Discussion

CS 5/7320
Artificial Intelligence

Solving problems by searching

AIMA Chapter 3

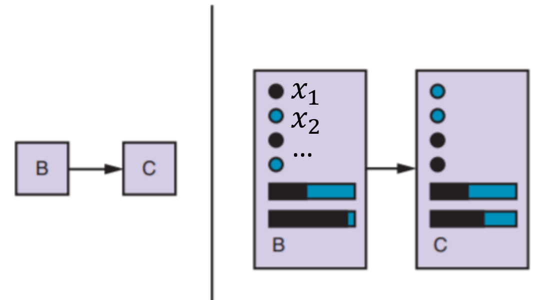
Slides by Michael Hahsler
based on slides by Svetlana Lazepnik
with figures from the AIMA textbook.

State Space for Search

State Space

- Number of different states the agent and environment can be in.
- **Reachable states** are defined by the initial state and the transition model. Not all states may be reachable from the initial state.
- **Search tree** spans the state space. Note that a single state can be represented by several search tree nodes if we have redundant paths.
- State space size is an indication of problem size.

State representation



(a) Atomic (b) Factored

The state consists of variables called fluents that represent conditions that can change over time.

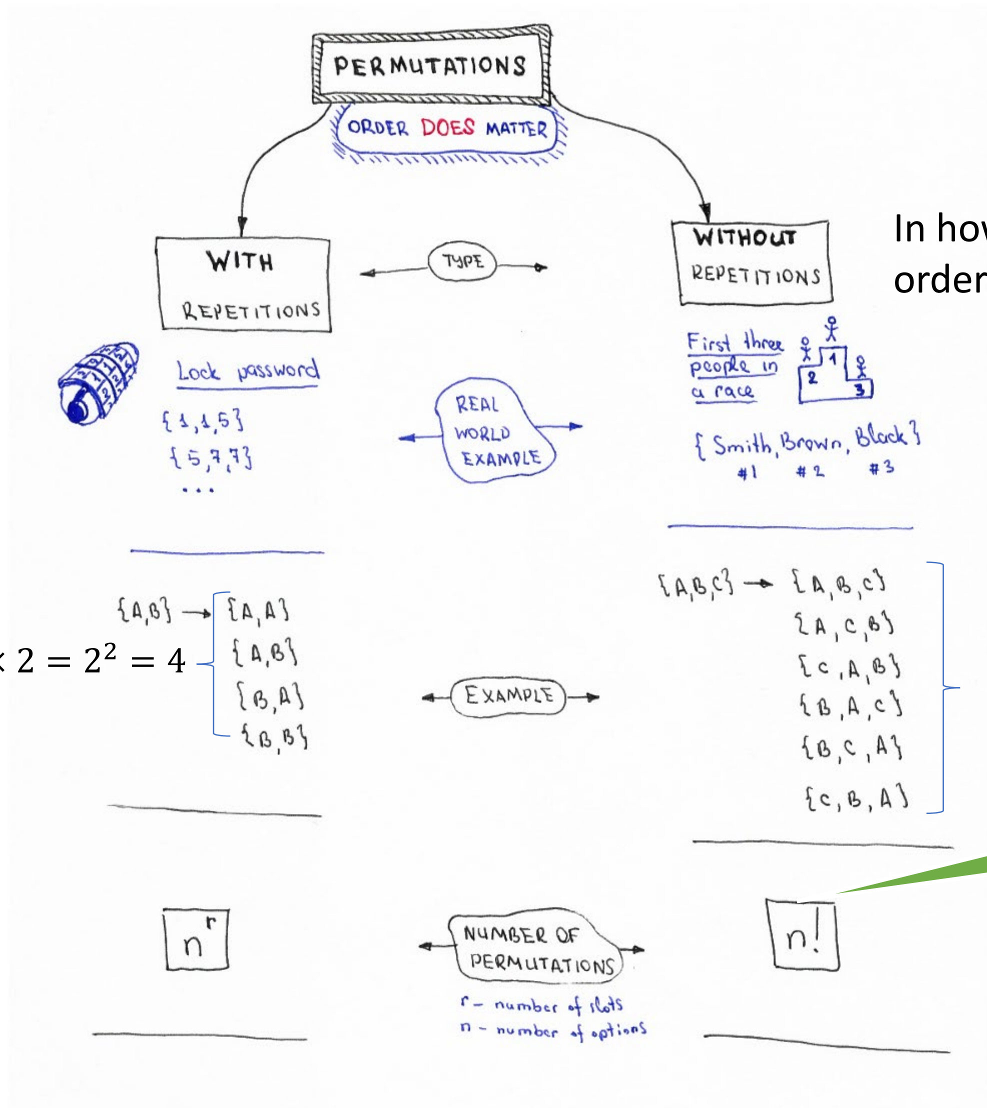
State Space Size Estimation

- Even if the used algorithm represents the state space using atomic states, we may know that internally they have a factored representation that can be used to estimate the problem size.
- The basic rule to calculate (estimate) the state space size for factored state representation with n fluents (variables) is:

$$|x_1| \times |x_2| \times \cdots \times \ |x_n|$$

where $|\cdot|$ is the number of possible values.

In how many ways can we order/arrange n objects?



$2 \times 2 = 2^2 = 4$

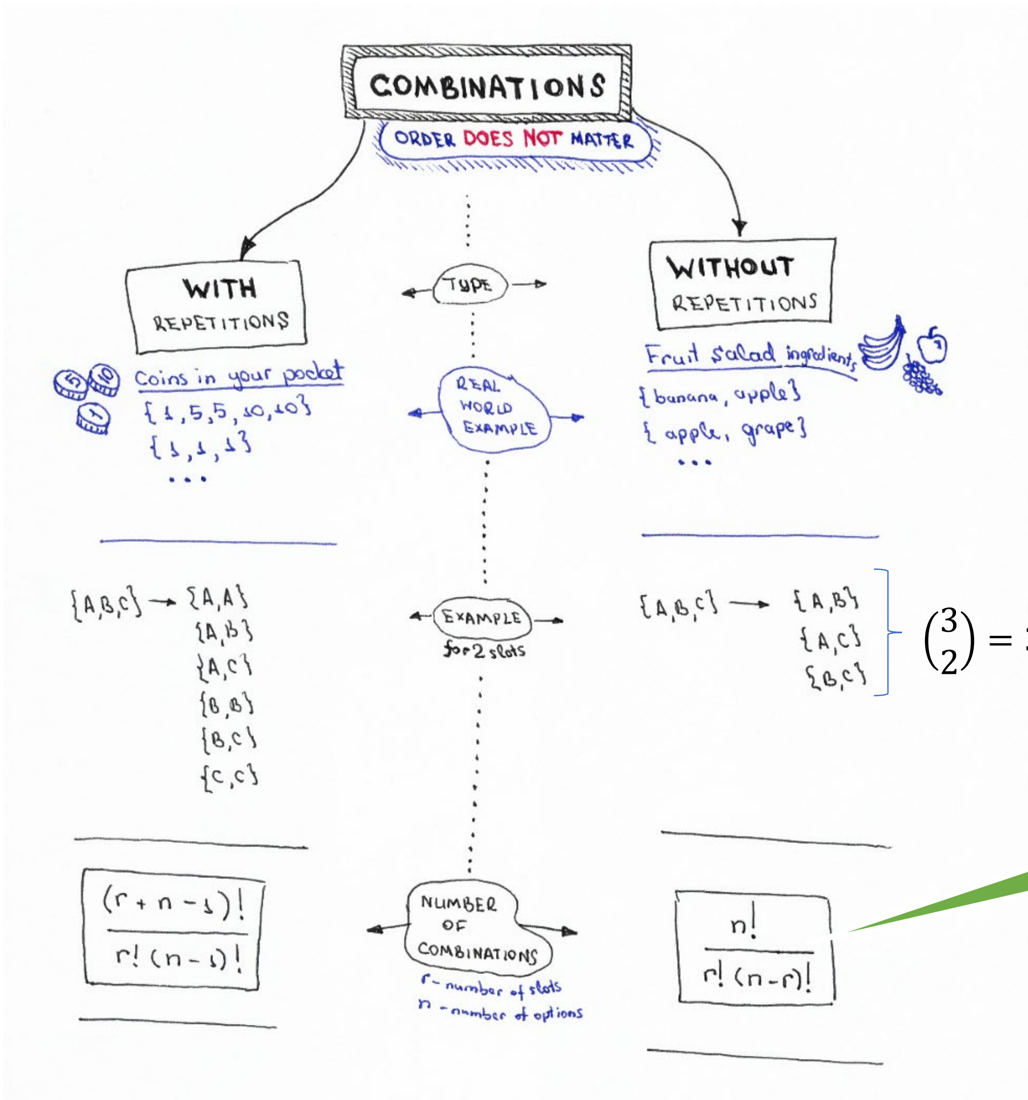
$3 \times 2 \times 1 = 6$

Factorial: $n! = n \times (n-1) \times \cdots \times 2 \times 1$

```
#Python
import math

print (math.factorial(23))
```

Source: Permutations/Combinations Cheat Sheets by Oleksii Trekhleb
https://itnext.io/permutations-combinations-algorithms-cheat-sheet-68c14879aba5



$\binom{3}{2} = 3$

Binomial Coefficient: $\binom{n}{r} = C(n,r) = {}_nC_r$

Read as "n choose r" because it is the number of ways can we choose r out of n objects?

Special case for $r = 2$: $\binom{n}{2} = \frac{n(n-1)}{2}$

```
#Python
import scipy.special

# the two give the same results
scipy.special.binom(10, 5)
scipy.special.comb(10, 5)
```

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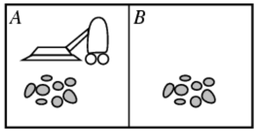
Example: What is the State Space Size?



Dirt

- **Permutation:** A and B are different rooms, order does matter!
- **With repetition:** Dirt can be in both rooms.
- There are 2 options (clean/dirty)

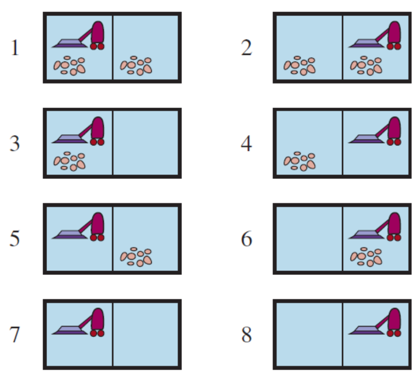
$\rightarrow 2^2$

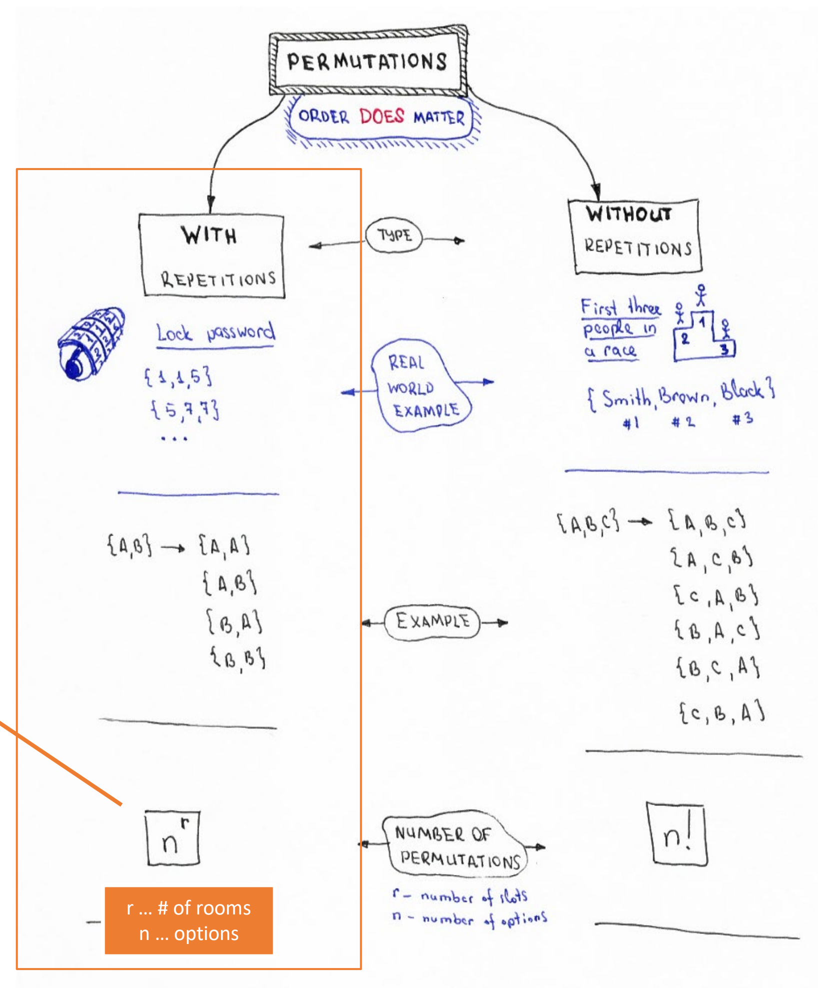
Robot location

- Can be in 1 out of 2 rooms.

$\rightarrow 2$

Total: $n = 2 \times 2^2 = 2^3 = 8$





Assignment

Q&A