. The solution requires balancing these costs while adhering to all constraints to yield a feasible configuration. Representing and solving this problem using Answer Set Programming (ASP) allows for programmatical generation of solutions that meet both the structural and cost-related requirements.

Progress Made

I started out by reading up on the original problem described in the 2019 ASP competition's problem description (. Revisiting the CSE 579 course videos as well as the TA's project explanation video on Canvas gave a rough idea of how to approach the House Reconfiguration problem. In this initial phase I looked through the given examples and test cases to understand the key constraints and requirements of the problem. Moving onto the ASP coding part, I drafted a couple of rudimentary solutions, which are for initial testing of the edge cases and base constraints. This was achieved with the help of continuous reviews of the course content, adjusting my approach towards better handling of constraints as well as optimality. Currently, I am in the process of building on top of this initial code draft, and plan to integrate additional variables and mappings as I progress through the more complex constraints and optimizations. This iterative development has proved useful for approaching the project's challenges in a structured manner, with the final implementation still in progress.

Challenges Encountered and Resolution Plans

At first, I was blocked by a few crucial issues when it came to understanding the innumerable edge cases and variations that this scenario presents. Without having a clear big picture of the problem, identifying the key concepts that would need detailed thought proved difficult. Moreover, academic sources that went over this problem in a novice-friendly manner were scarce to find.

Drafting code solutions has proved somewhat time consuming, as 'feature creep' is a problem – I seem to tend to overthink cases even in an iterative process. To tackle a real-world logistics problem statement of such immense complexity, I broke down the problem and addressed each part in successive iterations. For the next part of the project, I will continue adjusting the draft of the code by integrating each part and refining the logic. I intend to find more academic resources on the topic and consult with the course faculty in the face of any further uncertainty.

Completed Tasks

- Thoroughly reviewed course material and assignments to reinforce foundational knowledge of first-order logic and clingo programming.
- Developed a fundamental understanding of the problem, its constraints and applications, thus laying the groundwork for further analysis and problem-solving.
- Conducted a preliminary literature review of relevant academic papers and sources, including those cited in the problem description. This provided insights into how similar problems have been approached and solved in various contexts.
- Mocked up a comprehensive set of test cases designed to cover different scenarios and edge cases, minimizing the likelihood of unanticipated issues.
- Drafted some code focusing on capturing the fundamental constraints – thing-person ownership, thing and cabinet sizes, and other mappings, as well as the operational costs.
- Drafted a rough solution for the House Configuration problem, for which sample solutions can be constructed and tested easily by hand.

Pending Tasks

- Enumerate all remaining constraints in clingo for comprehensive coverage of test cases.
- Add the logic for the transition from the legacy configuration to the new state.
- Ensure that various modifications such as resizing or reassigning elements are considered, along with their associated costs.
- Implement and fine-tune the cost optimization constraints while maintaining valid solution spaces.
- Rigorously test the code using the given test cases as well as the newly crafted ones.
- Submit progress reports formatted per the AAAI guidelines.

References

- Friedrich, Gerhard; Ryabokon, Anna; Falkner, Andreas A.; Haselböck, Alois; Schenner, Gottfried; Schreiner, Herwig (2011): (Re)configuration using Answer Set Programming. Proceedings of the IJCAI 2011 Workshop on Configuration.
- Google Sites. 2019. ASP Challenge 2019 Problem Domains. https://sites.google.com/view/aspcomp2019/problem-domains. Accessed: 2024-11-17.
- Ryabokon, Anna (2015): Knowledge-Based (Re)Configuration of Complex Products and Services. Dissertation. Alpen-Adria-Universität, Klagen furt.