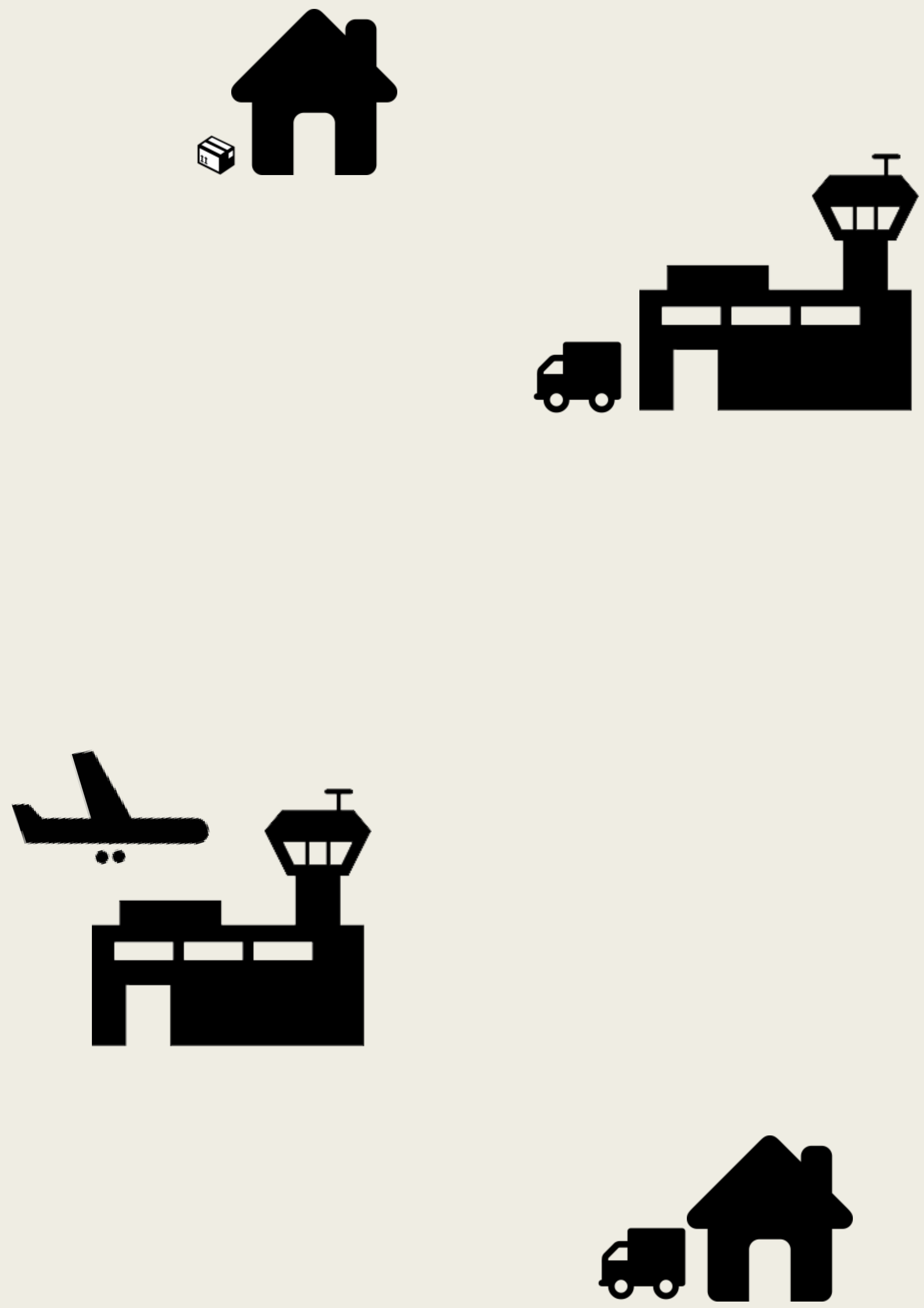
CONCEPT LANGUAGES AS EXPERT INPUT FOR GENERALIZED PLANNING

BSc Thesis Presentation

Rik de Graaff

The Logistics Problem



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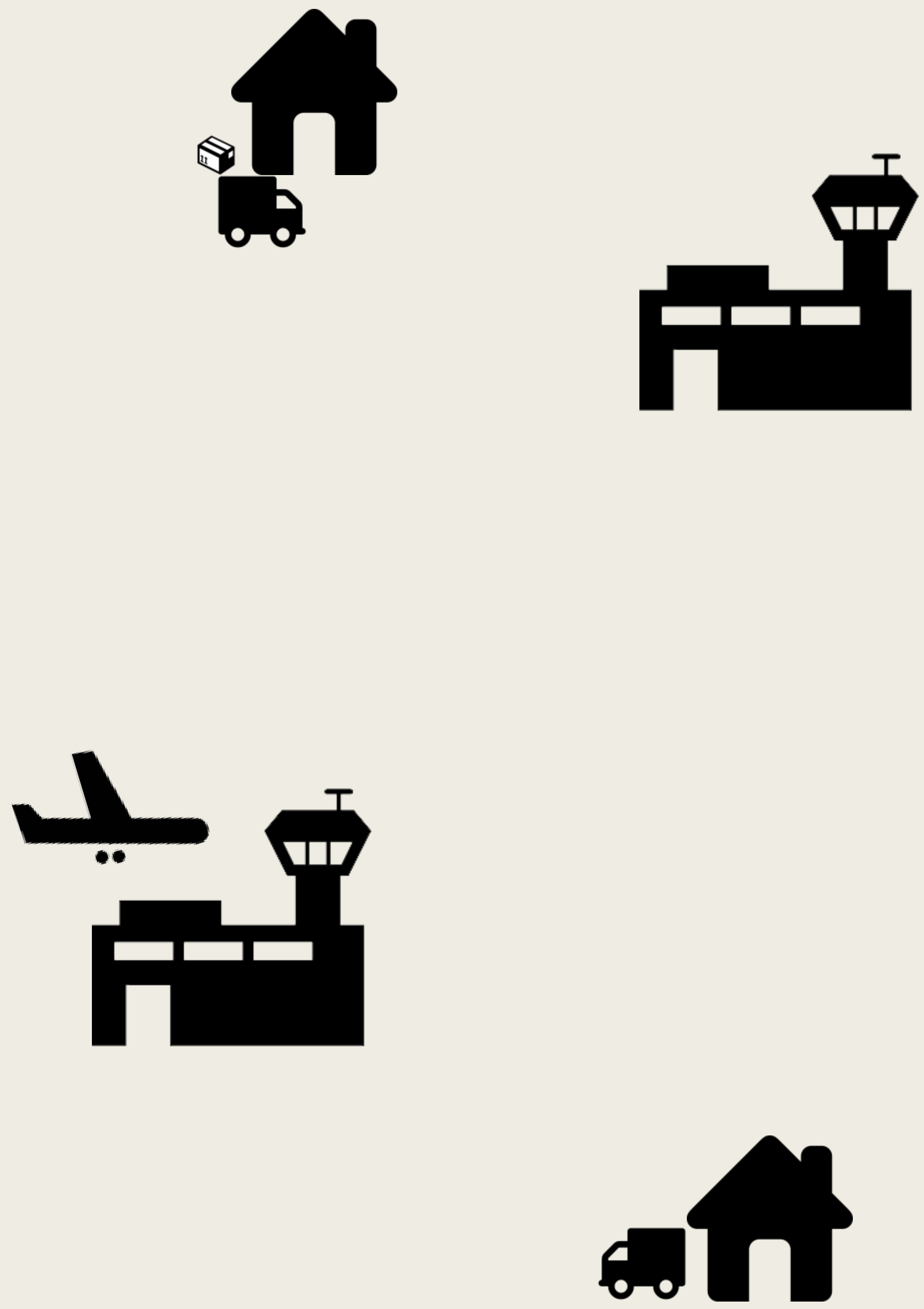

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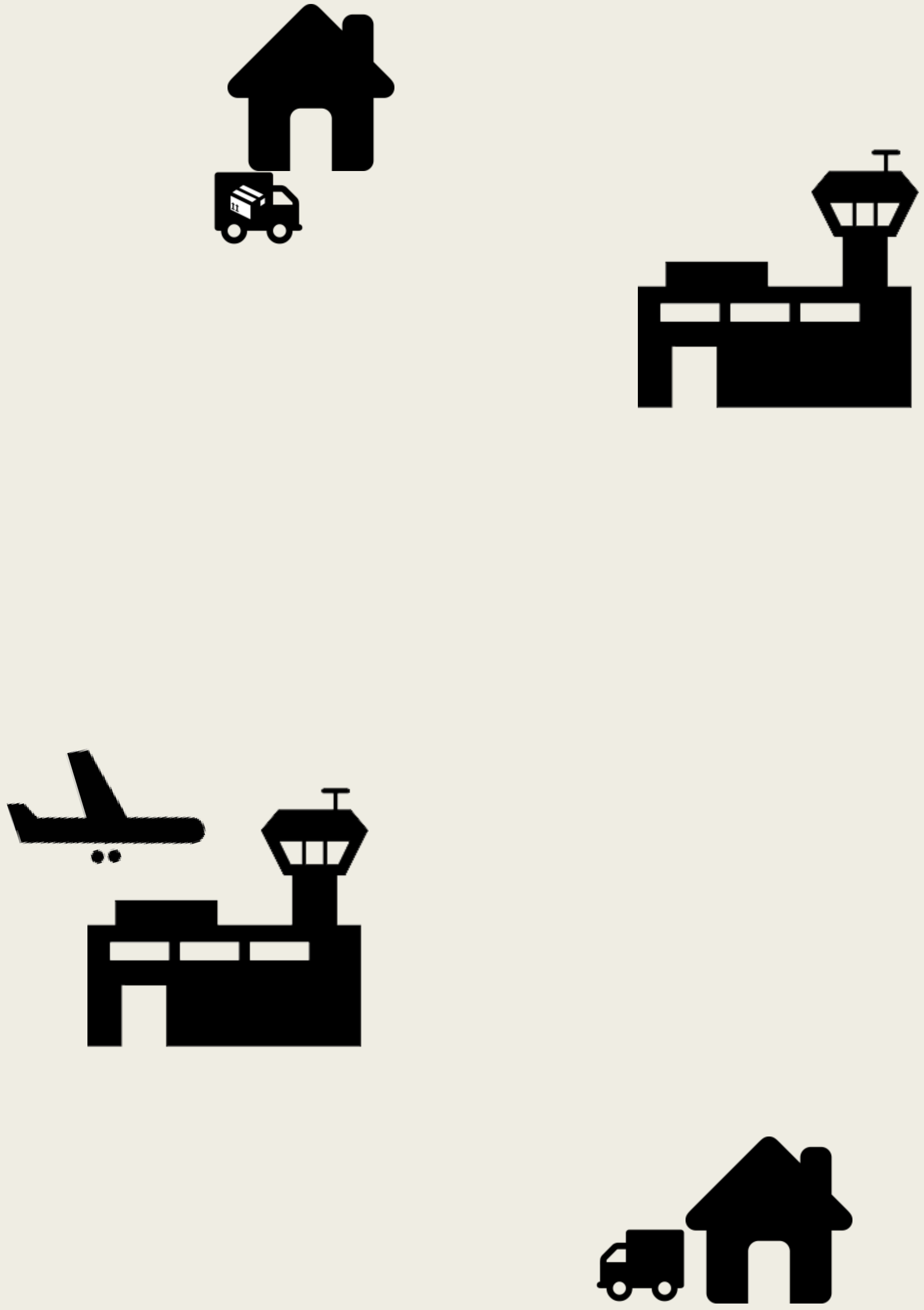

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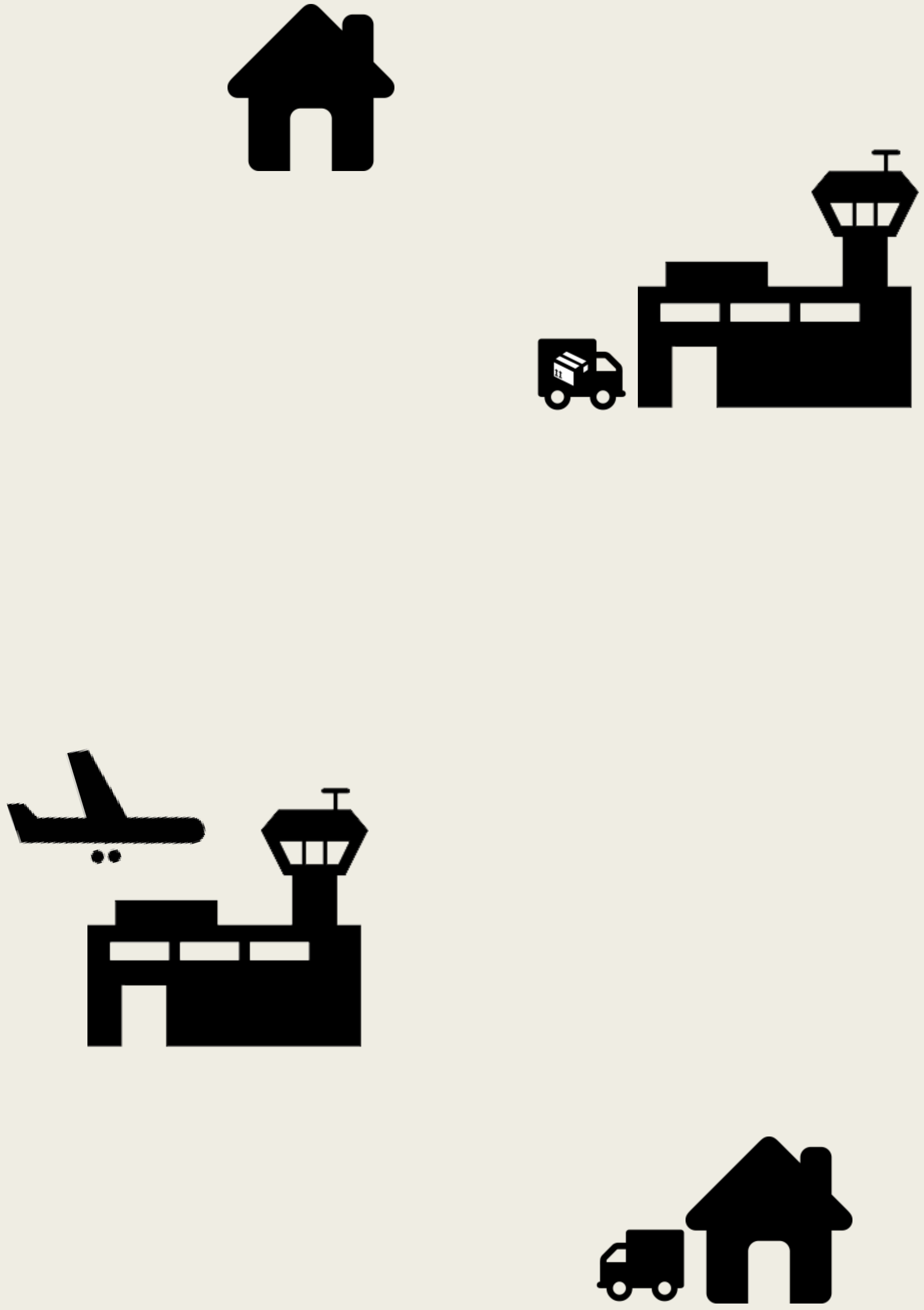

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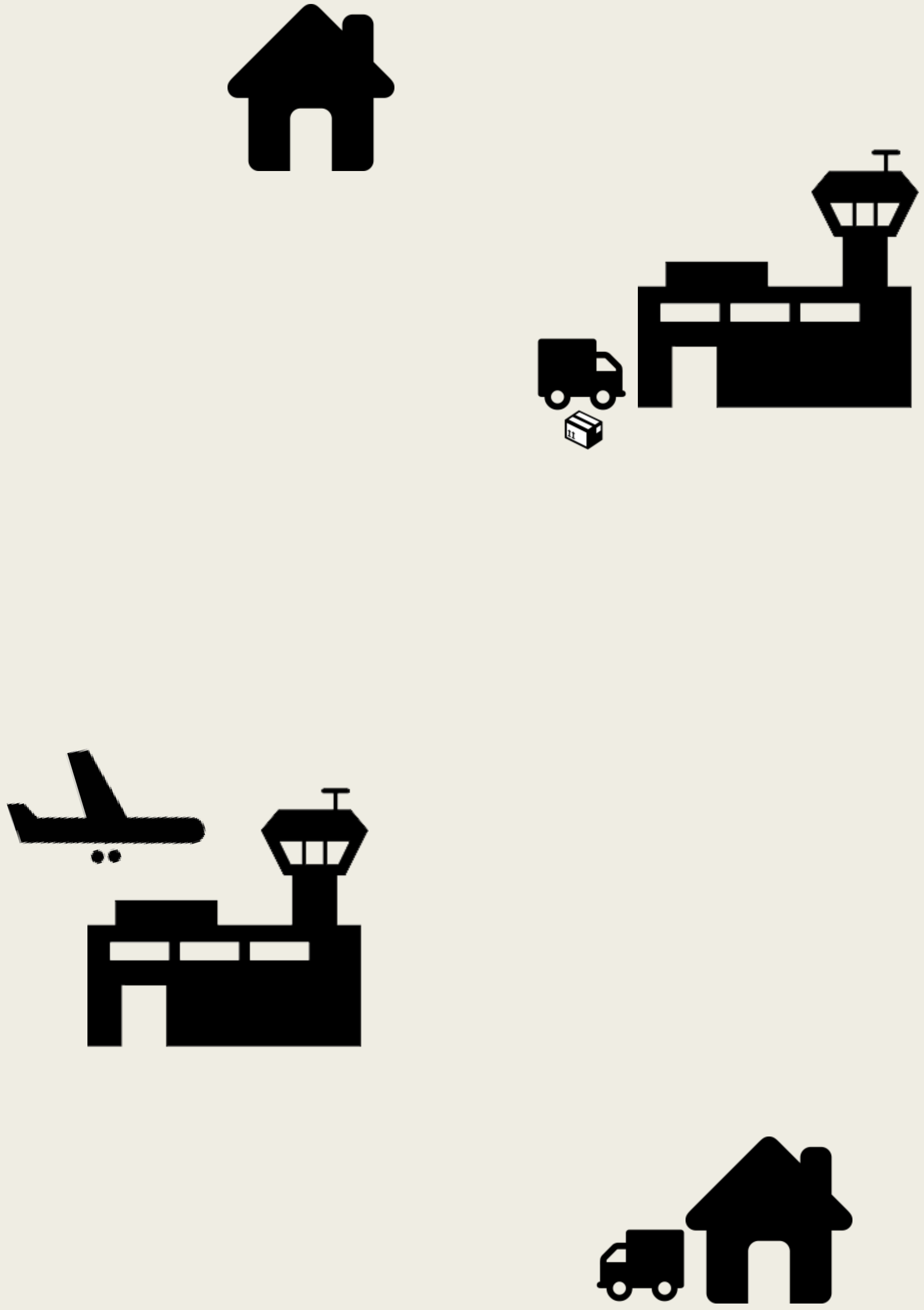

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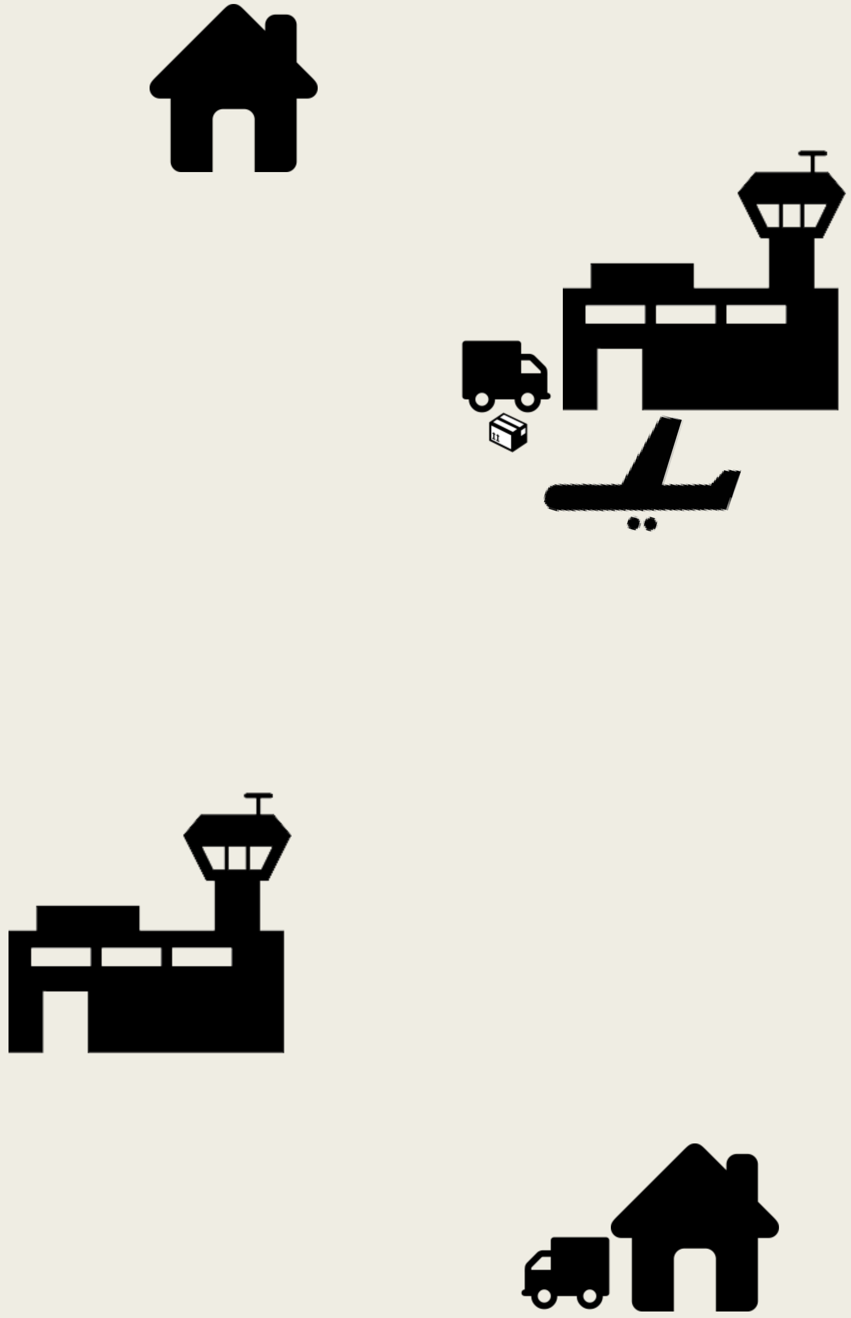

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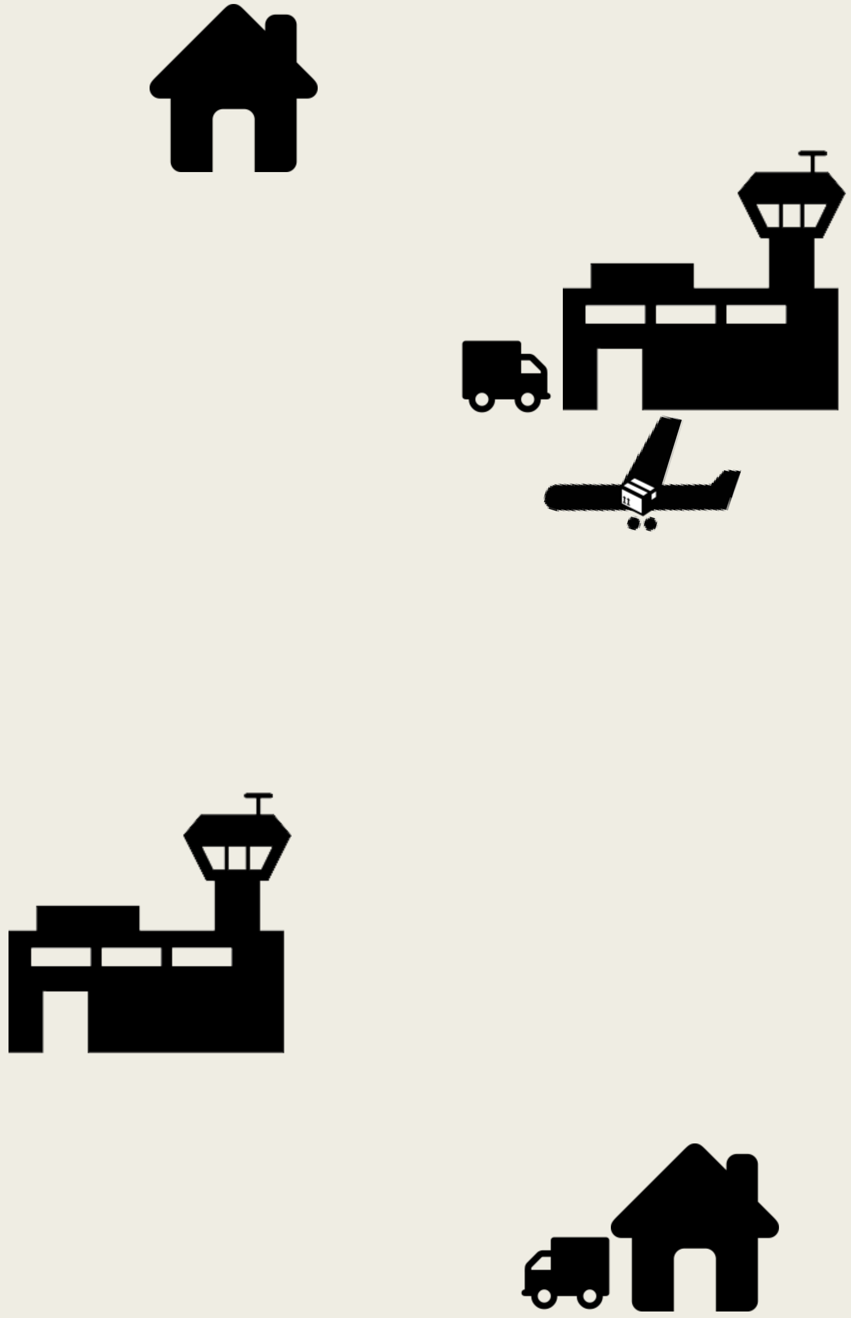

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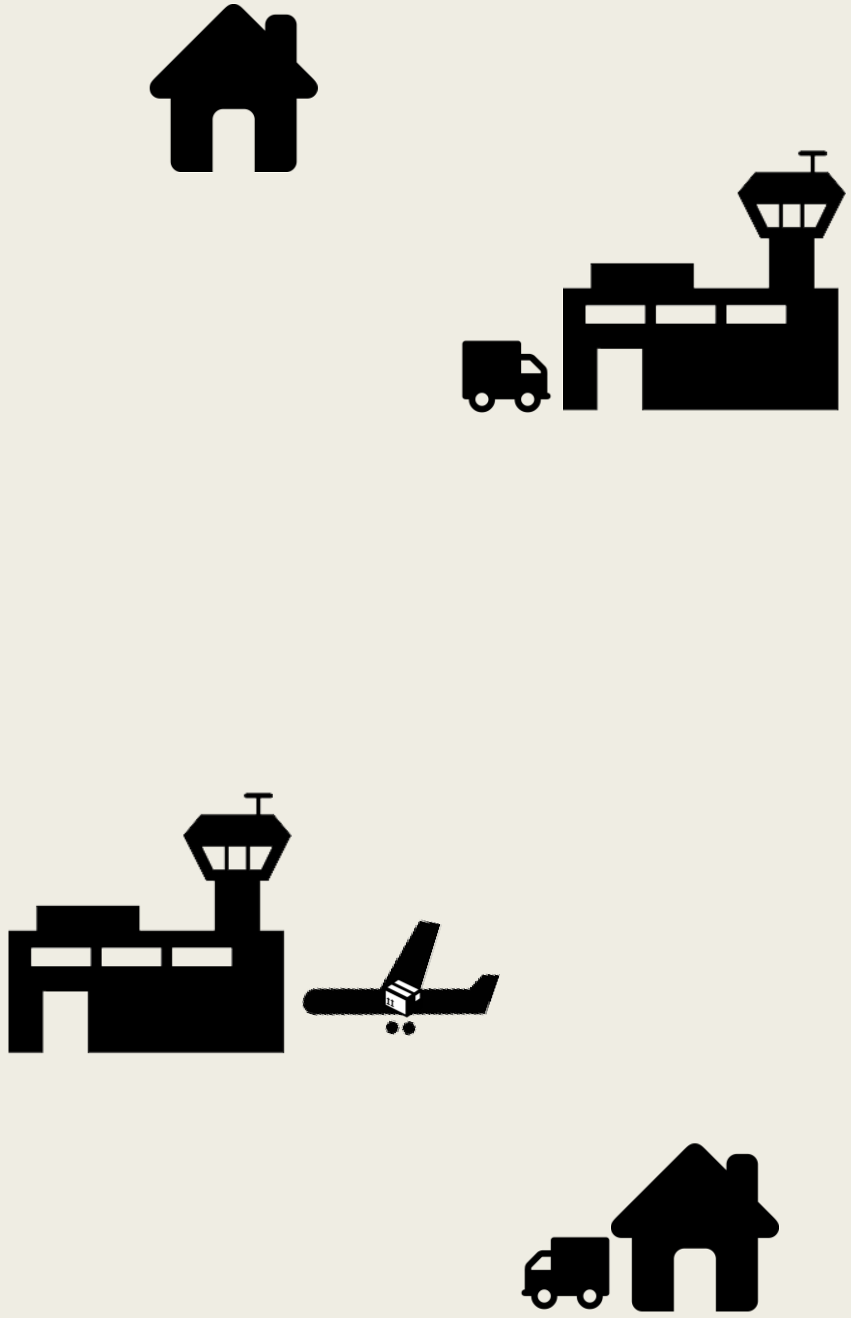

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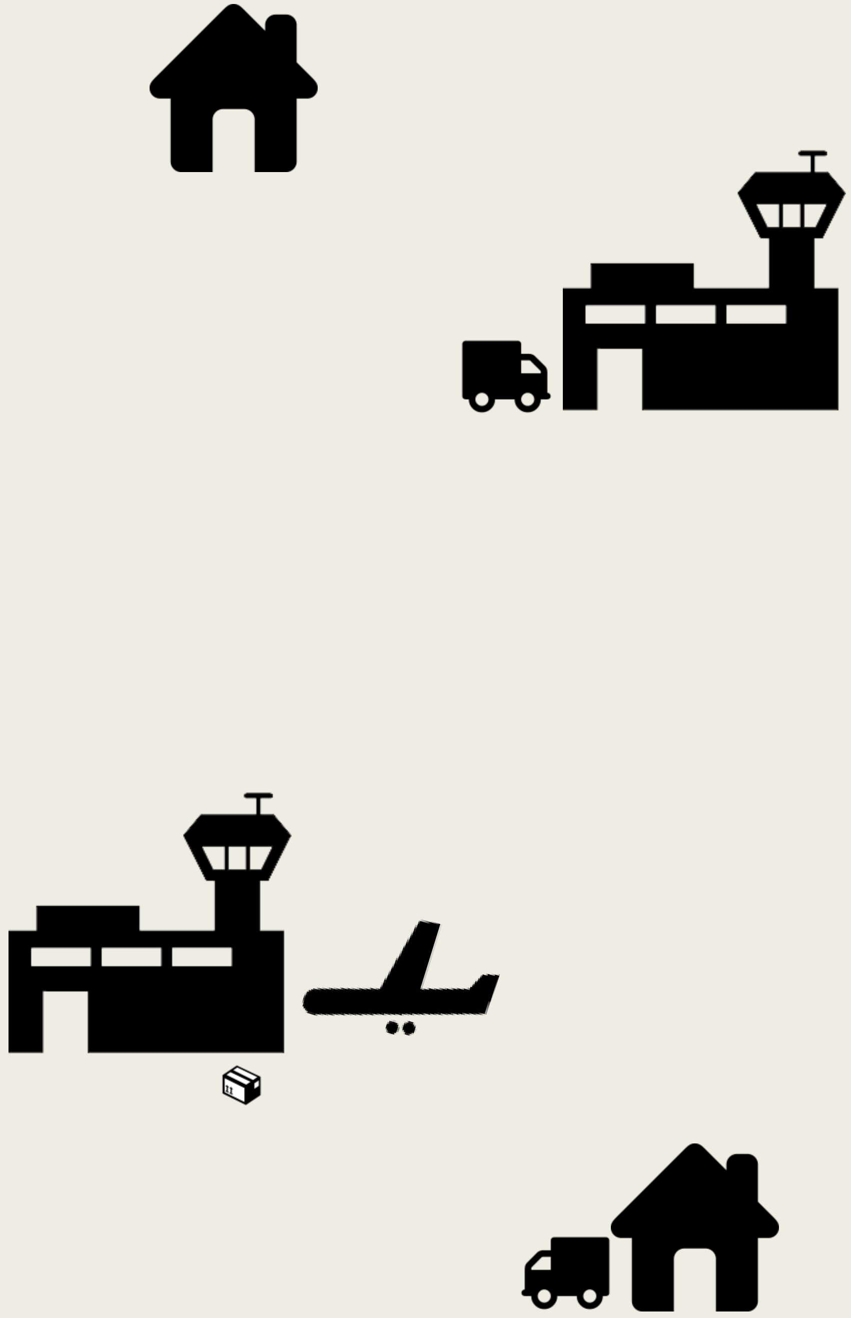

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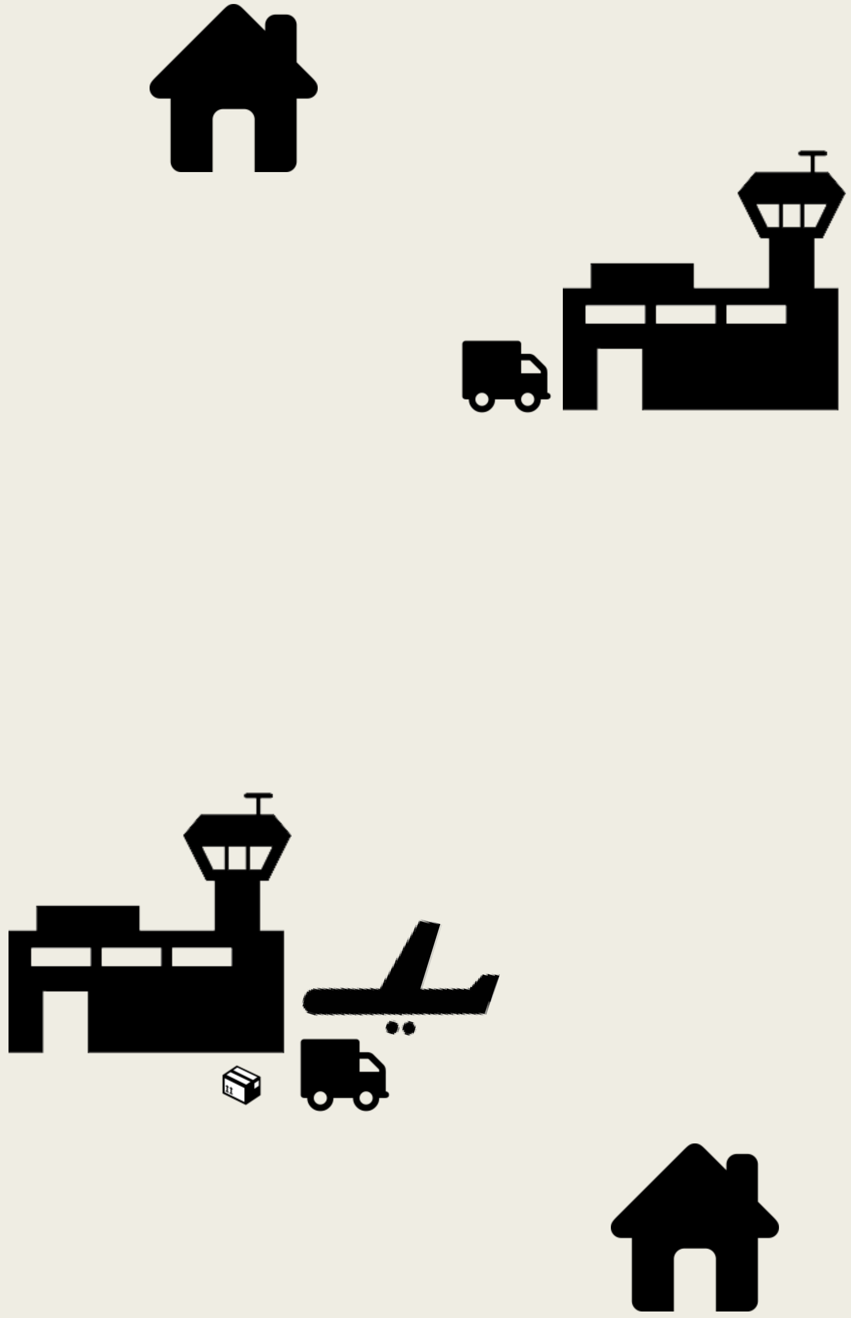

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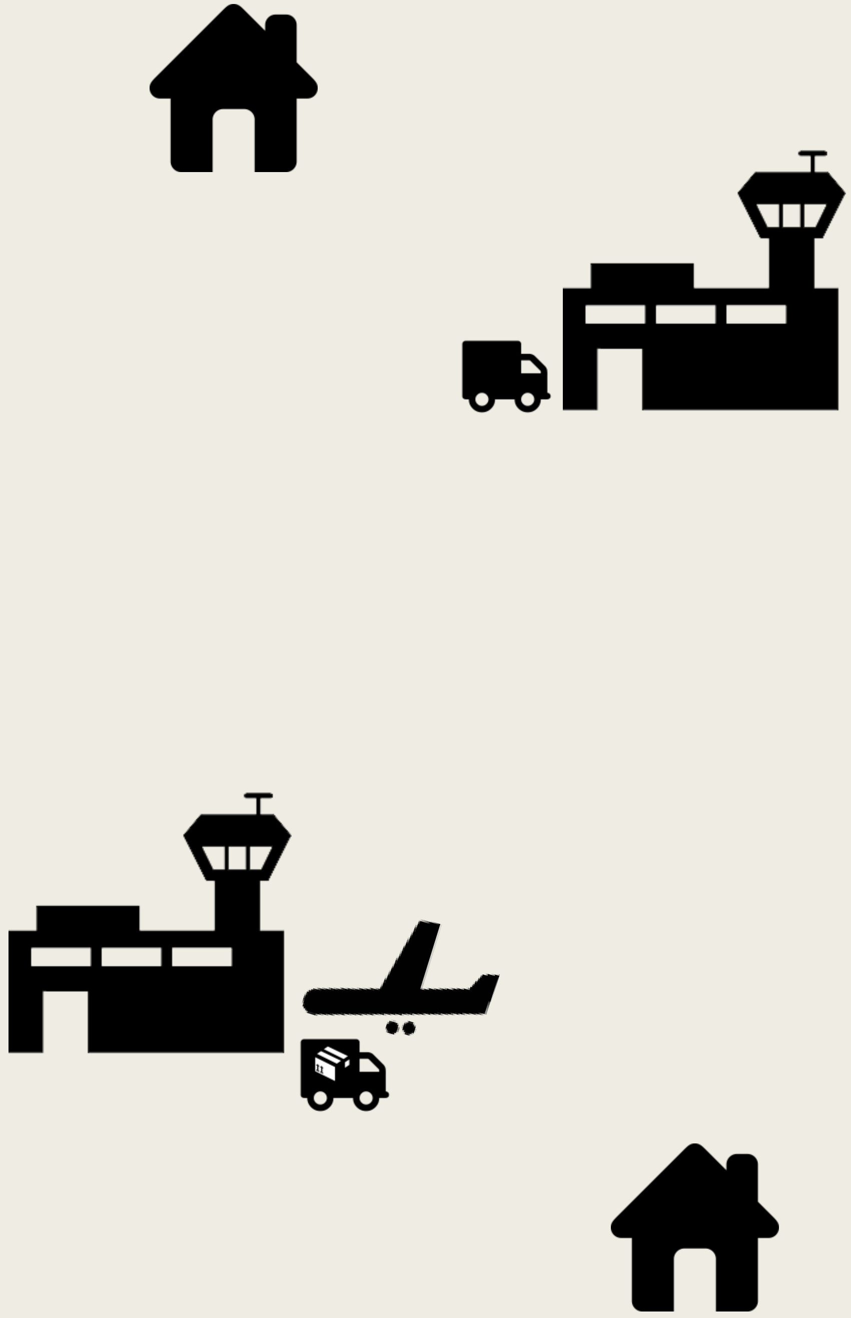

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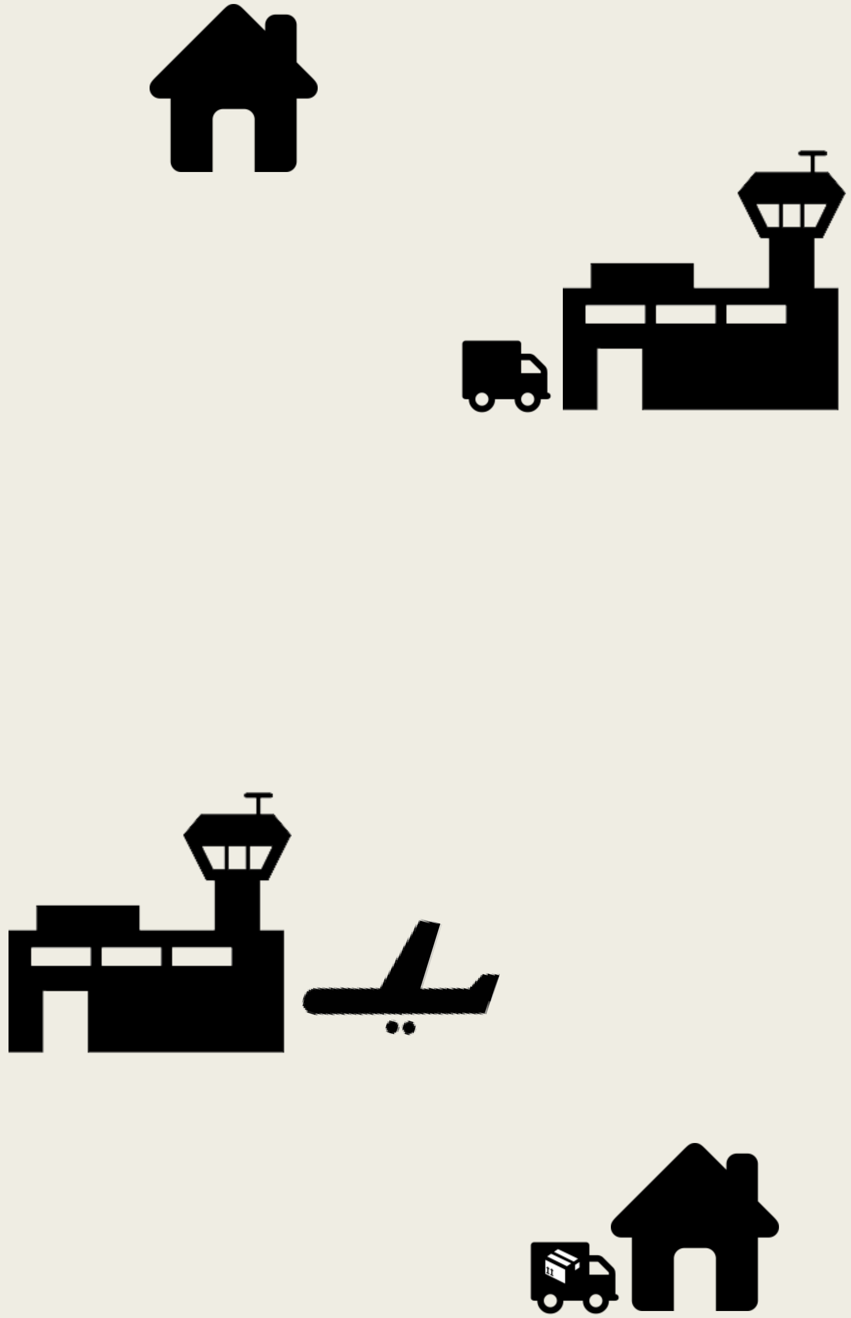

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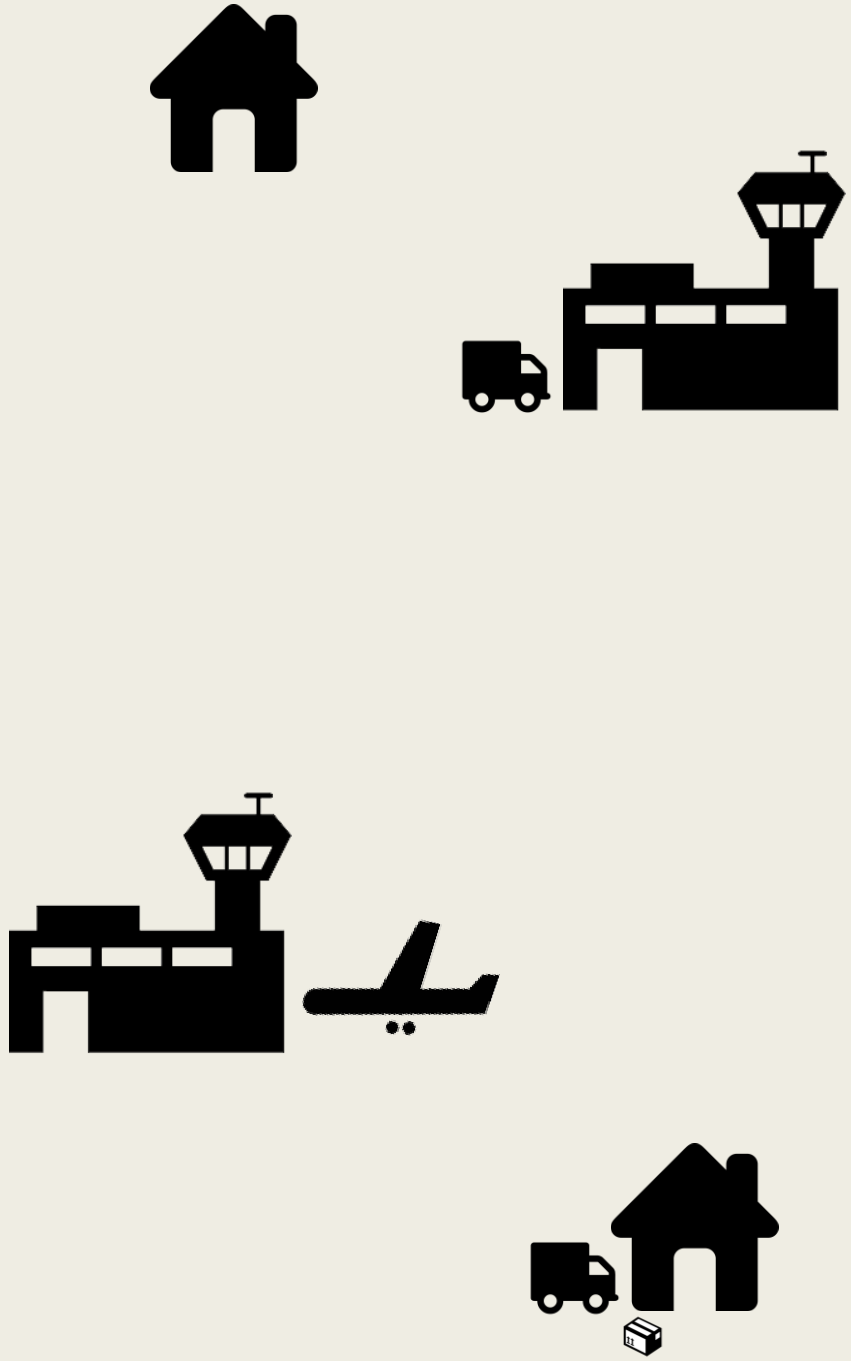


Solving your problem

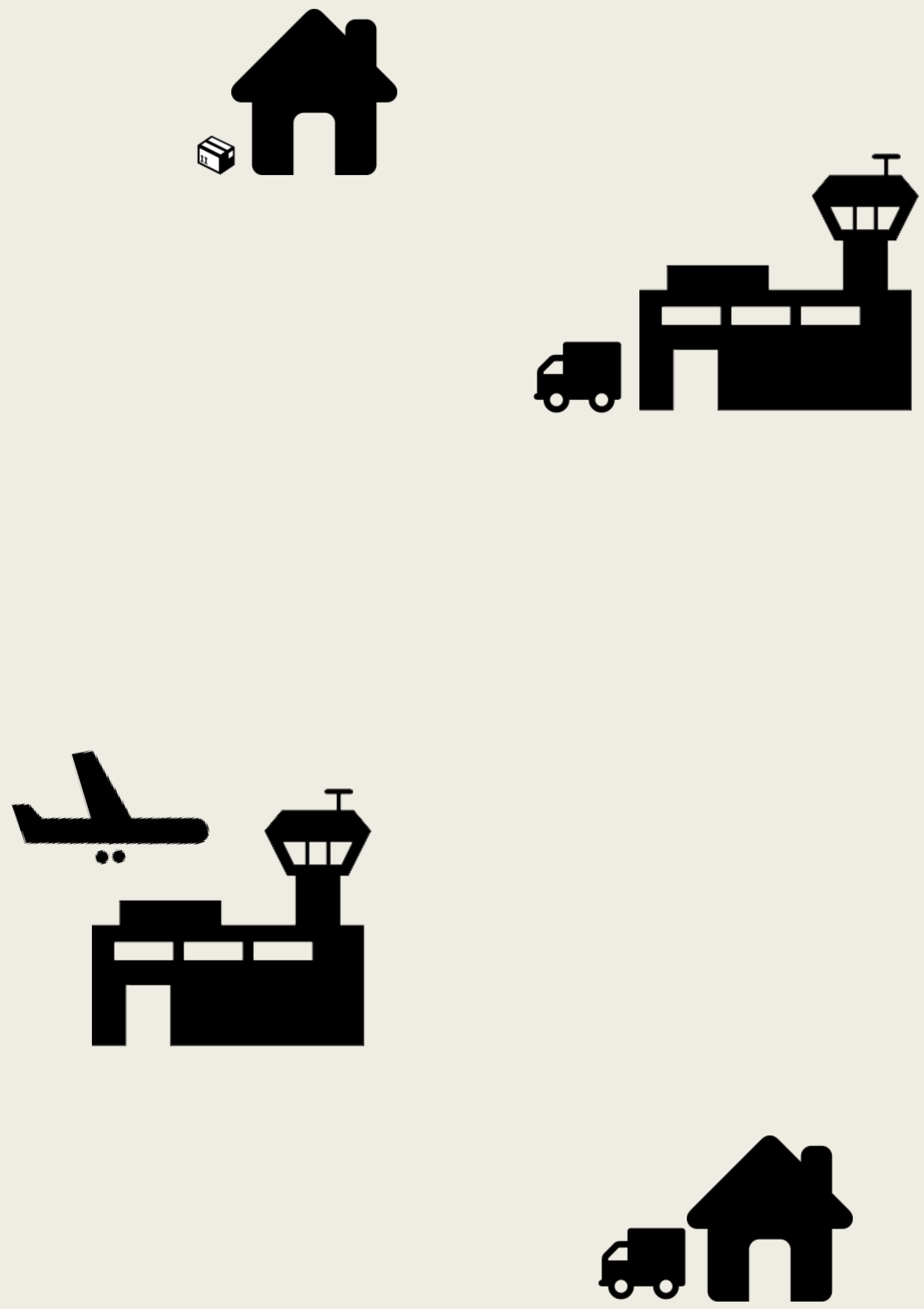
Domain specific solution

- Fast
- Takes development time
- Hard to get right

General solver (planning)

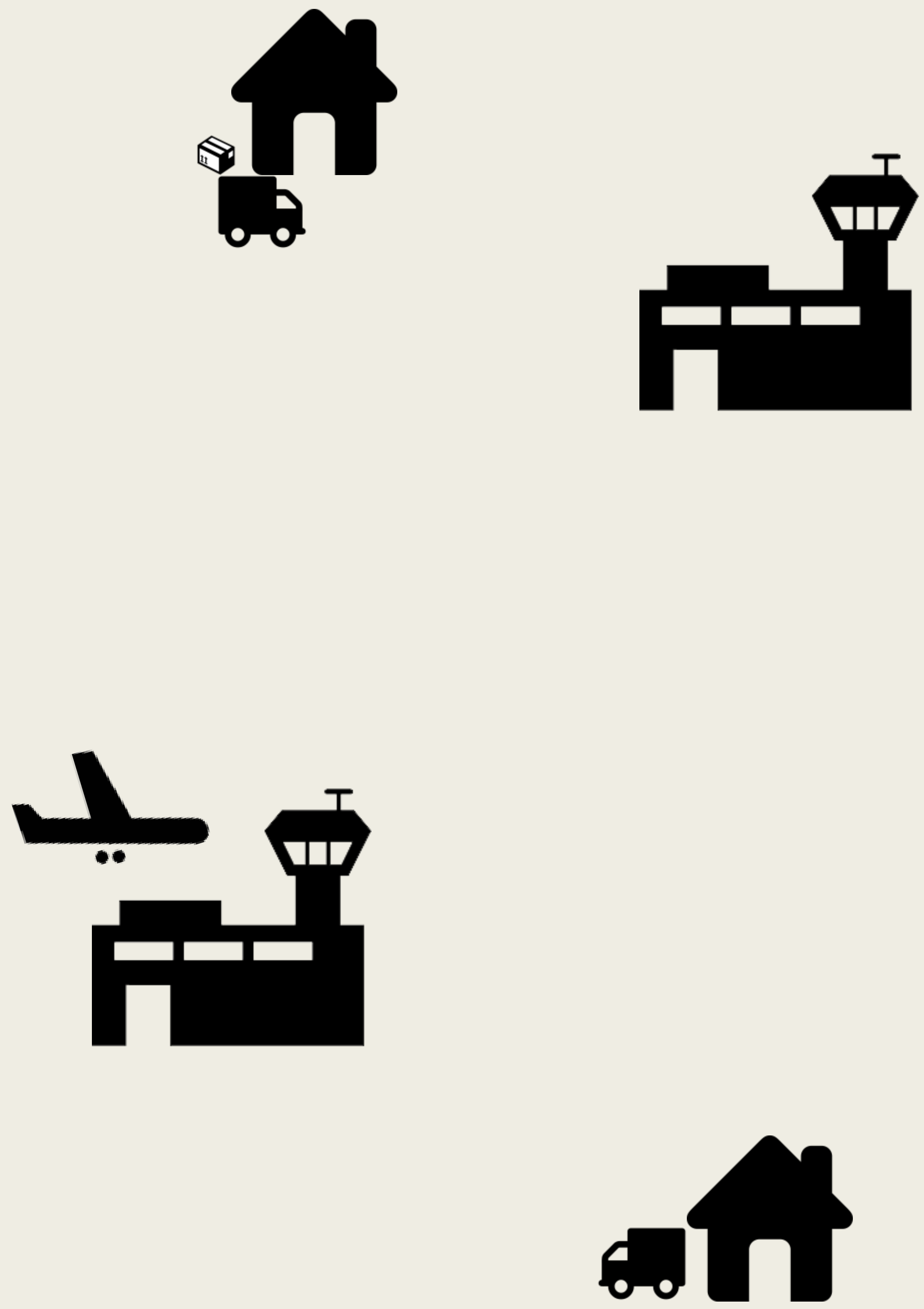
- Easy
- Highly optimized
- Requires just the right setup

A middle way?



A middle way?

- Identify interesting features

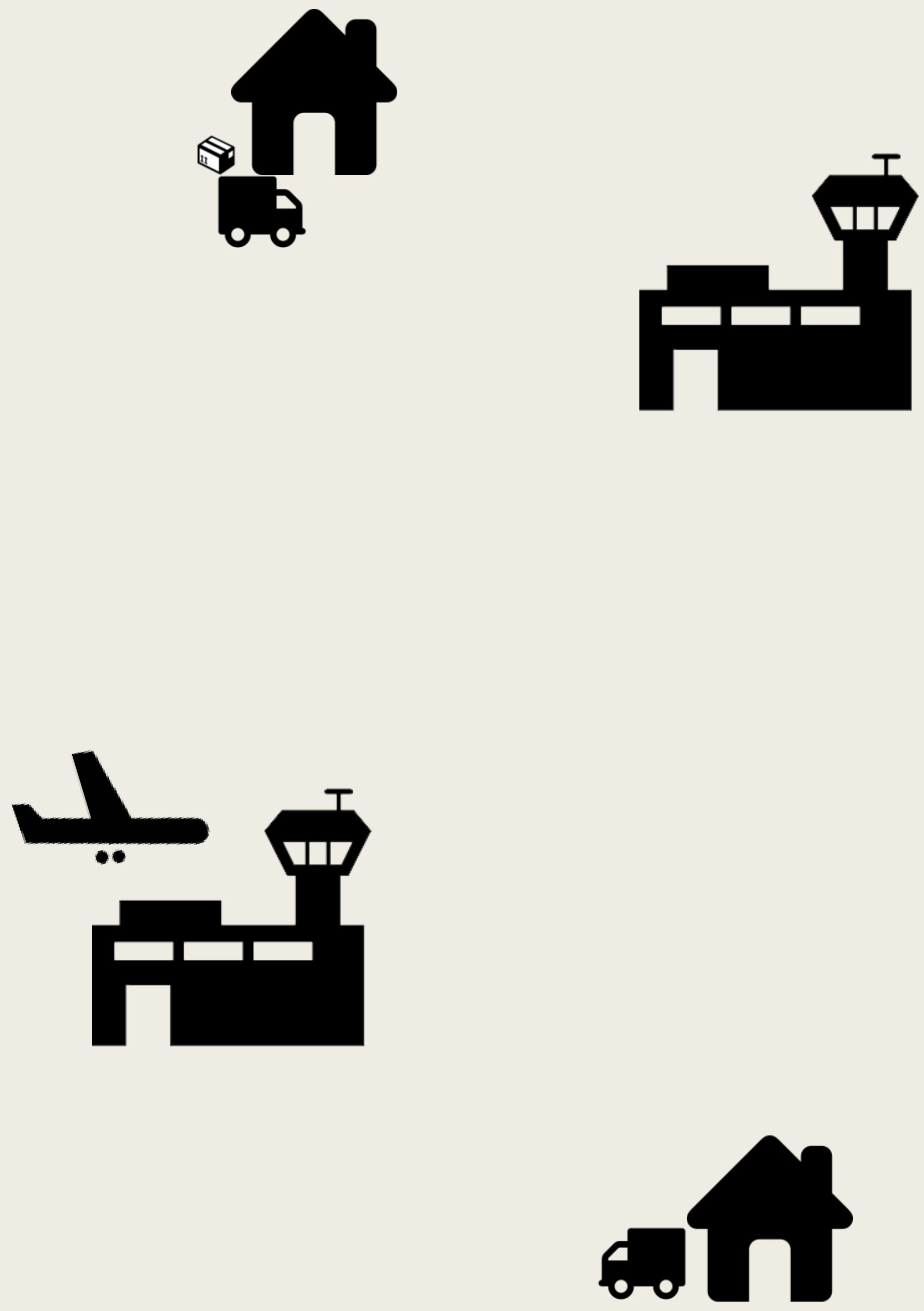


PDDL

package(package1)

at(package1, position1)
at(truck1, position1)
at(truck2, position2)
at(airplane, airport2)

in-city(position1, city1)
in-city(airport1, city1)
in-city(position2, city2)
in-city(airport2, city2)

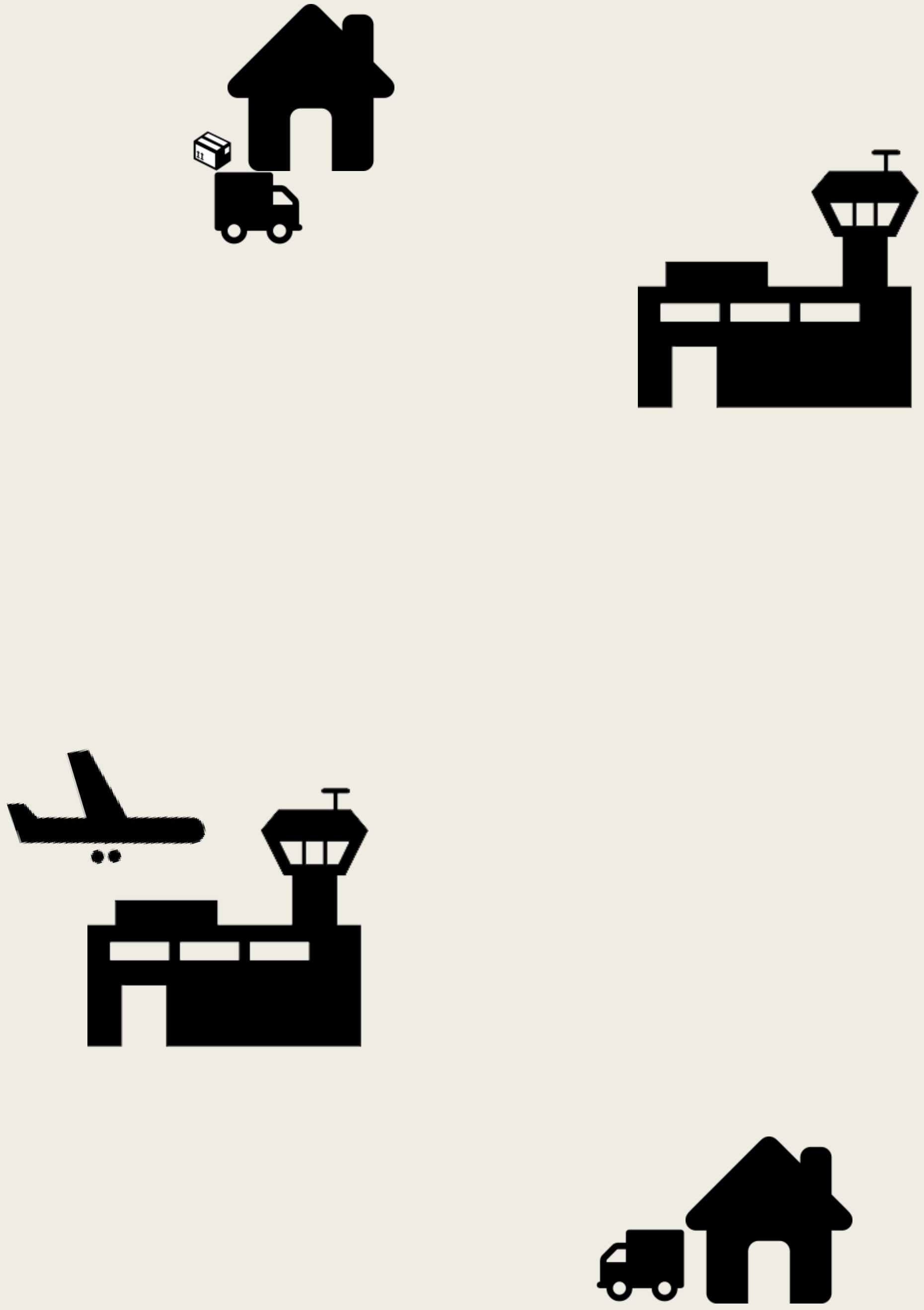


Concept languages

package → { package1 }

at → { (package1, position1),
(truck1, position1),
(truck2, position2),
(airplane, airport2) }

in-city → { (position1, city1),
(airport1, city1),
(position2, city2),
(airport2, city2) }

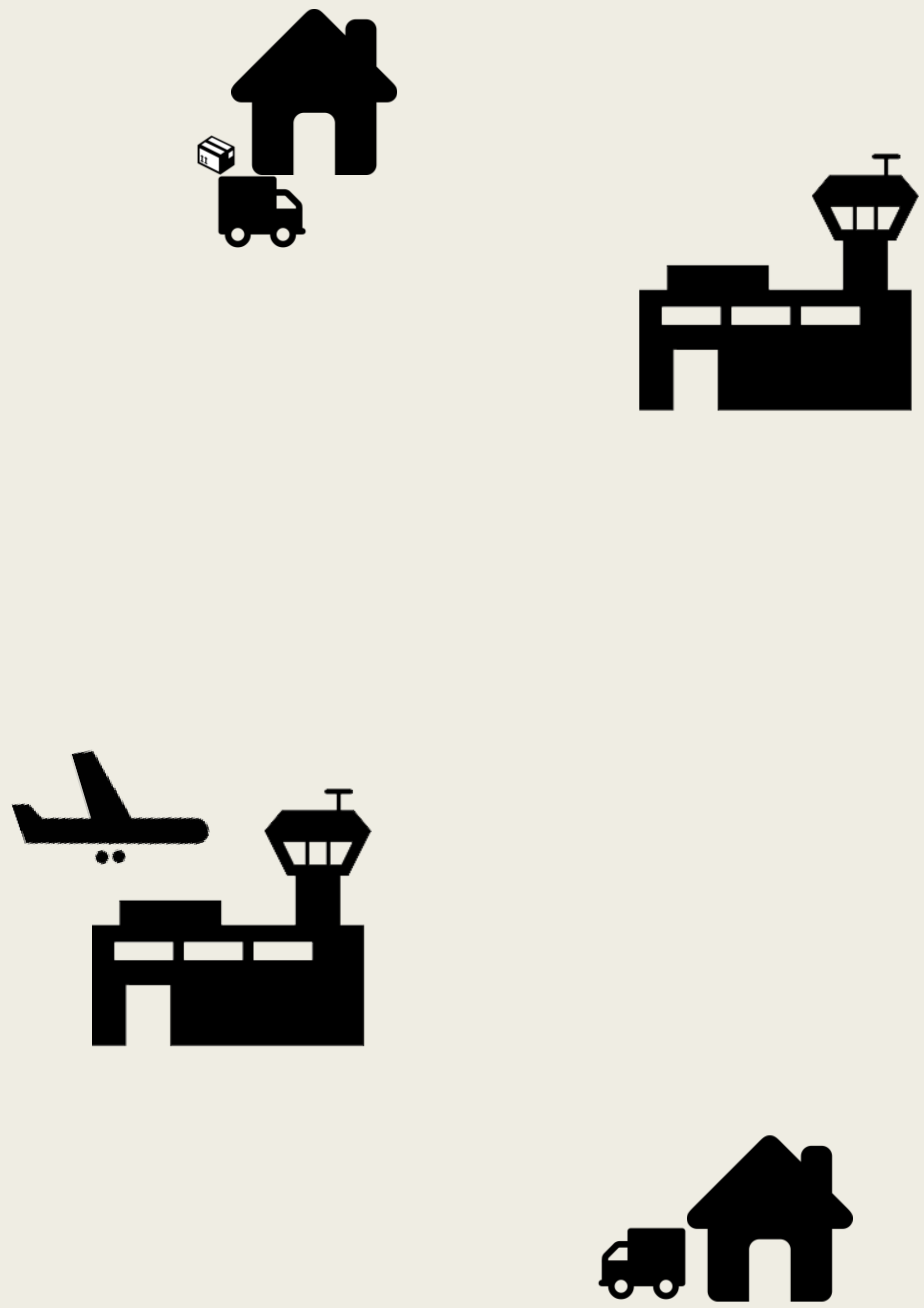


Concept languages

$\mathrm{truck} \sqcup airplane$
$\mathrm{truck} \sqcap airplane$
$\neg truck$

$\mathrm{in} \circ at$
$at = at_G$

$\exists at.airport$
$\forall in.truck$



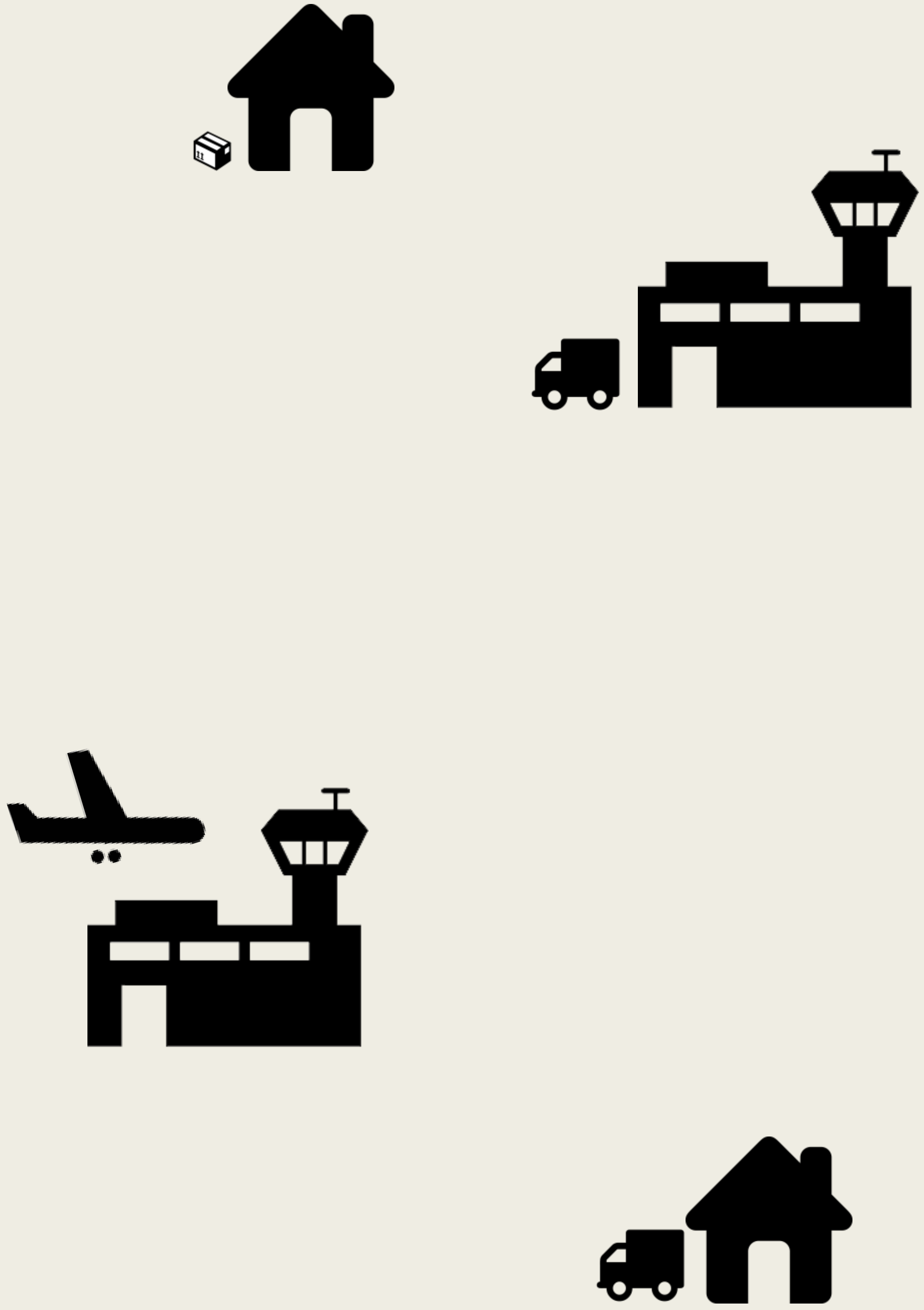
Features

- Cardinality: $|C|$
- Distance: $dist(C, R, C')$
- Multiplication: $f_1 \cdot f_2$

Features

#packages at wrong location with truck

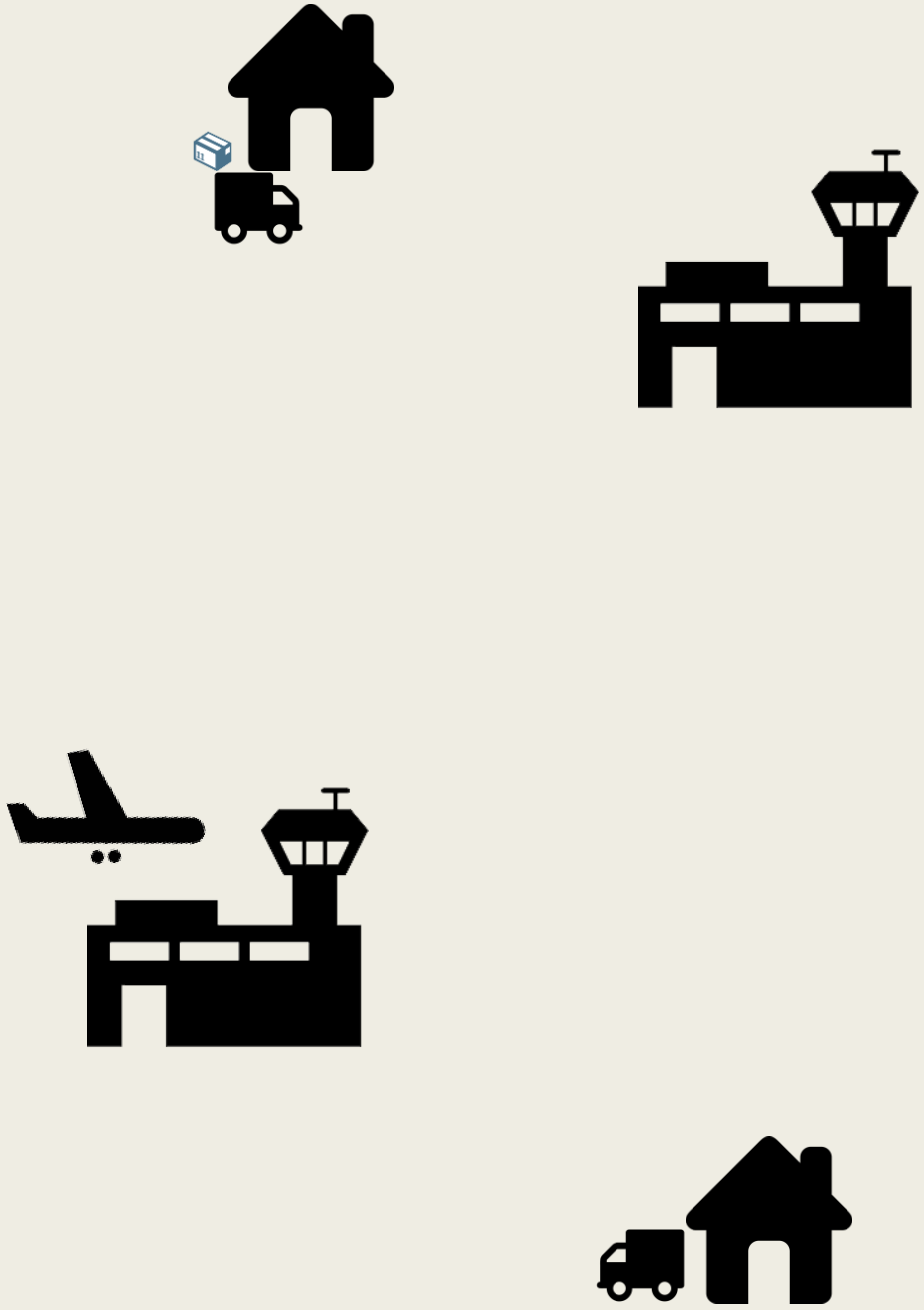
$$|package \sqcap \neg(at = at_G) \sqcap \exists at.truck| = 0$$



Features

#packages at wrong location with truck

$$|package \sqcap \neg(at = at_G) \sqcap \exists at.truck| = 1$$



Using features

- Fully explore small instances
- Learn a heuristic

Approach a descending heuristic

Minimize $\sum slack$

subject to $h(s) + slack \leq h(s') + 1$ for all states s and some successor s'

Locally approach h*

Minimize $\sum |slack|$

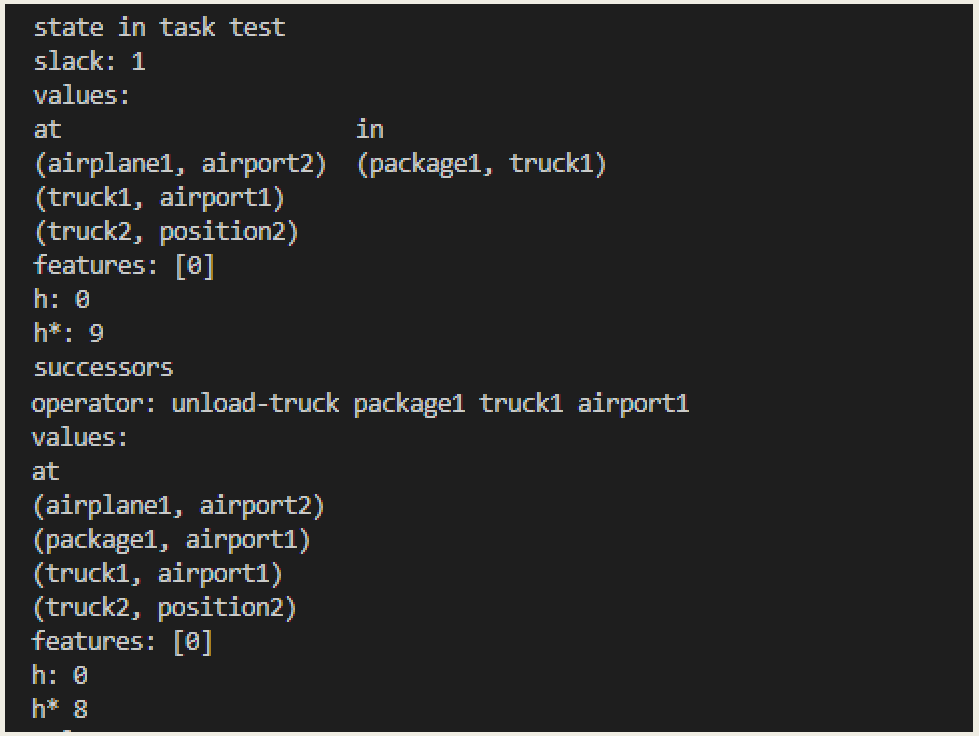
subject to $h(s) - h(s') + slack = h^*(s) - h^*(s')$ for all states s and all successors s'

Implementation

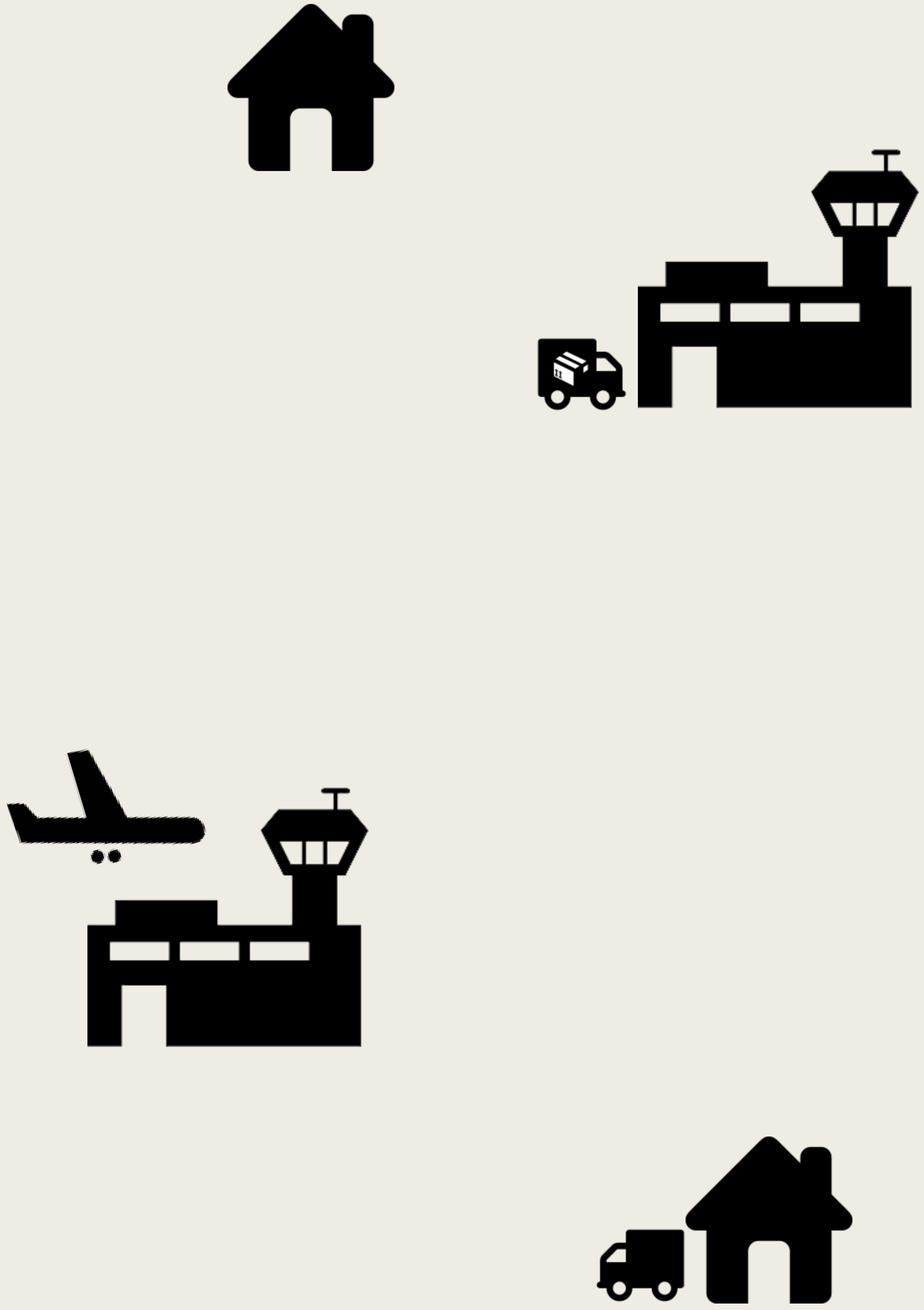
- Python command line tool
- Fast Downward
- CPLEX

Example

$|package \sqcap \neg(at = at_G) \sqcap \exists at.truck|$

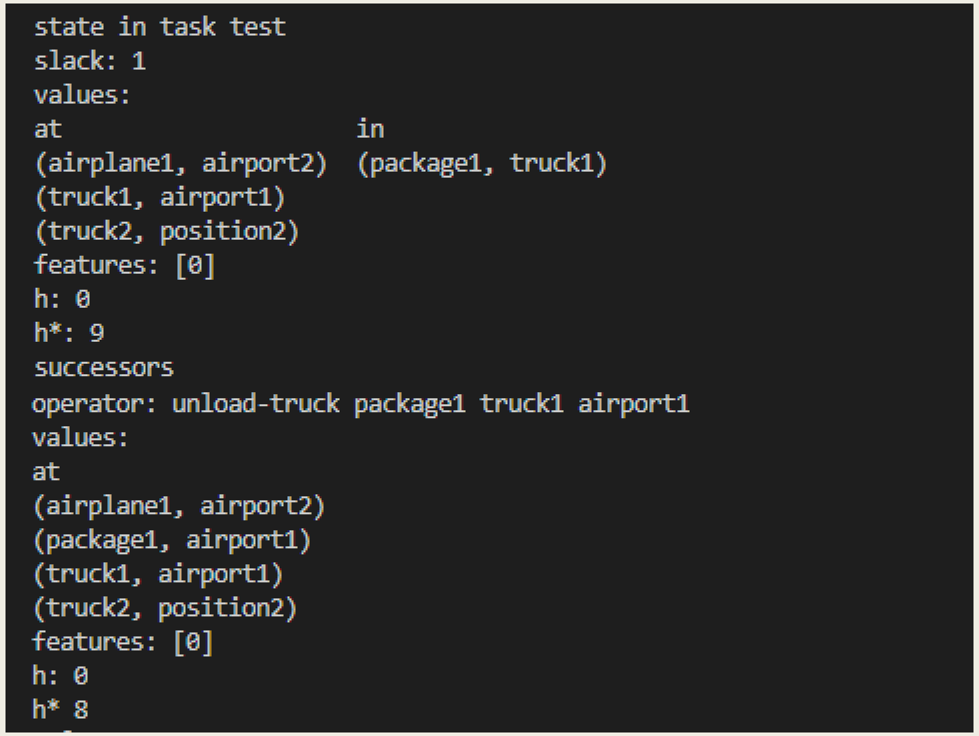


```
state in task test
slack: 1
values:
at                     in
(airplane1, airport2)  (package1, truck1)
(truck1, airport1)
(truck2, position2)
features: [0]
h: 0
h*: 9
successors
operator: unload-truck package1 truck1 airport1
values:
at
(airplane1, airport2)
(package1, airport1)
(truck1, airport1)
(truck2, position2)
features: [0]
h: 0
h* 8
```



Example

$$|package \sqcap \neg(at = at_G) \sqcap \exists at.truck|$$



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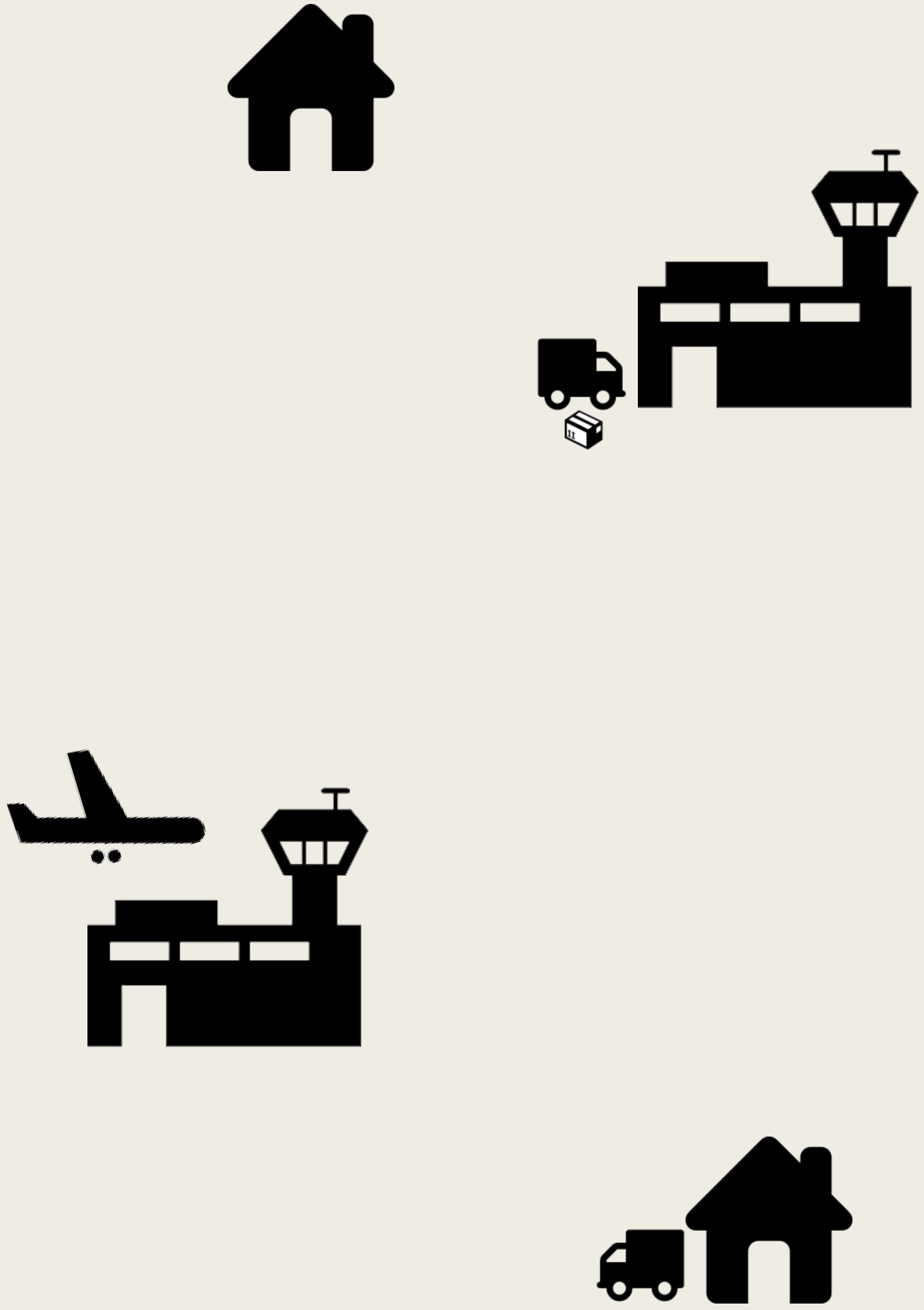
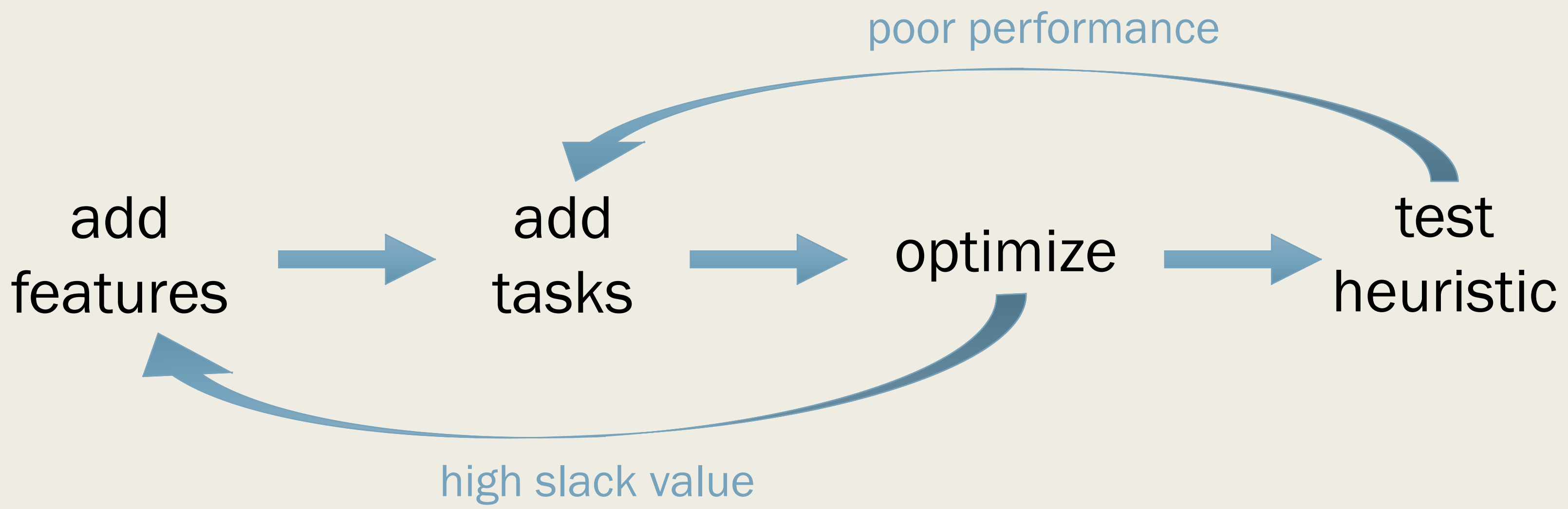
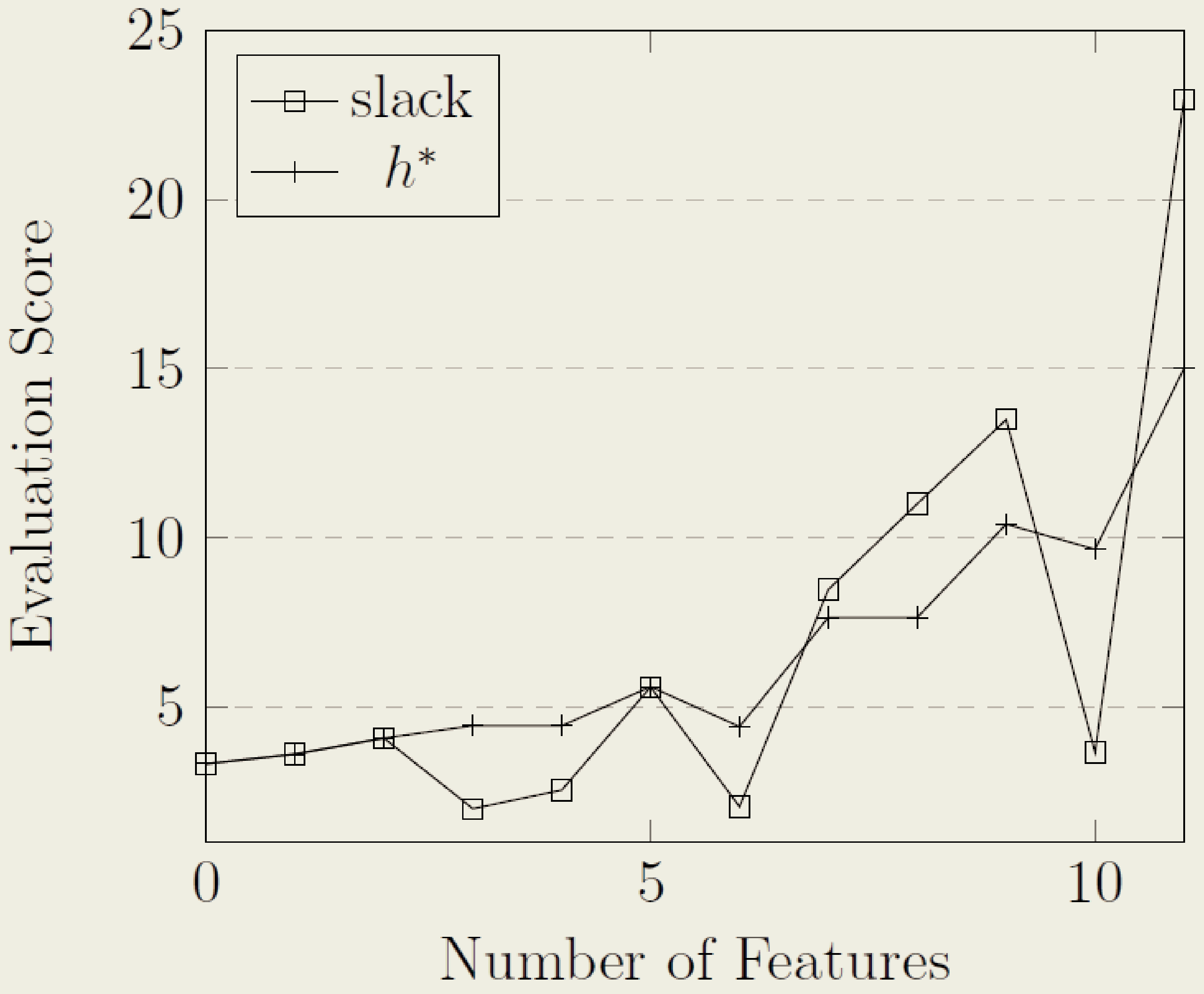


Workflow


poor performance
add features
add tasks
optimize
test heuristic
high slack value

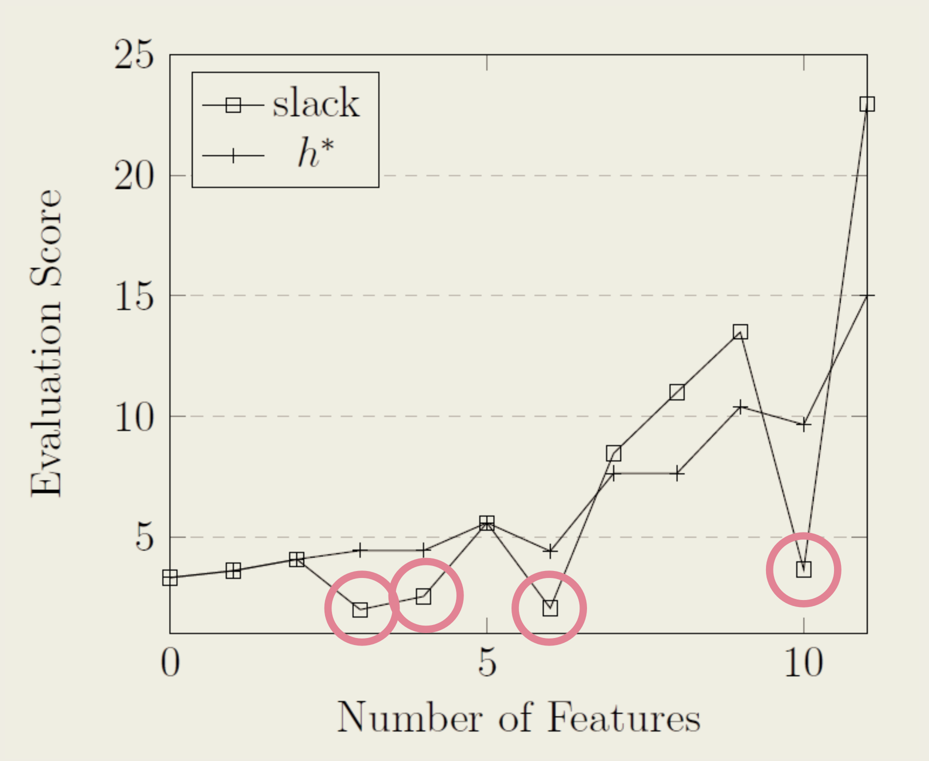


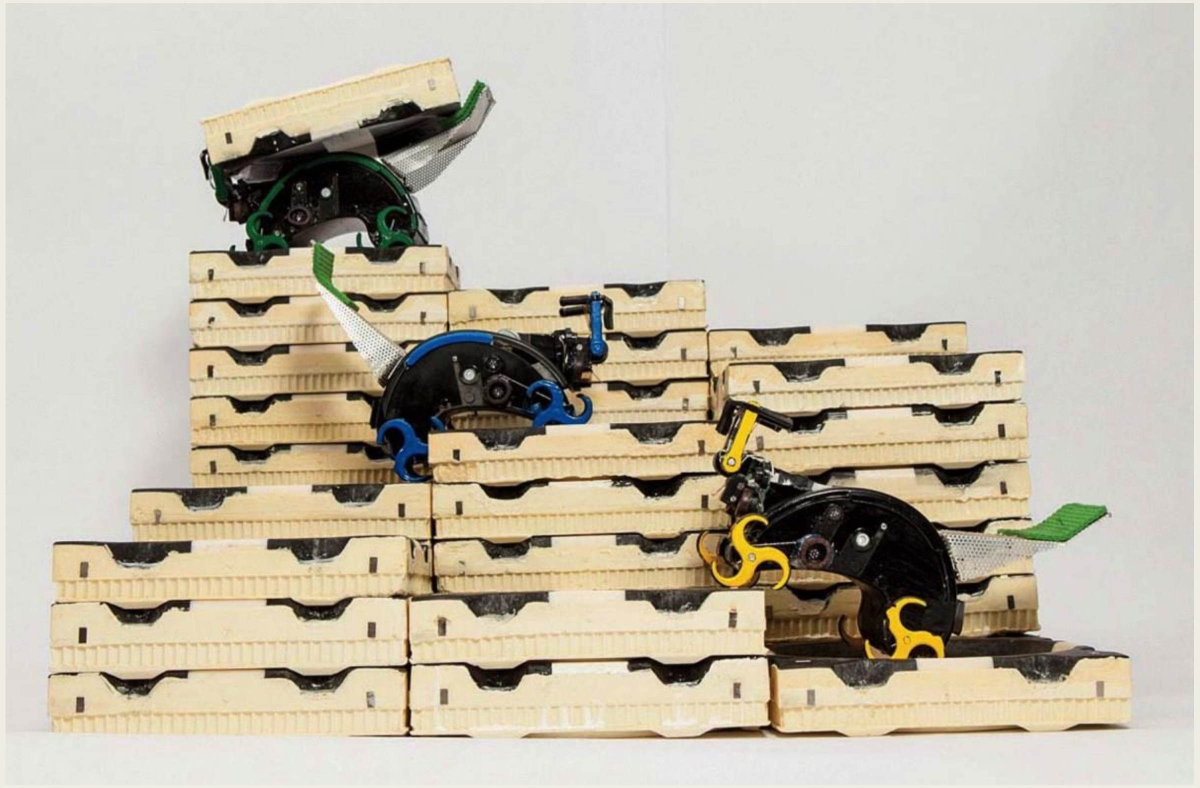
Results

- General upward trend
- h* more stable

Logistics problems

- With truck at airport ⟶ -6
- In truck at airport ⟶ -5
- In truck at destination ⟶ -4



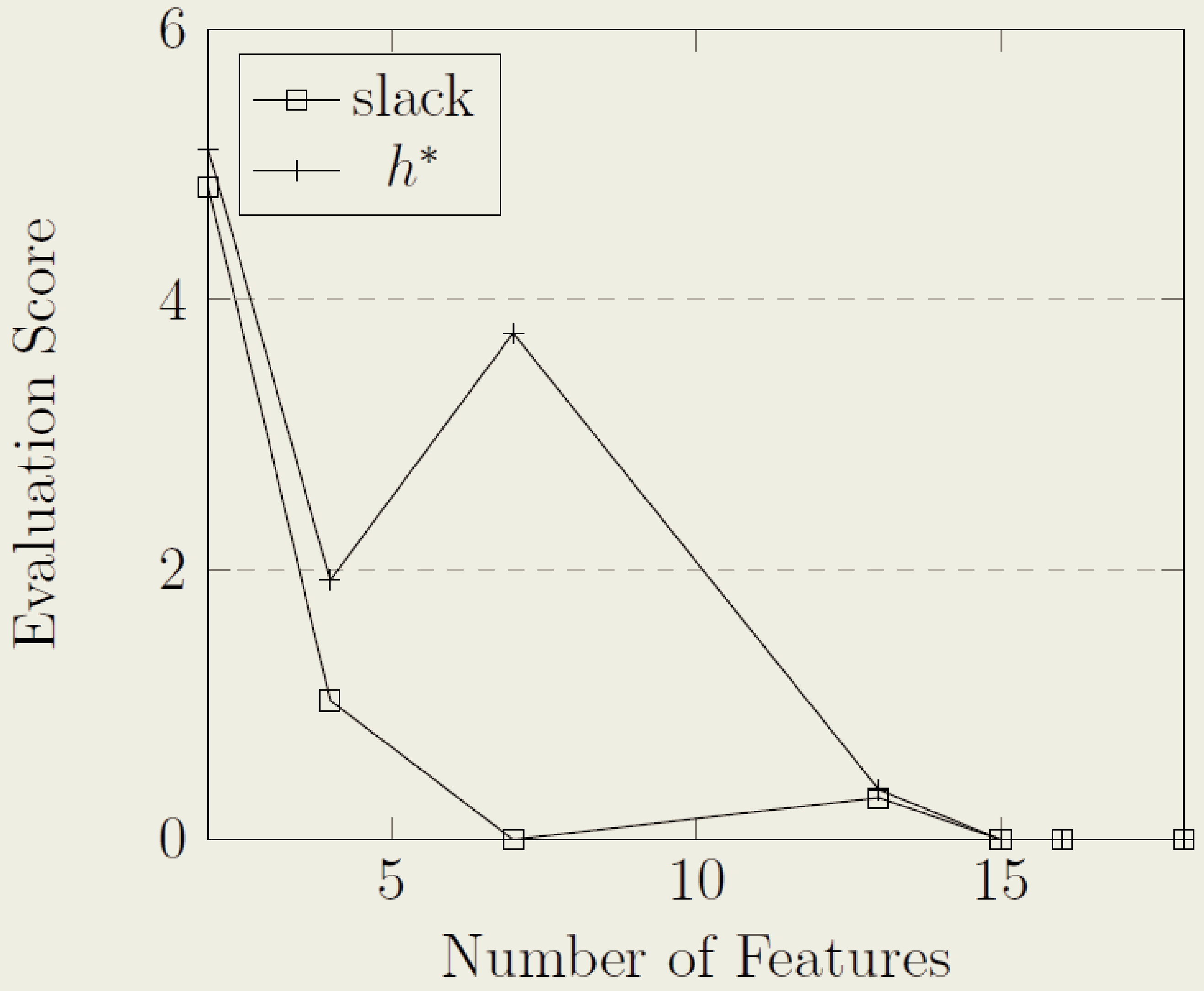


source: https://www.harvardmagazine.com/2017/11/robobee-harvard

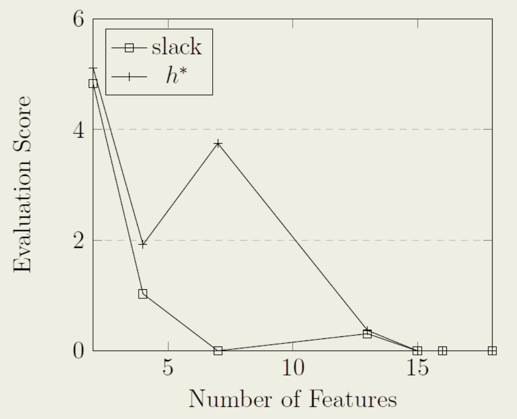
TERMES

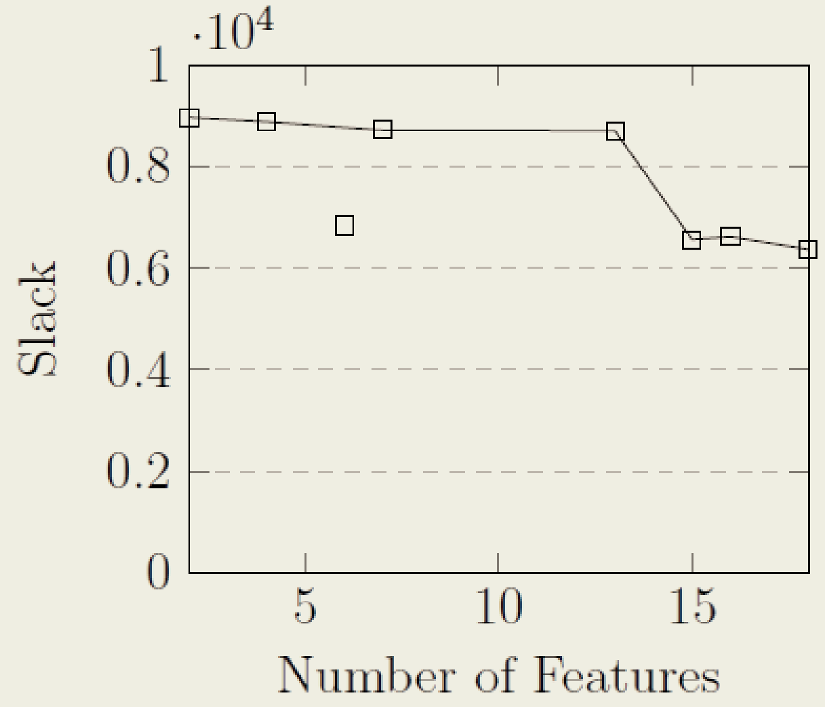
TERMES

- Downward trend
- h* more robust

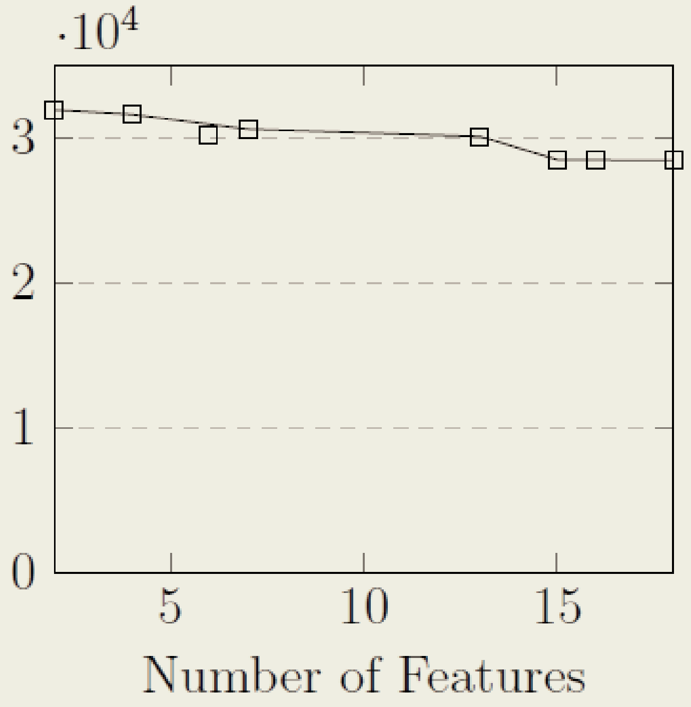


TERMES SLACK





(a) Heuristics found by $\mathcal{M}_{slack}$.



(b) Heuristics found by $\mathcal{M}^*$.

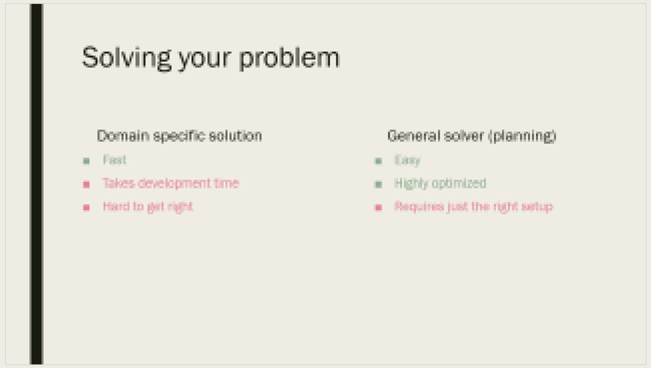
Conclusion

- Reasonably efficient and highly usable implementation
- Specifying domain knowledge
- Incorporating domain knowledge

Future work

- Automatically augment feature set
- Different learning objective
  - *Goal Distance Rank Correlation*
- Neural net for learning
- Interactive mode
- Scripting language

The Logistics Problem



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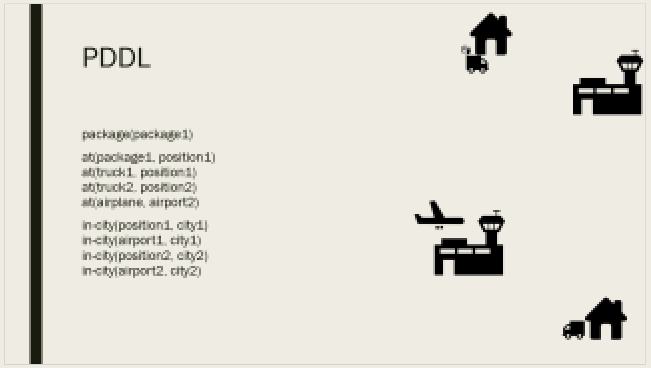

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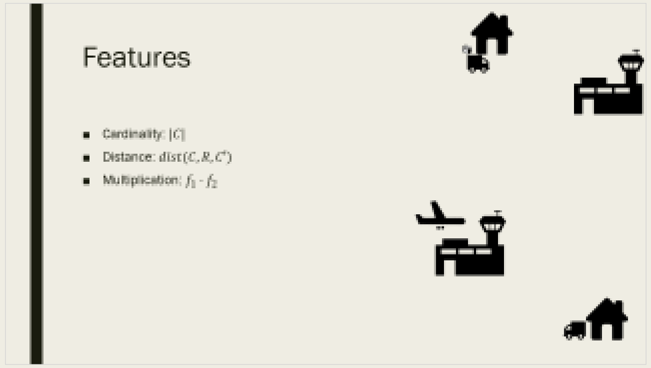

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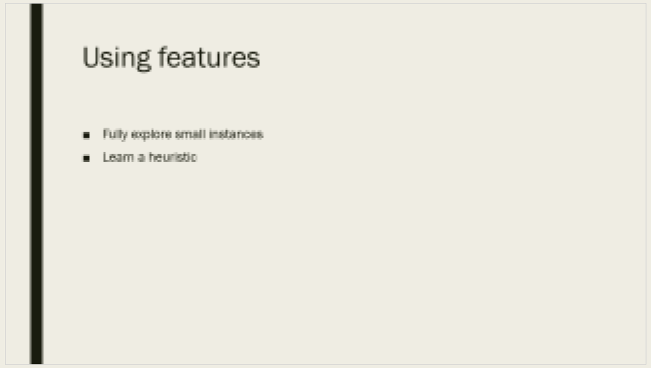

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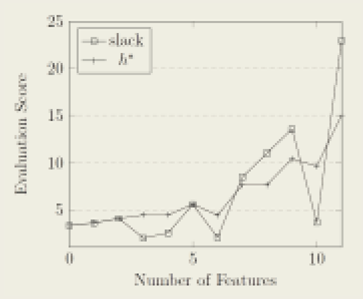

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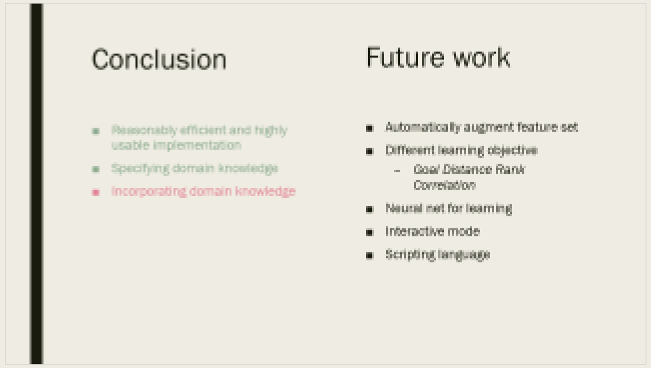

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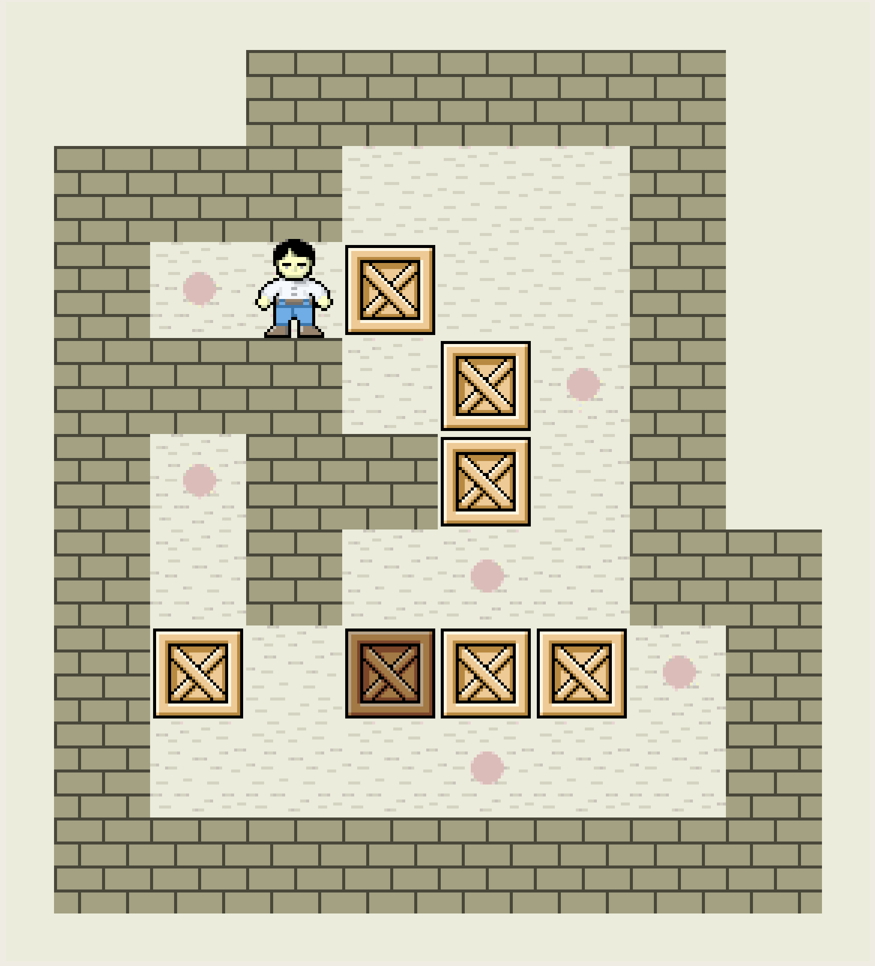
Extensions of Concept Languages

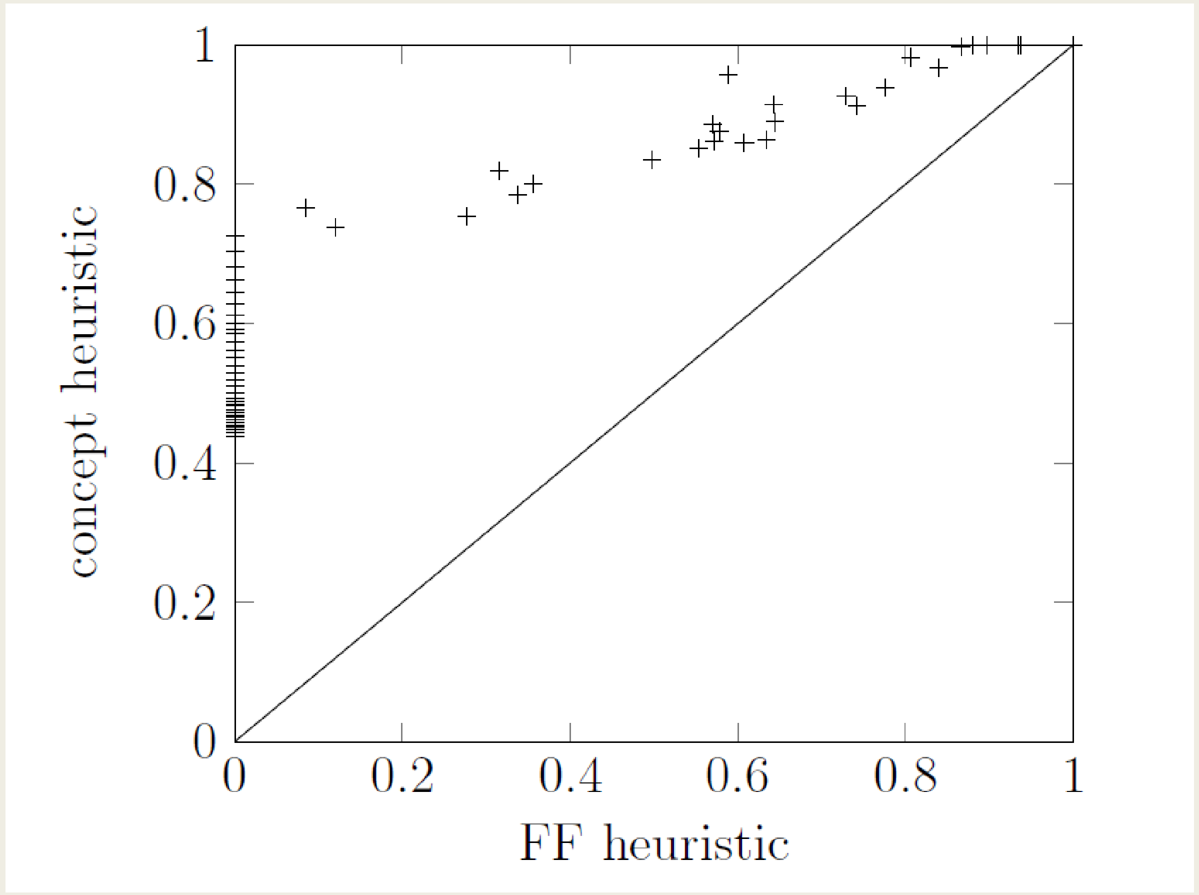
- n-ary roles
  - *selection + projection*
  - *existential and universal quantifier*
- role disjunction + conjunction
- Qualified cardinality restrictions
  - $> 2\ connected.clear$
- Heuristic feature

n-ary roles

MOVE-DIR location location direction

$connected = \exists x \in dir.\mathrm{MOVE{-}DIR}[\top, \top, x]$





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