ETH zürich

Übungsstunde W09

Informatik (RW & CBB & Statistik) – HS 23

Übersicht

Heutiges Programm

Follow-up
Feedback zu **code** expert
Ziele
Structs
Rekursion II
Outro

`rwko.ch/lily`

1. Follow-up

Follow-up aus vorherigen Übungsstunden

- Effizienz von "**`read_matrix`**":
  - Die Version mit der vorher initialisierten Matrix sollte im Allgemeinen effizienter sein, da weniger dynamisch allozierter Speicherplatz benötigt wird[1]
  - Es macht erst bei sehr grossen Matrizen wirklich einen Unterschied, ihr müsst euch also (noch) keine Sorgen darüber machen

[1] Ihr werdet gegen Ende des Semesters lernen, was das genau heisst

2. Feedback zu **code** expert

Allgemeines zu **code** expert

Ein paar Vereinfachungen für euren Code[2]

```
if(condition == true){
  // ...
}
```

→

```
if(condition){
  //...
}
```

```
if(condition){
  return true;
} else {
  return false;
}
```

→

```
return condition;
```

in Funktionen, die einen `bool` zurückgeben

[2] Nicht vergessen: Vereinfachungen sind nicht immer besser für die Verständlichkeit

Konkretes zu **code** expert

E7:T1: "Const and reference types"

- Was heisst `const`?
  - Sobald eine **cpp** Variable initialisiert ist, darf ihr Wert nich mehr verändert werden
  - Die Variable darf im Programm benutzt werden ("Lesezugriff")
- Wann wird constness (nicht) respektiert?
  - Default: ist nichts als `const` deklariert, so ist die constness respektiert
  - Sonst: Es darf nicht versucht werden, den Wert einer `const` Variable zu verändern (kein Schreibzugriff)

Fragen/Unklarheiten?

3. Ziele

Ziele

- ☐ Structs definieren und benutzen können
- ☐ Schwierigere Probleme, die Rekursion beinhalten, lösen können

4. Structs

Structs

Ein `struct` ist ein Bündel von Zeugs

- Das können Variablen, Funktionen, weitere structs und viel mehr sein ("Members")
- Typen müssen nicht dieselben sein
- Bieten uns eine Möglichkeit neue "Objekte" zu definieren, z.B. einen eigenen Zahlentypen oder mathematische Objekte wie Geraden, Quadrate, Kreise, etc.
- Wichtig: **;** am Schluss der Definition nicht vergessen

Struktur von `struct`

```
struct Person {
    unsigned int age;
    std::string field;
    std::vector<int> lucky_nums;
};

int main () {
    Person Adel  = {26, "Computer Science", {42, 161}};
    Person Deli  = Adel;
    Person Jules = {25, "Linguistics", {13, 12}};
    Person Lily  = {19, "Computational Science", {9, 19}};
    std::cout << "Adel's " << Adel.age <<
                 " years old" << std::endl;
    return 0;
}
```

Struktur von `struct`

```
struct Person {
    unsigned int age;
    std::string field;
    std::vector<int> lucky_nums;
    void function(std::string str){
        std::cout << str;
    }
};

int main () {
    Person Adel  = {26, "Computer Science", {42, 161}};
    Person Deli  = Adel;
    Person Jules = {25, "Linguistics", {13, 12}};
    Person Lily  = {19, "Computational Science", {9, 19}};
    Lily.function("hello, world!");
    return 0;
}
```

Fragen/Unklarheiten?

Aufgabe "Geometry Exercise"

- Öffnet "Geometry Exercise" auf **code** expert
- Überlegt euch, wie ihr das Problem mit Stift und Papier angehen würdet
- Programmiert eine Lösung (optional in Gruppen)

Lösung zu "Geometry Exercise"

```
// Subtask 1: adding vectors
// POST: returns the sum of a and b
vec sum(const vec& a, const vec& b) {
  // version 1: compact, used for the rest of the example
  return {a.x + b.x, a.y + b.y, a.z + b.z};

  // version 2: longer but maybe easier to understand
  // vec tmp;
  // tmp.x = a.x + b.x;
  // tmp.y = a.y + b.y;
  // tmp.z = a.z + b.z;
  // return tmp;
}
```

Lösung zu "Geometry Exercise"

```
// Subtask 2: defining a line in 3D
struct line {
  vec start;
  vec end;  // INV: start != end
};
// helper function to print a vector
void print_line(const line& l) {
  print_vec(l.start);
  std::cout << " <-> ";
  print_vec(l.end);
}
```

Lösung zu "Geometry Exercise"

```
// Subtask 3: shifting line by a vector
// POST: returns a new line obtained by shifting l
// by v.
line shift_line(const line& l, const vec& v) {
  return {sum(l.start, v), sum(l.end, v)};
}

// Subtask 4: overloading the + operator for vectors
vec operator+(const vec& a, const vec& b) {
    return sum(a, b);
}
```

Lösung zu "Geometry Exercise"

```
// Subtask 5: overloading the + operator for lines
// version 1: use the shift_line function
line operator+(const line& l, const vec& v) {
    return shift_line(l, v);
}

// version 2: make use of the overloaded + operator for vectors
line operator+(const line& l, const vec& v) {
    return {l.start + v, l.end + v};
}
```

Fragen/Unklarheiten?

5. Rekursion II

Aufgabe Power Set

DiskMath Recap

- Ein Potenzmenge ist die Menge aller Teilmengen
- $\mathcal{P}(S) := \{X | X \subseteq S\}$
- Beispiel:
  - Gegeben sei die Menge $A = \{a, b, c\}$
  - Die Potenzmenge ist
    $\mathcal{P}(A) = \{\{\}, \{a\}, \{b\}, \{c\}, \{a, b\}, \{a, c\}, \{b, c\}, \{a, b, c\}\}$

Einführung zu `set.h`

- **`set`** ist eine selbstgebastelter Typ! (ein **`class`**)
- Wie funktioniert er? Seht selbst in `set.h`!

```
template <typename T>
class Set {
    public:
    Set(const Set& other);
    // Creates an empty set
    Set();
    // Creates a new set from a set of elements
    Set(const std::set<T>& elements);
    // Creates a new set from a single element
    Set(T element);
    // ...
};
```

Aufgabe Power Set

- Öffnet "Power Set" auf **code** expert
- Überlegt euch, wie ihr das konzeptionell lösen könnt
- Programmiert eine Lösung
- Tipp: Die Funktionalitäten vom Typ `set` findet ihr im `main.cpp`-file
- Mögliche Leitfragen: Für welche (einfachen) Fälle kennen wir die Lösung immer?
  Gibt es ein Muster, dem die Potenzmengen folgen, wenn ein weiteres Element dazukommt?

Lösung zu "Power Set" (Konzeptionell)

Gegeben: $\{a, b, c, d\}$

```
// set has at least 1 element -> split set into two sets
```

$$\{a\}, \qquad \{b, c, d\}$$

```
// get power set for remaining subset[3]
```

$$\mathcal{P}(\{b, c, d\}) = \{\{\}, \{b\}, \{c\}, \{d\}, \{b, c\}, \dots\}$$

```
// init result with power set of remaining subset
```

$$\texttt{result} \leftarrow \{\{\}, \{b\}, \{c\}, \{d\}, \{b, c\}, \dots\}$$

```
// add first element to every set in the powerset
```

$$\left\{ \begin{matrix} \{\}, \{b\}, \{c\}, \{d\}, \{b, c\}, \dots, \\ \{a\}, \{a, b\}, \{a, c\}, \{a, d\}, \{a, b, c\}, \dots, \end{matrix} \right\}$$

[3] Hier kommt der Vertrauensvorschuss der Rekursion (*Recursive Leap of Faith*) zum Tragen

Lösung zu "Power Set" (Basisfall)

```
SetOfCharSets power_set(const CharSet& set) {
  // base case: empty set
  if (set.size() == 0) {
    return SetOfCharSets(CharSet());
  }
```

Lösung zu "Power Set"

```
// set has at least 1 element -> split set into two sets.
CharSet first_element_subset = CharSet(set.at(0));
CharSet remaining_subset = set - first_element_subset;

// get power set for remaining subset
SetOfCharSets remaining_subset_power_set = power_set(remaining_subset);

// init result with power set of remaining subset
SetOfCharSets result = remaining_subset_power_set;

// add first element to every set in the powerset
for (unsigned int i = 0; i < remaining_subset_power_set.size(); ++i) {
  result.insert(first_element_subset + remaining_subset_power_set.at(i));
}

return result;
```

Fragen/Unklarheiten?

Towers of Hanoi

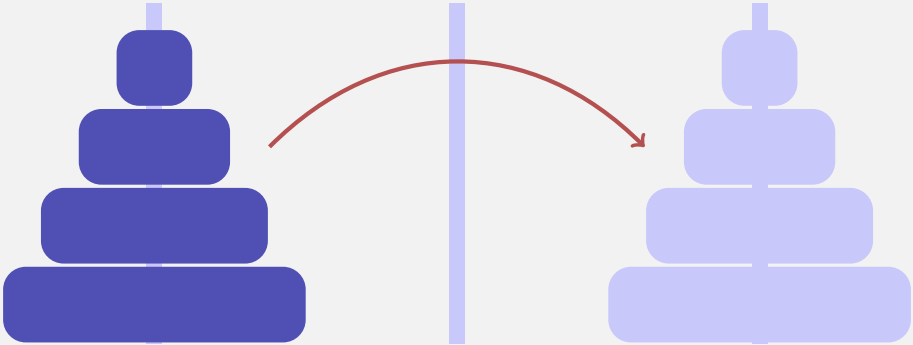
Everyone: it's a game for kids

Programmers:

Experiment: The Towers of Hanoi

left middle right

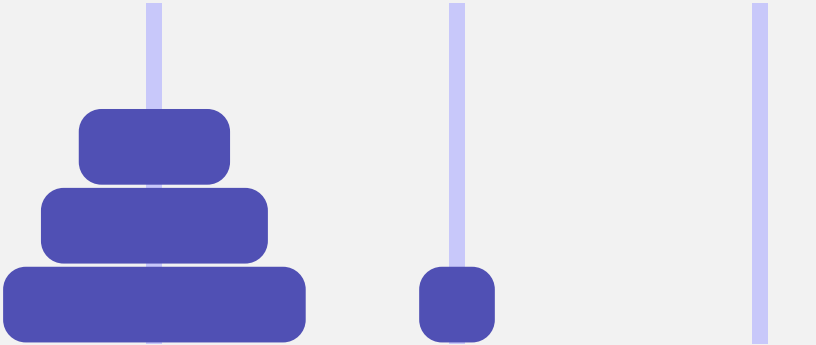
Experiment: The Towers of Hanoi



Die Türme von Hanoi - So gehts!

left middle right

Die Türme von Hanoi - So gehts!



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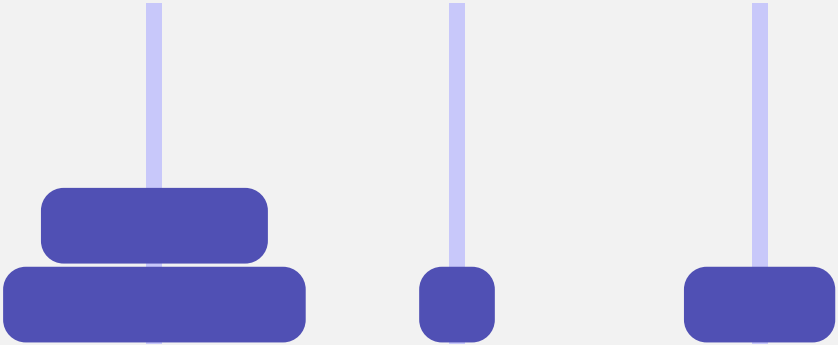

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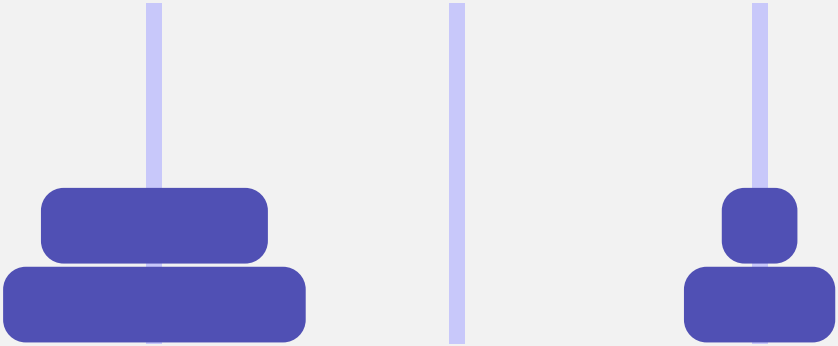

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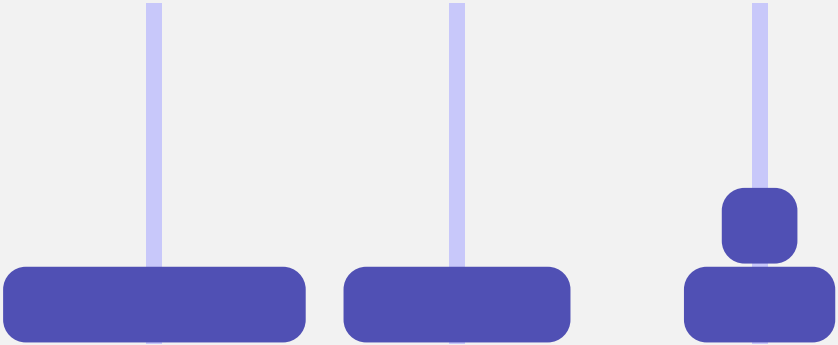

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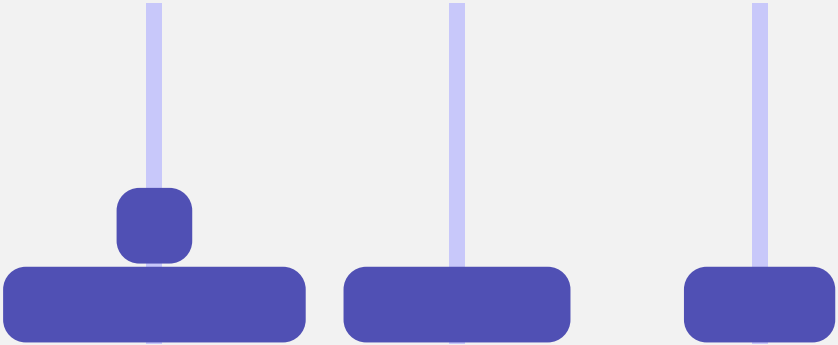

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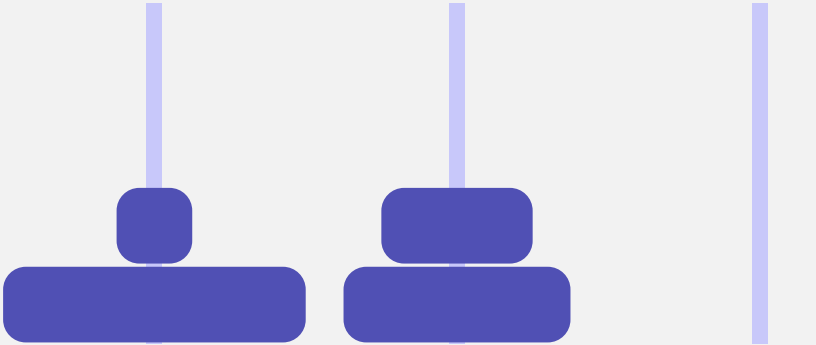

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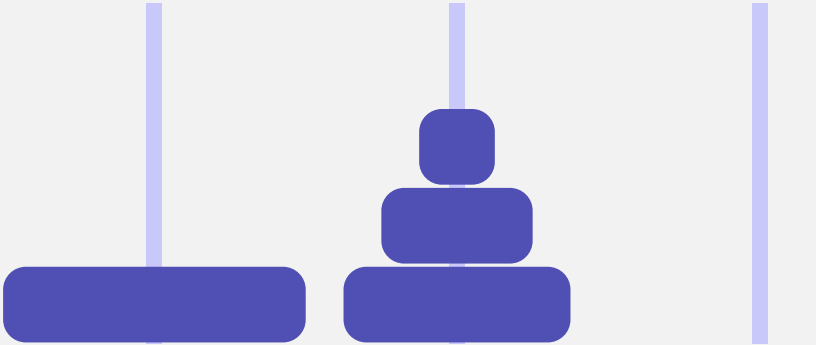

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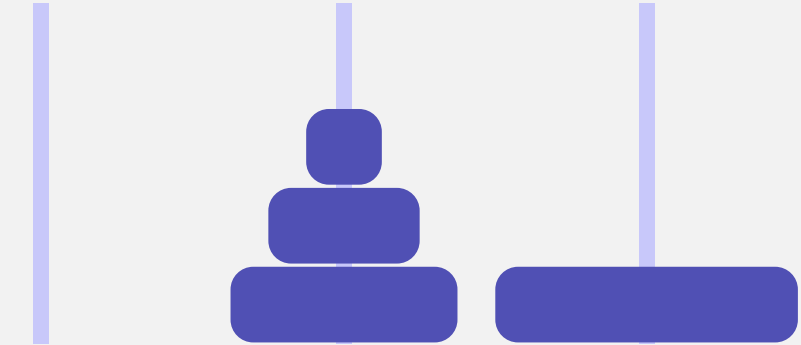

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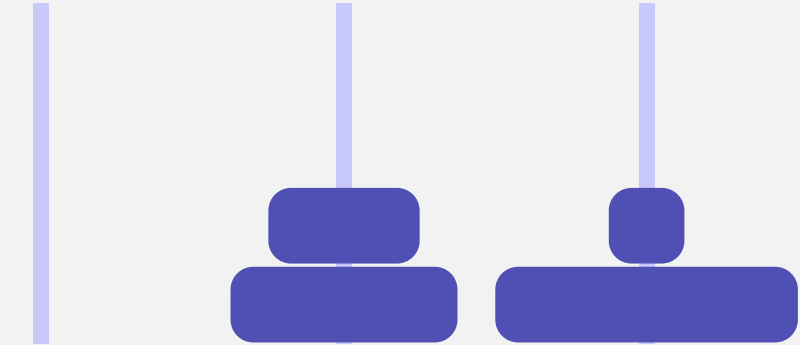

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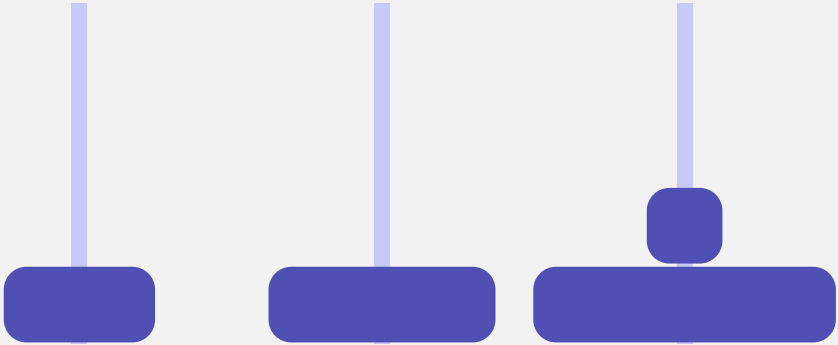

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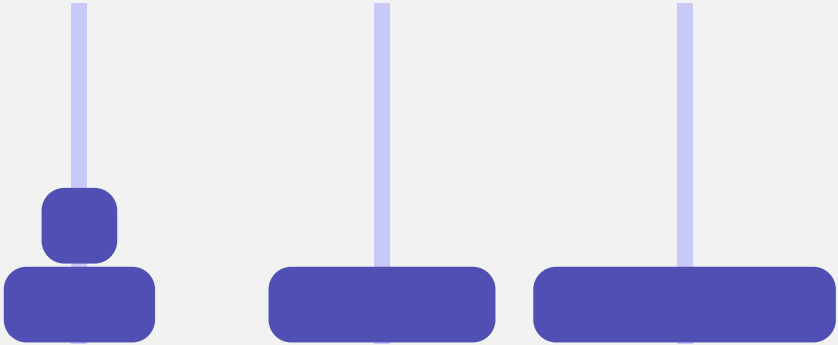

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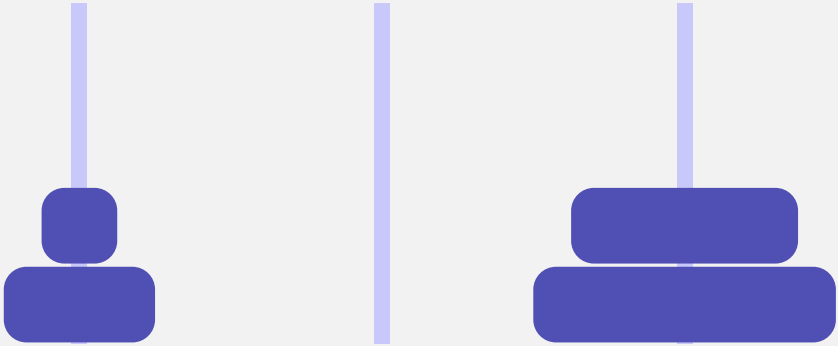

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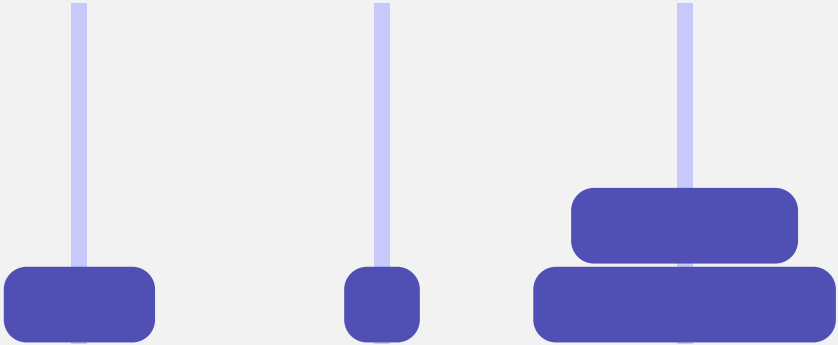

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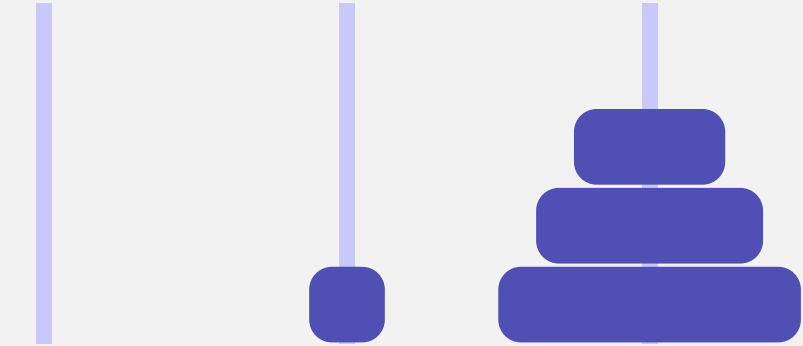

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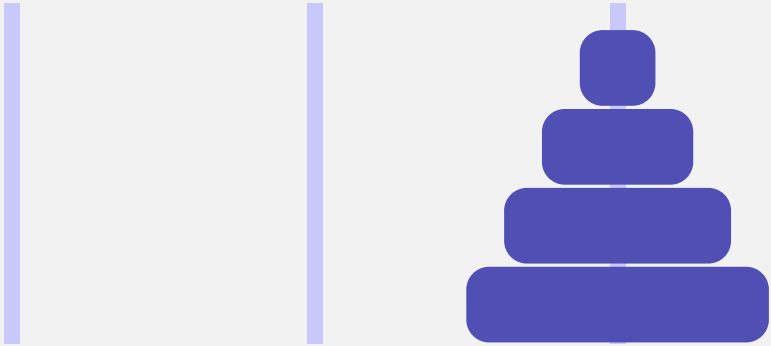


left middle right

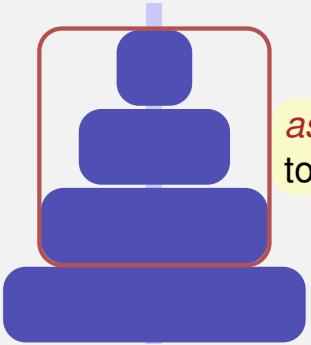
Aufgabe Towers of Hanoi

- Öffnet "Towers of Hanoi" auf **code** expert
- Überlegt euch, wie ihr das Problem mit Stift und Papier angehen würdet
- Programmiert eine Lösung (optional in Gruppen)

The Towers of Hanoi – Recursive Approach

left middle right

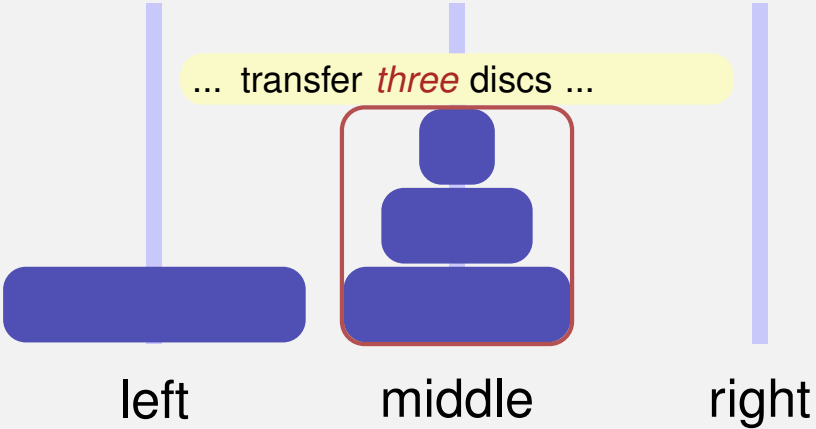
The Towers of Hanoi – Recursive Approach



assume we knew how to ...

left middle right

The Towers of Hanoi – Recursive Approach



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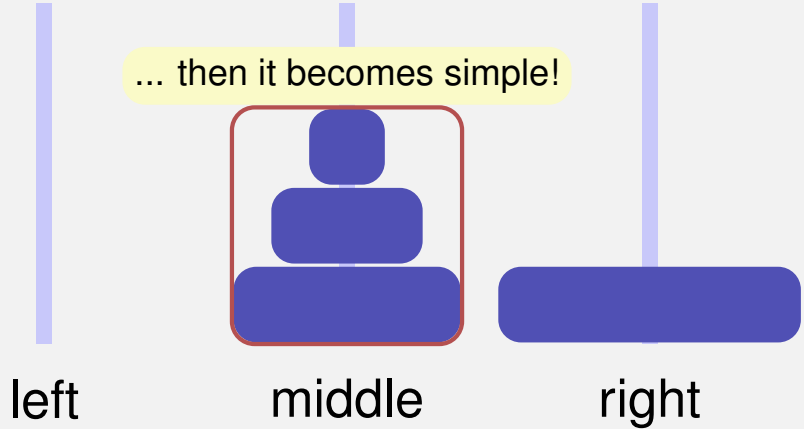

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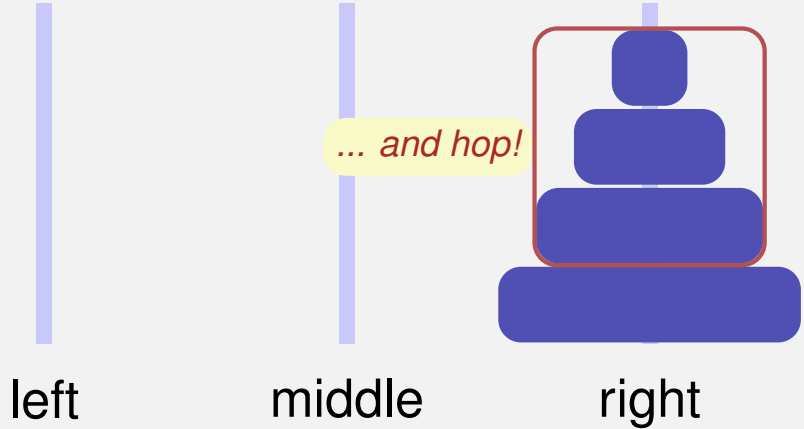
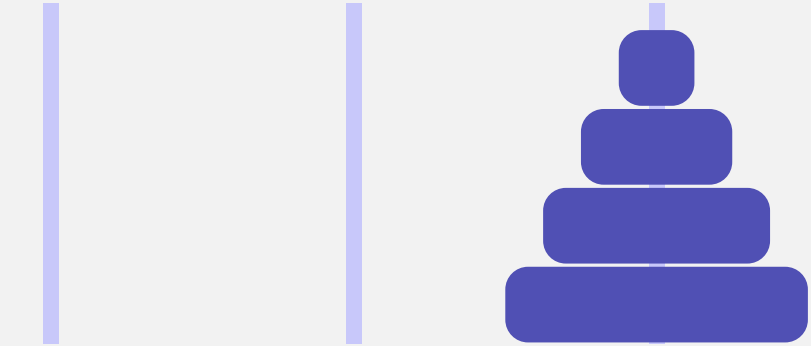
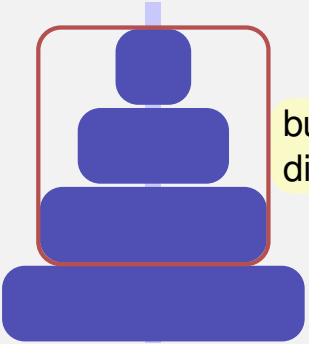


The Towers of Hanoi – Recursive Approach



The Towers of Hanoi – Recursive Approach



but *how* can we move three discs?

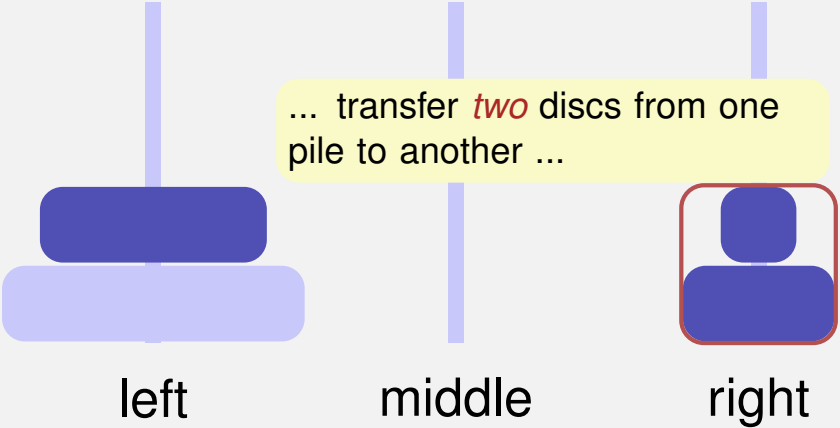
left middle right

The Towers of Hanoi – Recursive Approach

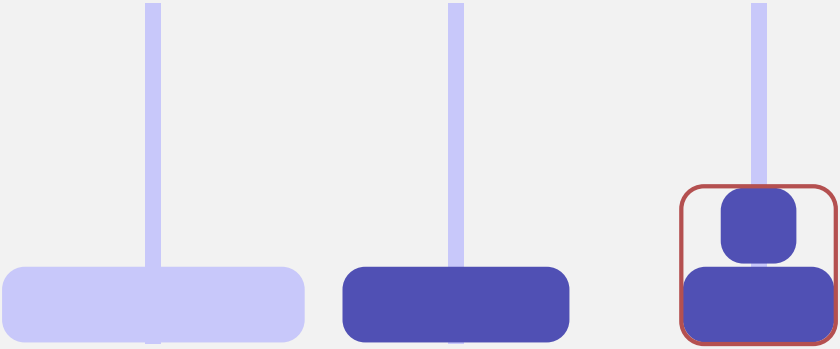
assume we knew how to ...

left middle right

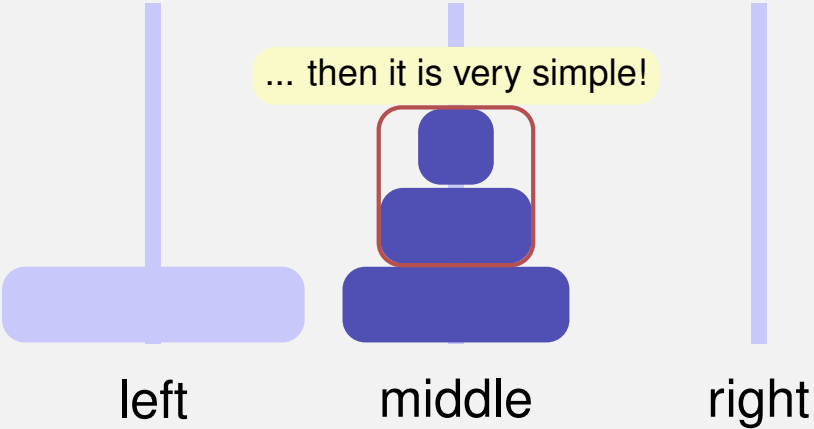
The Towers of Hanoi – Recursive Approach



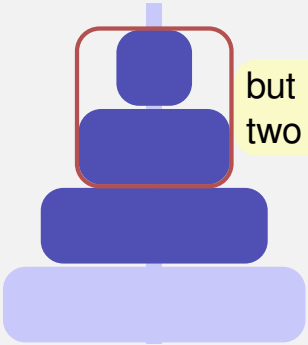
The Towers of Hanoi – Recursive Approach



The Towers of Hanoi – Recursive Approach



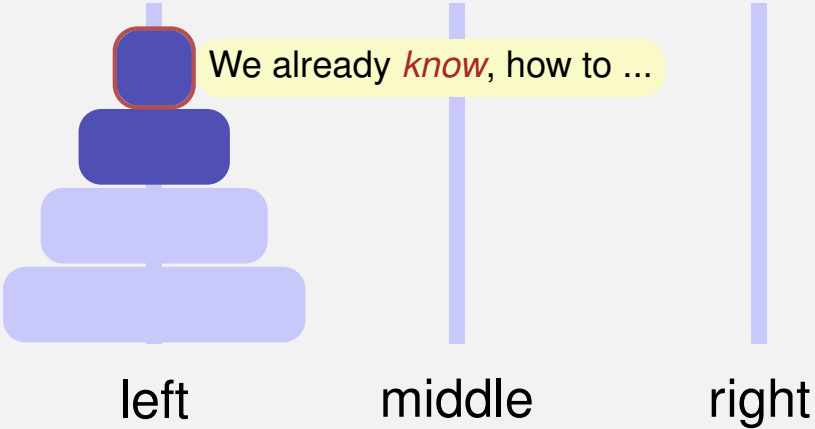
The Towers of Hanoi – Recursive Approach



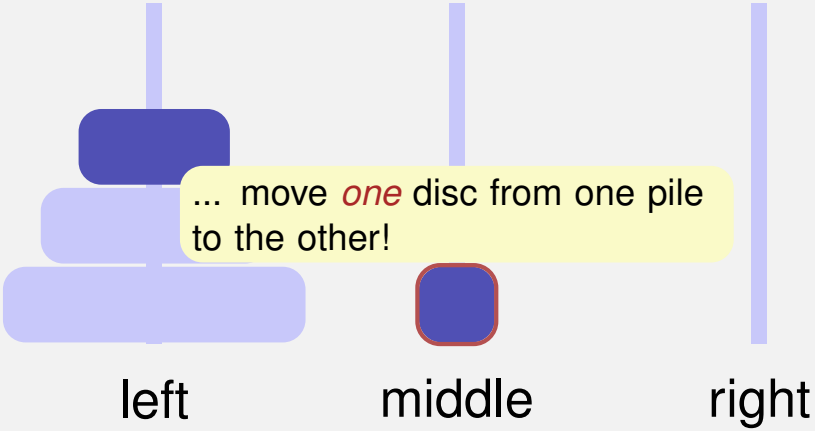
but *how* can we transfer two discs?

left middle right

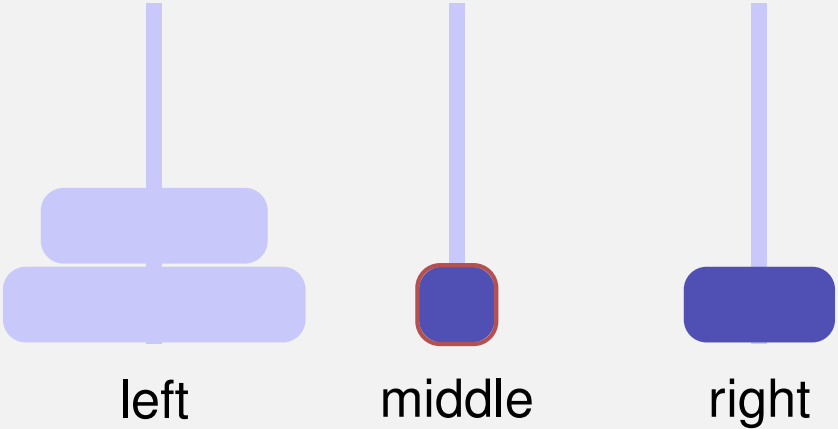
The Towers of Hanoi – Recursive Approach



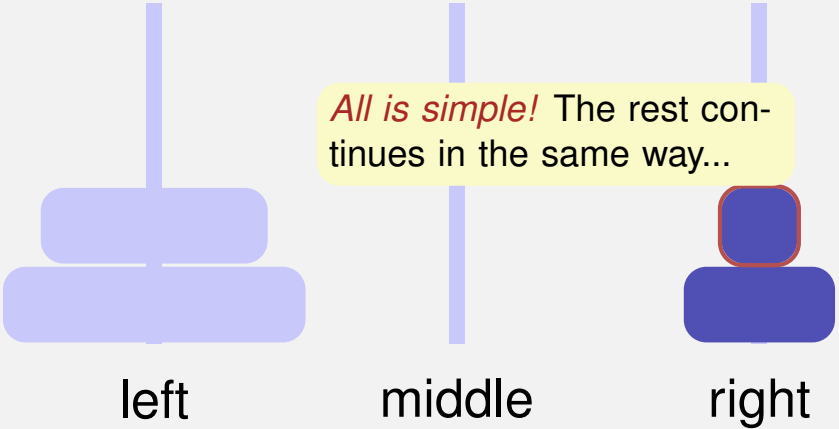
The Towers of Hanoi – Recursive Approach



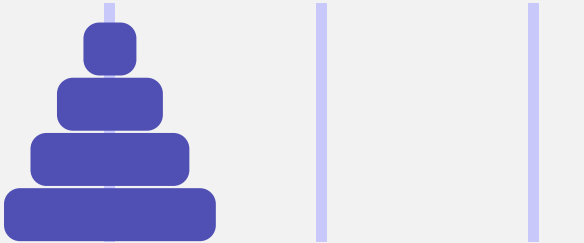
The Towers of Hanoi – Recursive Approach



The Towers of Hanoi – Recursive Approach



The Towers of Hanoi – Code



Move 4 discs from `left` to `right` with auxiliary staple `middle`:

```
move(4,"left","middle","right")
```

The Towers of Hanoi – Code

`move(`n`,` src`,` aux`,` dst`)` $\Rightarrow$

1. Move the top $n-1$ discs from src to aux with auxiliary staple dst:
   `move(`$n-1$`,` src`,` dst`,` aux`);`
2. Move 1 disc from src to dst
   `move(1,` src`,` aux`,` dst`);`
3. Move the top $n-1$ discs from aux to dst with auxiliary staple src:
   `move(`$n-1$`,` aux`,` src`,` dst`);`

The Towers of Hanoi – Code

```
void move(int n, const string &src, const string &aux, const string &dst){
    if (n == 1) {
        // base case (‘move’ the disc)
        std::cout << src << " --> " << dst << std::endl;
    } else {
        // recursive case



    }
}
```

The Towers of Hanoi – Code

```
void move(int n, const string &src, const string &aux, const string &dst){
    if (n == 1) {
        // base case (‘move’ the disc)
        std::cout << src << " --> " << dst << std::endl;
    } else {
        // recursive case
        move(n-1, src, dst, aux);


    }
}
```

The Towers of Hanoi – Code

```
void move(int n, const string &src, const string &aux, const string &dst){
    if (n == 1) {
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```

The Towers of Hanoi – Code

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        move(n-1, src, dst, aux);
        move(1, src, aux, dst);
        move(n-1, aux, src, dst);
    }
}
```

The Towers of Hanoi – Code

```
void move(int n, const string &src, const string &aux, const string &dst){
    if (n == 1) {
        // base case ('move' the disc)
        std::cout << src << " --> " << dst << std::endl;
    } else {
        // recursive case
        move(n-1, src, dst, aux);
        move(1, src, aux, dst);
        move(n-1, aux, src, dst);
    }
}
int main() {
    move(4, "left", "middle", "right");
    return 0;
}
```

The Towers of Hanoi – Code Alternative

```
void move(int n, const string &src, const string &aux, const string &dst){
    // base case
    if (n == 0) return;

    // recursive case
    move(n-1, src, dst, aux);
    std::cout << src << " --> " << dst << "\n";
    move(n-1, aux, src, dst);
}


int main() {
    move(4, "left", "middle", "right");
    return 0;
}
```

Fragen/Unklarheiten?

6. Outro

Allgemeine Fragen?

Bis zum nächsten Mal

Schöne Woche!