Advanced Problem Solving Techniques
Final Project

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MSc. Cognitive Systems

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Implementation

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Implementation – Intuition

- build globally optimal plan
- elevators move according to plan

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- not really what we were supposed to do
- not possible to add new floors while running
- ...

Implementation – Idea I

- naive solution: graph navigation problem
- way too slow
- couldn't handle more than five requests and one elevator $\rightarrow$ too complex

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- couldn't handle more than five requests and one elevator $\rightarrow$ too complex

- treated problem as graph navigation problem
- discovered this approach is way too slow

Implementation – Idea II

- derive solution incrementally in the style of a finite state machine
- fast, but failed for some instances
- difficult to understand and debug

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- fast, but failed for some instances
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- coolest idea
- treat elevators and their “ways” as a finite state machine
- elevator goes from state to state, like “serving”, “moving to target floor”, “being done”
- fastest (?) solution so far, but failures
- with more complex instances we got into problems, hard to debug what caused the failures

Implementation – Helpful Clues

- care about floors, not only requests
  - floors that need to be served
  - floors with nothing to do
- some requests have to be served by specific elevators → less choice
- divide requests equally amongst elevators
- compute travel distance without recursively constructing paths through a graph
- specifying of plan in the first shot iteration

Implementation – Helpful Clues
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- some clues we used: the actual floor position, not only requests
- distinguish about target floors and non-target floors
- deliver requests have to be served by a specific elevator → elevators have to go at least in this direction and will likely pass other floors on their way
- so save time, that is, steps, divide requests equally
- calculate travel distances to keep track of time/steps
- in the end: specified more and more of the “travel plan” before the elevators actually moved
- **venn diagram of an example 3 elevators and how requests would be divided amongst them?**

Implementation – Idea III

- identify floors that need to be served
- add deliver requests to corresponding elevator
- distribute remaining request equally
  - no elevator should be allowed to idle while another is still working
  - `move` as small a distance as possible
- behave differently when there's only one elevator

Implementation – Idea III
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- add deliver requests to corresponding elevator
- distribute remaining request equally
  - no elevator should be allowed to idle while another is still working
  - move as small a distance as possible
- behave differently when there's only one elevator

- wanted to have target floors and ignore the rest (only operation in remaining floors: `move`)
- deliver requests had assigned elevator, so we added them to the elevators "target list"
- wanted to assign the remaining `calls` equally
- elevators should move as little as possible to save time
- somewhat different behavior for single elevators since they have to serve all floors

Implementation – #program base.

- check if there is a request right on the floor where the elevator starts
- predicate that assigns "coordinates" from elevator to target
- get the distance to target furthest along some direction

```
% Create coordinates from elevator to target
target_coord(E, -1, F, | DIST |) :-
    init(at(elevator(E), FE)),
    target(E, F),
    DIST = FE - F,
    DIST > 0.
```


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- make sure that requests on the starting floor are served
- designed predicate that assigns the "way" from current elevator position to target position (direction in which to go, distance to travel)
- calculated distance to the targets with the greatest distance → after traveling this distance, the elevator doesn't have to go further (done with all requests)

Implementation – #program base.

- if elevator has targets above and below, the starting direction is direction of nearest target
- count `move` and `serve` operations
- combine number of `move` and `serve` operations to get the number of steps

```
% Combine serves and moves to get number of steps,
% which we then try to minimize.
n_steps(E, STEPS) :-
    STEPS = ST + D,
    total_n_serves(E, ST),
    total_n_moves(E, D),
    agent(elevator(E)).
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- determine the direction in which an elevator moves first → depends on distance to first target
- count how many `moves` in total occur on each side (direction) of the elevator's starting position
- if elevator needs to change directions (targets on both sides of starting position), the distance that is traveled twice should be the smaller distance
- same goes for the number of `serves`
- combine those numbers to get the number of need steps to complete a single elevator's mission
- this is also an aspect we want to minimize later

Implementation – #program base.

Elevator Instructions:

- fix the serving times: determine *where* and *when* the elevator has to serve
- determine when elevators have to switch direction
- determine the current direction for each time step

```
% For bidirectional elevators we need to know
% when they switch direction
switch_point(E, STEP) :-
    bidirectional(E),
    initial_direction(E, DIR),
    furthest_along(E, DIR, DIST),
    n_serves(E, DIR, STOPS),
    STEP = STOPS + DIST.
```


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STEP = STOPS + DIST.

- general elevator instructions → elevators act according to their predefined plan
- make sure to serve requests at the starting positions if there are any
- determine serving “where’s” and “when’s” → elevators have fixed schedule, calculations based on travel distances and previously made stops and moves
- set the switching directions time step → when elevator has reached target that was the furthest above or below
- make sure the elevator knows in each time step n which direction he has to move next

Implementation – #program step(t).

- derive `do` and `holds` predicates based on `serve_at` plans
- elevator moves if it does not serve and there are remaining targets
- carry requests along if they are not served yet
- update elevator positions after every `move`

```
% serve if the plan says so
do(elevator(E), serve, t) :-
    serve_at(E, F, t),
    holds(at(elevator(E), F), t - 1).

% move if there is something left to do
do(elevator(E), move(DIR), t) :-
    current_direction(E, DIR, t),
    not serve_at(E, _, t).
```


- entire incremental part is derived from the previously determined plan
- elevators only serve if the plan says “serve at this time step”
- if there is something left to do (`current_direction()`), the elevator has to move (no idling)
- if a request is not served, then it is carried along (if there was no serving on the request floor)
- update the position after each time step

Optimization

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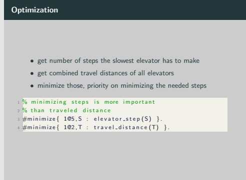
- get number of steps the slowest elevator has to make
- get combined travel distances of all elevators
- minimize those, priority on minimizing the needed steps

```
% minimizing steps is more important
% than traveled distance
#minimize{ 1@5,S : elevator_step(S) }.
#minimize{ 1@2,T : travel_distance(T) }.
```

- get the maximum number of steps the slowest elevator has to make
- slowest elevator = elevator with most requests/longest distance
- sum up travel distances of all elevators
- first minimize the steps, then the overall travel distance

Results

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- slowest instance: test case 58 with 11927 ms
- overall time: 149028 ms

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