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

    // generates code for a jump to this label
    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

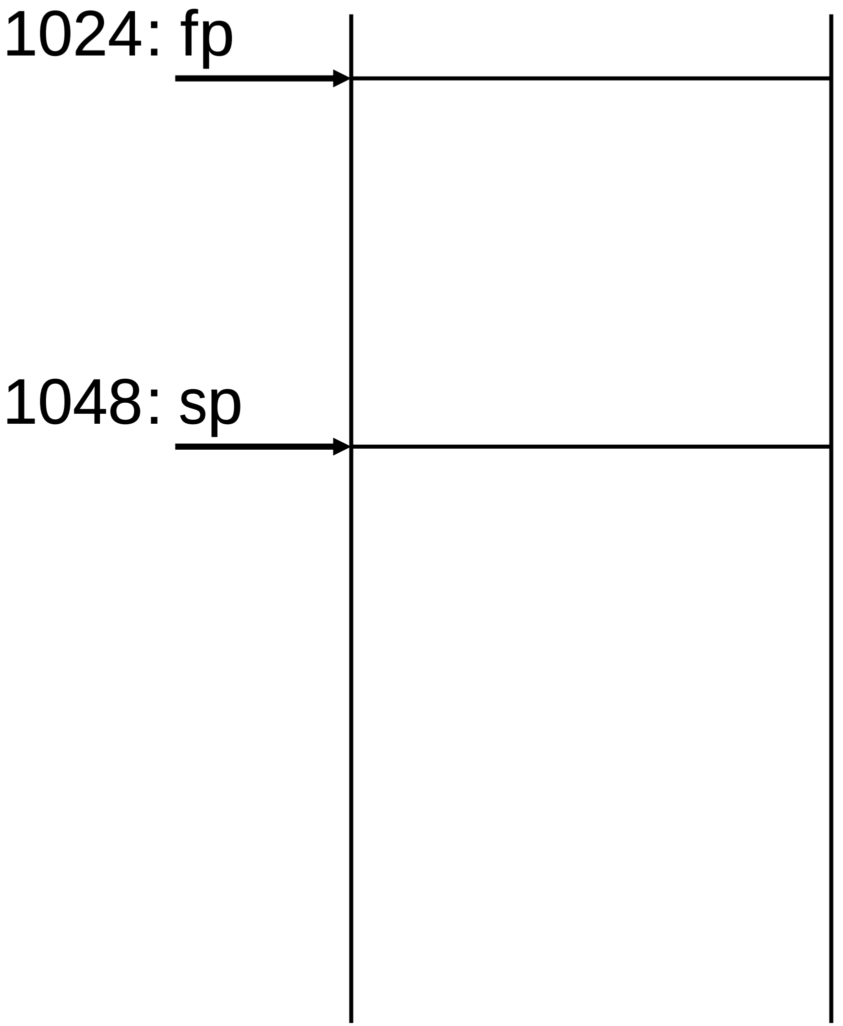
Beispiel: Methoden & Methodenaufrufe

```
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: …
```

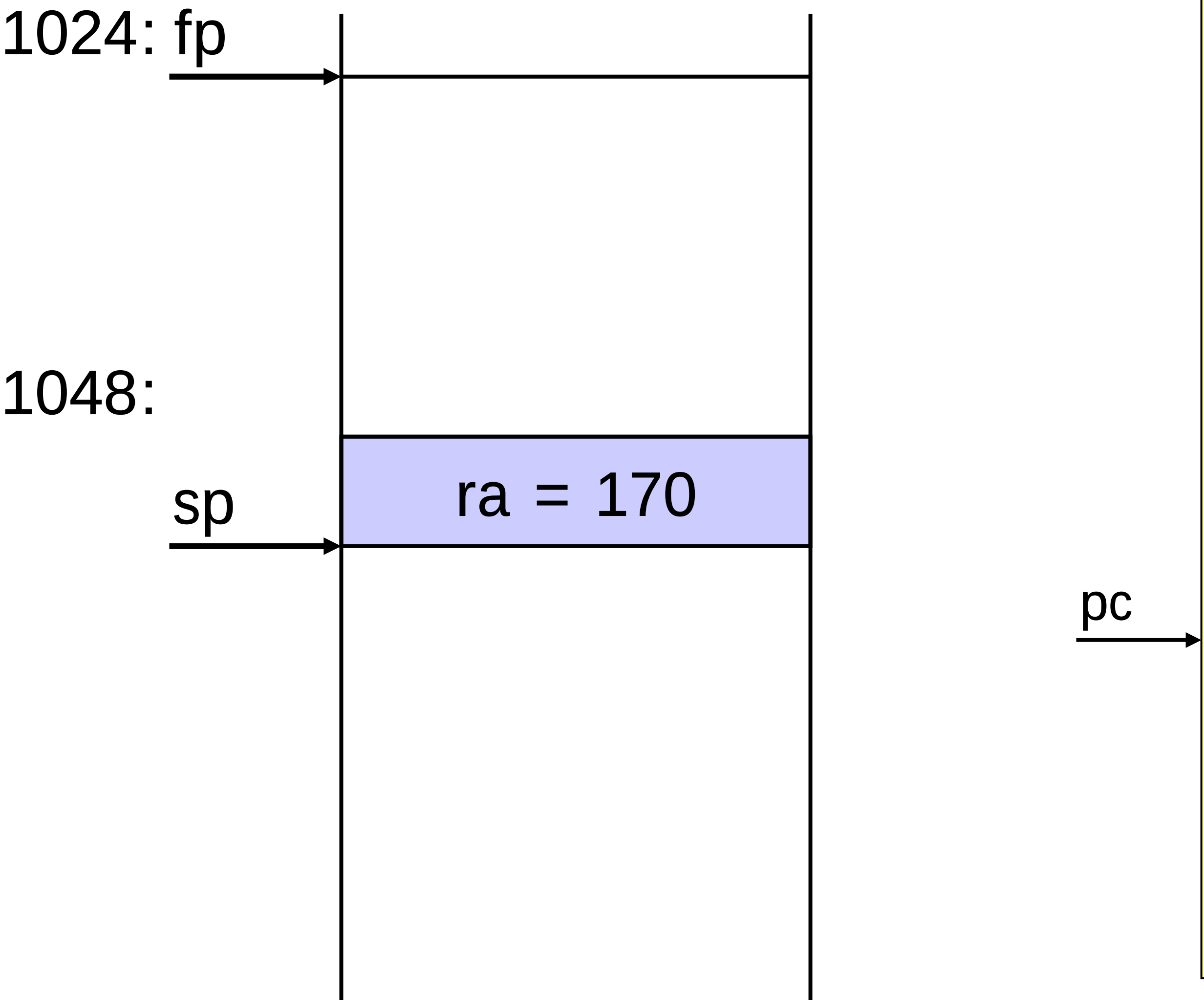
Methodenaufruf m1



pc

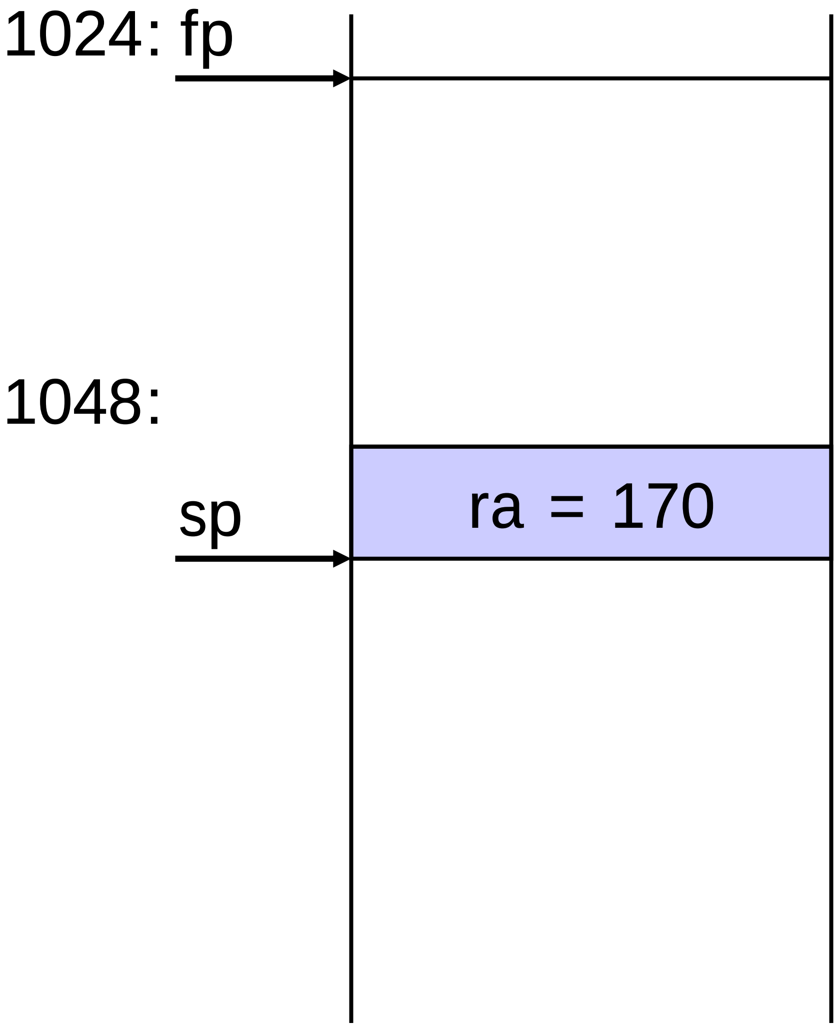
```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

Methodenaufruf m1



```
  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


1024: fp

1048:

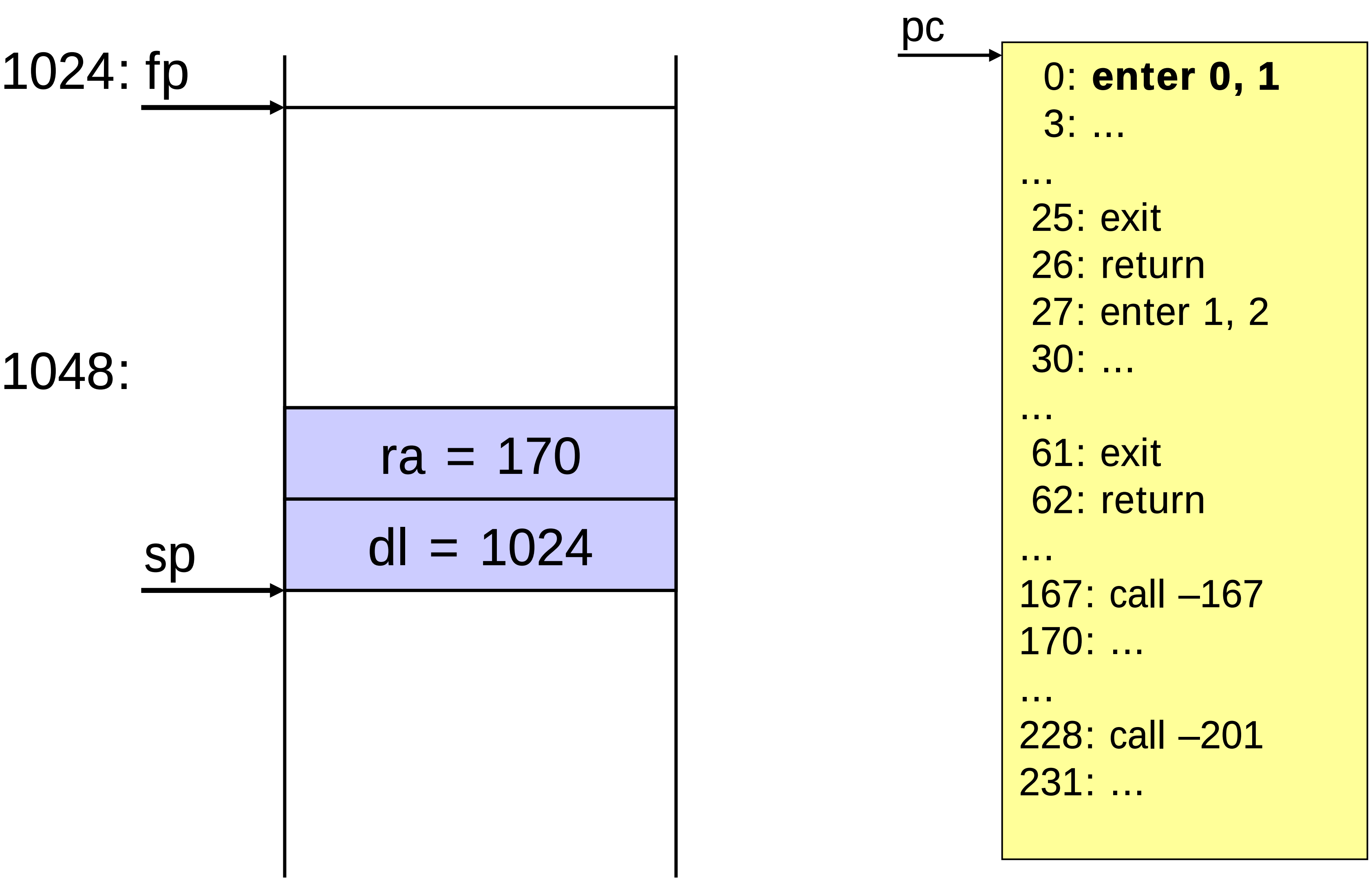
sp

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: ...
```

Einsprung in Methode m1



1024: fp

1048:

ra = 170

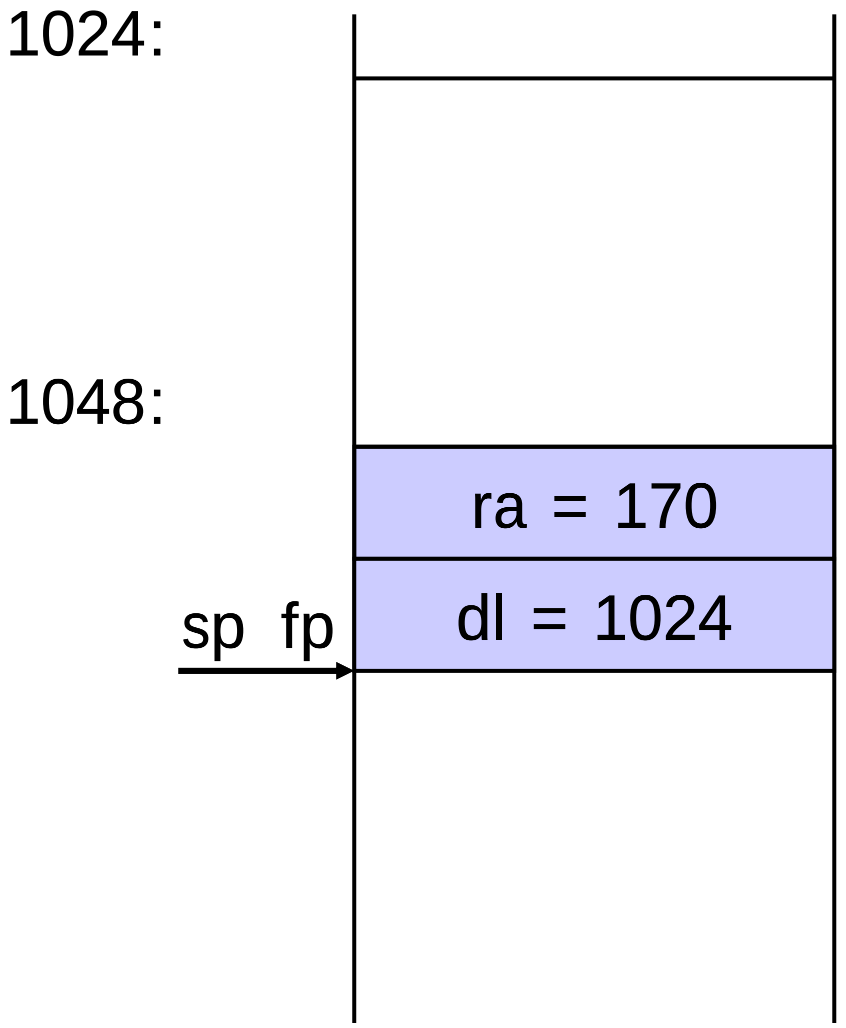
dl = 1024

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: ...
```

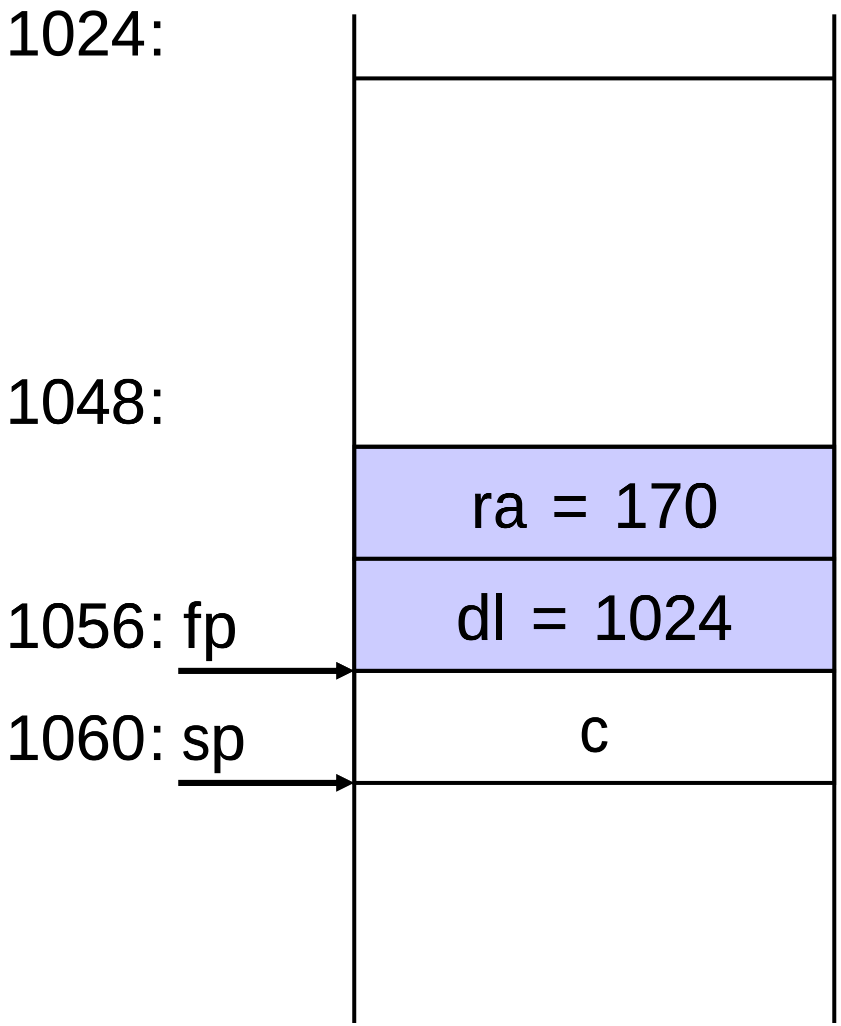
Einsprung in Methode m1



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: ...
```

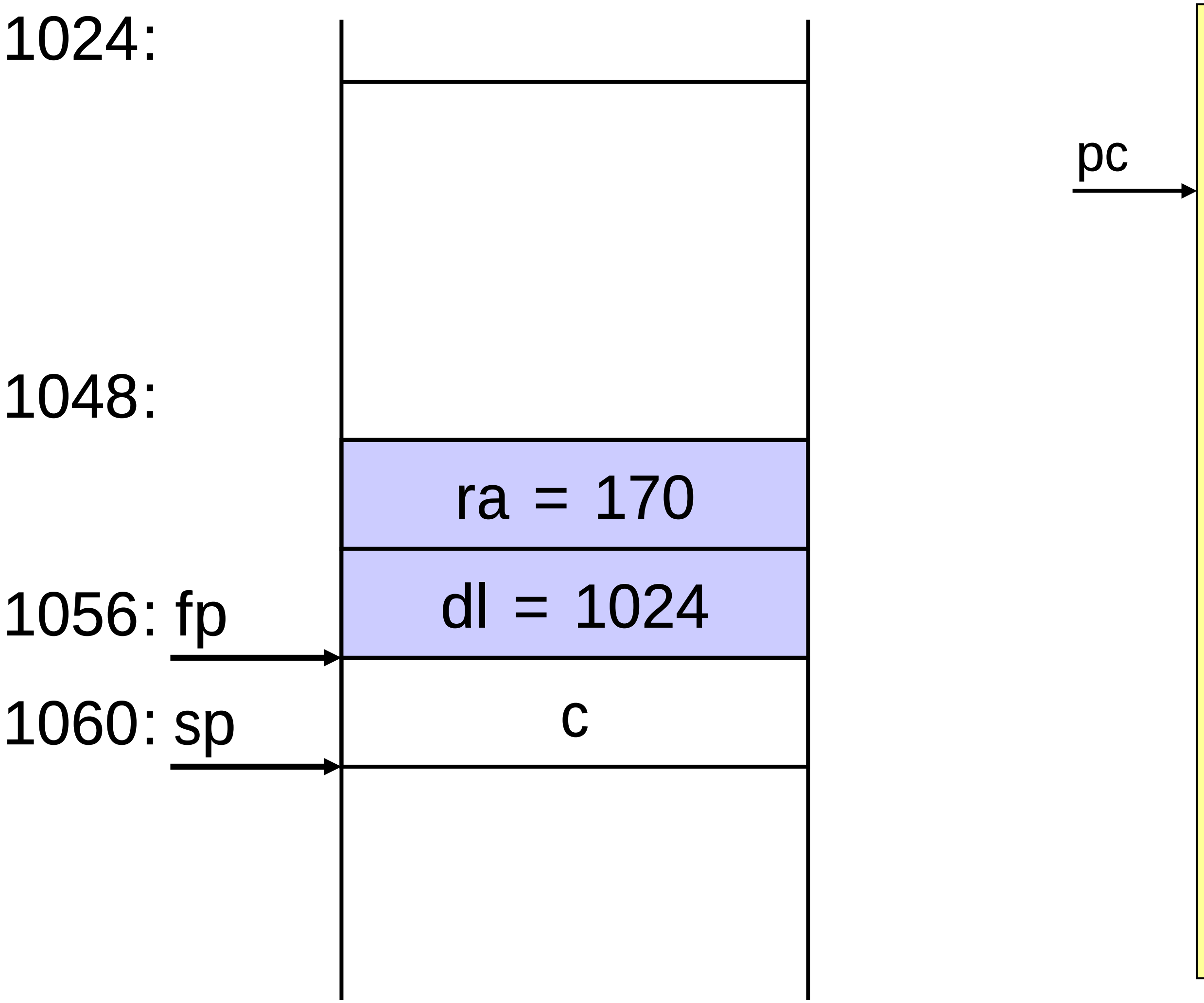
Einsprung in Methode m1



pc

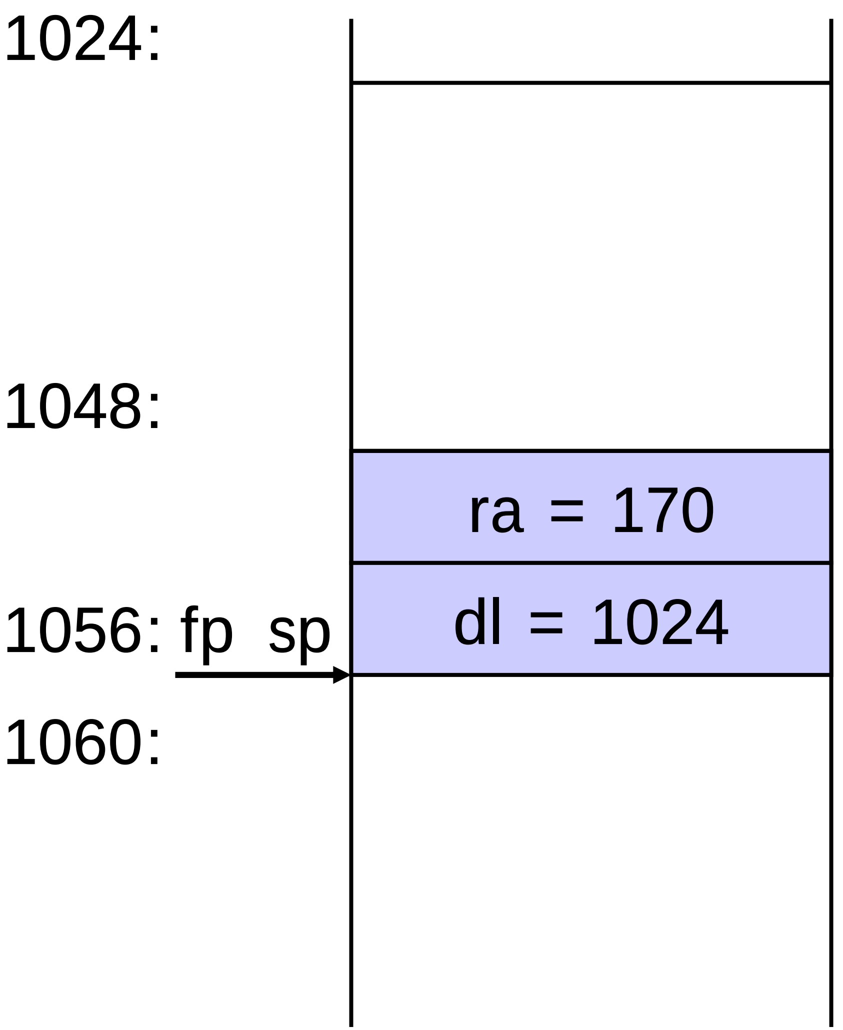
```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

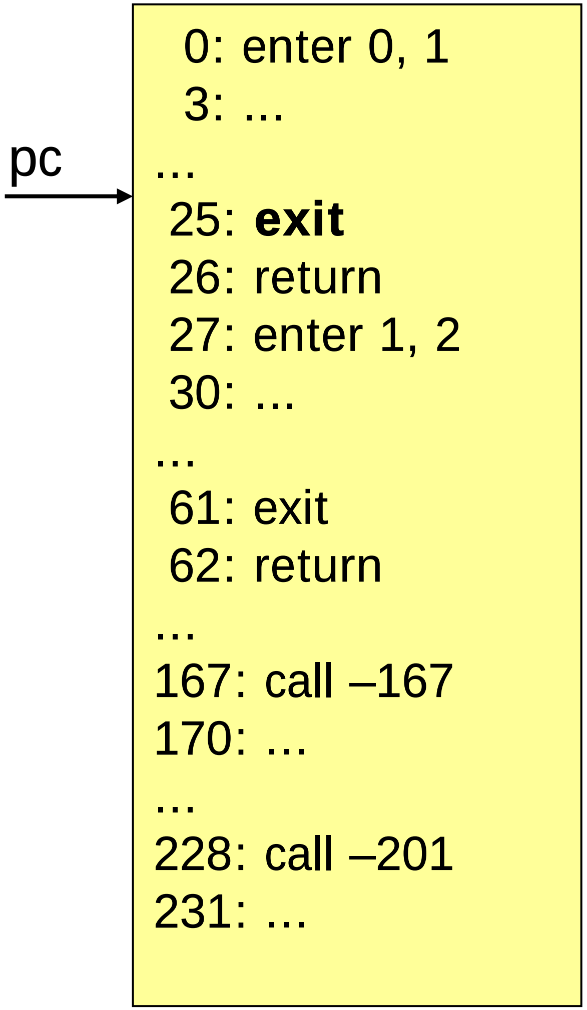
Ende der Methode m1



```
  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: ...
```

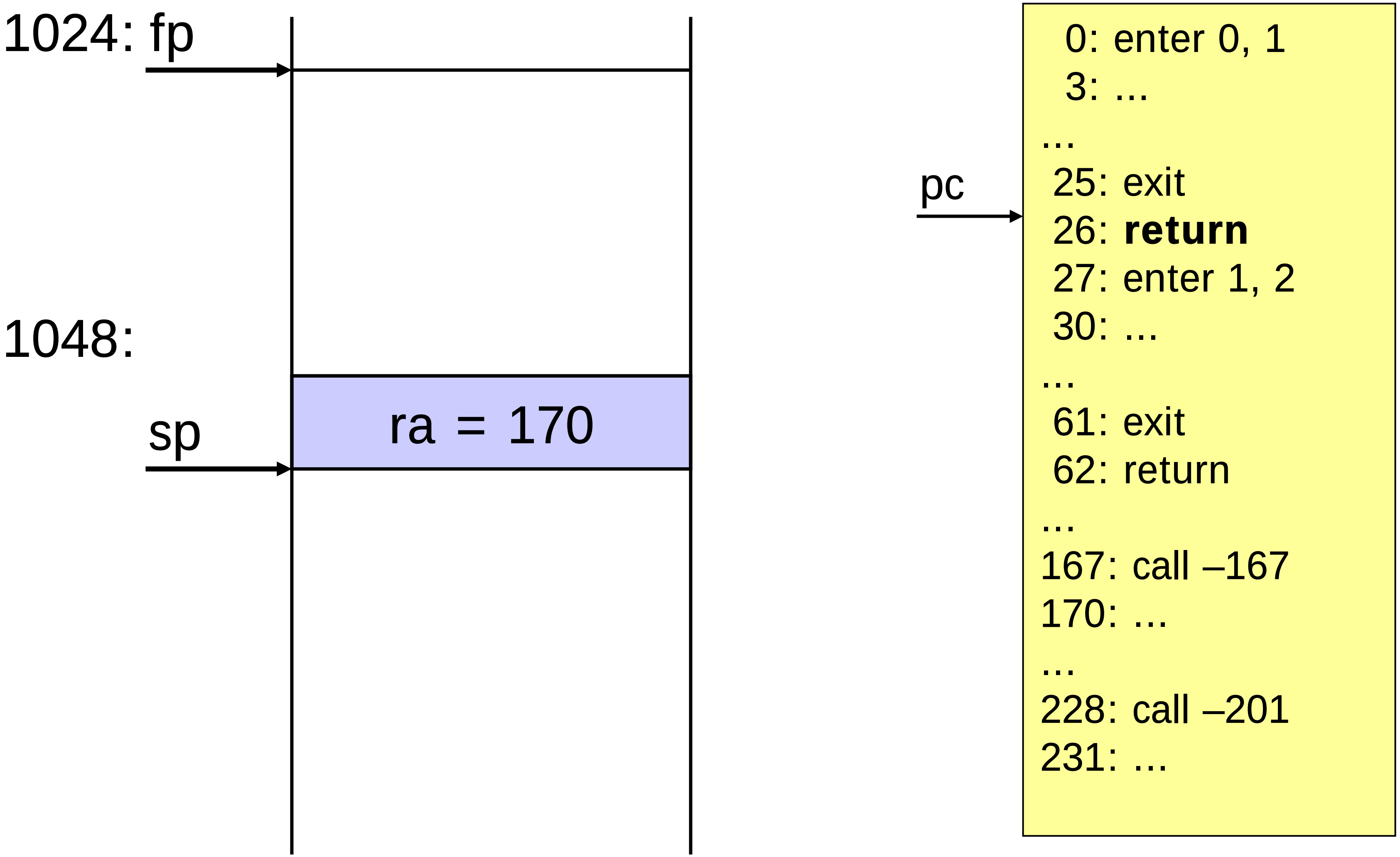
Ende der Methode m1





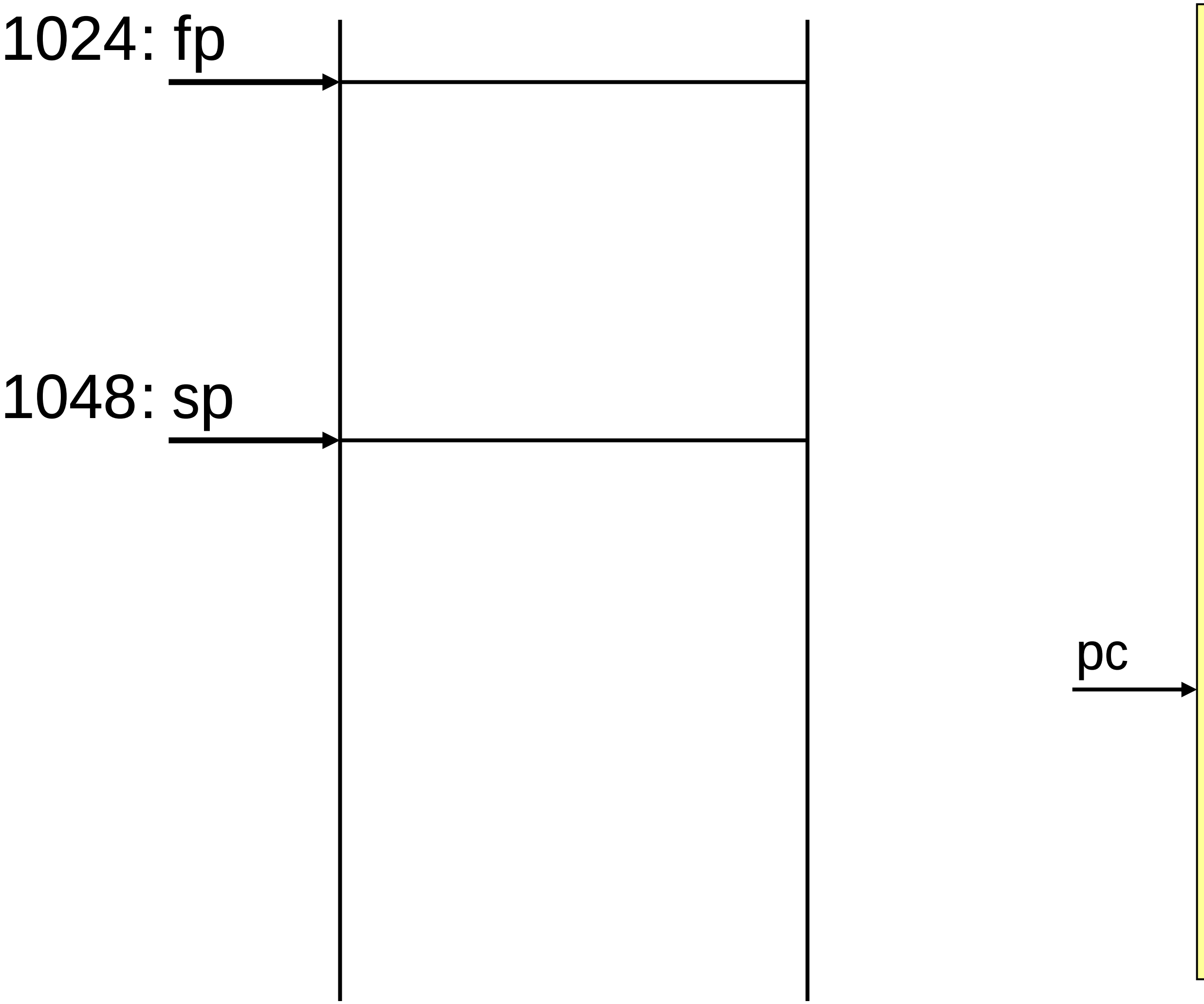
```
  0: enter 0, 1
  3: ...
...
 25: exit
 26: return
 27: enter 1, 2
 30: ...
...
 61: exit
 62: return
...
167: call –167
170: ...
...
228: call –201
231: ...
```

Rücksprung zum Rufer der Methode m1



```
  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



```
  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
    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
    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
    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:   ...
```