### Motivating Example, Part I

- **Objective**: drive truck from location 1 to 4 (over 2 or 3)
- **Typical formulations in STRIPS and SAS** tightly coupled (mutually interfering operators)
- Factored planning and partial order reduction do not fire

### Motivating Example, Part II

- **Factorization** of variable `pos` into binary variables `x` and `y`
- **Factorized Product** and `pos`
- Cartesian product (extended with edge labels) of factorized graphs structurally isomorphic to the graph corresponding to the original variable `pos`
- Factorized operators `x` and `y` are independent
- Factorization: decoupled but equivalent semantics

### Cartesian Graph Factorization

- Well-studied problem in discrete mathematics since the 1960's
- Problem: given graph `G` without self-loops, find graphs `G_1, ..., G_n` such that the Cartesian product of `G_1, ..., G_n` yields `G`
- `G_1, ..., G_n` are the (unique) prime graphs of `G`
- Computation in polynomial time

### Self-Loops in Transition Systems

- Self-loop in `v`'s transition system if there is operator `o` with
  - `o` reads `v`, but does not write to `v`, or
  - `o` does not read `v`, but writes to `v`, or
  - `o` does not mention `v` at all.

### Variable Factorization

- **Factorization of `v`** into `v_1, ..., v_n` determined by factorization of `v`'s transition system (self-loops removed) into `G_1, ..., G_n`
- Bijective mapping from `v`'s values to value tuples of `v_1, ..., v_n`

### Future Work

- Turn theory into practice
- More specialized factorization algorithms for atomic abstractions
- Weaker factorization: only reachable part of product relevant