LEC 10

CSE 123

Exhaustive Search

Questions during Class?

Raise hand or send here

sli.do #cse123A

BEFORE WE START

Talk to your neighbors:

What's your favorite rainy day activity?

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TAs:	Arohan	Ashar	Neha	Rohini	Rushil
	Ido	Zachary	Sebastian	Joshua	Sean
	Hayden	Caleb	Justin	Heon	Rashad
	Srihari	Benoit	Derek	Chris	Bhaumik
	Kuhu	Kavya	Cynthia	Shreya	Ashley
	Ziao	Kieran	Marcus	Crystal	Eeshani
	Prakshi	Packard	Cora	Dixon	Nichole
	Niyati	Trien	Lawrence	Evan	Cady

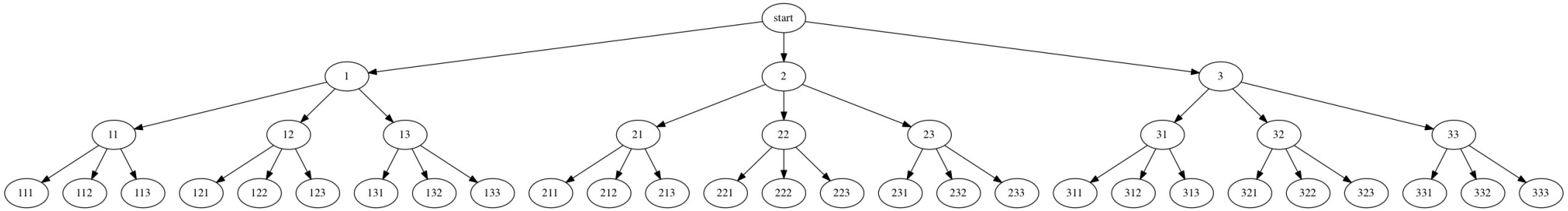
Announcements

- Yay Quiz 1 is done!
  - Again, grades before Quiz 2 but we have makeups to take care of…
  - Quiz 2 is scheduled for May 26, so you have a bit of a break!
- Programming Assignment 1 due tonight (May 7) at 11:59pm
- Creative Project 2 released tomorrow (Thurs, May 8), due in one week (Wed, May 14)
  - Focused on recursion!
- Resubmission Cycle 3 is open, closes on Friday, May 9
  - ***P0***, C1 eligible
- The CSE 12x/14x TA application is now open for Autumn 2025!

Exhaustive Search

- We suppose we want to explore the space of all possible solutions…
- So what do we do?
  - We “exhaustively search” through every possibility
  - We need some sort of plan or process to follow to do this programmatically
- What do we need? Recursion + some kind of accumulator
  - public / private pair

Tracing through printNums

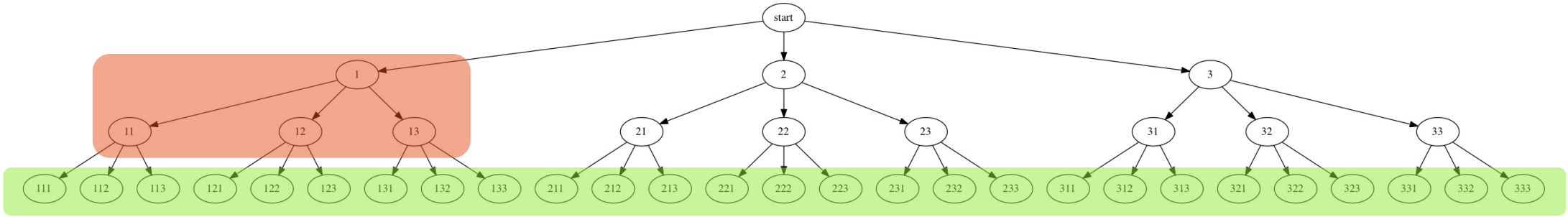



```
public static void printNums() {
    printNums("");
}

private static void printNums(String soFar) {
    if (soFar.length() == 3) {
        System.out.println(soFar);
    } else {
        printNums(soFar+ "1");
        printNums(soFar+ "2");
        printNums(soFar+ "3");
    }
}
```

Decision Trees

- Visual we use to help understand what our process is
  - Visualization tool, not a data structure
  - If you can draw a decision tree, you can implement exhaustive search



- Can glean important information
  - **Base case (end nodes)**
  - **Recursive case (middle nodes)**
  - **“Dead end” case (more on this later…)**

Exhaustive Search Pattern (search)

```
public static void search(input) {
    search(input, "");
}

private static void search(input, String soFar) {
    if (base case) {
        // Do something with soFar (e.g. print it out)
        System.out.println(soFar);
    } else {
        // Might not be a loop, but 1 recursive call for each option
        for (each option) {
            search(input, soFar + option);
        }
    }
}
```

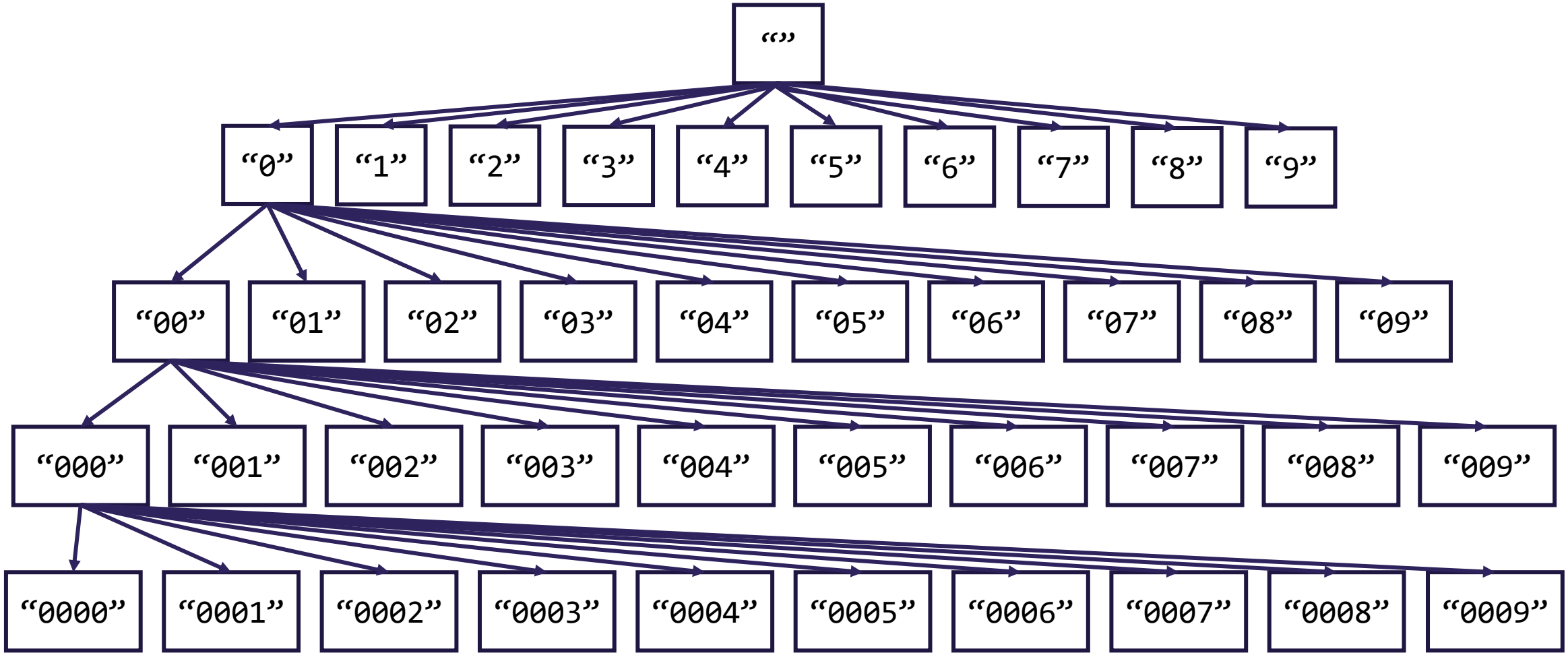
Exhaustive Search Pattern (printNums)

```
public static void printNums() {
    printNums("");
}

private static void printNums(String soFar) {
    if (soFar.length() == 3) {
        // Do something with soFar (e.g. print it out)
        System.out.println(soFar);
    } else {
        // Might not be a loop, but 1 recursive call for each option
        for (int i = 1; i <= 3; i++) {
            printNums(soFar + i);
        }
    }
}
```

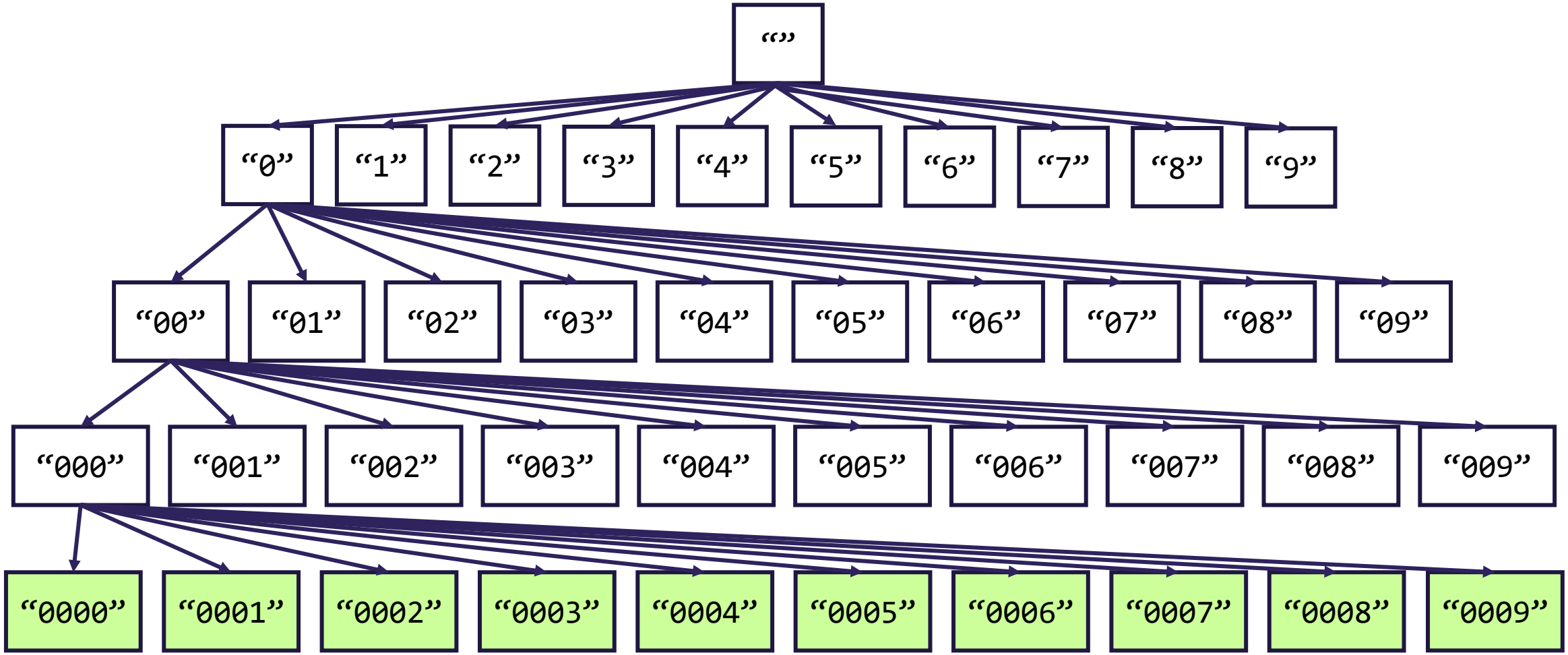
Password Cracker

- Let's say we want to crack the password of a 4 digit combination lock



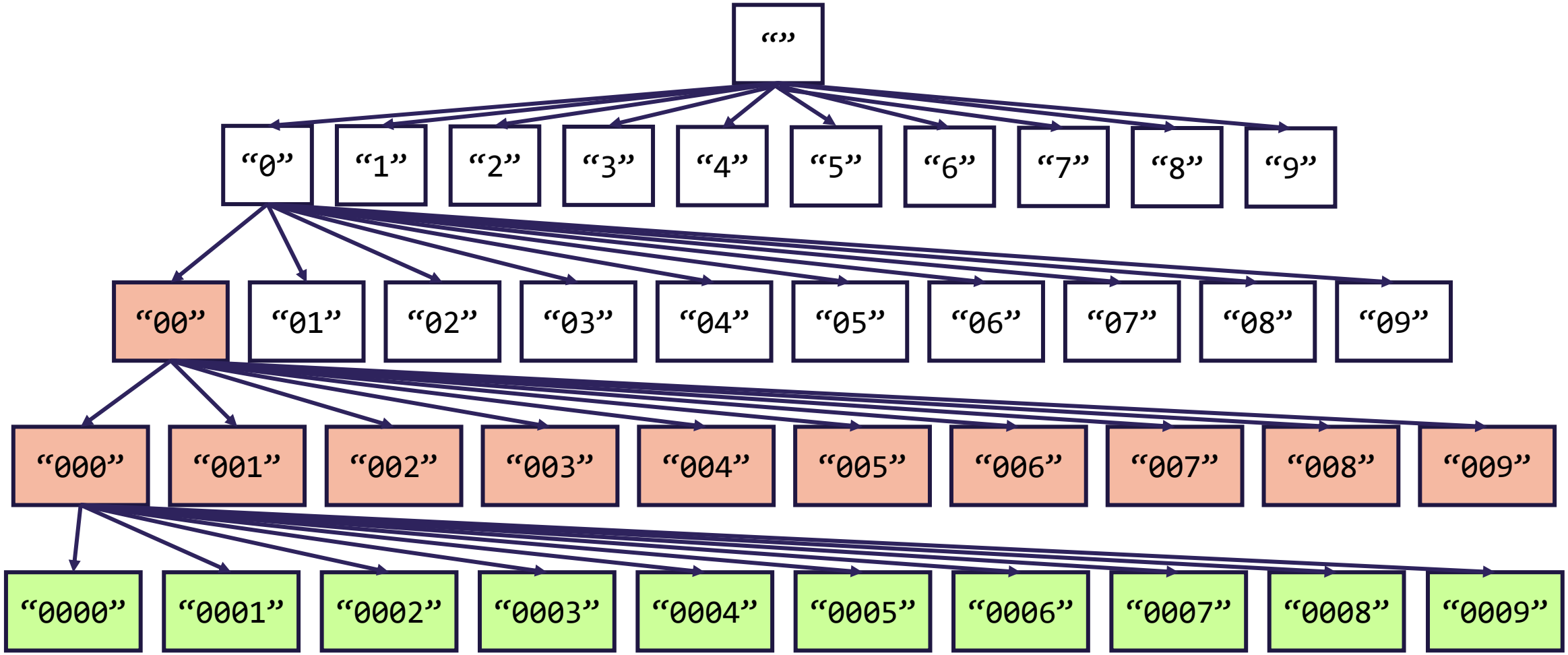
Password Cracker

- Let's say we want to crack the password of a 4 digit combination lock



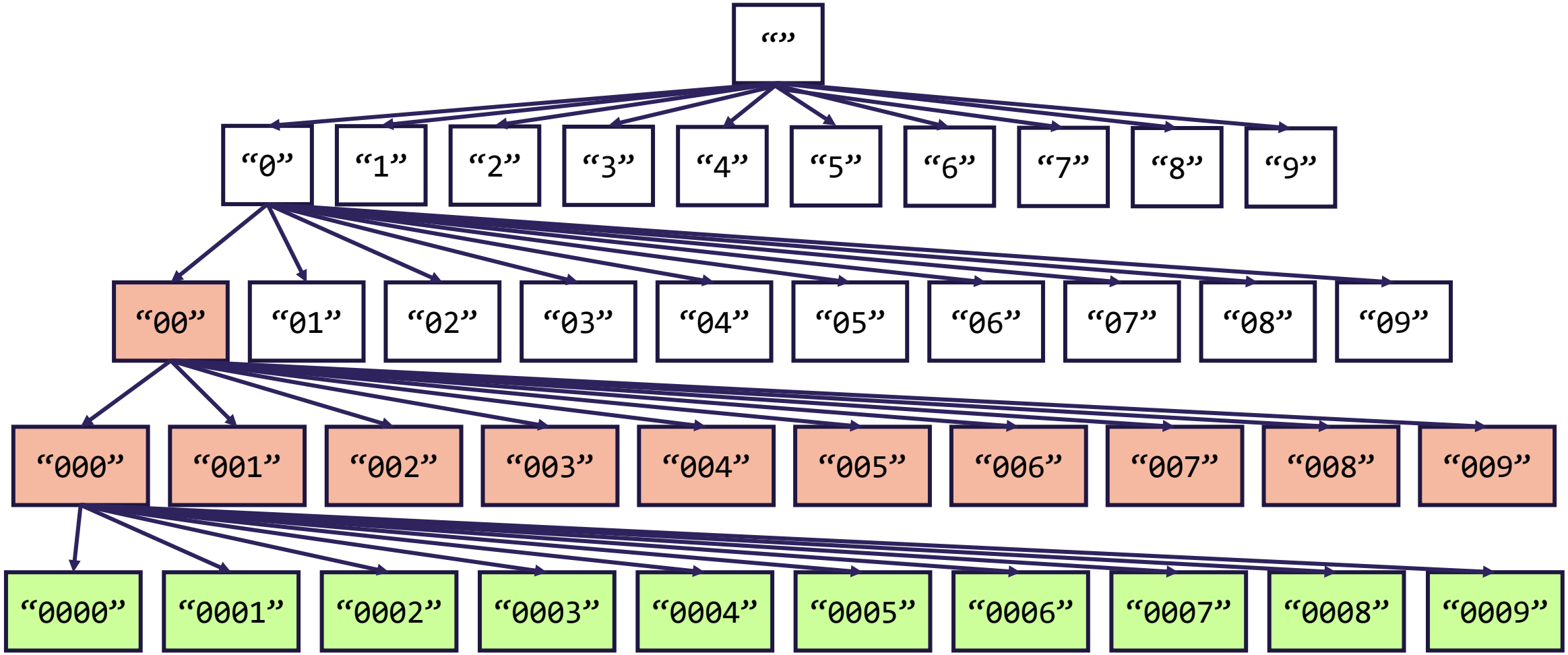
Password Cracker

- Let's say we want to crack the password of a 4 digit combination lock



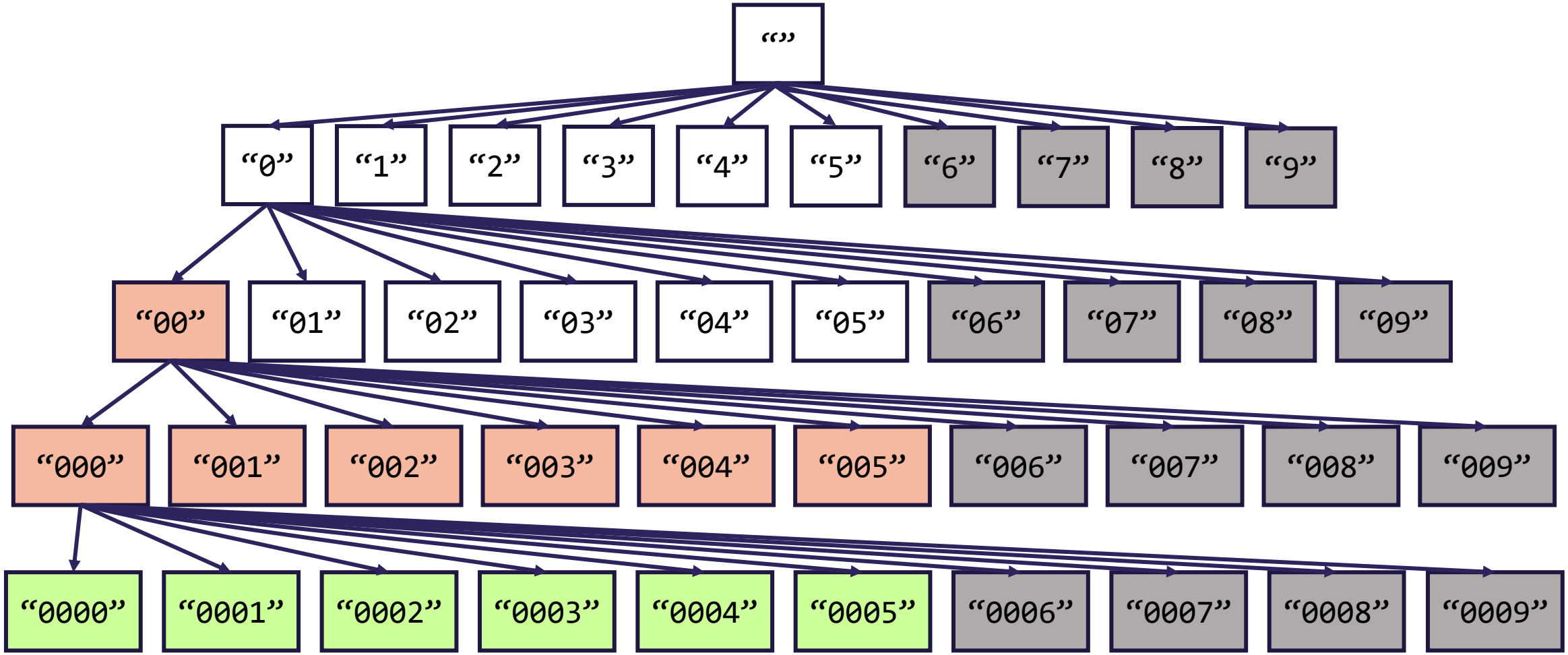
Password Cracker

- Now, what if we knew the sum of all digits was 5?



Password Cracker

- Now, what if we knew the sum of all digits was 5?



Updated Exhaustive Search Pattern

```
public static void search(input) {
    search(input, “”);
}

private static void search(input, String soFar) {
    if (base case) {
        // Do something with soFar (e.g. print it out)
        System.out.println(soFar);
    } else if (not dead end) {
        // Might not be a loop, but 1 recursive call for each option
        for (each option) {
            search(input, soFar + option);
        }
    }
}
```

Sidenote:

- There are some problems computers can solve, but not very cleverly…

- Two "classes" of problems…
  - **P**olynomial
    - Problems with a polynomial-time solution
  - **N**ondeterministic **P**olynomial
    - *Problems that can be solved by a non-deterministic Turing machine in polynomial time…*
    - Problems that we don't think have polynomial-time solutions…
    - Often these solutions are *exponential* time because we are sort of "brute-forcing" a solution…
      - Generative every possible solution and see if it works!

- Open problem: P = NP?