Der eilige Graal

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Die (nicht vorhandene) ideale Maschine

```
class Simple {
    int half(int x) {
        return x / 2;
    }
    int f(int x, int y) {
        int r = x + y;
        r = half(r);
        if (r < 50) {
            return 50;
        }
        return r;
    }

    public static void main(String[] a) {
        Simple s = new Simple();
        System.out.println(s.f(37, 44));
    }
}
```

```
int half(int x) {
    return x / 2;
}
```

```
int half(int);
  0:  iload_1
  1:  iconst_2
  2:  idiv
  3:  ireturn
```

```
int f(int x, int y) {
    int r = x + y;
    r = half(x);
    if (r < 50) {
        return 50;
    }
    return r;
}
```

```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20; //Method half:(I)I
  9:  istore_3
 10:  iload_3
 11:  bipush 50
 13:  if_icmpge 19
 16:  bipush 50
 18:  ireturn
 19:  iload_3
 20:  ireturn
```

```
public static void main(java.lang.String[]);
  0:  new    #1; //class Simple
  3:  dup
  4:  invokespecial  #27; //Method "<init>":()V
  7:  astore_1
  8:  getstatic    #28; //Field java/lang/System.out:Ljava/io/PrintStream;
 11:  aload_1
 12:  bipush 37
 14:  bipush 44
 16:  invokevirtual  #34; //Method f:(II)I
 19:  invokevirtual  #36; //Method java/io/PrintStream.println:(I)V
 22:  return
```

```
public static void main(java.lang.String[]);
  0:  new    #1; //class Simple
  3:  dup
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 22:  return
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```
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```

*2023B6

```
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```

37
*2023B6

```
 11:  aload_1
 12:  bipush 37
 14:  bipush 44
 16:  invokevirtual  #34; //Method f:(II)I
 19:  invokevirtual  #36; //Method java/io/PrintStream.println:(I)V
```

44
37
*2023B6

```
 11:  aload_1
 12:  bipush 37
 14:  bipush 44
 16:  invokevirtual  #34; //Method f:(II)I
 19:  invokevirtual  #36; //Method java/io/PrintStream.println:(I)V
```

44
37
*2023B6

```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
        //Method half:(I)I
  9:  istore_3
 10:  ...
```

3 (r):	
2 (y):	44
1 (x):	37
0 (this):	*2023B6

```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
        //Method half:(I)I
  9:  istore_3
 10:  ...
```

37	
3 (r):	
2 (y):	44
1 (x):	37
0 (this):	*2023B6

```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
        //Method half:(I)I
  9:  istore_3
 10:  ...
```

44	
37	
3 (r):	
2 (y):	44
1 (x):	37
0 (this):	*2023B6

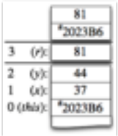
```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
        //Method half:(I)I
  9:  istore_3
 10:  ...
```

81	
3 (r):	
2 (y):	44
1 (x):	37
0 (this):	*2023B6

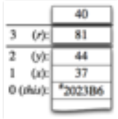
```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
        //Method half:(I)I
  9:  istore_3
 10:  ...
```

*2023B6	
3 (r):	81
2 (y):	44
1 (x):	37
0 (this):	*2023B6

```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
          //Method half:(I)I
  9:  istore_3
 10:  ...
```




```
int f(int, int);
  0:  iload_1
  1:  iload_2
  2:  iadd
  3:  istore_3
  4:  aload_0
  5:  iload_3
  6:  invokevirtual  #20;
          //Method half:(I)I
  9:  istore_3
 10:  ...
```




```
int f(int, int);
  0:  iload_1
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  2:  iadd
  3:  istore_3
  4:  aload_0
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  6:  invokevirtual  #20;
          //Method half:(I)I
  9:  istore_3
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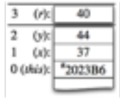
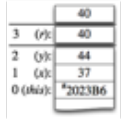
```




```
int f(int, int);
  6:  ...
  9:  istore_3
 10:  iload_3
 11:  bipush 50
 13:  if_icmpge 19
 16:  bipush 50
 18:  ireturn
 19:  iload_3
 20:  ireturn
```

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int f(int, int);
  6:  ...
  9:  istore_3
 10:  iload_3
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 13:  if_icmpge 19
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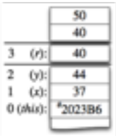


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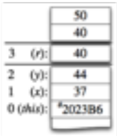


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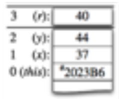


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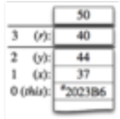


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  6:  ...
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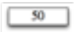


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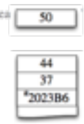


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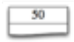


Hot Spot

Hot Spot: Nachtlokal
—Duden

Hot Spot: Krisenherd
—Duden

Hot Spot: Spitzenlastpunkt
—LEO

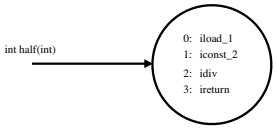
Spot: Abk. für **Spotlight** das; -s, -s <engl.>:
Beleuchtung od. Scheinwerfer, der auf einen Punkt gerichtet ist u. dabei die Umgebung im Dunkeln lässt
—Duden

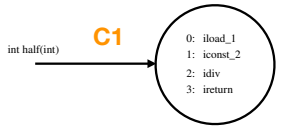
```
int half(int);
0:  iload_1
1:  iconst_2
2:  idiv
3:  ireturn
```

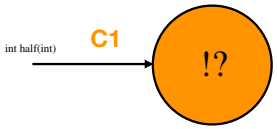
```
while (code.hasNext()) {
  switch (code.next()) {
    case iload_1:      … break;
    case iconst_2:     … break;
    case ireturn:      … break;
    case idiv:         … break;
    …
  }
}
```

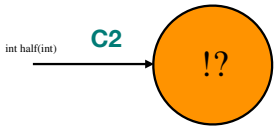
```
int f(int, int);
0: iload_1
1: iload_2
2: iadd
3: istore_3
4: aload_0
5: iload_3
6: invokevirtual #20 // half:(I)I
9: istore_3
…
```

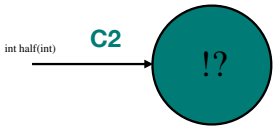
```
while (code.hasNext()) {
  switch (code.next()) {
    case iload_1:      … break;
    case iconst_2:     … break;
    case ireturn:      … break;
    case invokevirtual: … break;
    …
  }
}
```

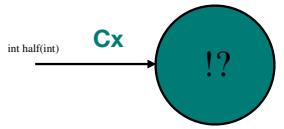


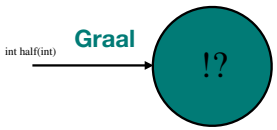






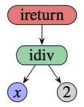


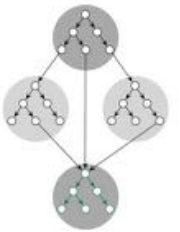


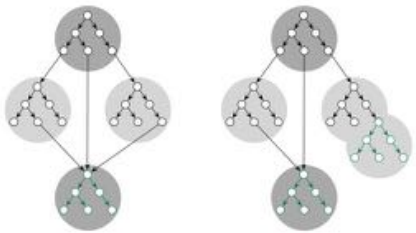


Der eilige Graal

```
int half(int);
0:  iload_1
1:  iconst_2
2:  idiv
3:  ireturn
```



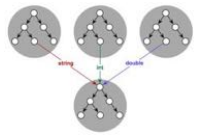


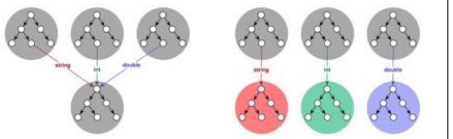


```
fun add(a, b) {
  return a + b
}
```

```
fun add(a, b) {
  return a + b
}
```

```
assert add(1, 2) = 3
assert add(½, ¼) = ¾
assert add(½, −1) = −½
assert add("a", "b") = "ab"
assert add("a", 1) = "a1"
assert add([1, 2], [3, 4]) = [1, 2, 3, 4]
```





-XX:+UnlockExperimentalVMOptions
-XX:+UseJVMCICompiler

“That library is not available in my language. I need to rewrite it.”

“That language would be the perfect fit for my problem,
but we cannot run it in our environment.”

“That problem is already solved in my language,
but the language is too slow.”


```
var ArrayList = Java.type("java.util.ArrayList");
var list = new ArrayList();
list.add("Apfel");
list.add("Birne");
list.add("Zitrone");
print(list);
```

```
String script = "console.log('Hello from the project')";

Context jsContext = Context.create("js");
jsContext.eval("js", script);
```

```
var array = Polyglot.eval("R", "c(1, 2, 42, 4)")
console.log(array[2]);
```

```
$ js --polyglot --jvm polyglot.js
42
$ node --polyglot --jvm polyglot.js
42
```

```
array <- eval.polyglot("js", "[1, 2, 42, 4]")
print(array[3L])
```

```
$ Rscript --polyglot --jvm polyglot.R
[1] 42
```

```
array = Polyglot.eval('js', '[1, 2, 42, 4]')
puts array[2]
```

```
$ ruby --polyglot --jvm polyglot.rb
42
```

```
import polyglot
array = polyglot.eval(language="js", string="[1, 2, 42, 4]")
print(array[2])
```

```
$ graalpython --polyglot --jvm polyglot.py
42
```

```
import org.graalvm.polyglot.*;
class Polyglot {
  public static void main(String[] args) {
    Context polyglot = Context.create();
    Value array = polyglot.eval("js", "[1, 2, 42, 4]");
    int result = array.getArrayElement(2).asInt();
    System.out.println(result);
  }
}
```

```
$ javac Polyglot.java
$ java Polyglot
42
```

```
#include <stdio.h>

#include <polyglot.h>
int main() {
  void* array = polyglot_eval("js", "[1,2,42,4]");
  int element = polyglot_as_i32(polyglot_get_array_element(array, 2));
  printf("%d\n", element);
  return element;
}
```

```
$ clang -g -O1 -c -emit-llvm -I$GRAALVM_HOME/jre/languages/llvm
polyglot.c
$ lli --polyglot --jvm polyglot.bc
42
```

Indy
(und Condy)

```
void f(List<Integer> list) {
    …
    … list.stream().filter(x -> x % 2 == 0) …
    …
}
```

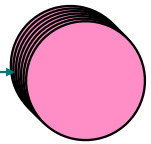
```
0: aload_1
1: invokeinterface #18    // java.util.List.stream:
                                    ()Ljava/util/stream/Stream;
6: invokedynamic #27      // #0:test:
                                    ()Ljava/util/function/Predicate;
11: invokeinterface #28   // java/util/stream/Stream.filter:
                (Ljava/util/function/Predicate;)Ljava/util/stream/Stream;
```

```
BootstrapMethods:
0:      #58 REF_invokeStatic
            java/lang/invoke/LambdaMetafactory.metafactory:(
                Ljava/lang/invoke/MethodHandles$Lookup;
                Ljava/lang/String;
                Ljava/lang/invoke/MethodType;
                Ljava/lang/invoke/MethodType;
                Ljava/lang/invoke/MethodHandle;
                Ljava/lang/invoke/MethodType;
            )Ljava/lang/invoke/CallSite;
        Method arguments:
            #60 (Ljava/lang/Object;)Z
            #63 REF_invokeStatic simple/S.lambda$0:(Ljava/lang/Integer;)Z
            #64 (Ljava/lang/Integer;)Z
```

```
private static boolean lambda$0(java.lang.Integer);
    0: aload_0
    1: invokevirtual #40 // java/lang/Integer.intValue:()I
    4: iconst_2
    5: irem
    6: ifne          13
    9: iconst_1
    10: goto         14
    13: iconst_0
    14: ireturn
```

boolean lambda$0(Integer)

boolean lambda$0(Integer)



int[] *a* = {1000, 1001, 1002};

```
0: iconst_3
1: newarray       int
3: dup
4: iconst_0
5: sipush         1000
8: iastore
9: dup
10: iconst_1
11: sipush        1001
14: iastore
15: dup
16: iconst_2
17: sipush        1002
20: iastore
21: astore_1
```

int[] *a* = {1000, 1001, 1002, 1003, 1004, 1005, 1006};

```
0: bipush         7
2: newarray       int
4: dup
5: iconst_0
6: sipush         1000
9: iastore
10: dup
11: iconst_1
12: sipush        1001
15: iastore
16: dup
17: iconst_2
18: sipush        1002
21: iastore
22: dup
23: iconst_3
24: sipush        1003
27: iastore
28: dup
29: iconst_4
30: sipush        1004
33: iastore
34: dup
35: iconst_5
36: sipush        1005
39: iastore
40: dup
41: bipush        6
43: sipush        1006
46: iastore
47: astore_1
```

int[] *a* = {

1000, 1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009,

1010, 1011, 1012, 1013, 1014, 1015, 1016, 1017, 1018, 1019,

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1030, 1031, 1032, 1033, 1034, 1035, 1036, 1037, 1038, 1039,

1040, 1041, 1042, 1043, 1044, 1045, 1046, 1047, 1048, 1049,

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1060, 1061, 1062, 1063, 1064, 1065, 1066, 1067, 1068, 1069,

1070, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079,

1080, 1081, 1082, 1083, 1084, 1085, 1086, 1087, 1088, 1089,

1090, 1091, 1092, 1093, 1094, 1095, 1096, 1097, 1098, 1099

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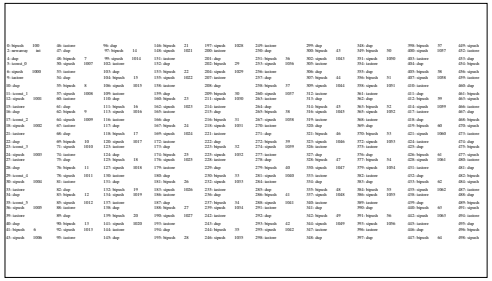

Fazit

(Unbedingt) ausprobieren

(Unbedingt) ausprobieren

Verzögerungen berücksichtigen

(Unbedingt) ausprobieren

Verzögerungen berücksichtigen

Sicherstellen, dass man das hat, was man will

(Unbedingt) ausprobieren

Verzögerungen berücksichtigen

Sicherstellen, dass man das hat, was man will

Eventuell *Ahead of Time Compilation* (AOT)

(Unbedingt) ausprobieren

Verzögerungen berücksichtigen

Sicherstellen, dass man das hat, was man will

Eventuell *Ahead of Time Compilation* (AOT)

Und gegebenenfalls polyglottes Programmieren

Fragen?

Vielen Dank!