Stack and Queue

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Table of Contents

1. Algorithmic Complexity
2. Stack - Last In First Out (LIFO)
   - Stack Functionality
   - Java Stack Implementation
   - Overview of All Operations
3. Queue - First In First Out(FIFO)
   - Queue Functionality
   - Java Stack Implementation
   - Overview of All Operations
4. Priority Queue

Have a Question?

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#java-advanced

Algorithmic Complexity

Algorithmic Complexity

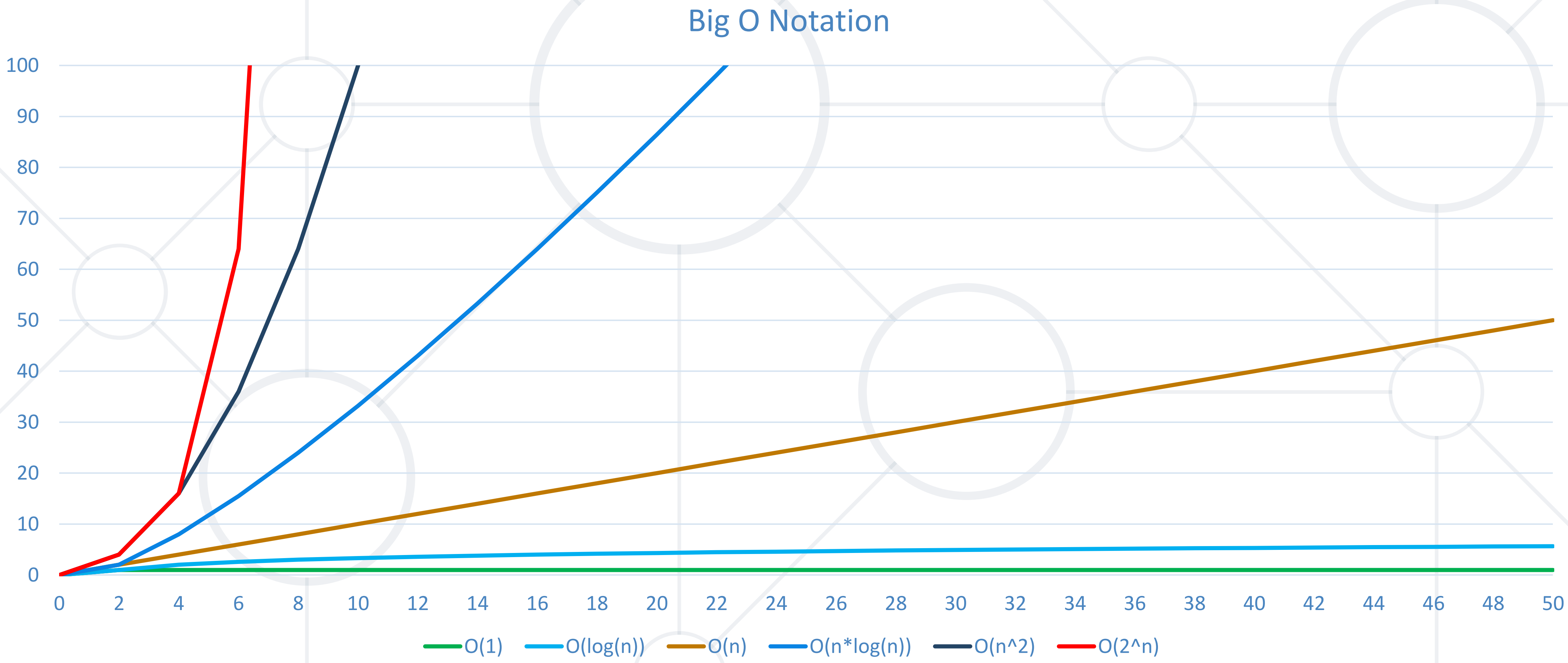
- Describes performance of particular algorithm
  - Runtime and memory consumption based on the input size **N**
  - We usually care about the **worst-case** performance
- We measure the complexity as the **Big O notation**
  - Numerical function depending on the input size **O(N)**
  - We measure time as the number of **simple steps**
  - We measure memory as input data **N** by it's **type size**

Algorithmic Complexity

- O(1) – Constant time – time does not depend on **N**
- O(log(N)) – Logarithmic time – grows with rate as **log(N)**
- O(N) – Linear time grows at the same rate as **N**
- O(N^2),O(N^3) – Quadratic, Cubic grows as square or cube of **N**
- O(2^N) – Exponential grows as **N** becomes the exponent worst algorithmic complexity
  - For input size of 10 - 1024 steps
  - For input size of 100 – 1267650600228229401496703205376 steps
- http://bigocheatsheet.com/

Asymptotic Functions

- Below are some examples of **common algorithmic** grow:



Get Sum Number of Steps

- Calculate maximum steps to find sum of even elements in an array

```
int getSumEven(int[] array) {
  int sum = 0;
  for (int i = 0; i < array.length; i++)
    if (array[i] % 2 == 0) sum += array[i];
  return sum;
}
```

Solution:

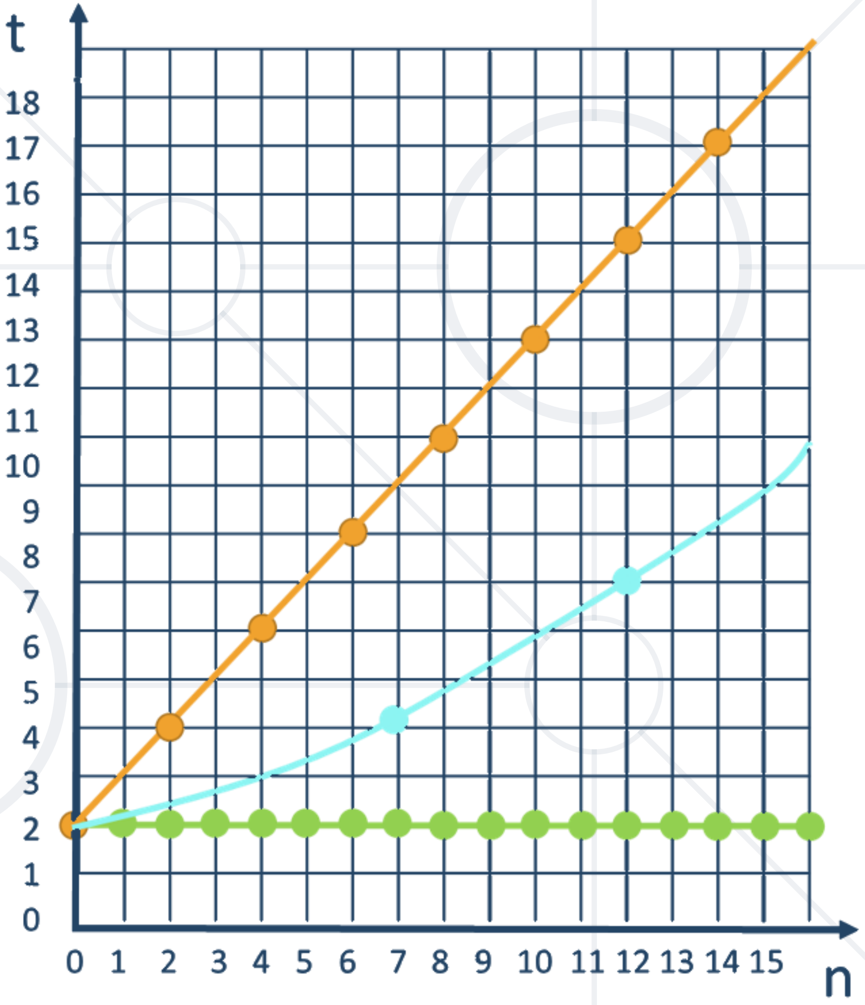
T(n) = 9n + 3

Counting maximum steps is called **worst-case** analysis

- Assume that a **single step** is a single CPU instruction:
  - assignments, array lookups, comparisons, arithmetic operations

Time Complexity

- **Worst-case**
  - An upper bound on the running time
- **Average-case**
  - Average running time
- **Best-case**
  - The lower bound on the running time (the optimal case)



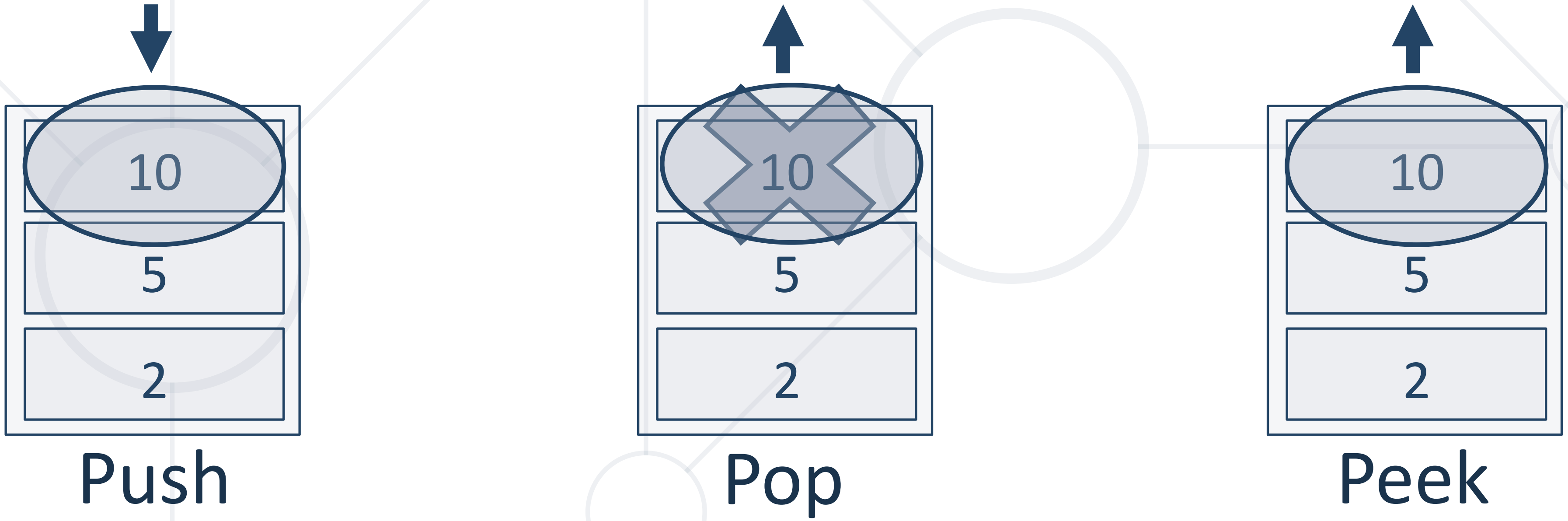
Stacks and Queue vs. ArrayDeque

- Why don't use Stack and Queue?
  - Implementation details which make **unsecure usability**
  - In many cases those structures will **decrease the performance**
- Why to use ArrayDeque?
  - Implementation which makes the structure **more secure**
  - **Better performance** and usability
  - Methods which operate as those structures suggest

Stack

Stack Functionality

- Stacks provide the following functionality:
  - Pushing an element at the top of the stack
  - Popping element from the top of the stack
  - Getting the topmost element without removing it



ArrayDeque<E> – Java Stack Implementation

- Creating a Stack

```
ArrayDeque<Integer> stack = new ArrayDeque<>();
```

- Adding elements at the top of the stack

```
stack.push(element);
```

- Removing elements

```
Integer element = stack.pop();
```

- Getting the value of the topmost element

```
Integer element = stack.peek();
```

Stack – Utility Methods

```
ArrayDeque<Integer> stack = new ArrayDeque<>();

int size = stack.size();
boolean isEmpty = stack.isEmpty();
boolean exists = stack.contains(2);
```

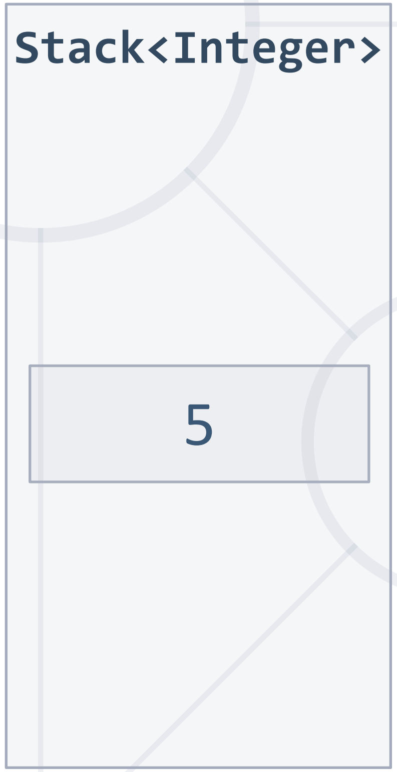
Stack – Overview of All Operations

132

`push()`

`pop()`

`peek()`



Stack<Integer>

5

`size():` 5

Problem: Browser History

- Write a program which takes 2 types of **browser instructions**:
  - Normal navigation: a **URL** is set, given by a string
  - The string **"back"** that sets the current URL to the last set URL

Input

```
https//softuni.bg/
back
https//softuni.bg/trainings/courses
back
https//softuni.bg/trainings/2056
back
https//softuni.bg/trainings/live
https//softuni.bg/trainings/live/details
Home
```

Output

```
https//softuni.bg/
no previous URLs
https//softuni.bg/trainings/courses
https//softuni.bg/
https//softuni.bg/trainings/2056
https//softuni.bg/
https//softuni.bg/trainings/live
https//softuni.bg/trainings/live/details
```

Solution: Browser History (1)

```
Scanner scanner = new Scanner(System.in);

ArrayDeque<String> browser = new ArrayDeque<>();
String line = scanner.nextLine();

String current = "";

// continue…
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Browser History (2)

```
while(!line.equals("Home")) {
  if(line.equals("back")) {
    if(!browser.isEmpty()) { current = browser.pop();
    } else {
    System.out.println("no previous URLs");
    line = scanner.nextLine();
    continue; }
  } else {
    if(!current.equals("")) { browser.push(current); }
    current = line; }
  System.out.println(current);
  line = scanner.nextLine(); }
```

Problem: Simple Calculator

- Implement a simple calculator that can evaluate simple expressions (only addition and subtraction)

Input
`2 + 5 + 10 - 2 - 1`
`2 - 2 + 5`

Output
14
5

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Simple Calculator (1)

```
Scanner scanner = new Scanner(System.in);
String[] tokens = scanner.nextLine().split("\\s+");

Deque<String> stack = new ArrayDeque<>();
Collections.addAll(stack, tokens);

// continues…
```

Split by regex

Adds a collection to another collection

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Simple Calculator (2)

```
while (stack.size() > 1) {
  int first = Integer.valueOf(stack.pop());
  String op = stack.pop();
  int second = Integer.valueOf(stack.pop());

  switch (op)
    case "+": stack.push(String.valueOf(first + second));
      break;
    case "-": stack.push(String.valueOf(first - second));
      break;
}

System.out.println(stack.pop());
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Problem: Decimal to Binary Converter

- Create a converter which takes a **decimal number** and **converts it into a binary number**

Input
10
1024

Output
1010
10000000000

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Decimal to Binary Converter

```
Scanner scanner = new Scanner(System.in);
int decimal = Integer.valueOf(scanner.nextLine());

ArrayDeque<Integer> stack = new ArrayDeque<>();

// TODO: check if number is 0

while (decimal != 0)
  stack.push(decimal % 2);
  decimal /= 2;

while (!stack.isEmpty())
  System.out.print(stack.pop());
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Problem: Matching Brackets

- We are given an arithmetical expression with brackets (with nesting)
- Goal: extract all sub-expressions in brackets

```
1 + (2 - (2 + 3) * 4 / (3 + 1)) * 5
```

```
(2 + 3)
(3 + 1)
(2 - (2 + 3) * 4 / (3 + 1))
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Matching Brackets (1)

```
Scanner scanner = new Scanner(System.in);
String expression = scanner.nextLine();

Deque<Integer> stack = new ArrayDeque<>();

// continue…
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Matching Brackets (2)

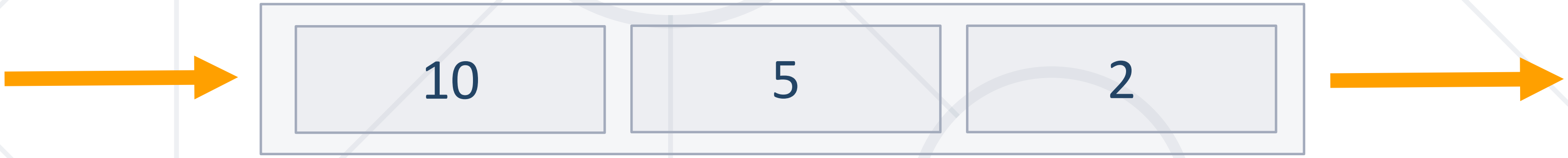
```
for (int i = 0; i < expression.length(); i++) {
  char ch = expression.charAt(i);
  if (ch == '(')
    stack.push(i);
  else if (ch == ')')
    int startIndex = stack.pop();
    String contents =
    expression.substring(startIndex, i + 1);
    System.out.println(contents);
}
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Queues

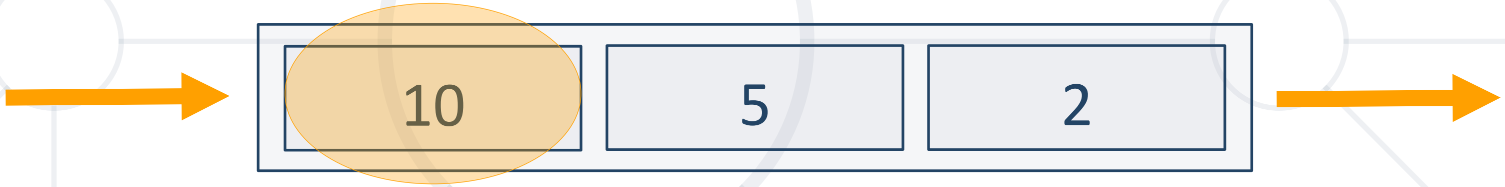
Queue

- **First In First Out**

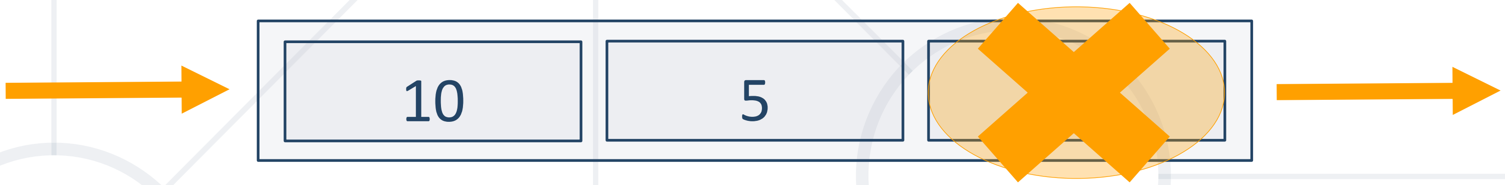


Queue – Abstract Data Type

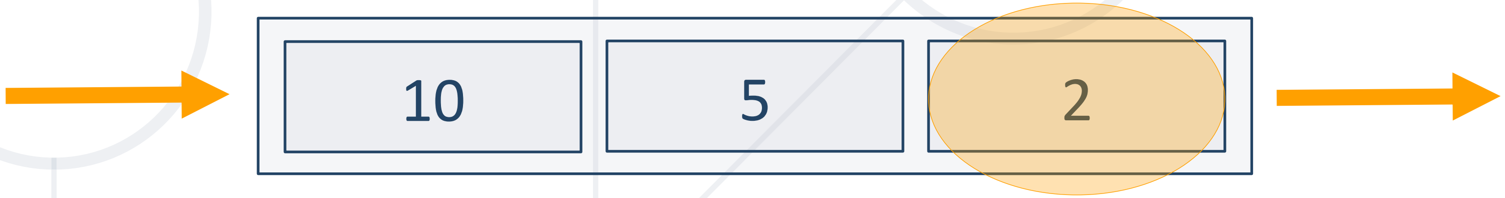
- Queues provide the following functionality:
  - Adding an element at the end of the queue



  - Removing the first element from the queue



  - Getting the first element of the queue without removing it



ArrayDeque<E> – Java Queue Implementation

- Creating a Queue

```
ArrayDeque<Integer> queue = new ArrayDeque<>();
```

- Adding elements at the end of the queue

```
queue.add(element);
queue.offer(element);
```

  - add() – throws exception if queue is full
  - offer() – returns false if queue is full

ArrayDeque<E> – Java Queue Implementation (2)

- Removing elements

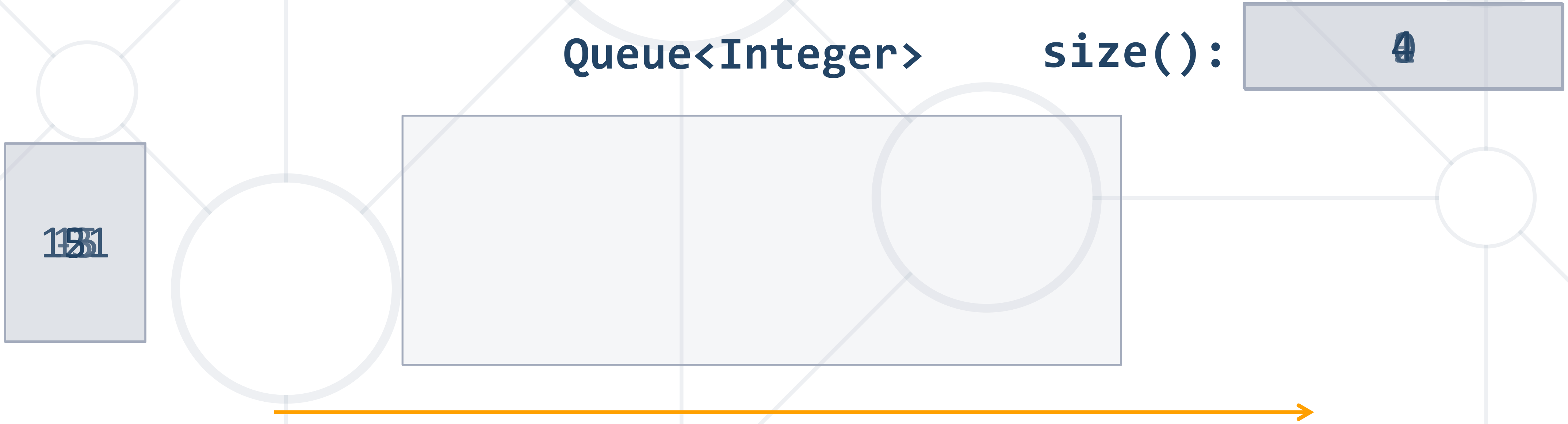
```java
element = queue.remove();
element = queue.poll();
```

  - remove() - throws exception if queue is empty
  - poll() - returns null if queue is empty
- Check first element

```java
element = queue.peek();
```

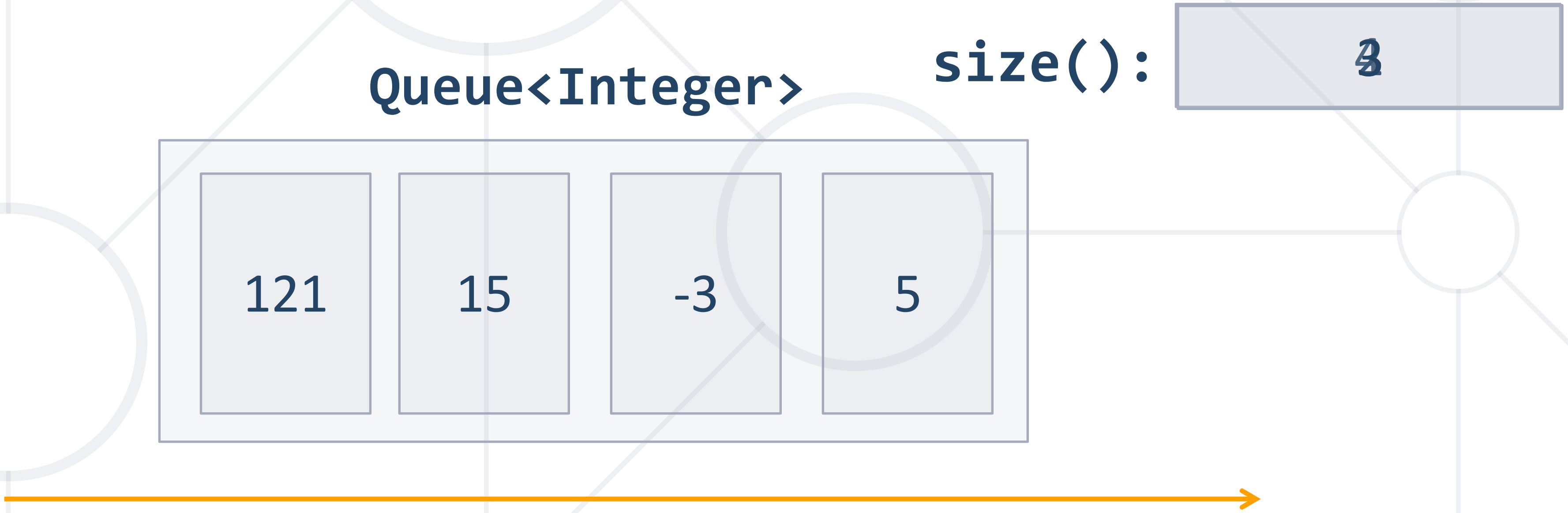
Add() / Offer()

- Adds an element to the queue



Remove() / Poll()

- Returns and removes first element



Problem: Hot Potato

- Children form a circle and pass a hot potato clockwise
- Every nth toss a child is removed until only one remains
- Upon removal the potato is passed forward
- Print the child that remains last

Input	Output

`Sam John Sara`
`2`
	Removed John
	Removed Sam
	Last is Sara

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Hot Potato (1)

```
Scanner scanner = new Scanner(System.in);
String[] children = scanner.nextLine().split("\\s+");
int n = Integer.valueOf(scanner.nextLine());

ArrayDeque<String> queue = new ArrayDeque<>();

for (String child : children)
  queue.offer(child);

// continue…
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Hot Potato (2)

```
while (queue.size() > 1) {
  for (int i = 1; i < n; i++)
    queue.offer(queue.poll());

  System.out.println("Removed " + queue.poll());
}

System.out.println("Last is " + queue.poll());
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

ArrayDeque<E> – Java Queue Implementation (3)

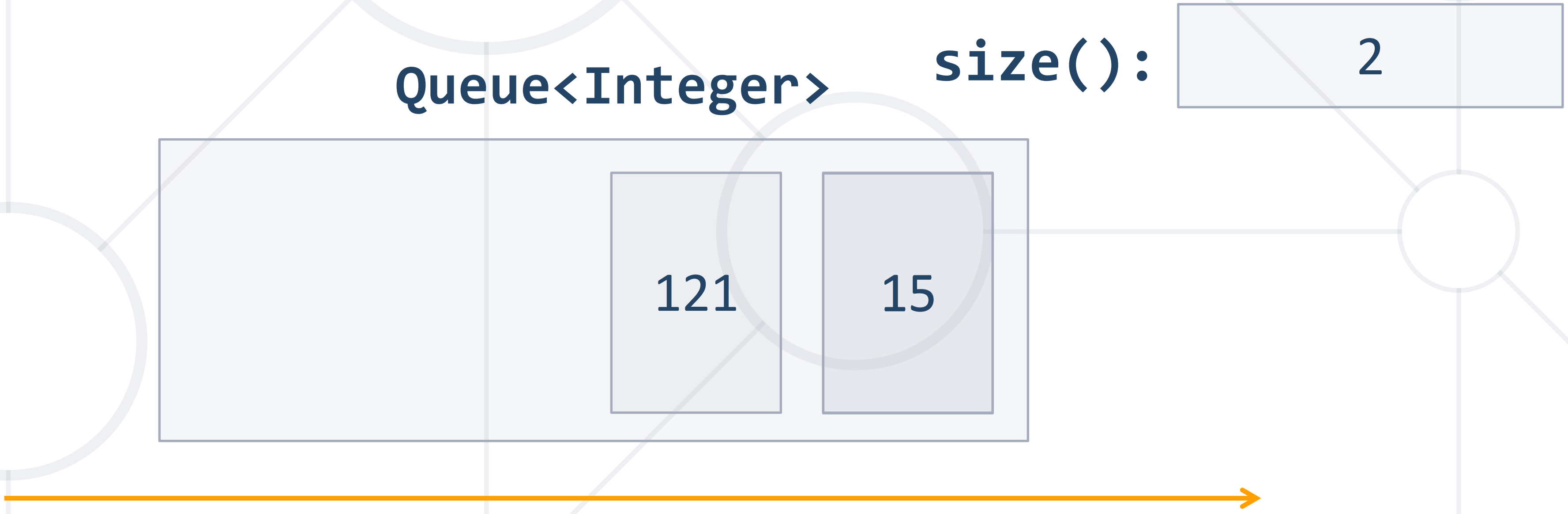
- Utility Methods

```
Integer element = queue.peeк();
Integer size = queue.size();
Integer[] arr = queue.toArray();
boolean exists = queue.contains(element);
```

  - `peek()` - checks the value of the first element
  - `size()` - returns queue size
  - `toArray()` - converts the queue to an array
  - `contains()` - checks if element is in the queue

Peek()

- Gets the first element without removing it



Problem: Math Potato

- Rework the previous problem so that a child is removed only on a prime cycle (cycles start from 1)
- If a cycle is not prime, just print the child's name

Input

```
Maria Peter George
2
```

→

Output

```
Removed Peter
Prime Maria
Prime George
Removed Maria
Last is George
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Solution: Math Potato

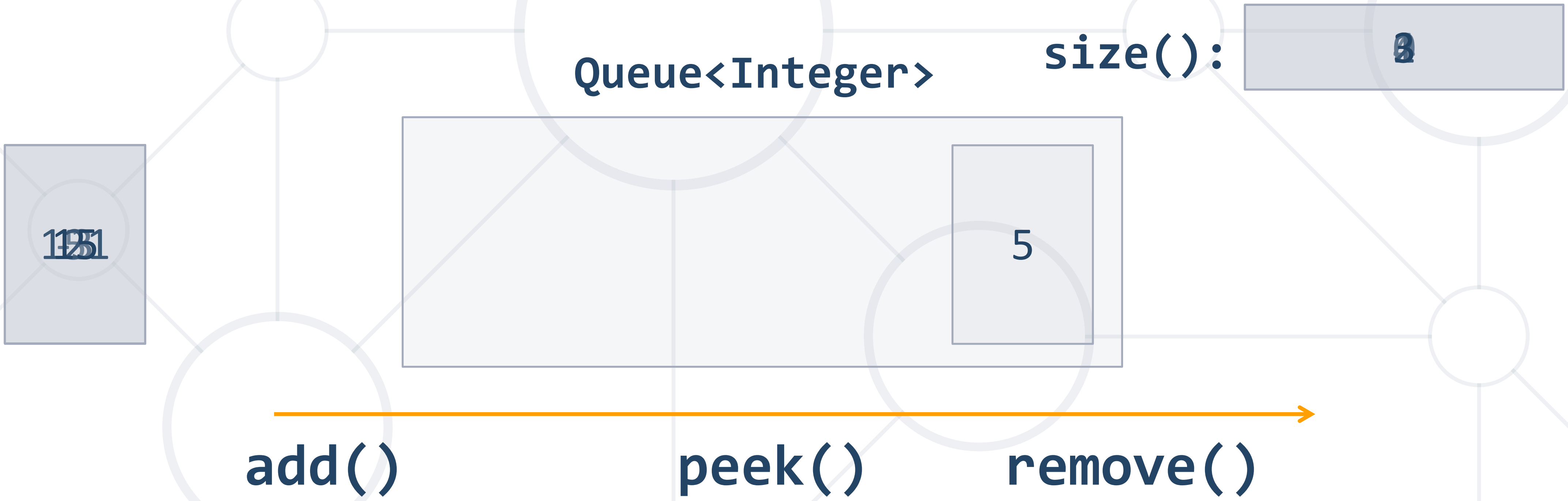
```
int cycle = 1;
while (queue.size() > 1) {
  for (int i = 1; i < n; i++)
    queue.offer(queue.poll());

  if (isPrime(cycle))
    System.out.println("Prime " + queue.peek());
  else
    System.out.println("Removed " + queue.poll());

  cycle++;
}
System.out.println("Last is " + queue.poll());
```

Check your solution here: https://judge.softuni.bg/Contests/1437/Stacks-and-Queues-Lab

Queue – Overview of All Operations



Queue<Integer>

size(): 3

1251

5

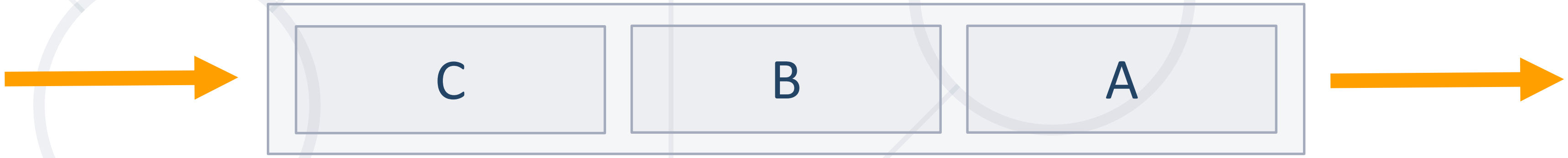
add()

peek()

remove()

Priority Queue

- Retains a specific order to the elements
- Higher priority elements are pushed to the beginning of the queue
- Lower priority elements are pushed to the end of the queue



Summary

- Algorithmic Complexity
- **Stack** - Last In First Out (LIFO)
  - push(), pop(), peek()
- **Queue** - First In First Out (FIFO)
  - add(), poll(), peek()
- **Priority Queue**

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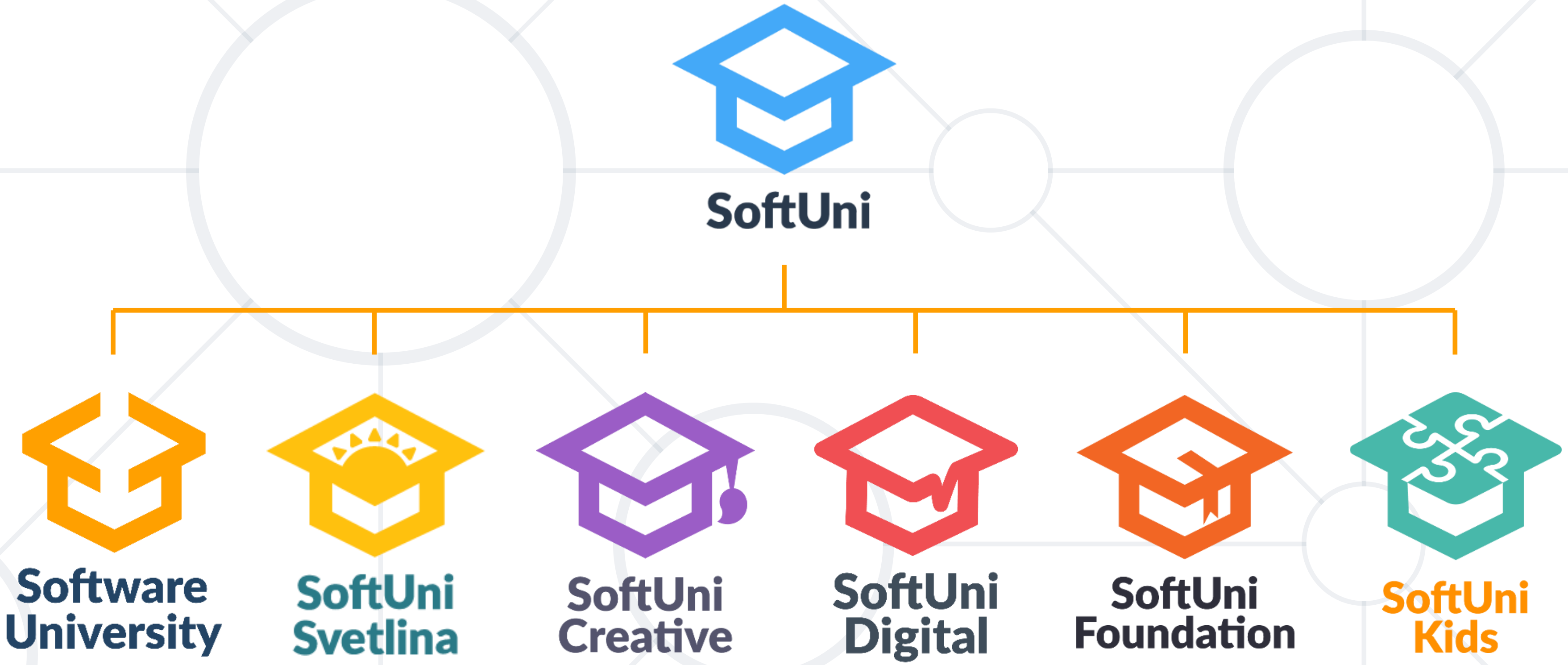
Questions?



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