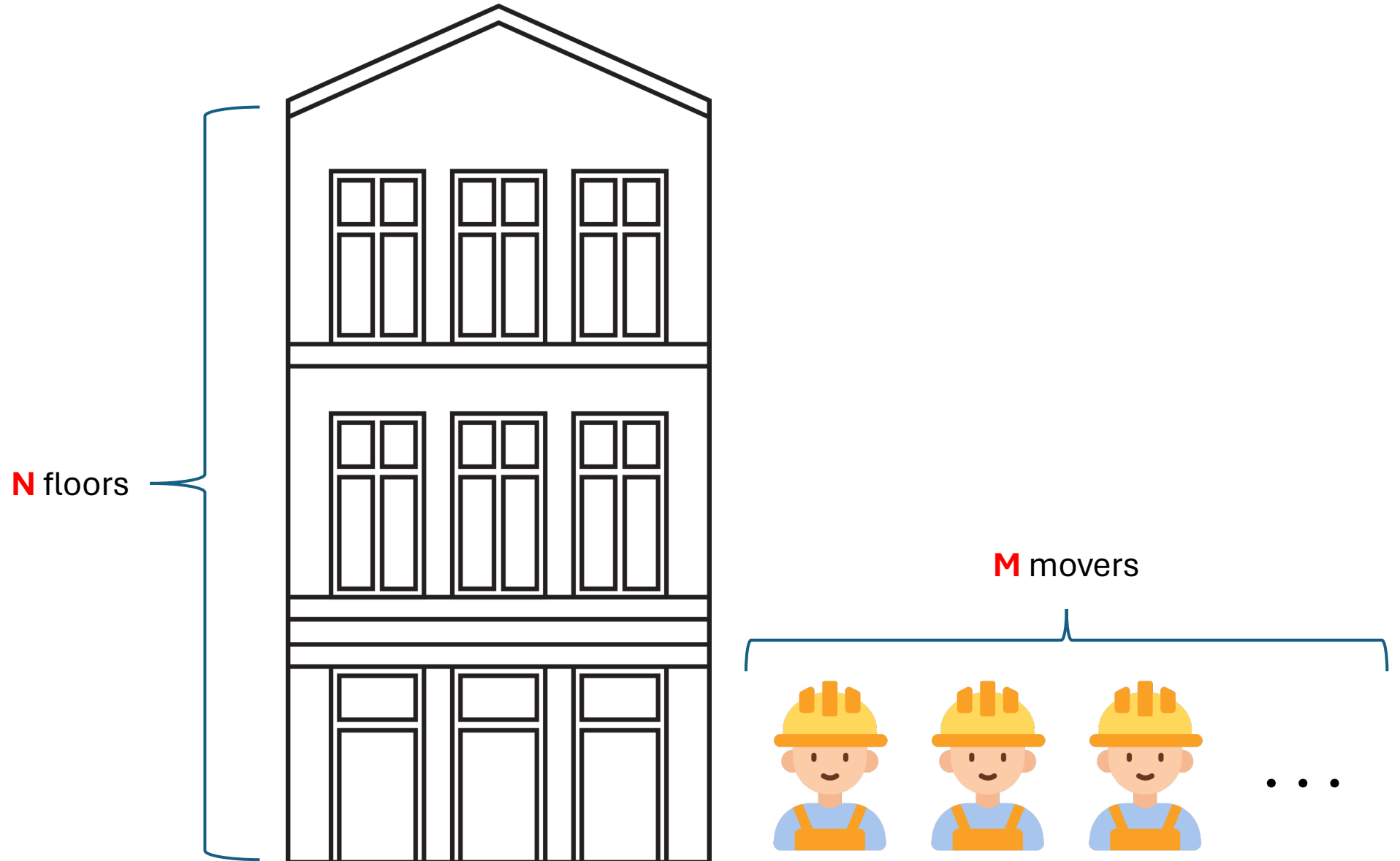


Movers

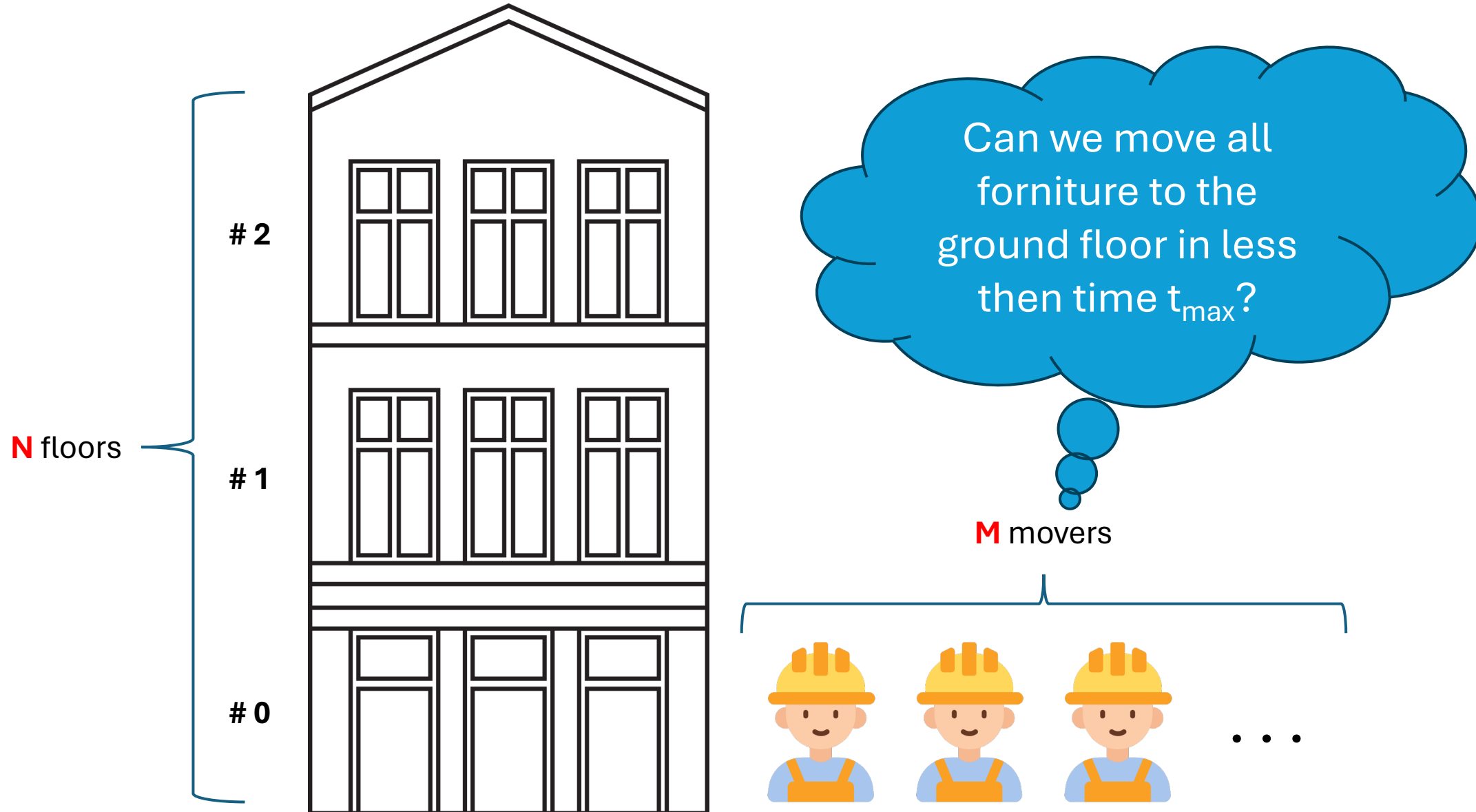
Theory of Computation – Spring 2024

Università della Svizzera Italiana

Problem description



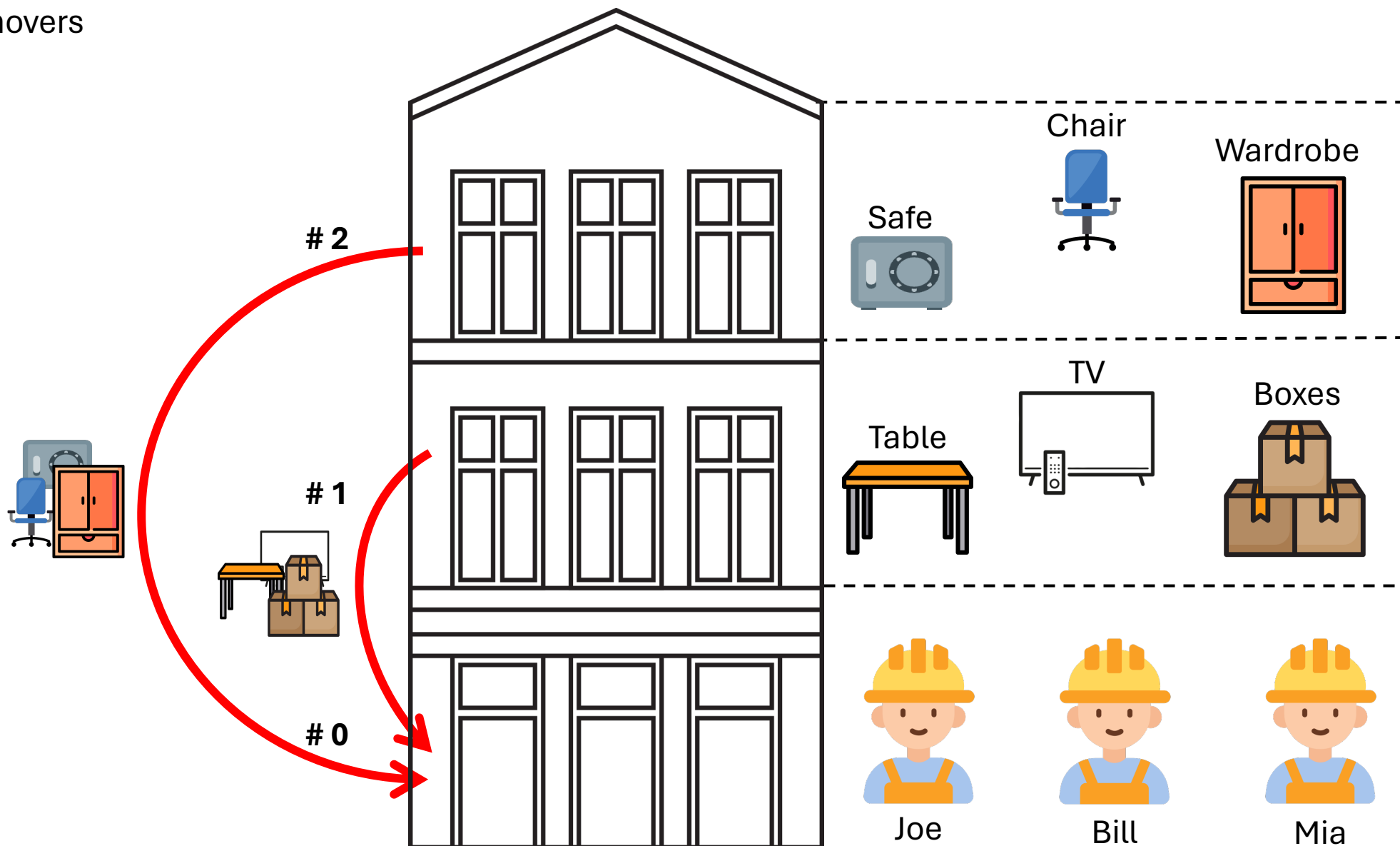
Problem description



 **N** floors

 **M** movers

Problem description: objective



State variables

- $atFloor(m_i, l_j, t) \in \{0, 1\} \forall l_j \in L, m_i \in M$

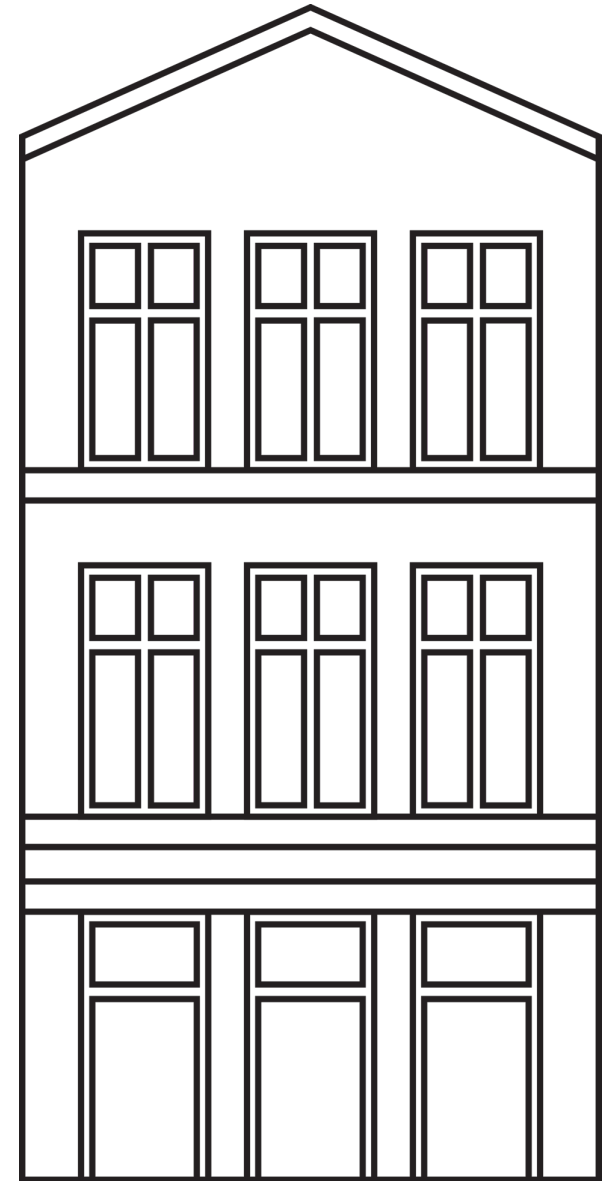
true if mover m_i is at floor l_j at time t

- $atFloorFurniture(f_i, l_j, t) \in \{0, 1\} \forall l_j \in L, f_i \in F$:

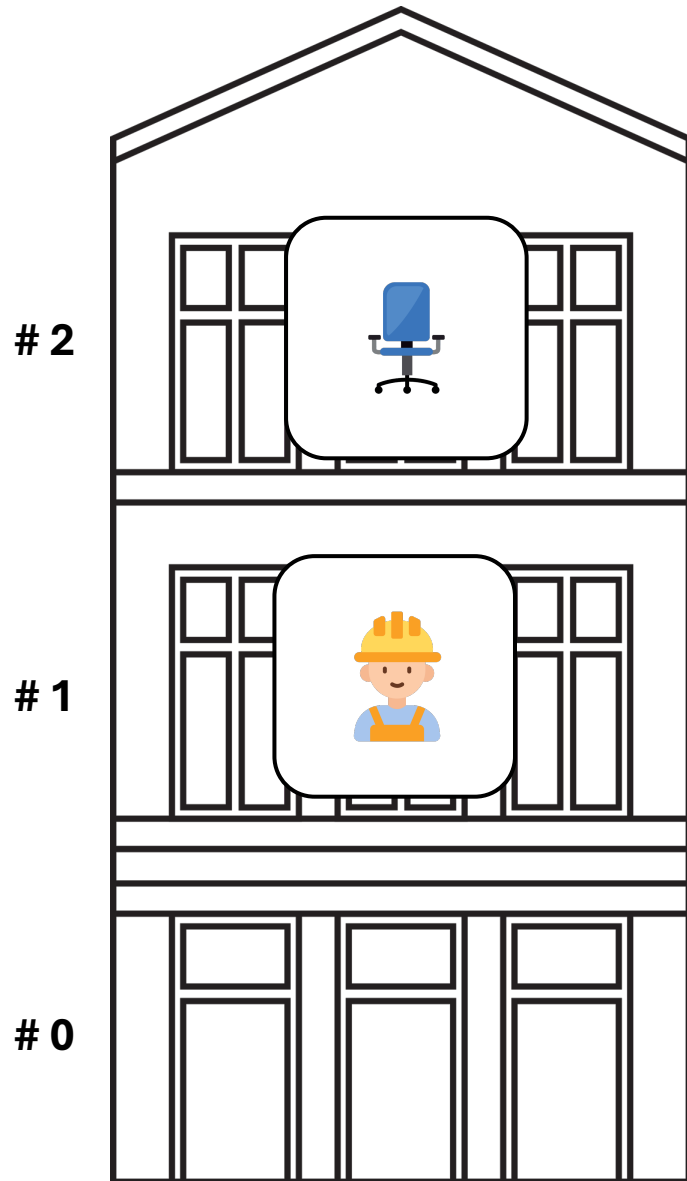
true if furniture f_i is at floor l_j at time t , otherwise false

$M = \{ \text{worker icon}, \text{worker icon}, \text{worker icon} \}$

$F = \{ \text{chair icon}, \text{cabinet icon}, \text{boxes icon} \}$



State variables



$$atFloorFurniture(\text{office chair}, \#2, t) = 1$$

$$atFloor(\text{worker}, \#1, t) = 1$$

t = 2

Movers actions

- $\text{ascend}(m_i, t) \in \{0, 1\} \forall m_i \in M, t \in T$

true if mover m_i is ascending at time t

- $\text{descend}(m_i, t) \in \{0, 1\} \forall m_i \in M, t \in T$

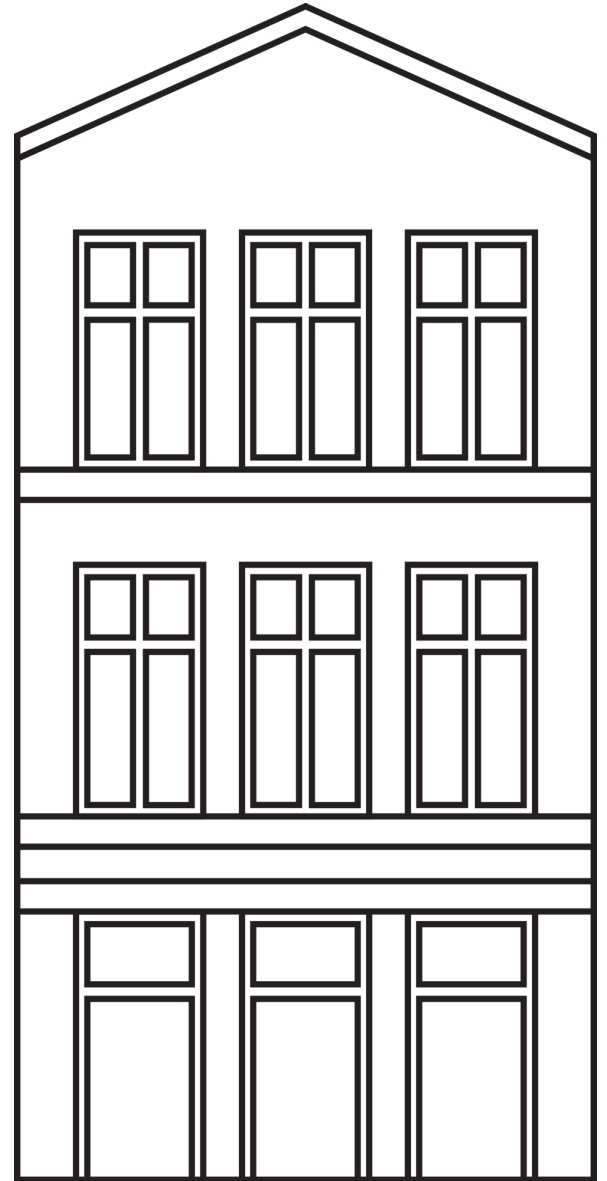
true if mover m_i is descending at time t

- $\text{carry}(m_i, f_j, t) \in \{0, 1\} \forall m_i \in M, f_j \in F, t \in T$

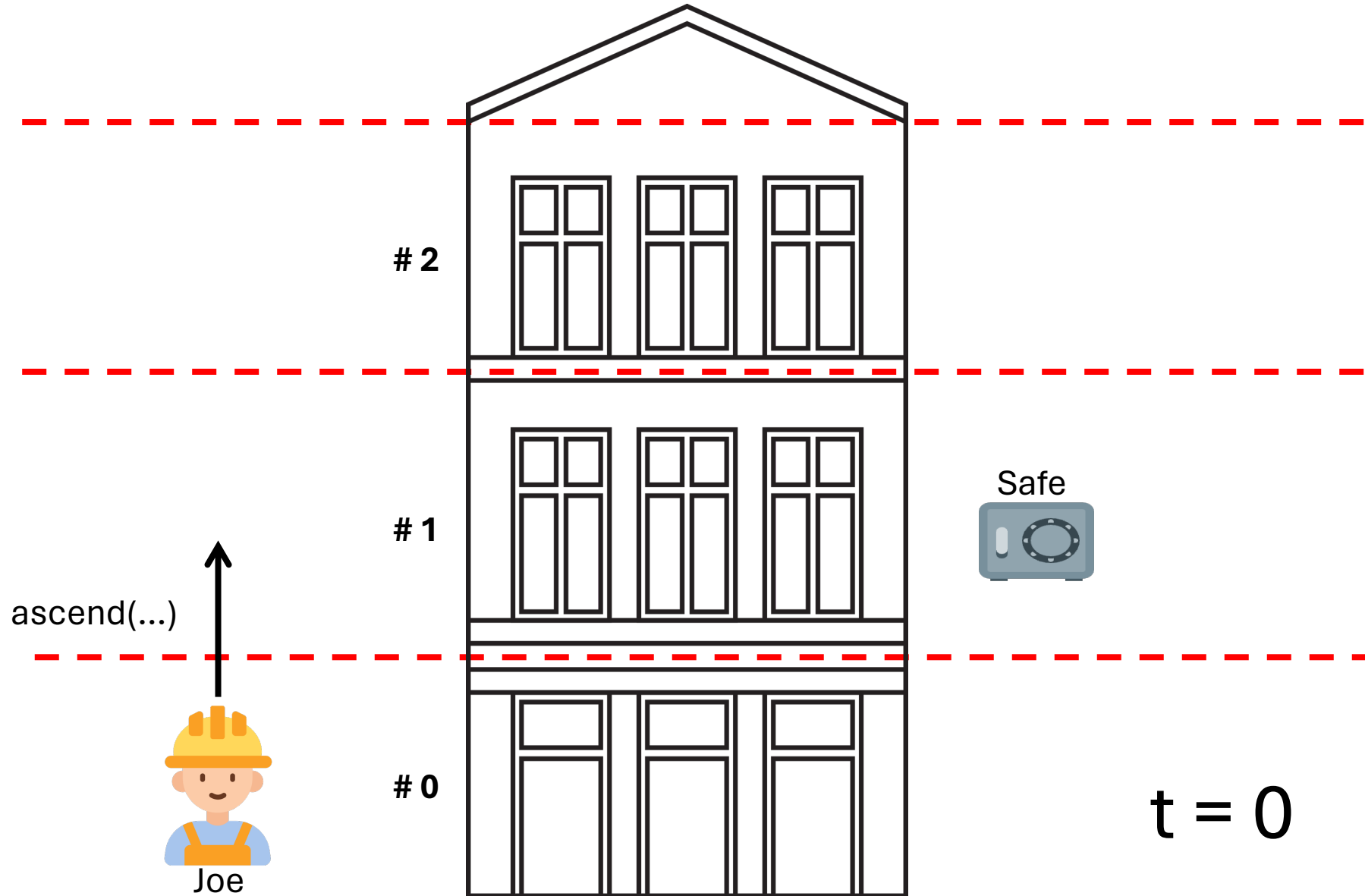
true if mover m_i is carrying furniture f_k at time t , otherwise false

$M = \{ \text{👷}, \text{👷}, \text{👷} \}$

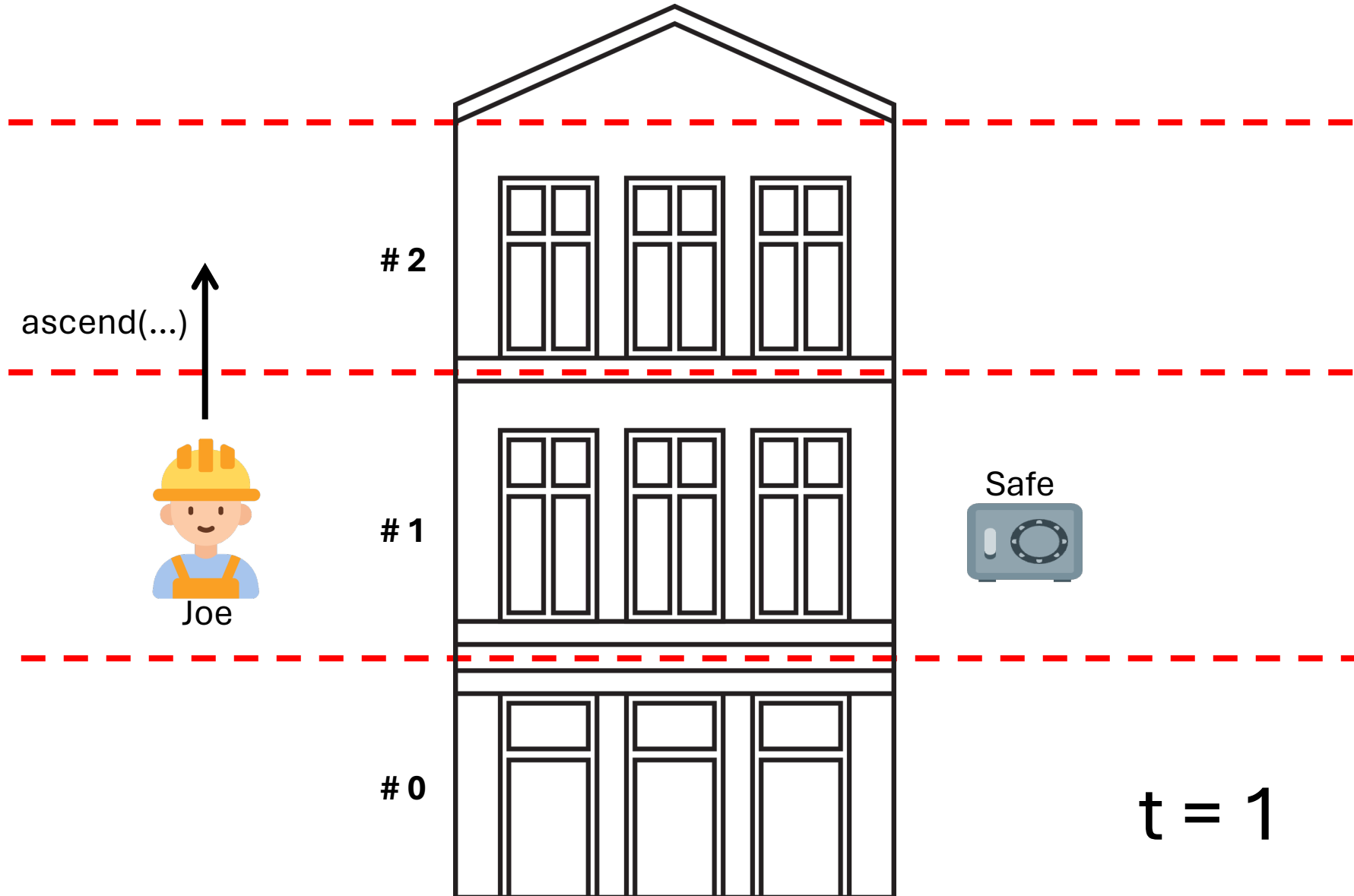
$F = \{ \text{🪑}, \text{🗄️}, \text{📦} \}$



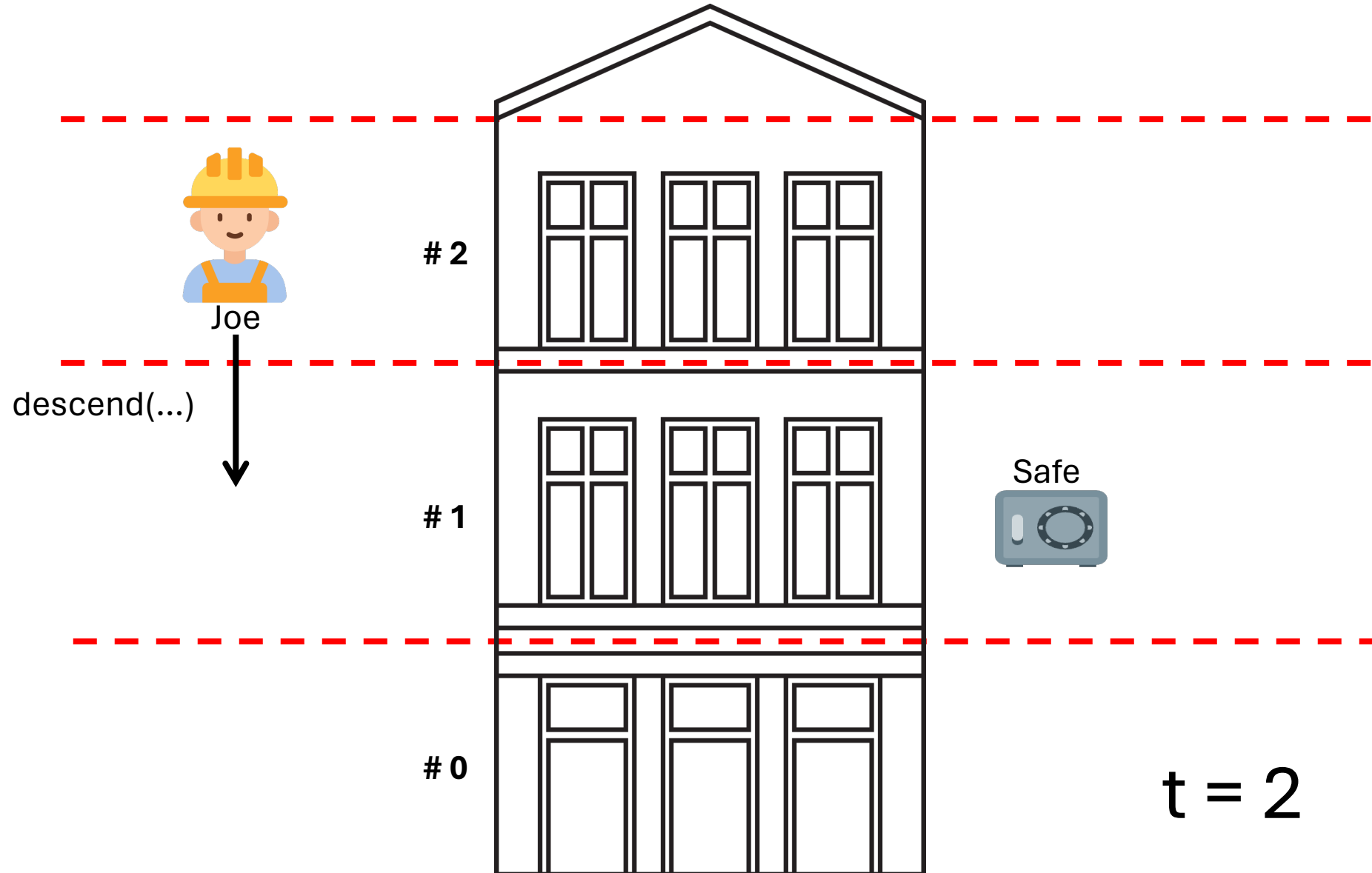
Movers: simulation



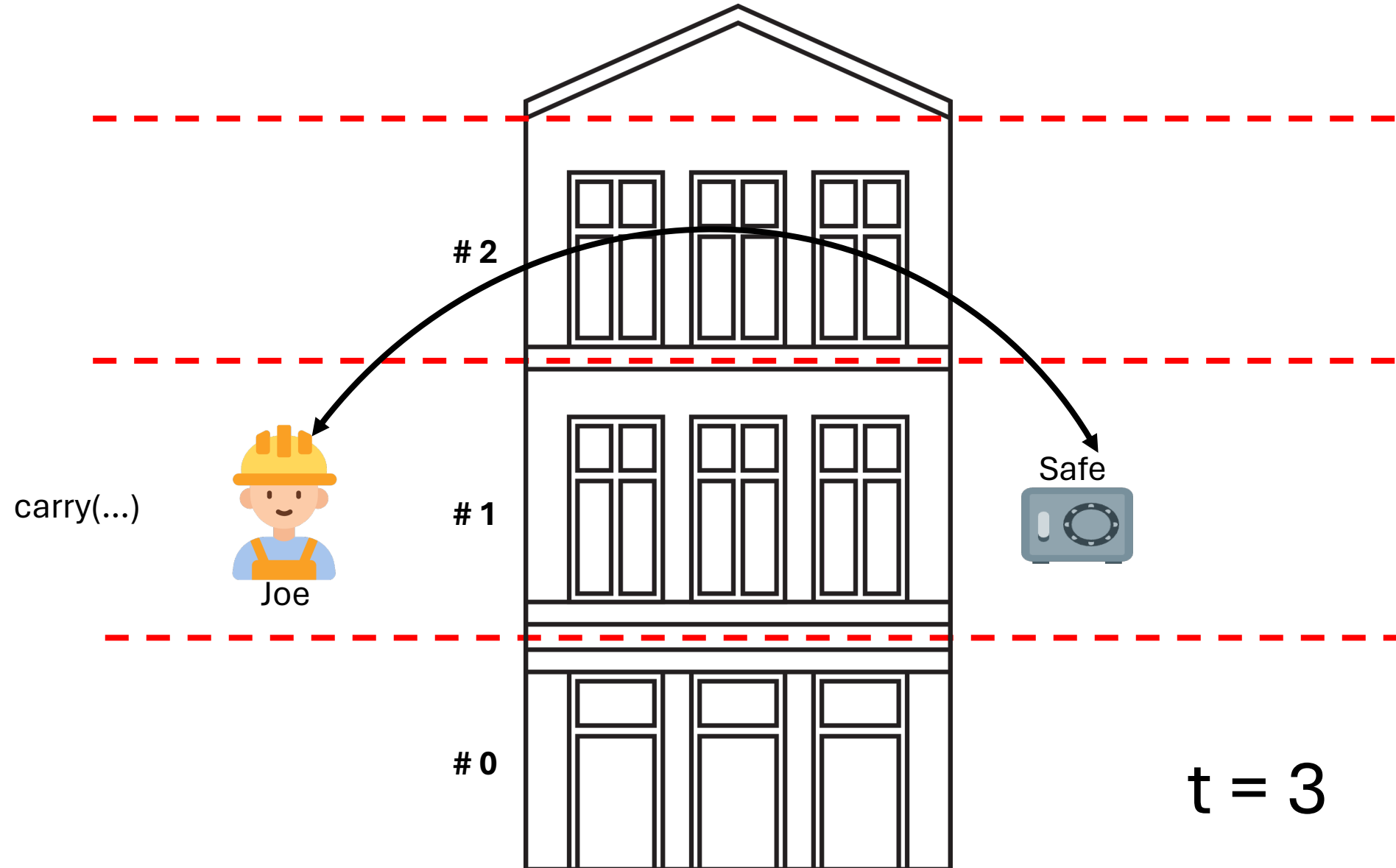
Movers: simulation



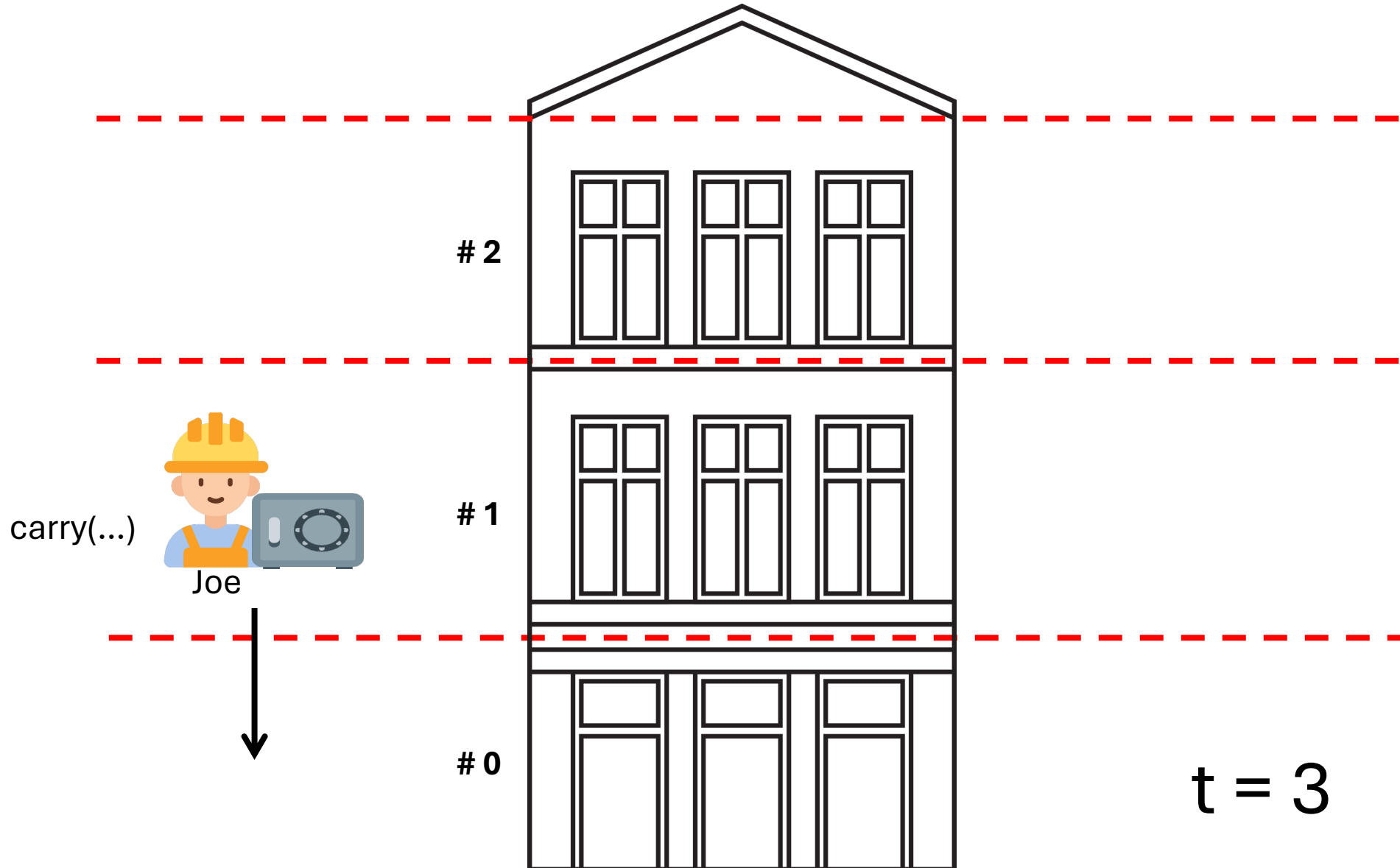
Movers: simulation



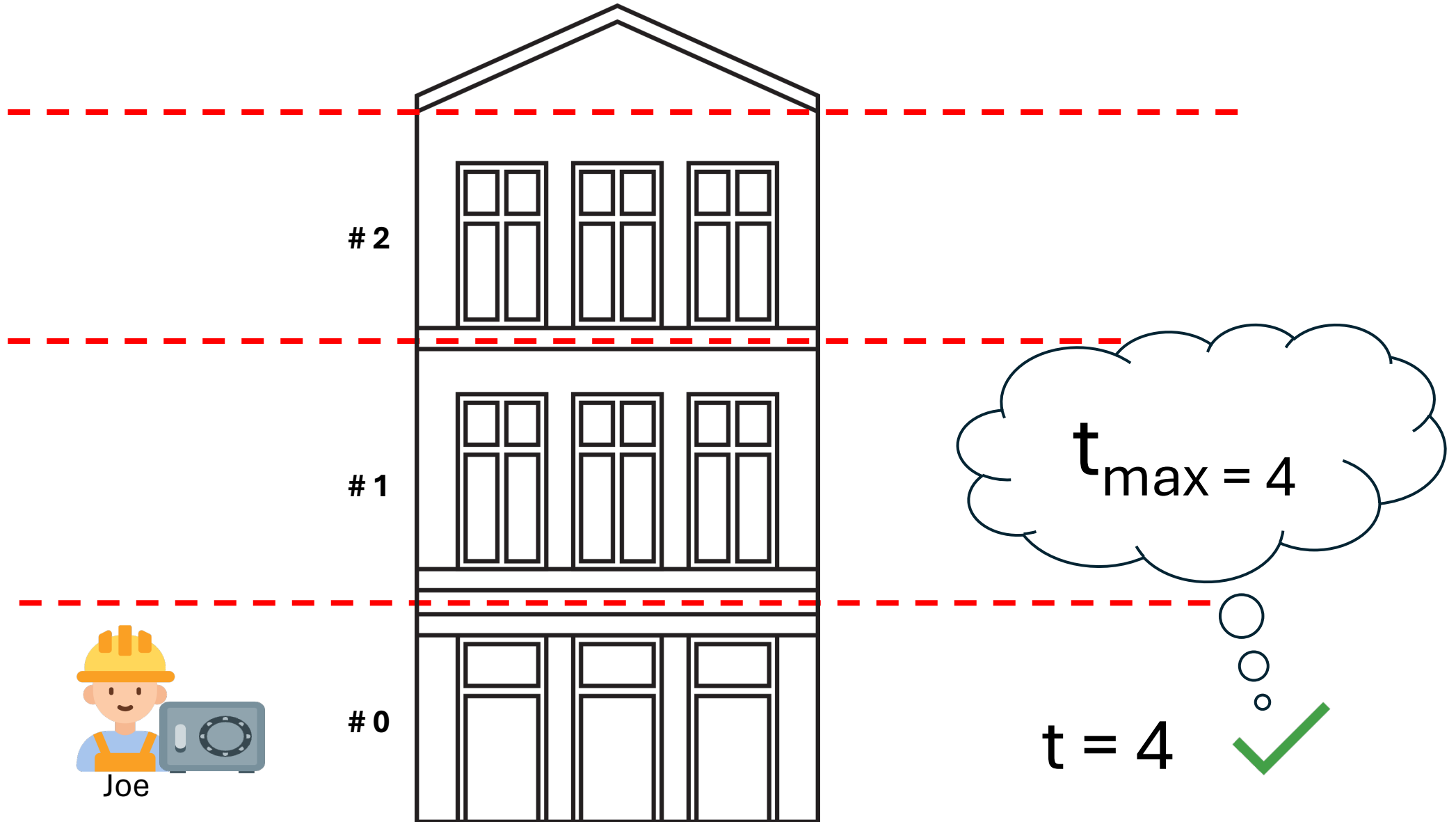
Movers: simulation



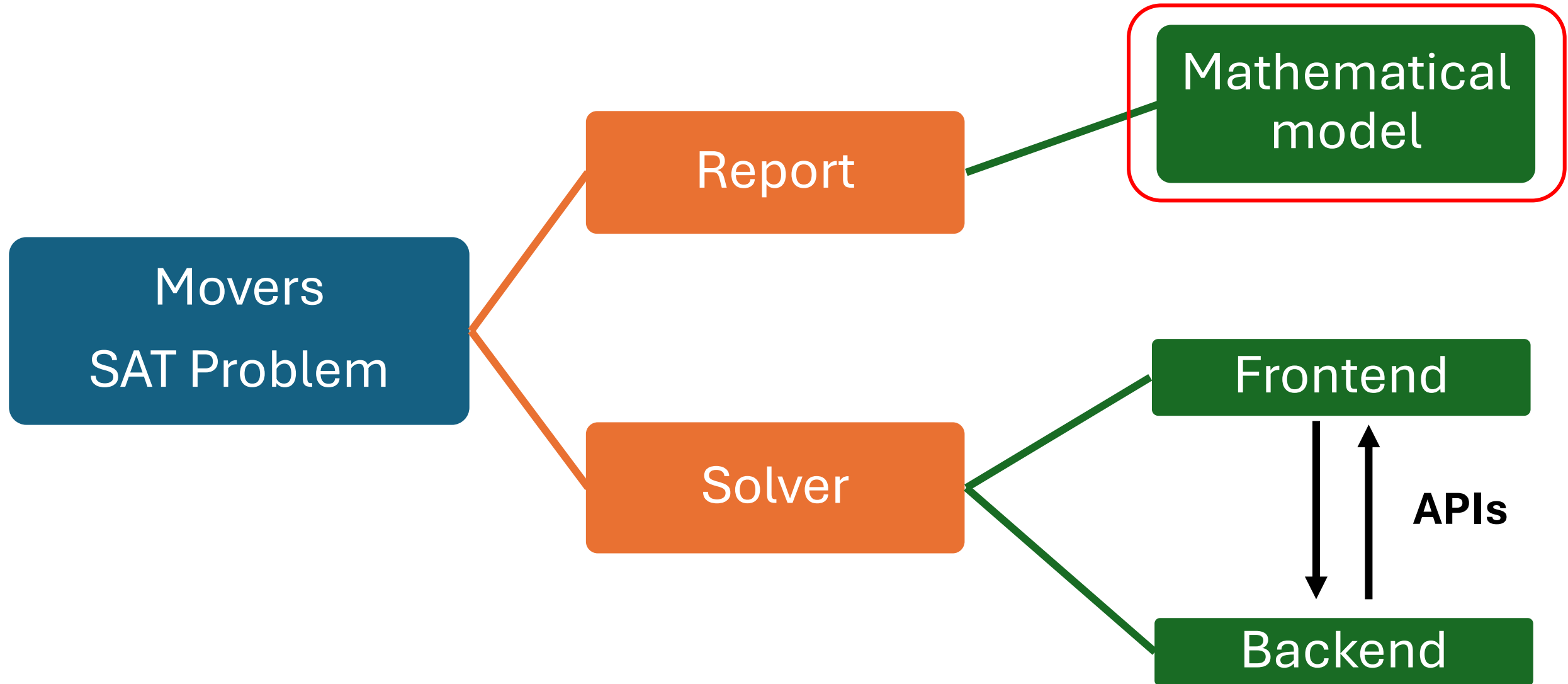
Movers: simulation



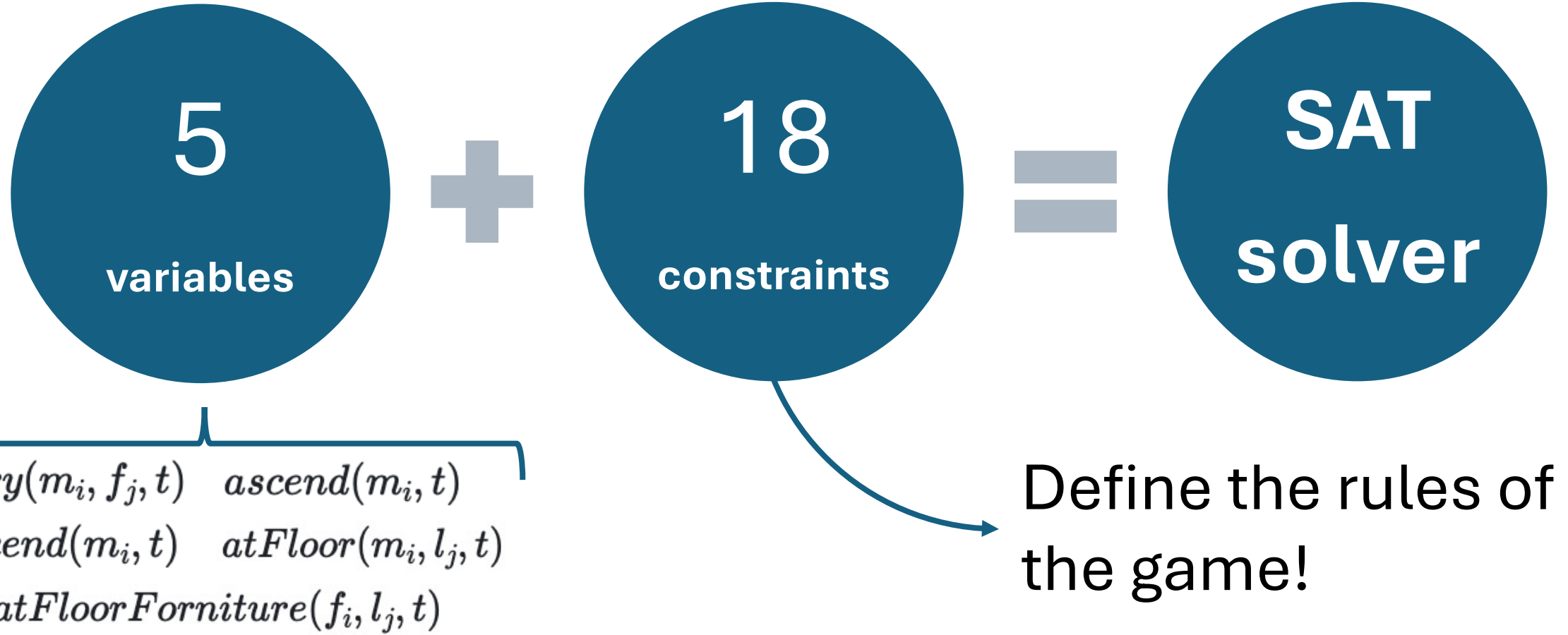
Movers: simulation



How we have solved this problem



Mathematical model



Mathematical model: some constraints

- # 1 • Each mover is at least at one floor

$$\bigvee_{m \in M, l \in L, t \in T} atFloor(m, l, t)$$

- # 2 • A mover cannot be at more than one floor

$$atFloor(m, l_1, t) \implies \neg atFloor(m, l_2, t)$$

$$\forall \text{ mover } m \in M, \text{ floors } l_1 \neq l_2 \in L, \text{ time } t \in T$$

...

Mathematical model: some constraints

3 If a mover is not ascending, descending, or carrying it stays at the same floor

$$atFloor(m, l, t) \wedge \neg ascend(m, t) \wedge \neg descend(m, t) \wedge \bigwedge_{f \in F} \neg carry(m, f, t) \implies atFloor(m, l, t + 1)$$

\forall mover $m \in M$, floor $l \in L$, time $t \in T$

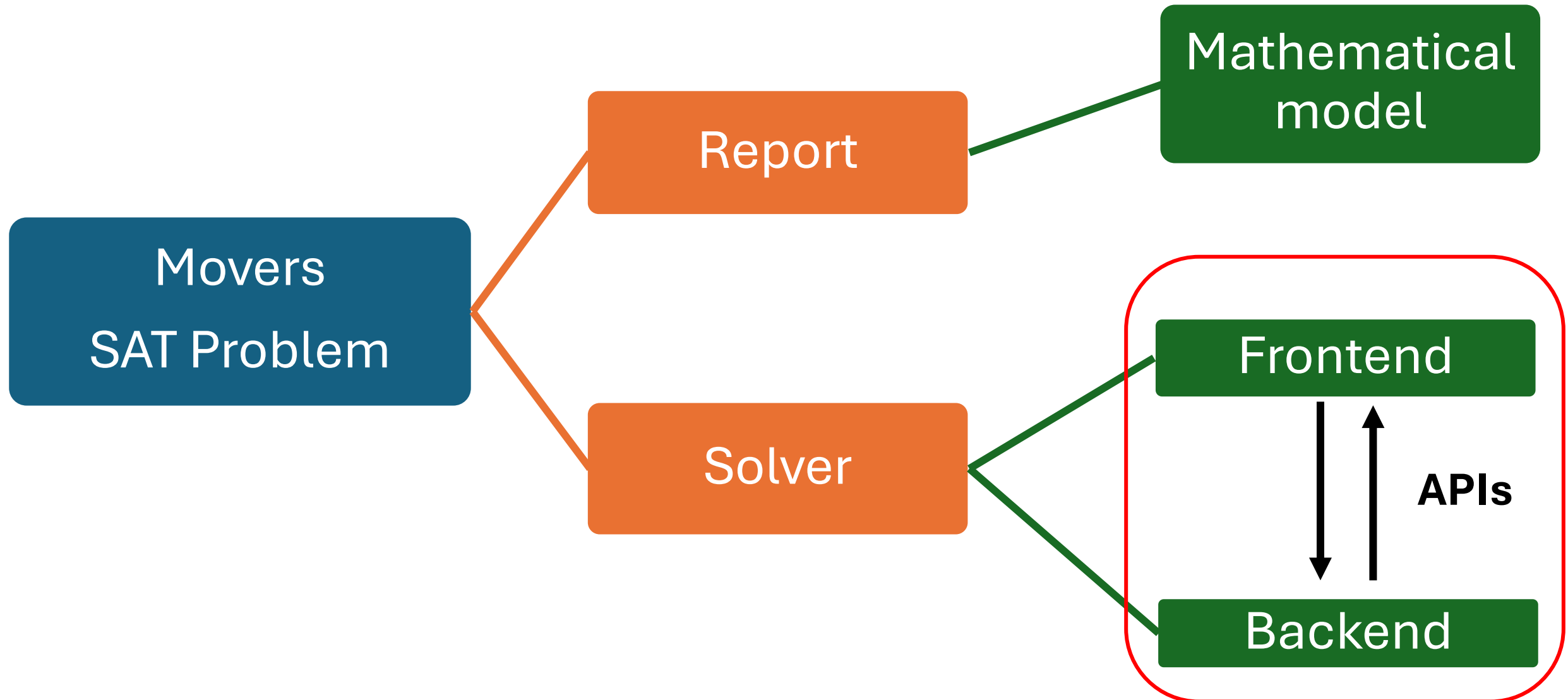
4 If a furniture is not being carried, it stays at the same floor

$$atFloorFurniture(f, l, t) \wedge \bigwedge_{m \in M} \neg carry(m, f, t) \implies atFloorFurniture(f, l, t + 1)$$

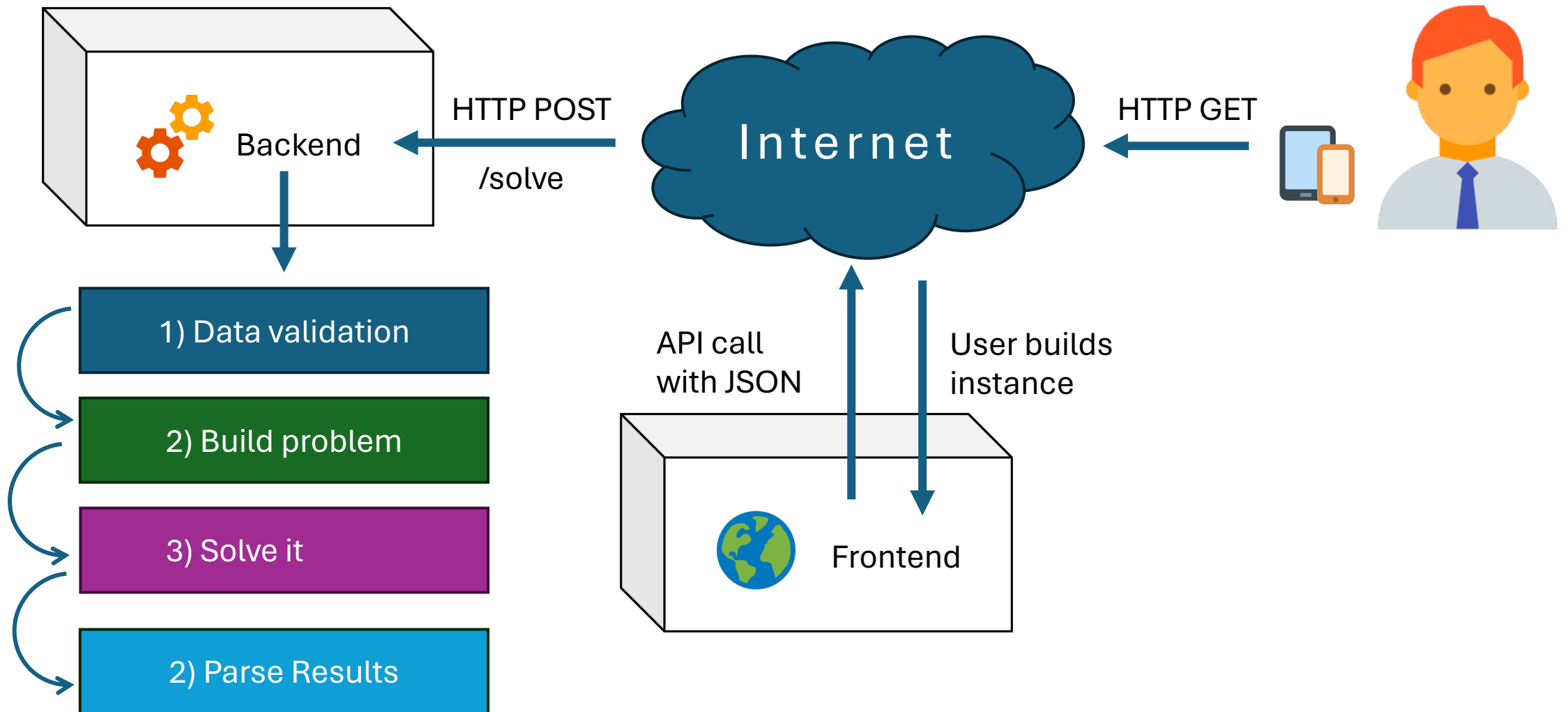
\forall furniture $f \in F$, floor $l \in L$, time $t \in T$

...

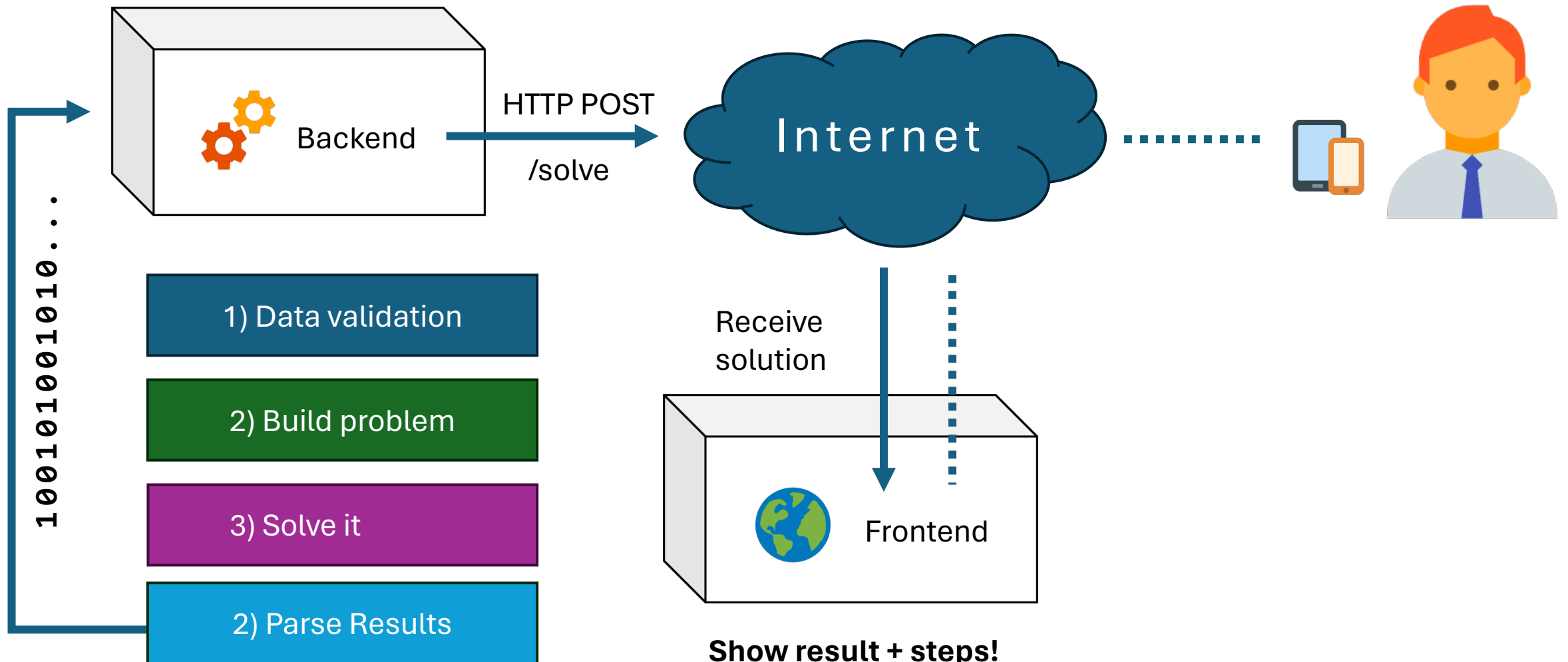
How we have solved this problem



System Design



System Design



Demo: try the solver on your devices!



<https://movers.lucadibello.ch>