Informatik II (D-ITET)

Tutorial 4

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Outlook

- Exercise 3: solution discussion
- Exercise 4: overview (Stack, Ackermann, Bytecode)
- Demo: Bytecode (String/StringBuffer)
Excercise 4

1. Stack
   - Possible implementation using arrays
   - Interface is known but what happens in the background (depends on the programmer). We make a better implementation with lists later!

2. Ackermann – exploding recursion... :-) 
   - How much is (4, 2)?

3. Java Bytecode
   - Finally we will have a look at low-level stuff 😊
Hints Ex4.Q1 - Stack

- Data structure
- Only the last element is accessed
  - last-in-first-out queue (LIFO queue)
Exercise 4 - Q1 (a-c)

- **Constructor**
  - Initializes internal Array
  - Capacity is an argument to the constructor

- **toString() with StringBuffer**
  - Expected Output: "[e0, e1, e2, …]"
  - Concatenation
    - String: `str += "bar";`
    - StringBuffer: `buf.append("bar");`

- **grow()**
  - Capacity doubled, copy old values
Exercise 4 - Q1 (d)

• push(), pop(), peek(), empty()
  ▪ Standard stack functions
  ▪ Arguments are of type int
  ▪ If necessary, call grow()

• size()
  ▪ Number of elements currently on the stack

• capacity()
  ▪ Total number of elements which fit on the current stack until the next grow
Exercise 4 – Ackermann Function Q2

- Recursive Definition

\[
A(0, m) = m + 1 \\
A(n + 1, 0) = A(n, 1) \\
A(n + 1, m + 1) = A(n, A(n + 1, m))
\]

- Grows extremely fast
  - \(A(3,3) = 61\)
  - \(A(4, 2)\) has already 19729 decimal places!!

Wilhelm Ackermann (1986 – 1962, Deutschland)
Exercise 4 – Q2

- You should calculate $A(n,m)$...
  - First, calculate $A(2,1)$ by hand on paper
    - Write down all steps then (b) gets easier ...
      $A(2,1) = A(1+1,0+1) = A(1,A(2,0))$...
  - Then, write the Pseudocode
    - «Descriptive», but in the form of programming language
    - Think about Stacks... :-)  
    - The function has the property that one can not say in advance how deep the recursion is → use while instead of for-loop!
  - Implement using the stack implementation in Question 1 with an iterative algorithm
Exercise 4 - Iterative Approach Q2c

- Ackermann’s formula always requires (exactly) two values:
  - The currently required values should be at the top of the stack…
  - What does it mean when there is one item left in the stack?

```java
Stack stack = new Stack();
stack.push(4);
stack.push(7);

while (stack.size() != 1)
{
  ...
}
```

stack
Exercise 4 – Implementation Q2c

```python
stack.push(m)
stack.push(n)

if n == 0 → result = m+1
else if m == 0 → push(n-1), push(1)
else push(n-1), push(n), push(m-1)
```
Exercise 4 – Implementation Q2c

- Stack
  - Use the stack implementation in Q1
  - The interface should NOT be modified

- “Snapshots”
  - With toString() method of the stack

- What if I can not do Q1?
  - Use java.util.Stack<Integer>
    you just need push(), pop(), size und toString()
  - If necessary: send me an Email
Exercise 4 – Java Bytecode Q3

```java
class HelloWorldApp {
    public static void main(String[] args) {
        System.out.println("Hello World!");
    }
}
```

HelloWorldApp.java

![Diagram of Java bytecode process]
Exercise 4 – Java Bytecode Q3

Method int f(int, int, int)
0 iload_0
1 iload_1
2 iadd
3 iload_2
4 idiv
5 ireturn

Method int g(int, int)
0 iload_0
1 iload_1
2 iconst_3
3 invokestatic #f
4 ireturn
Method int f(int, int, int)

0 iload_0 \quad a_0
1 iload_1 \quad a_1
2 iadd \quad a_0 + a_1
3 iload_2 \quad a_2
4 idiv \quad (a_0 + a_1) / a_2
5 ireturn

http://docs.oracle.com/javase/specs/jvms/se7/html/jvms-6.html
Outlook

- Exercise 3 solution discussion
- Exercise 4 overview (Stack, Ackermann, Bytecode)
- Demo: Bytecode (String/StringBuffer)
Demo: Bytecode and Strings/Stringbuffer

D:\Projects\DisassemblerDemo>
javac JavaTip.java  //compiler
java JavaTip         //run
javap -c -private JavaTip  //disassembler

- **Common mistake:** „javap is not recognized as an internal or external command, operable program or batch file”
- **Reason:** java binaries are not defined in System variable PATH
- **Solution:** Right Click on Computer → Properties → Advanced System Settings → Environment Variables → PATH → add (where you installed the Java JDK) and restart Windows
  C:\Program Files\Java\jdk1.7.0_31\bin
Have Fun!