

Elevator Project Report

Target-Based Incremental Approach

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Introduction

```

1 % initialize and create targets
2 move().
3 move = 1.
4 holds(A,0) :- init(A).
5 targets(elevator(X,Y)) :- holds(at(elevator(X),Y),0), holds(request(deliver(X,Y),0),0).
6 (targets(elevator(X,Y)) :- holds(at(elevator(X),Y),0) :- holds(request(call(X,Y),0), not holds(request(
7 deliver(X,Y),0)).
8
9 % constraints to ensure all tasks are targetted, and no double tasking
10 :- targets(elevator(X,Y), targets(elevator(X',Y'),X' != X, holds(request(call(X',Y'),0), not holds(request(
11 deliver(X',Y'),0)).
12 :- holds(request(X,Y),0), not targets(X,Y).
13
14 % calculate number of tasks per elevator
15 number(elevator(X,M)) :- M = #sum[_,Y:targets(elevator(X,Y)), holds(at(elevator(X),Y),0).
16
17 % distribution parameter for elevator vs. requests, given multiple targets
18 param(elevator(X,M,N)) :- holds(at(elevator(X),Y),0), M = #sum[Y:Y:holds(at(elevator(X),Y),0), targets(ele
19 vator(X,Y'),M = #min[Y:Y:holds(at(elevator(X),Y),0), targets(elevator(X,Y'))], L > 1, number(elevator
20 (X),L).
21
22 % action if only one target exists
23 target1(elevator(X),Q) :- targets(elevator(X),Y), M = 1, number(elevator(X),M).
24 target2(elevator(X),Y) :- target1(elevator(X),Y), M = 1, number(elevator(X),M).
25
26 % action if multiple targets exist, elevator inside target span
27 target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #min([M]:[K]), param(ele
28 vator(X,M,K), #M <= 0, Q = Y+M, not target2(elevator(X),Q), L > 1, number(elevator(X),L), #false:target
29 (elevator(X),Q'), Q' >= 0.
30 target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #min([M]:[K]), param(ele
31 vator(X,M,K), #M <= 0, Q = Y+M, not target2(elevator(X),Q), L > 1, number(elevator(X),L), #false:target
32 (elevator(X),Q'), Q' <= 0.
33 target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #max([M]:[K]), param(ele
34 vator(X,M,K), #M <= 0, Q = Y+M, target1(elevator(X),Q'), Q' >= 0, L > 1, number(elevator(X),L), #false
35 :target(elevator(X),Q'), Q' <= 0.
36 target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #max([M]:[K]), param(ele
37 vator(X,M,K), #M <= 0, Q = Y+M, target1(elevator(X),Q'), Q' >= 0, L > 1, number(elevator(X),L), #false
38 :target(elevator(X),Q'), Q' <= 0.
39
40 % action if multiple targets exist, elevator outside target span
41 target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #min([M]:[K]), param(ele
42 vator(X,M,K), #M <= 0, Q = Y+M, L > 1, number(elevator(X),L).
43 target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q), M = #min([M]:[K]), param(ele
44 vator(X,M,K), #M <= 0, Q = Y+M, L > 1, number(elevator(X),L).

```

Fig. 1. Snippet of encoding in elevator.lp

- Encoding utilizes target-based incremental approach
- Approach deemed faster over a pure combinatorial approach
- Encoding succeeds on all Yeti cases

Target Assignment

```
% initialize and create targets
```

```
targets(elevator(X),Y')  
:- holds(at(elevator(X),Y),0), holds(request(deliver(X),Y'),0).
```

```
{targets(elevator(X),Y'): holds(at(elevator(X),_),0)}  
:- holds(request(call(_),Y'),0),  
not holds(request(deliver(_),Y'),0).
```

```
% ensure no double targets and all requests targetted
```

```
:- targets(elevator(X),Y), targets(elevator(X'),Y), X' != X,  
holds(request(call(_),Y),0), not holds(request(deliver(_),Y),0).
```

```
:- holds(request(_,Y),0), not targets(_,Y).
```

Distribution Parameter Generation

```
% calculate number of tasks per elevator

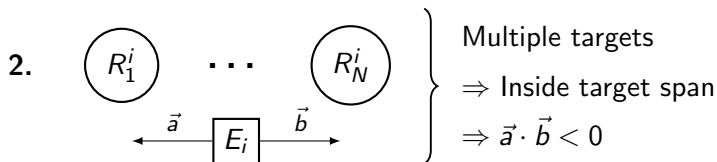
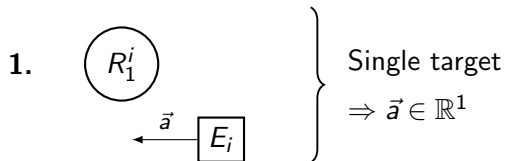
number(elevator(X),N) :- N = #sum{1,Y:targets(elevator(X),Y)},
holds(at(elevator(X),_),0).

% distribution parameter given multiple targets

param(elevator(X),M,N) :- holds(at(elevator(X),_),0),
M = #max{Y-Y':holds(at(elevator(X),Y),0),
targets(elevator(X),Y')},
N = #min{Y-Y':holds(at(elevator(X),Y),0),
targets(elevator(X),Y')}, L > 1, number(elevator(X),L).
```

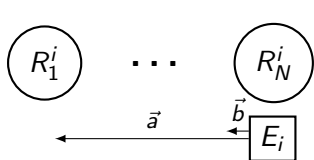
- Parameters are useful in deciphering position of elevator wrt. corresponding targets

Target Distribution Cases I



Target Distribution Cases II

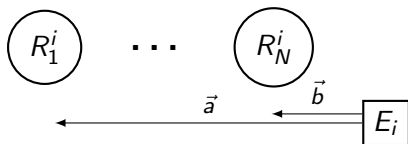
3.



Multiple targets

 \Rightarrow On target span $\Rightarrow \vec{a} \cdot \vec{b} = 0$

4.



Multiple targets

 \Rightarrow Outside target span $\Rightarrow \vec{a} \cdot \vec{b} > 0$

End-Targets Assignment I

Case 1 (Single Target):

```
target1(elevator(X),Y) :- targets(elevator(X),Y), N = 1,  
number(elevator(X),N).
```

```
target2(elevator(X),Y) :- target1(elevator(X),Y), N = 1,  
number(elevator(X),N).
```

- End-Targets are defined to be the same for consistency
- Necessary measure to keep end-targets framework

End-Targets Assignment II

Case 2/3 (Inside/On Span):

```
target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #min{|M|;|K|}, param(elevator(X),M,K), M*K <= 0, Q = Y+N,
not target2(elevator(X), Q), L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'>Q.
```

```
target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #min{|M|;|K|}, param(elevator(X),M,K), M*K <= 0, Q = Y-N,
not target2(elevator(X), Q), L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'<Q.
```

```
target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #max{|M|;|K|}, param(elevator(X),M,K), M*K <= 0, Q = Y+N,
target1(elevator(X), Q''), Q''!= Q, L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'>Q.
```

```
target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #max{|M|;|K|}, param(elevator(X),M,K), M*K <= 0, Q = Y-N,
target1(elevator(X), Q''), Q''!= Q, L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'<Q.
```

End-Targets Assignment III

Case 4 (Outside Span):

```
target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #min{|M|;|K|}, param(elevator(X),M,K), M*K > 0, Q = Y+N, L > 1,
number(elevator(X),L).
```

```
target1(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #min{|M|;|K|}, param(elevator(X),M,K), M*K > 0, Q = Y-N, L > 1,
number(elevator(X),L).
```

```
target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #max{|M|;|K|}, param(elevator(X),M,K), M*K > 0, Q = Y+N,
target1(elevator(X), Q''), Q'' != Q, L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'>Q.
```

```
target2(elevator(X),Q) :- holds(at(elevator(X),Y),0), targets(elevator(X),Q),
N = #max{|M|;|K|}, param(elevator(X),M,K), M*K > 0, Q = Y-N,
target1(elevator(X), Q''), Q'' != Q, L > 1, number(elevator(X),L),
#false:targets(elevator(X),Q'), Q'<Q.
```

Move Calculation

```
% calculate per-elevator moves
```

```
moves(elevator(X),N) :- N = #sum{|Y-Y'|;|Y'-Y''|},  
holds(at(elevator(X),Y),0), target1(elevator(X),Y'),  
target2(elevator(X),Y'').
```

```
% calculate cumulative moves
```

```
allmoves(N) :- N = #sum{M:moves(elevator(_),M)}.
```

- Deterministic (pre-iterative) approach to quantify moves
- Useful for optimization/minimization purposes

Target Actions: Moving

% moving to target1

```
do(elevator(X),move(V),t) :- holds(at(elevator(X),Y),t-1),  
target1(elevator(X),Y'), holds(request(deliver(X),Y'),t), move(V),  
|Y+V-Y'|<|Y-Y'|, not do(elevator(X),serve,t).
```

```
do(elevator(X),move(V),t) :- holds(at(elevator(X),Y),t-1),  
target1(elevator(X),Y'), holds(request(call(_),Y'),t), move(V),  
|Y+V-Y'|<|Y-Y'|, not do(elevator(X),serve,t).
```

% moving to target2

```
do(elevator(X),move(V),t) :- holds(at(elevator(X),Y),t-1),  
target2(elevator(X),Y'), holds(request(deliver(X),Y'),t),  
target1(elevator(X),Y''), move(V), |Y+V-Y'|<|Y-Y'|,  
not holds(request(deliver(X),Y''),t), not holds(request(call(_),Y''),t),  
not do(elevator(X),serve,t).
```

```
do(elevator(X),move(V),t) :- holds(at(elevator(X),Y),t-1),  
target2(elevator(X),Y'), holds(request(call(_),Y'),t),  
target1(elevator(X),Y''), move(V), |Y+V-Y'|<|Y-Y'|,  
not holds(request(deliver(X),Y''),t), not holds(request(call(_),Y''),t),  
not do(elevator(X),serve,t).
```

Target Actions: Serving

```
% serving delivery request
```

```
do(elevator(X),serve,t) :- holds(request(deliver(X),Y),t-1),  
holds(at(elevator(X),Y),t-1), targets(elevator(X),Y).
```

```
% serving call request
```

```
do(elevator(X),serve,t) :- holds(request(call(_),Y),t-1),  
holds(at(elevator(X),Y),t-1), targets(elevator(X),Y).
```

```
% serving floor
```

```
serving(Y,t) :- do(elevator(X),serve,t),  
holds(at(elevator(X),Y),t-1).
```

Target Actions: Transfer Positions/Requests

```
% transfer elevator positions
```

```
holds(at(elevator(X),Y+V),t) :- holds(at(elevator(X),Y),t-1),  
do(elevator(X),move(V),t).
```

```
holds(at(elevator(X),Y),t) :- holds(at(elevator(X),Y),t-1),  
do(elevator(X),serve,t).
```

```
holds(at(elevator(X),Y),t) :- holds(at(elevator(X),Y),t-1),  
not do(elevator(X),_,t).
```

```
% transfer requests
```

```
holds(request(call(V),Y),t) :- holds(request(call(V),Y),t-1),  
not serving(Y,t).
```

```
holds(request(deliver(X),Y),t) :- holds(request(deliver(X),Y),t-1),  
not holds(at(elevator(X),Y),t-1).
```


Optimizations

```
% minimize deterministic cumulative moves
```

```
#minimize{N:allmoves(N)}.
```

- Pre-iterative calculation of `allmoves(N)` makes minimization more efficient
- Reduction of target search-space in pre-solving phase
- Overall target assignment methodology more efficient than pure combinatorical approach

Results



Kurse ■	
Meine Daten ■	
Logout ■	

Testfall 47	Zeit: 11517 ms success
Testfall 48	Zeit: 13220 ms success
Testfall 49	Zeit: 19017 ms success
Testfall 50	Zeit: 42516 ms success
Testfall 51	Zeit: 1315 ms success
Testfall 52	Zeit: 3916 ms success
Testfall 53	Zeit: 7017 ms success
Testfall 54	Zeit: 13717 ms success
Testfall 55	Zeit: 10316 ms success
Testfall 56	Zeit: 19018 ms success
Testfall 57	Zeit: 32017 ms success
Testfall 58	Zeit: 47017 ms success
Gesamtzeit	563199 ms

- Encoding succeeds on all 58 Yeti test-cases
- Total runtime ≈ 560 s
- Longest runtime on instance 31 ≈ 85 s
- This was due to a large search space, resulting in 2048 optimal solutions

Fig. 2. Snippet of Yeti performance for encoding