Klasse *Label*

```
class Label {
    boolean defined;    // true if label has been defined
    int adr;            // if (defined) adr == position of label in code
                        // else adr == position of prev. fixup label

    // inserts offset to label at current pc
    void put ();

    // defines label to be at the current pc position
    void here ();
}
```

Klasse *Item* - Erweiterung für Sprünge

```
class Item {
   public enum Kind {    // Mögliche Item-Arten
      Con, Local, Static, Stack, Fld, Elem, Meth, Cond
   }

    public Kind kind;        // Item-Art
    public Struct type;      // Typ des Operanden
    public int val;          // Con: Wert
    public int adr;          // Local, Static, Fld, Meth: Adresse
    public Obj obj;          // Meth: Methodenobjekt aus Symbolliste
    public CompOp op;        // Cond: Vergleichsoperator (eq=0,ne=1,…)

    public Label tLabel; // Cond: Ziel von true jumps
    public Label fLabel; // Cond: Ziel von false jumps
}
```

Klasse *Code* - neue Methoden für Sprünge

```
class Code {
    ...

    // generates unconditional jump instruction to lab
    void jump (Label lab);

    // generates conditional jump instruction for true jump
    // x represents the condition
    void tJump (Item x);

    // generates conditional jump instruction for false jump
    // x represents the condition
    void fJump (Item x);
}
```

Klasse *Label* - Methode *put*

```
// inserts offset to label at current pc
void put () {
    if (defined) {
        code.put2(adr - (code.pc - 1));
    }
    else {
        code.put2(adr);
        adr = code.pc - 2;
    }
}
```

Klasse *Label* - Methode *here*

```
// defines label to be at current pc
void here () {
    if (defined) {
        throw new Error("label defined twice");
    }

    while (adr != 0) {
        int pos = adr;
        adr = code.get2(adr);
        code.put2(pos, code.pc - (pos - 1));
    }

    defined = true;
    adr = code.pc;
}
```

Semantische Aktionen

```
Item CondTerm () {
    Item x = CondFact();
    while (sym == and) {
        code.fJump(x);
        scan();
        Item y = CondFact();
        x.op = y.op;
    }
    return x;
}
```

```
Item Condition () {
    Item x = CondTerm();
    while (sym == or) {
        code.tJump(x);
        scan();
        x.fLabel.here();
        Item y = CondTerm();
        x.fLabel = y.fLabel;
        x.op = y.op;
    }
    return x;
}
```

```
Ausschnitt aus Statement ()
    case if_:
        [...]
        Item x = Condition();
        code.fJump(x);
        x.tLabel.here();
        [...]
```

Semantische Aktionen

Ausschnitt aus **Statement** ()

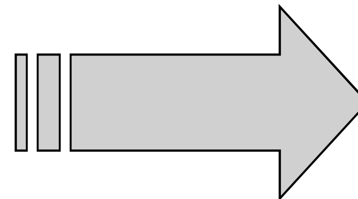
```
case while_:
    scan();
    check(lpar);
    Label top = new Label(code);
    top.here();
    Item x = Condition();
    code.fJump(x);
    x.tLabel.here();
    check(rpar);
    Statement();
    code.jump(top);
    x.fLabel.here();
```

Für die Codeerzeugung von "break" braucht Statement ein Label als Parameter

Beispiel: Methoden & Methodenaufrufe

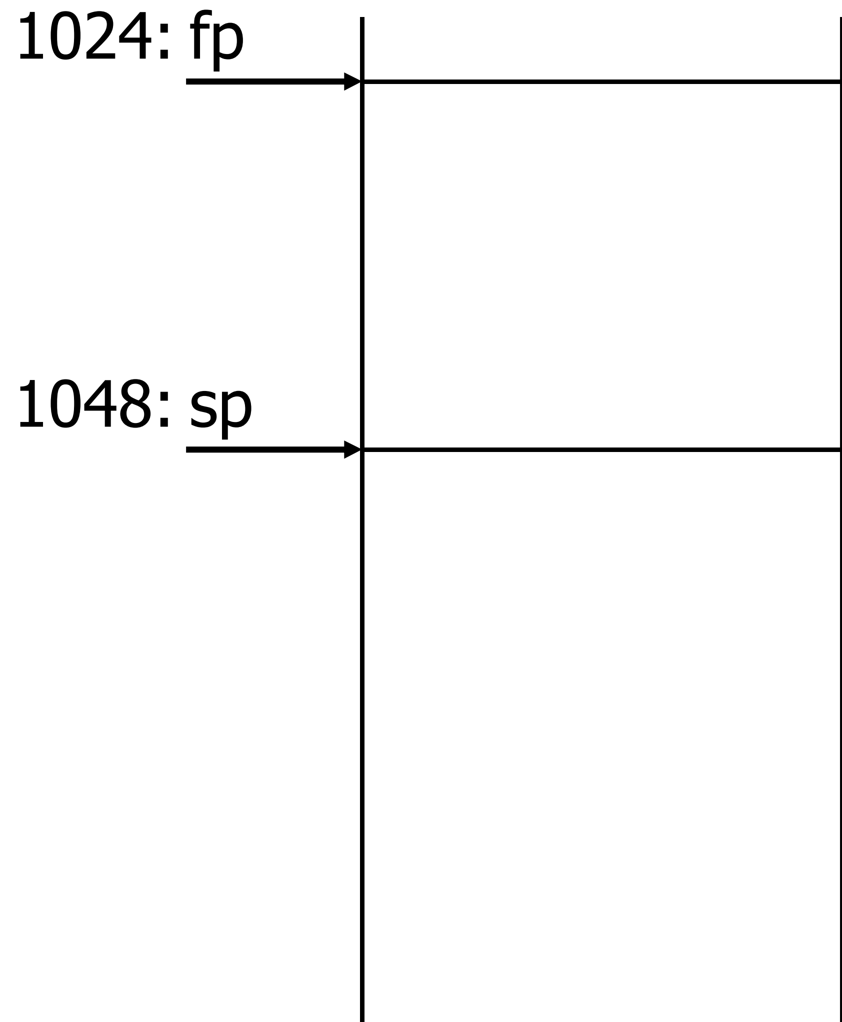
```
void m1 ()
    char c;
{...}

void m2 (int i)
    int j;
{...}
...
void main () ... {
    m1();
    ...
    m2(1);
}
...
```



```
  0: enter 0, 1
  3: ...
  ...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
  ...
 61: exit
 62: return
  ...
167: call –167
170: ...
  ...
228: call –201
231: ...
```

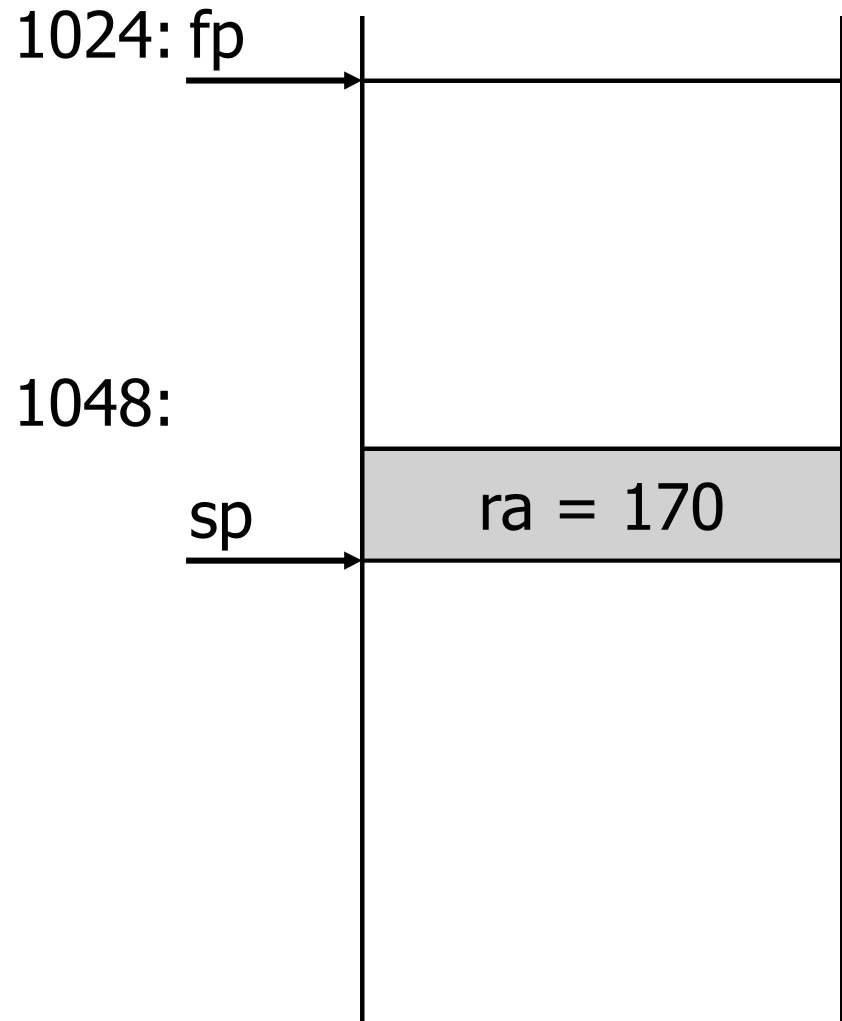
Methodenaufruf m1

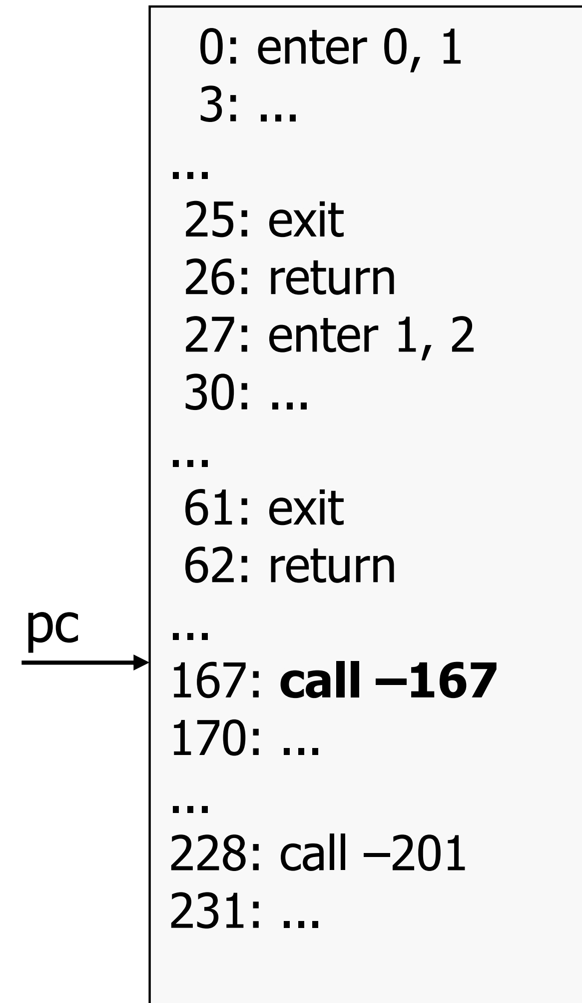


pc →

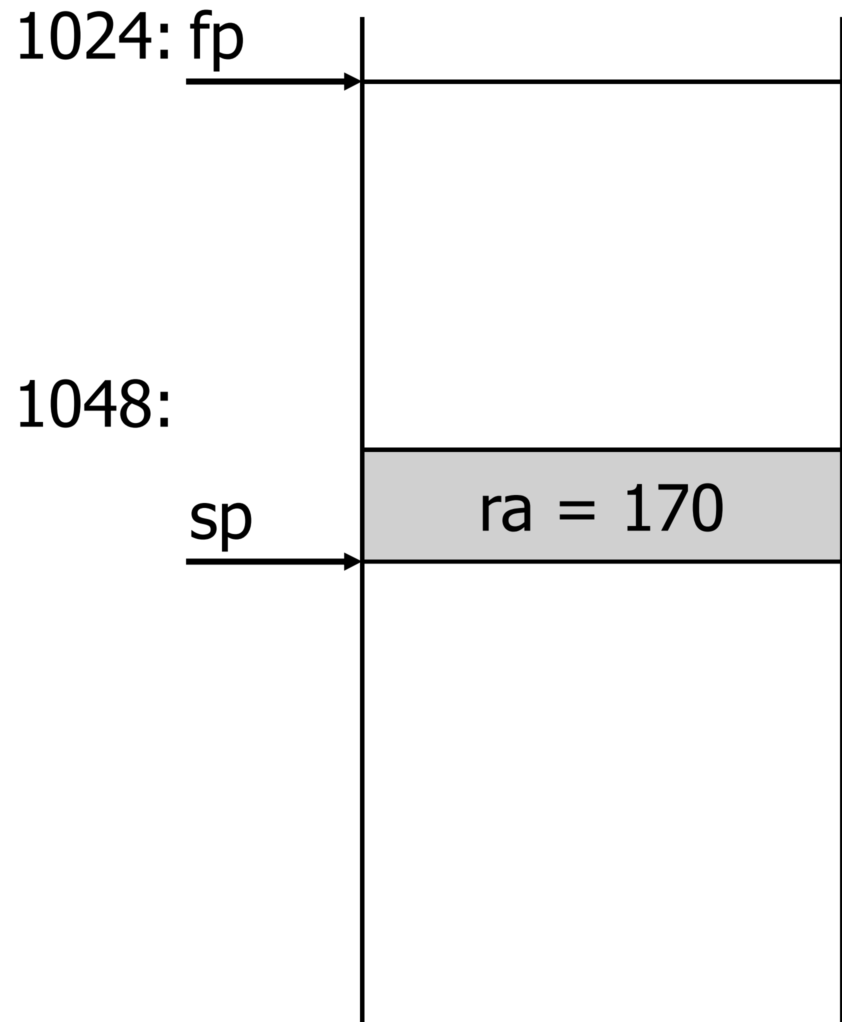
```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

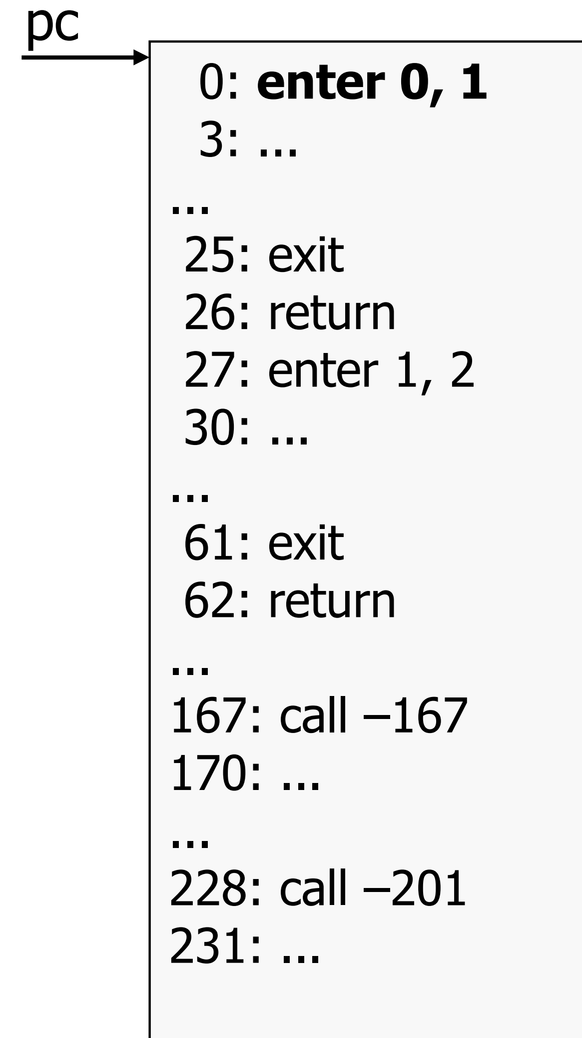
Methodenaufruf m1





Einsprung in Methode m1





Einsprung in Methode m1

1024: fp

1048:

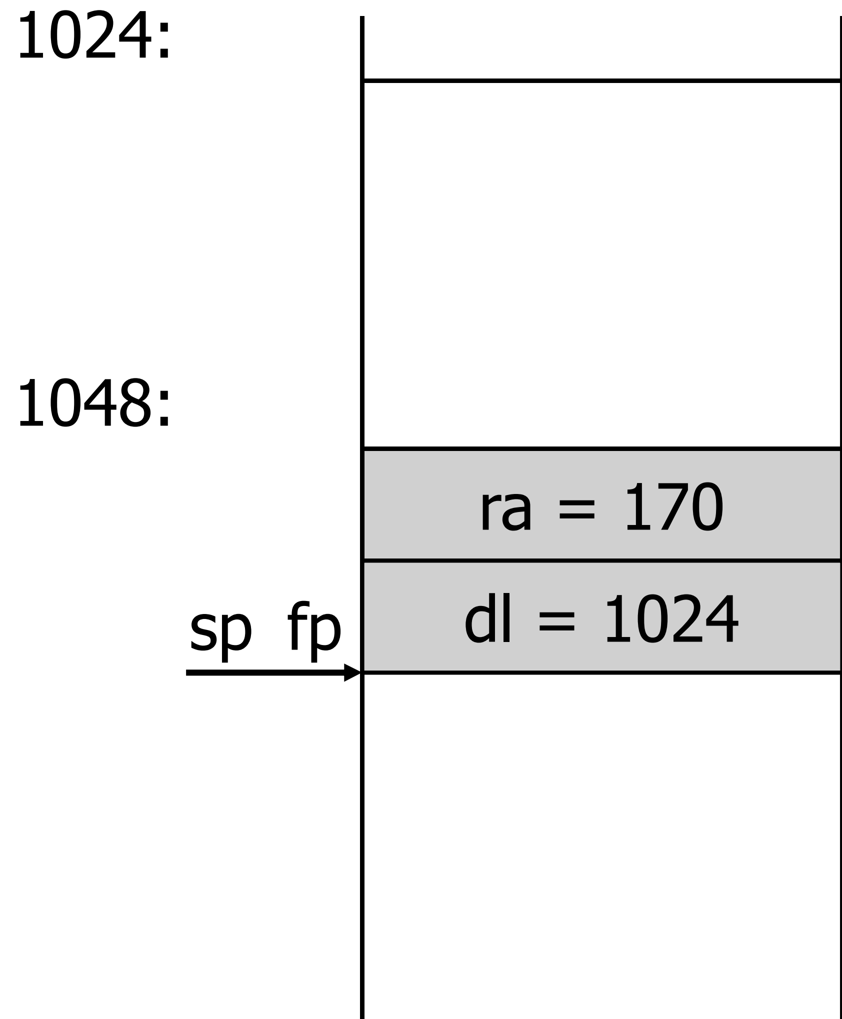
ra = 170
dl = 1024

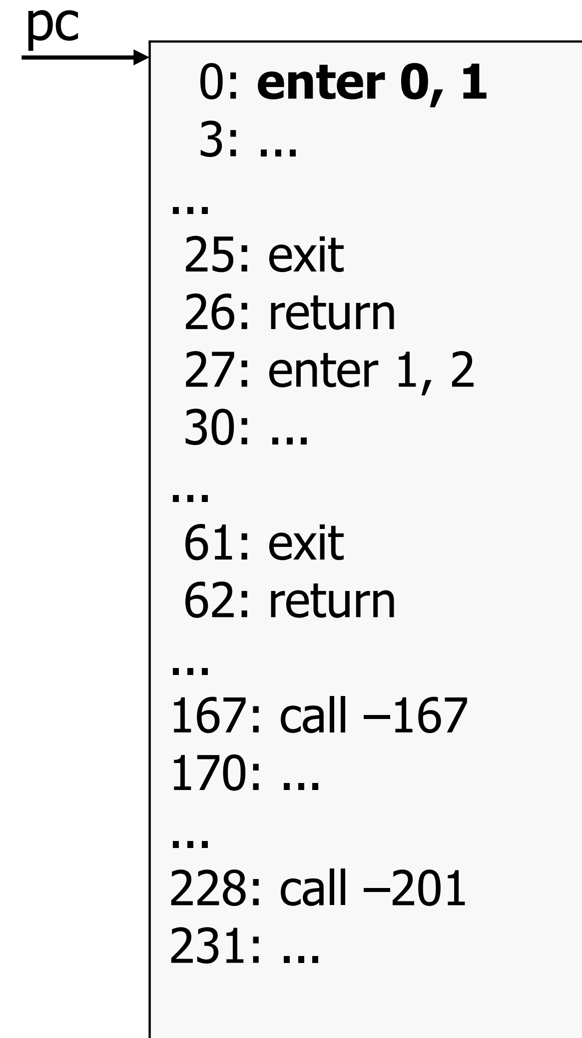
sp

pc

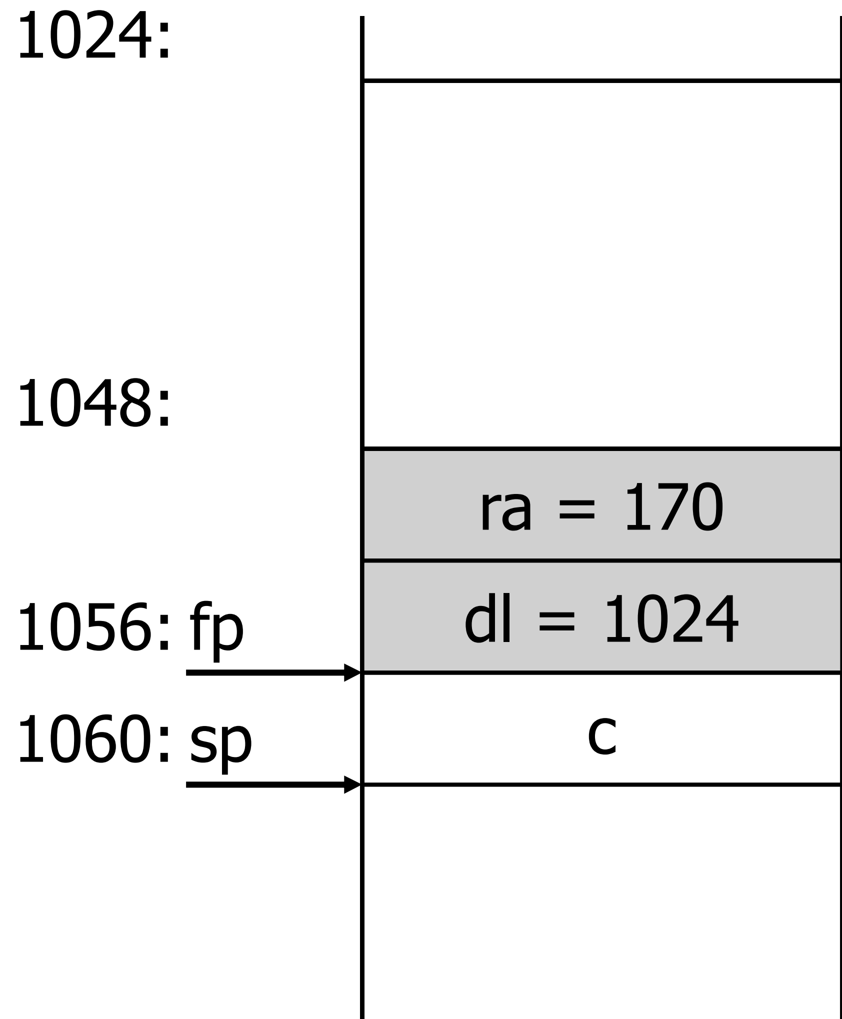
```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

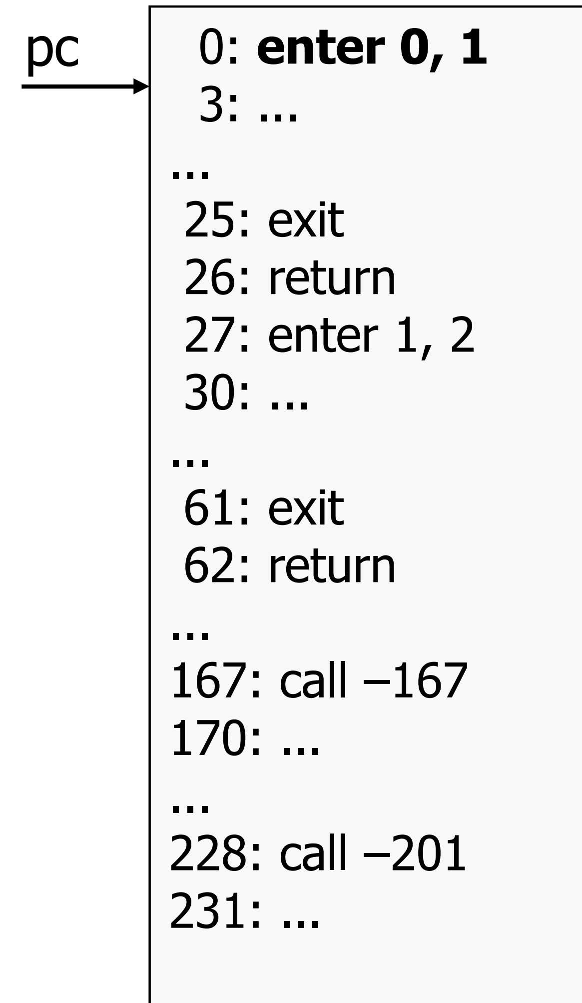
Einsprung in Methode m1



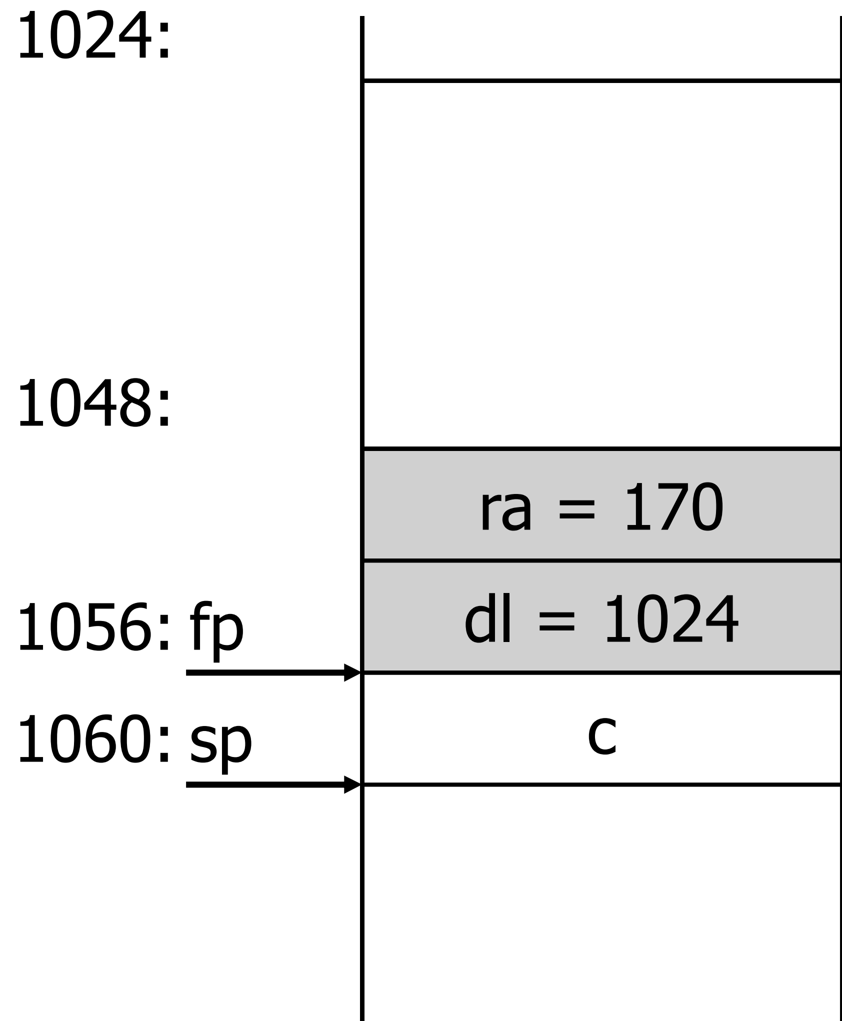


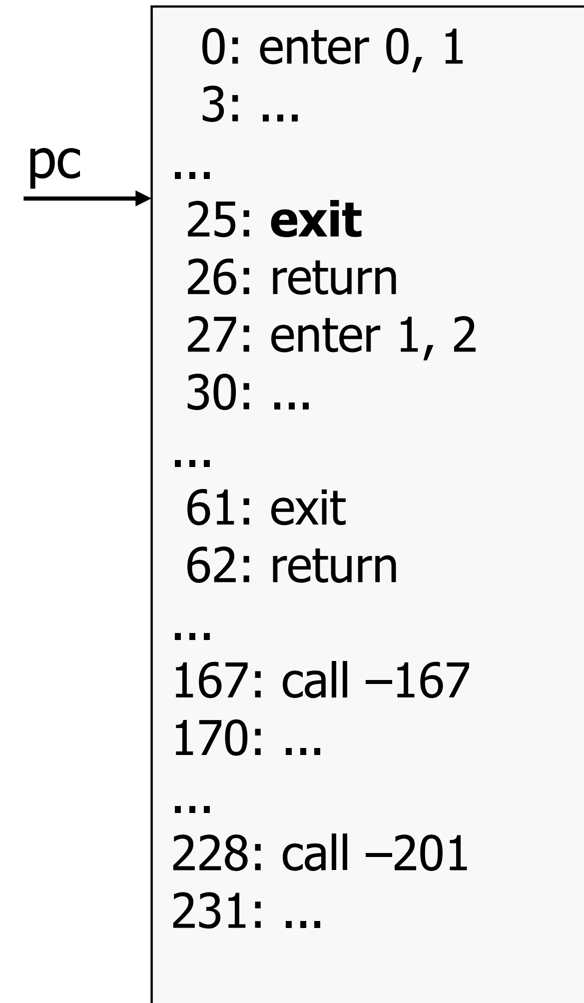
Einsprung in Methode m1





Ende der Methode m1





Ende der Methode m1

Adresse	Zeiger	Inhalt
1024:		
1048:		ra = 170
1056:	fp sp	dl = 1024
1060:		

pc → 25: **exit**

```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

Rücksprung zum Rufer der Methode m1

1024: fp

1048:

sp

ra = 170

pc

```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

Rücksprung zum Rufer der Methode m1

1024: fp

1048: sp

pc

```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

Bsp 11: **if (i <= n)** n=0**;**

Deklaration: **class A**

```
class A
    final int max = 12;           // Konstante
    char c; int i;                // globale Variablen
    class B { int x, y; }         // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

```
10:   getstatic 1
13:   load_2
14:   jgt 5        (--> 19)
17:   const_0
18:   store_2
19:   ...
```

Bsp 12: **if (i <= n && n < 0)** n=0**;**

Deklaration:

```
class A
    final int max = 12;          // Konstante
    char c; int i;               // globale Variablen
    class B { int x, y; }        // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

```
10:   getstatic 1
13:   load_2
14:   jgt 10          (--> 24)
17:   load_2
18:   const_0
19:   jge 5           (--> 24)
22:   const_0
23:   store_2
24:   ...
```

Bsp 13: **if (i <= n || n < 0)** n=0**;**

Deklaration: **class A**

```
    final int max = 12;          // Konstante
    char c; int i;               // globale Variablen
    class B { int x, y; }        // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

```
10:   getstatic 1
13:   load_2
14:   jle 8              (--> 22)
17:   load_2
18:   const_0
19:   jge 5              (--> 24)
22:   const_0
23:   store_2
24:   ...
```

Bsp 14: **if (i<=n || n<0 && i>0)** n=0**;**

Deklaration: **class A**

```
    final int max = 12;         // Konstante
    char c; int i;              // globale Variablen
    class B { int x, y; }       // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

```
10:   getstatic 1
13:   load_2
14:   jle 15          (--> 29)
17:   load_2
18:   const_0
19:   jge 12          (--> 31)
22:   getstatic 1
25:   const_0
26:   jle 5           (--> 31)
29:   const_0
30:   store_2
31:   ...
```

Bsp 15: **while (i<=n)** n++**;**

Deklaration: **class A**

```
class A
    final int max = 12;          // Konstante
    char c; int i;               // globale Variablen
    class B { int x, y; }        // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

10: getstatic 1
13: load_2
14: **jgt 9** (--> 23)
17: inc 2 1
20: **jmp -10** (--> 10)
23: ...

Bsp 16: **if (i <= n)** n=0 **else** n=1**;**

Deklaration: **class A**

```
class A
    final int max = 12;          // Konstante
    char c; int i;               // globale Variablen
    class B { int x, y; }        // innere Klasse mit Feldern
{   void foo ()   int[] iarr; B b; int n;   {...}   }
```

```
10:   getstatic 1
13:   load_2
14:   jgt 8         (--> 22)
17:   const_0
18:   store_2
19:   jmp 5         (--> 24)
22:   const_1
23:   store_2
24:   ...
```