Teil 8: Dynamische Strukturen

Gliederung

Datenabstraktion

Stack

Queue

Verkettete Liste

Binärer Suchbaum

Motivation

```
typedef struct
{
    char name[20];
    char vorname[20];
    unsigned int ma_nummer;
    float gehalt;
} MITARBEITER;
```

Problem: Wie kann man eine Beliebige Anzahl von Strukturen des Typs `MITARBEITER` effizient verwalten?

Bedingungen:

- Anzahl der Strukturen variabel
- Speicher effizient verwenden
- schneller Zugriff

Statisches Array

```
MITARBEITER ma_datenbank[200];
```

char name[20]	char name[20]	char name[20]	char name[20]
char vorname[20]	char vorname[20]	char vorname[20]	char vorname[20]
unsigned int ma_nummer;	unsigned int ma_nummer;	unsigned int ma_nummer;	unsigned int ma_nummer;
float gehalt;	float gehalt;	float gehalt;	float gehalt;

...

Statisches Array

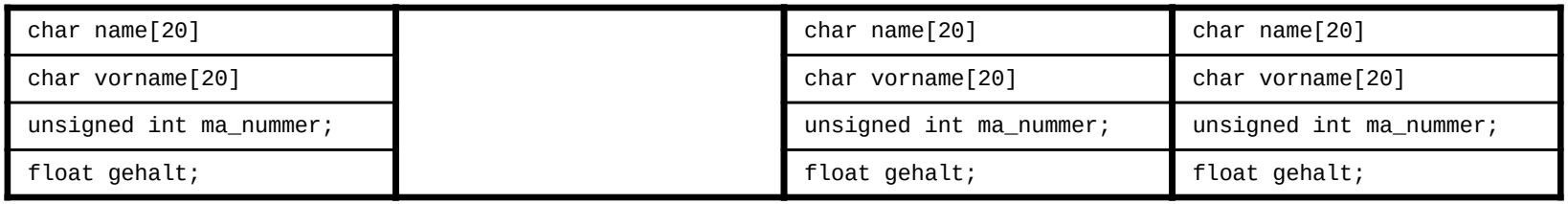
```
MITARBEITER ma_datenbank[200];
```

char name[20]	char name[20]	char name[20]	char name[20]
char vorname[20]	char vorname[20]	char vorname[20]	char vorname[20]
unsigned int ma_nummer;	unsigned int ma_nummer;	unsigned int ma_nummer;	unsigned int ma_nummer;
float gehalt;	float gehalt;	float gehalt;	float gehalt;

...

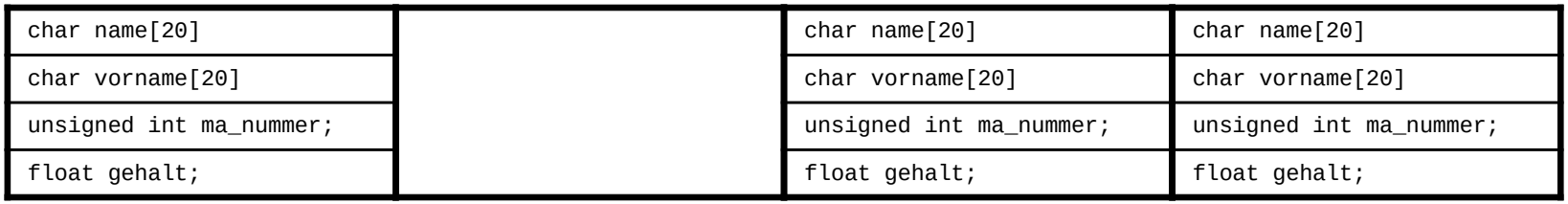
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



Statisches Array

```
MITARBEITER ma_datenbank[200];
```

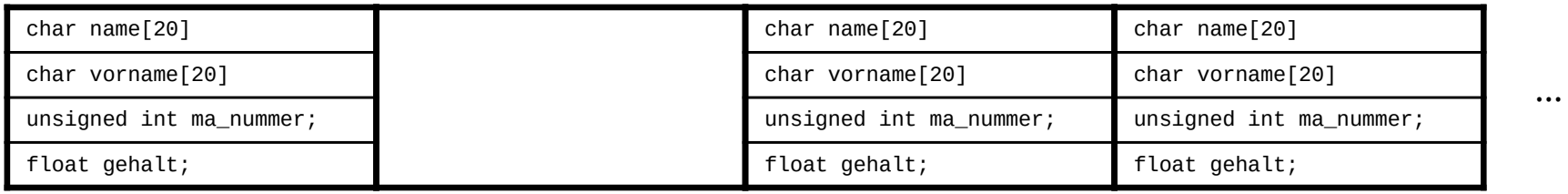


Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```

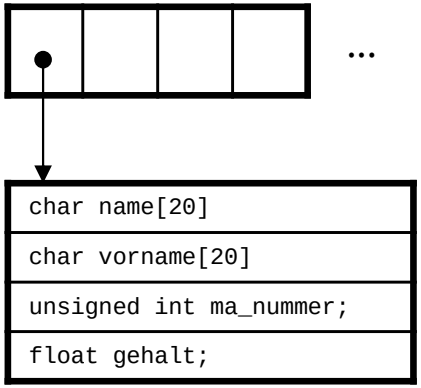
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



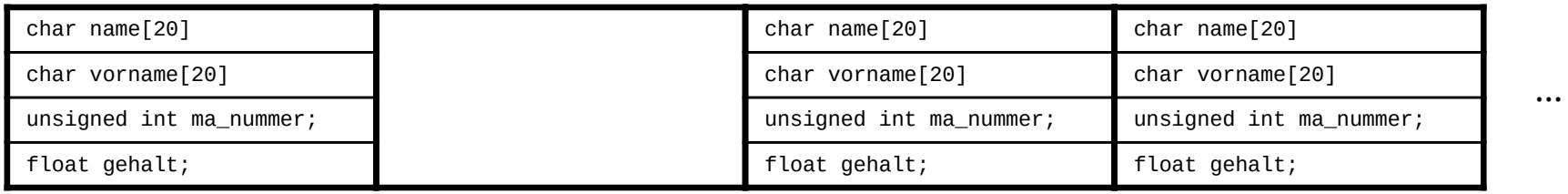
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



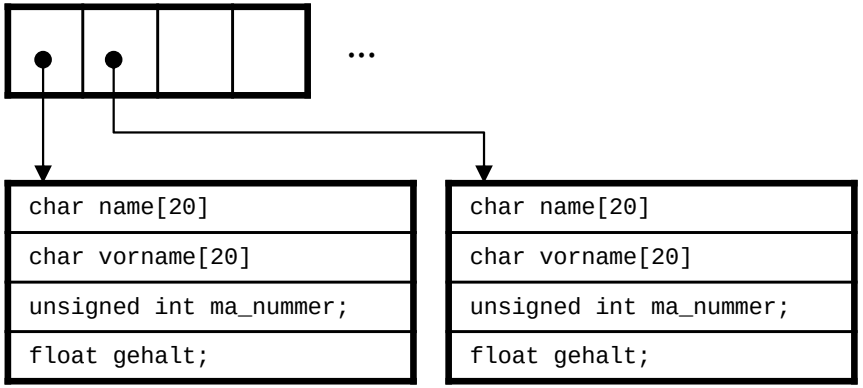
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



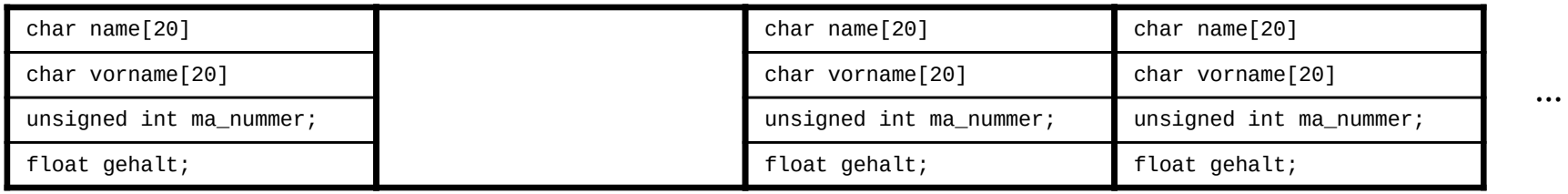
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



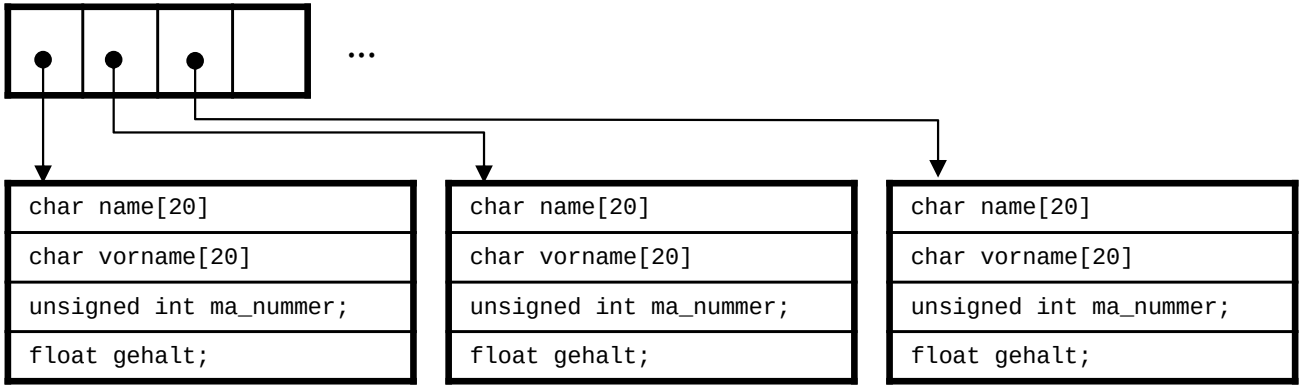
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



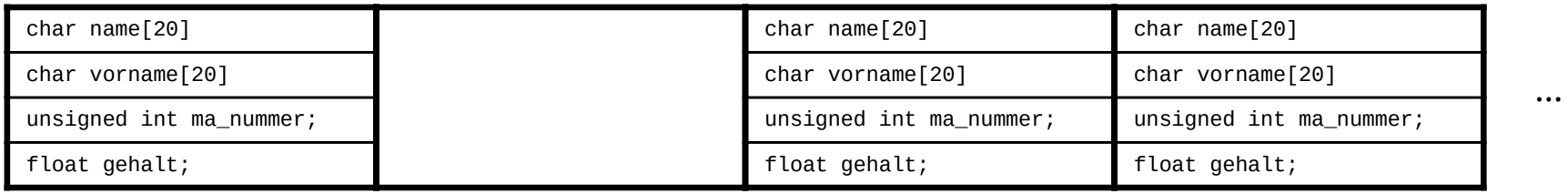
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



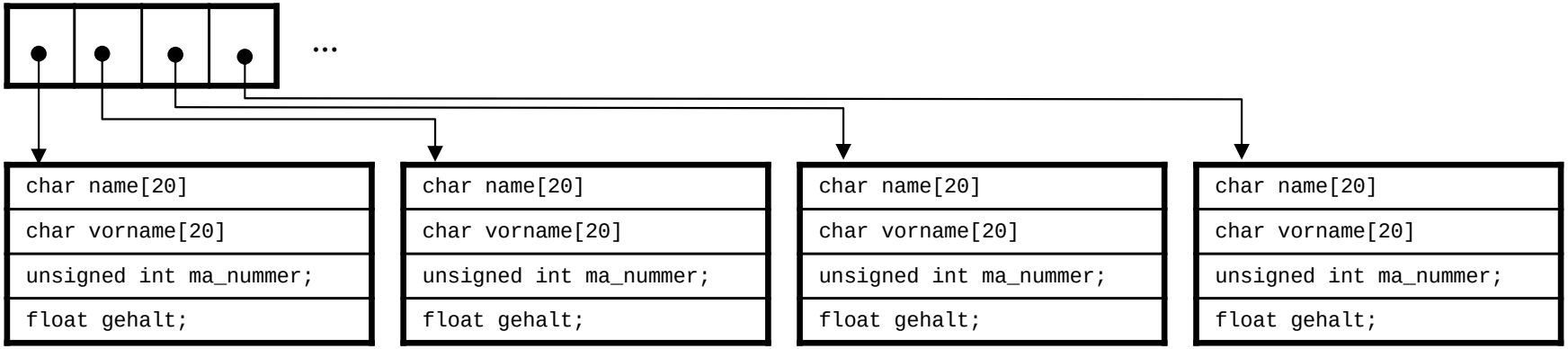
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



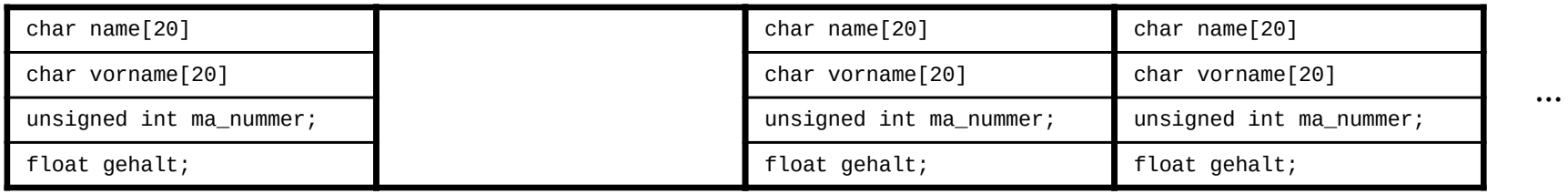
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



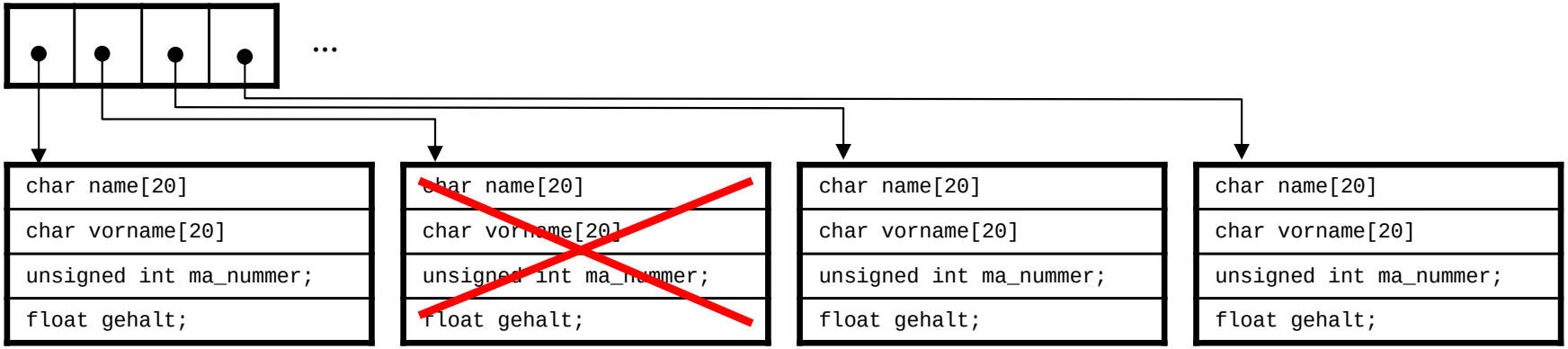
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



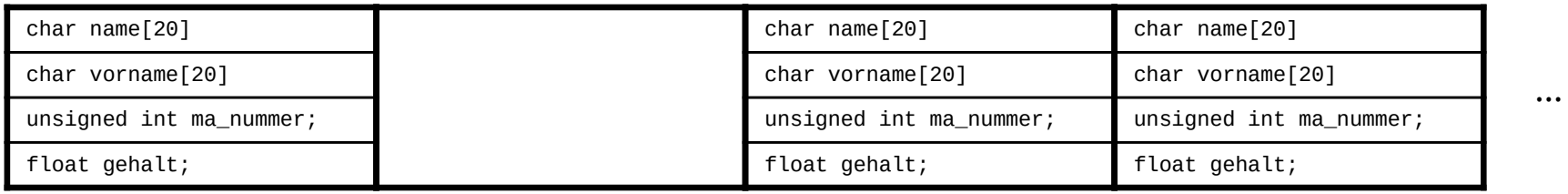
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



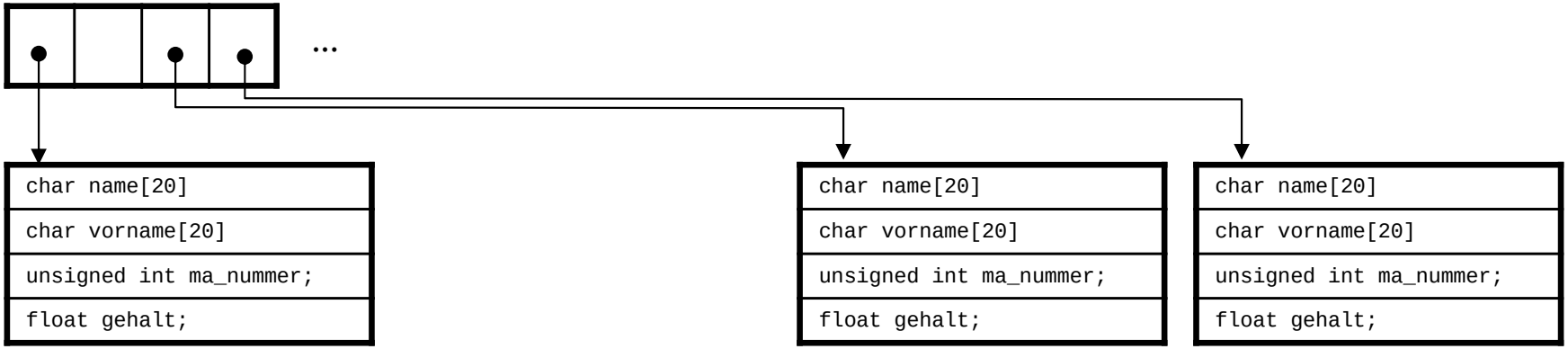
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



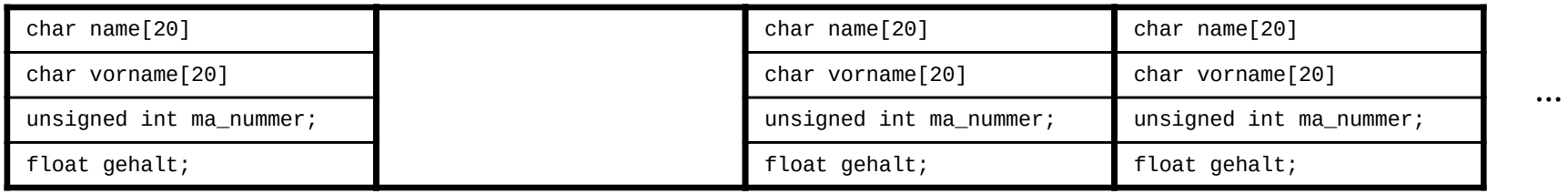
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



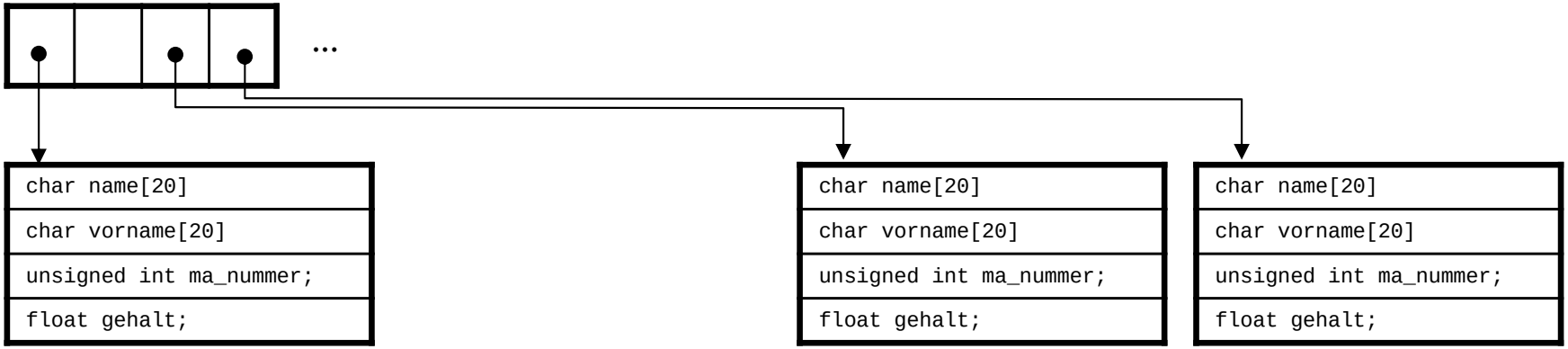
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```

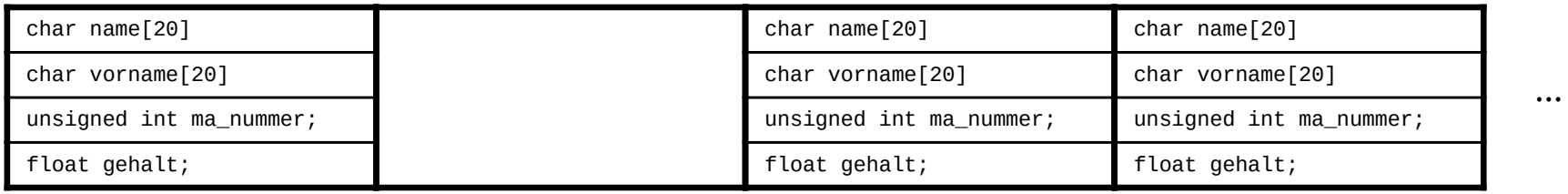


Verkettete Liste

```
MITARBEITER *ma_liste;
```

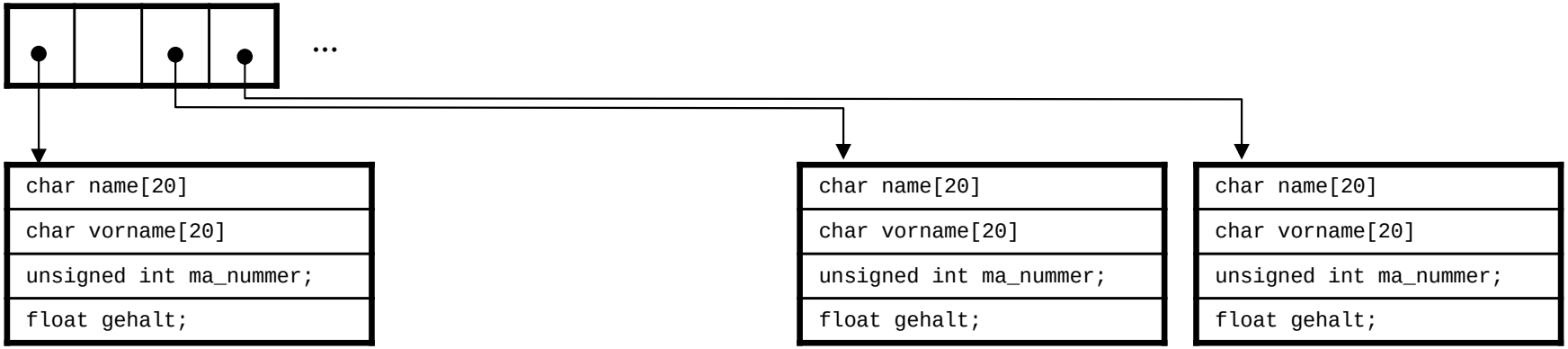
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



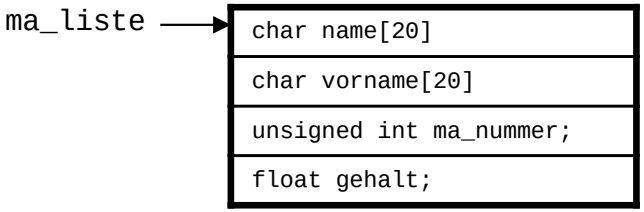
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



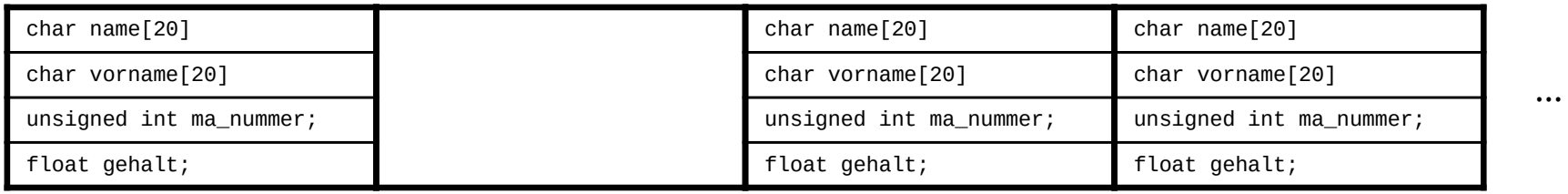
Verkettete Liste

```
MITARBEITER *ma_liste;
```



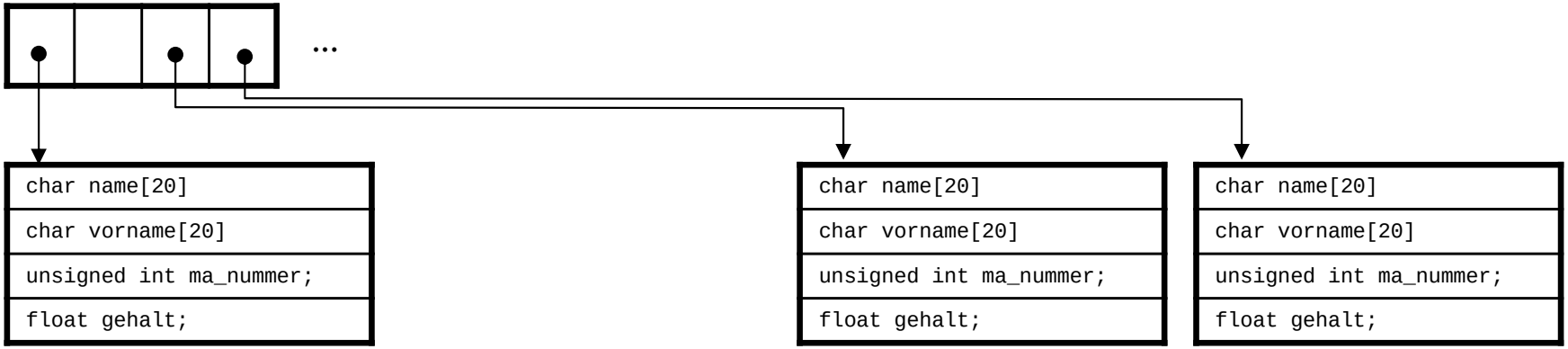
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



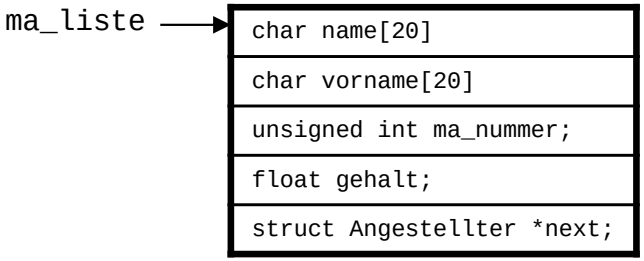
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



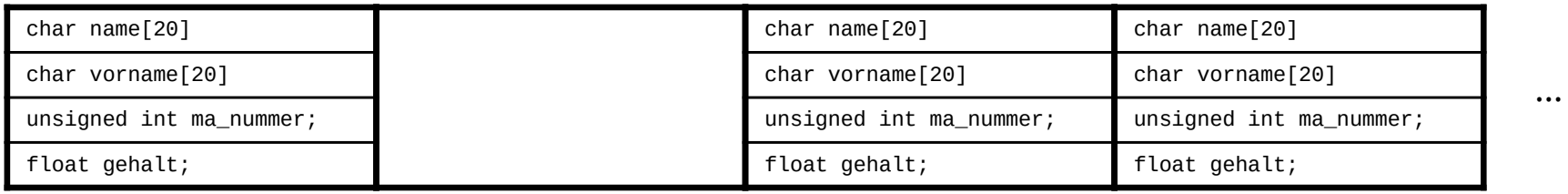
Verkettete Liste

```
MITARBEITER *ma_liste;
```



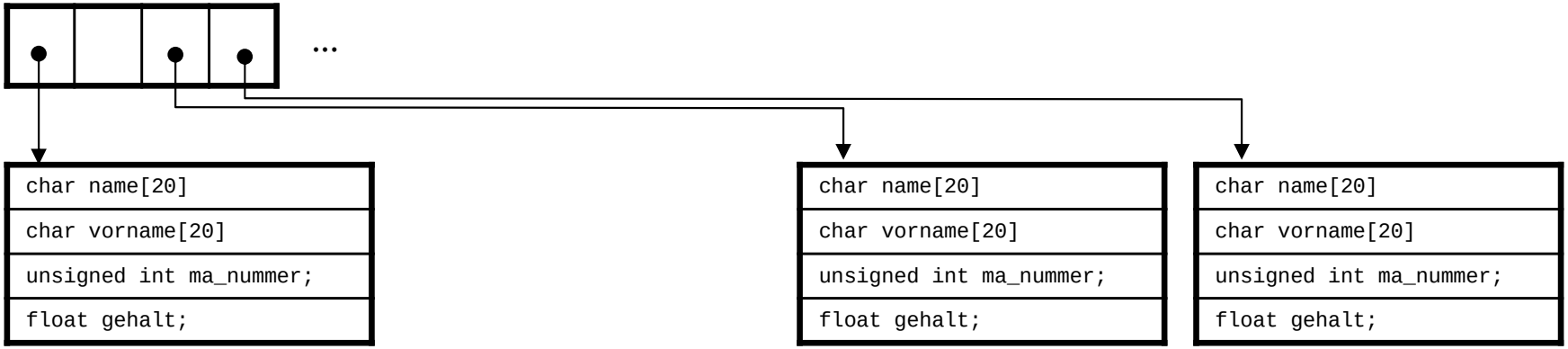
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



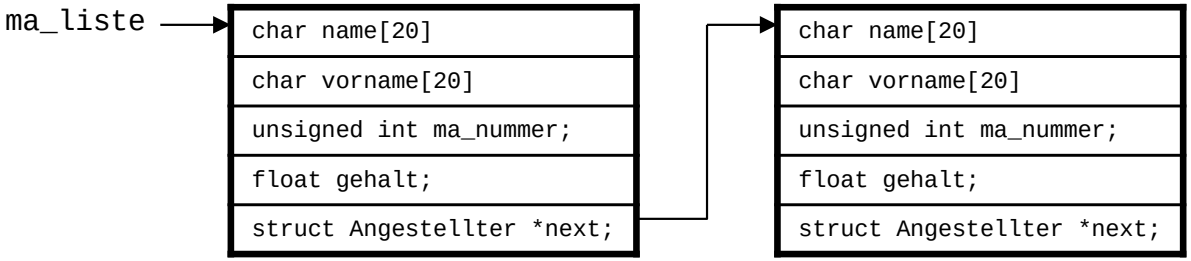
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



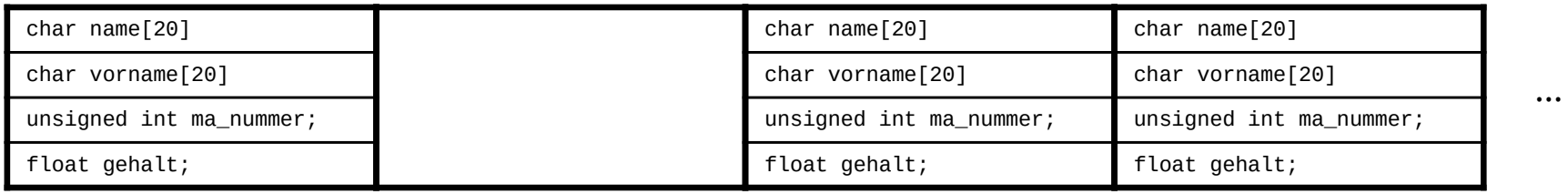
Verkettete Liste

```
MITARBEITER *ma_liste;
```



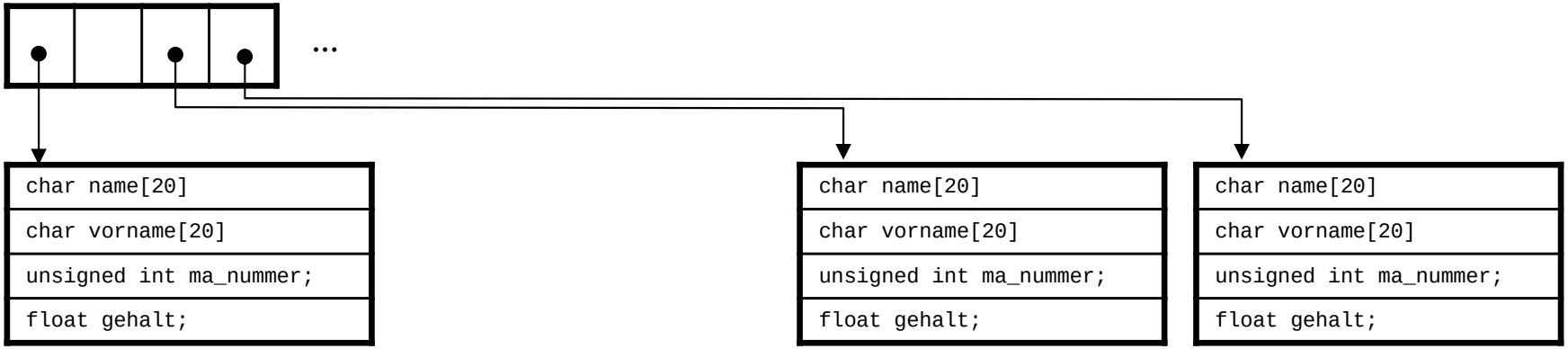
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



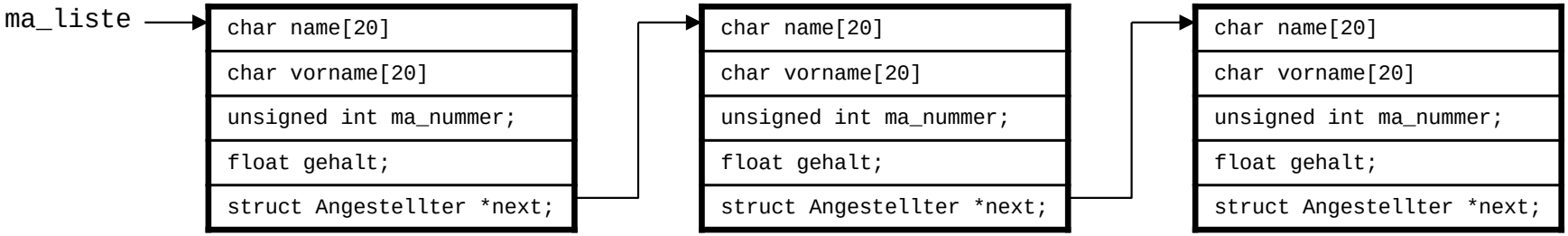
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



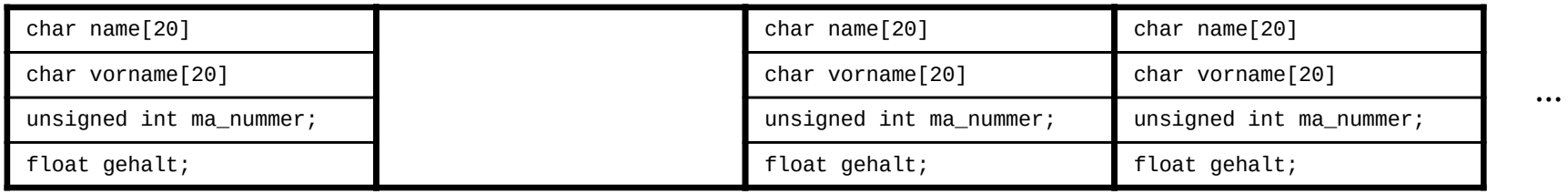
Verkettete Liste

```
MITARBEITER *ma_liste;
```



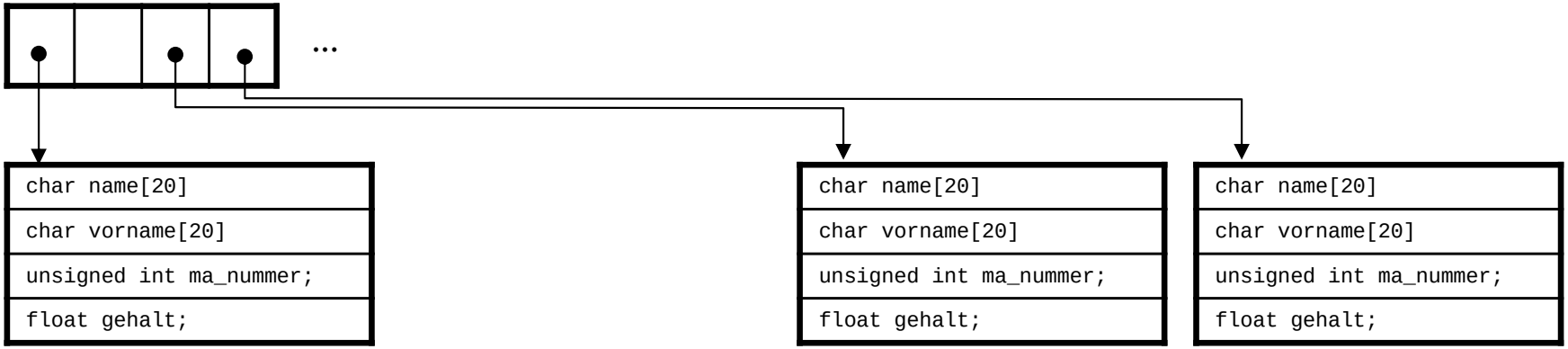
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



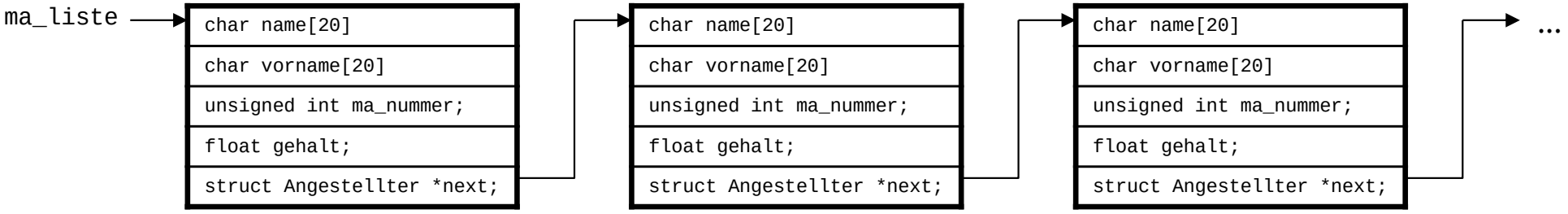
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



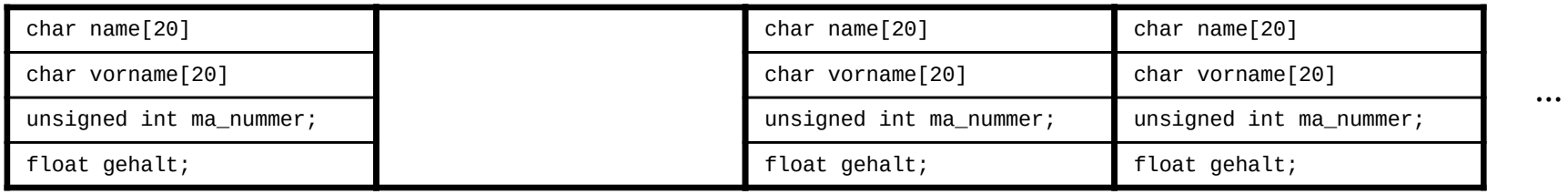
Verkettete Liste

```
MITARBEITER *ma_liste;
```



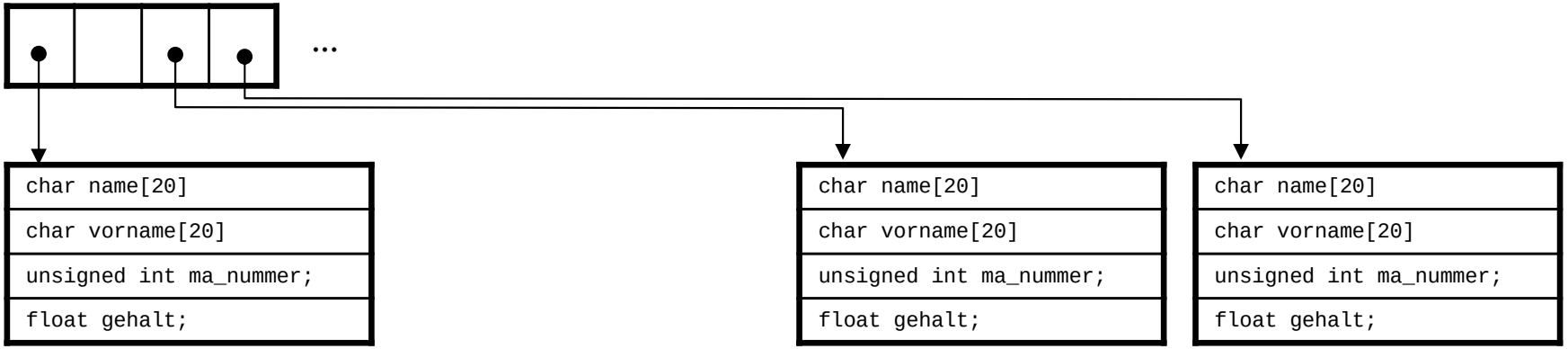
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



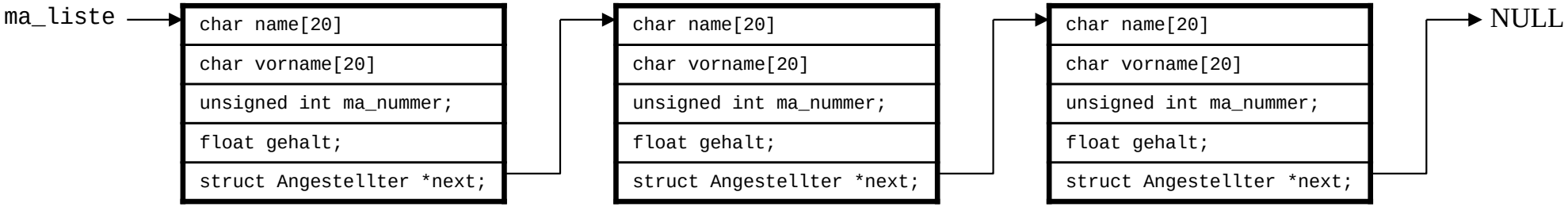
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



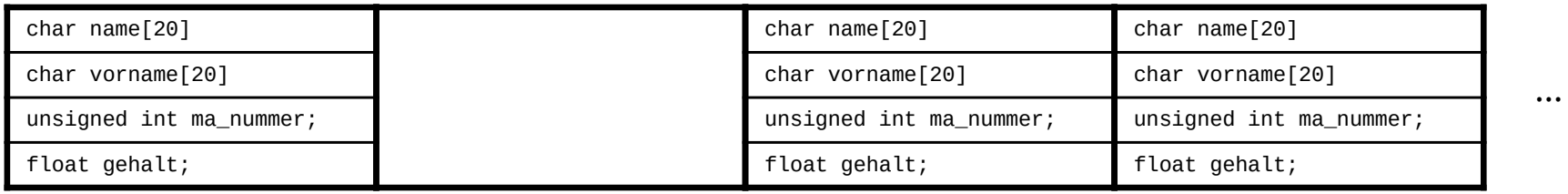
Verkettete Liste

```
MITARBEITER *ma_liste;
```



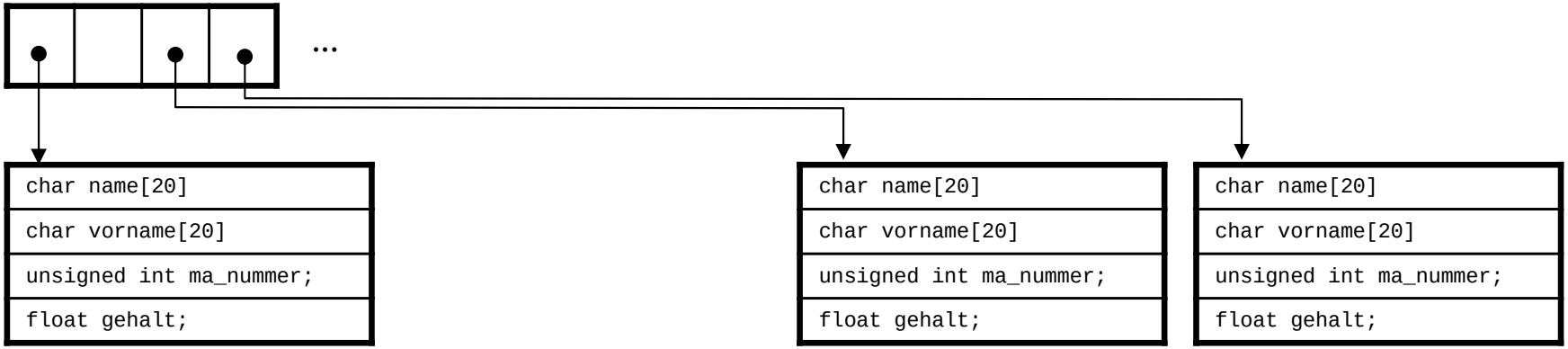
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



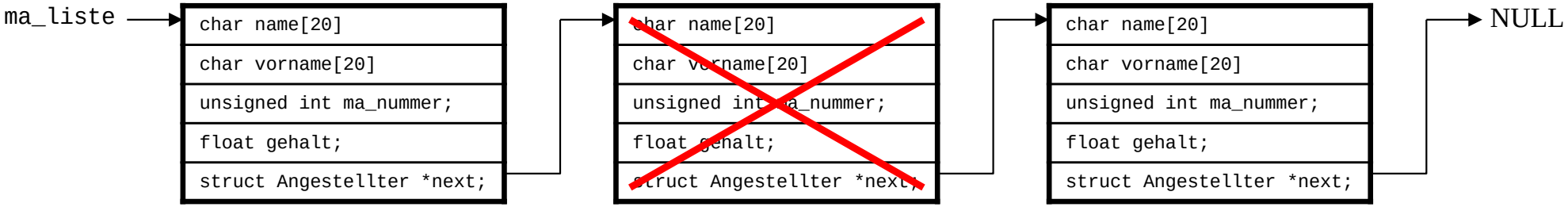
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



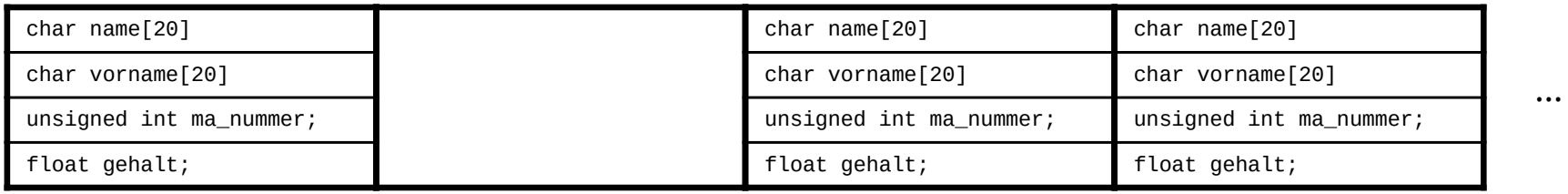
Verkettete Liste

```
MITARBEITER *ma_liste;
```



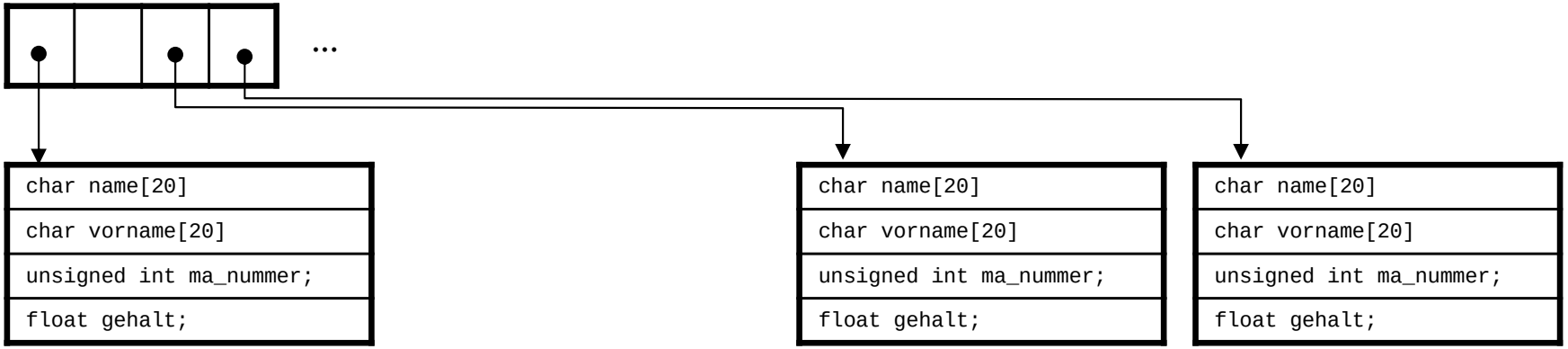
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```

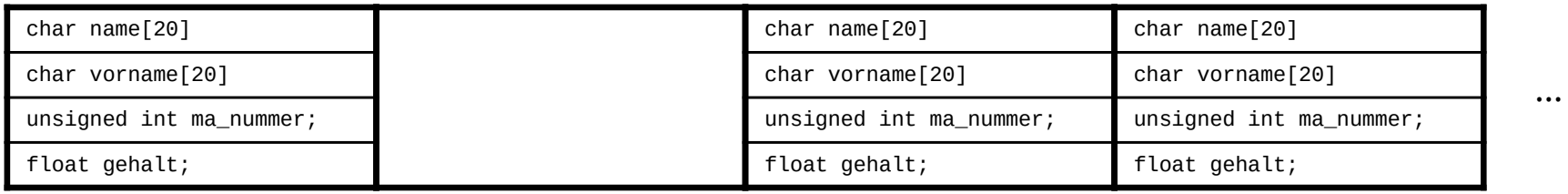


Verkettete Liste

```
MITARBEITER *ma_liste;
```

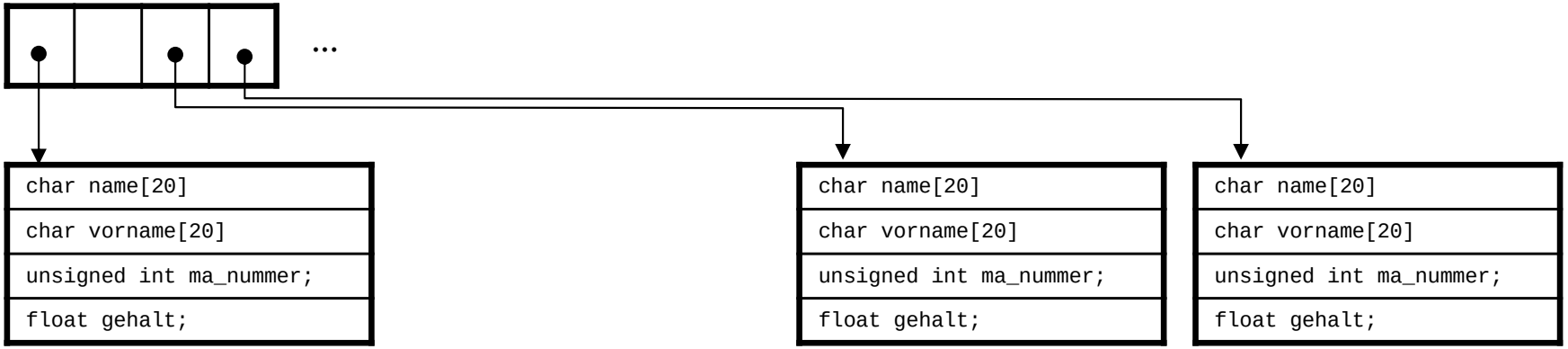
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



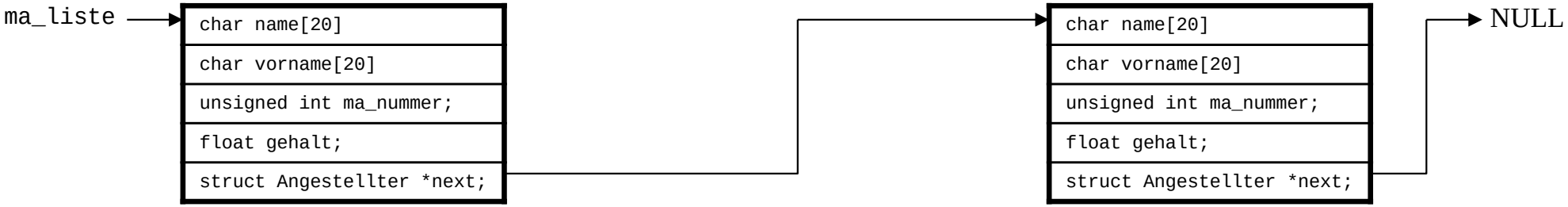
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```



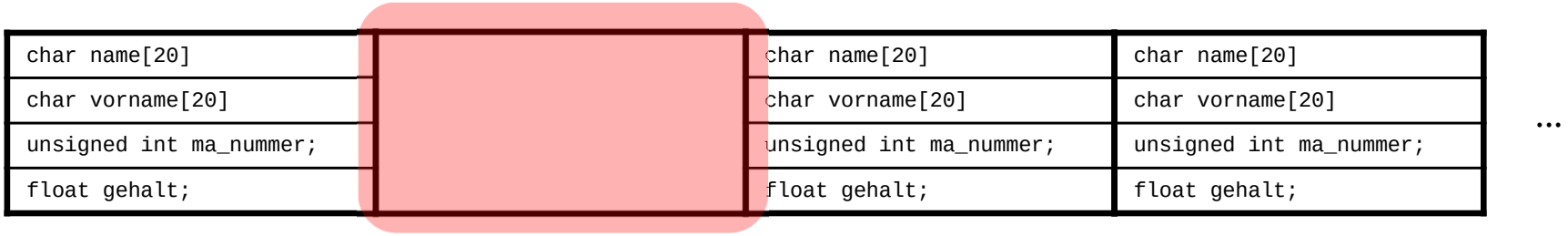
Verkettete Liste

```
MITARBEITER *ma_liste;
```



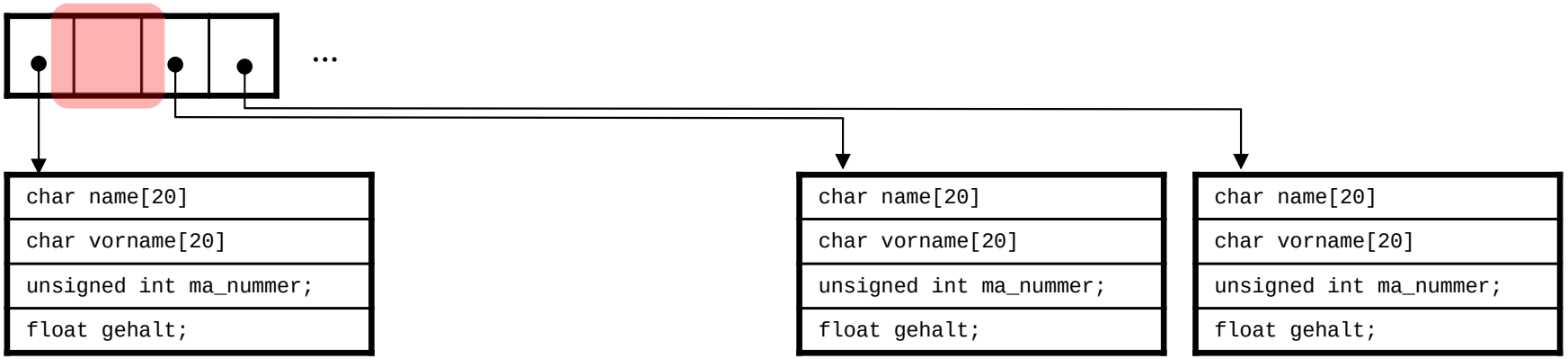
Statisches Array

```
MITARBEITER ma_datenbank[200];
```



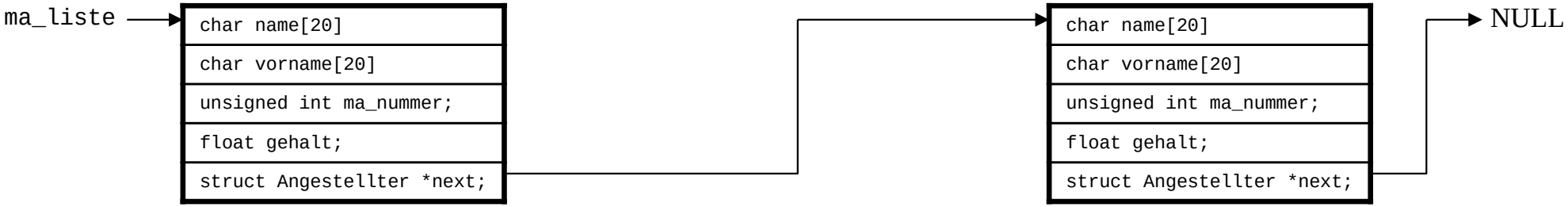
Zeiger-Array

```
MITARBEITER *ma_datenbank[200];
```

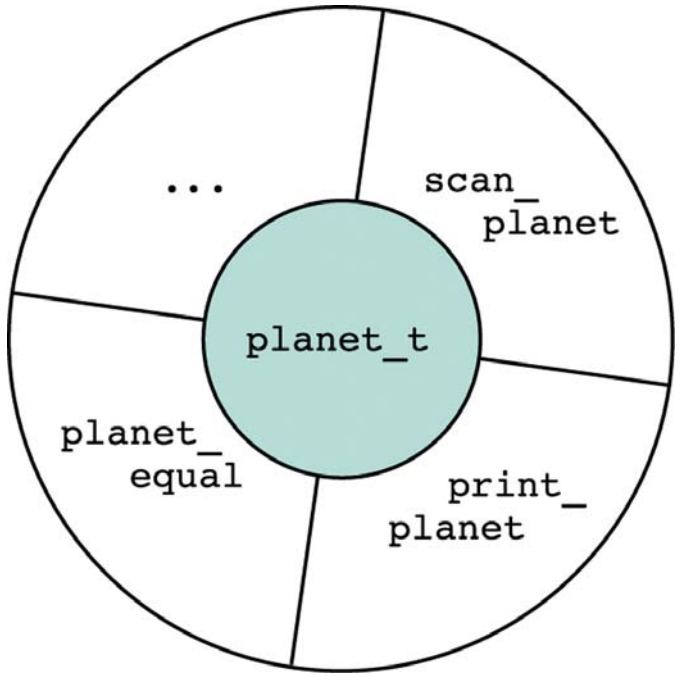


Verkettete Liste

```
MITARBEITER *ma_liste;
```

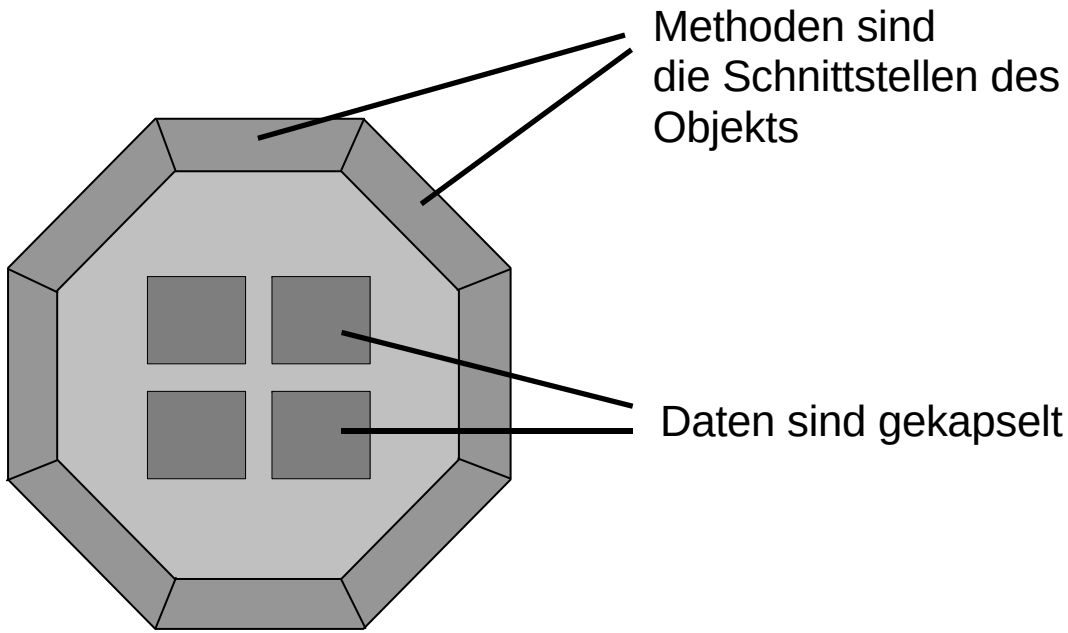


Datenabstraktion

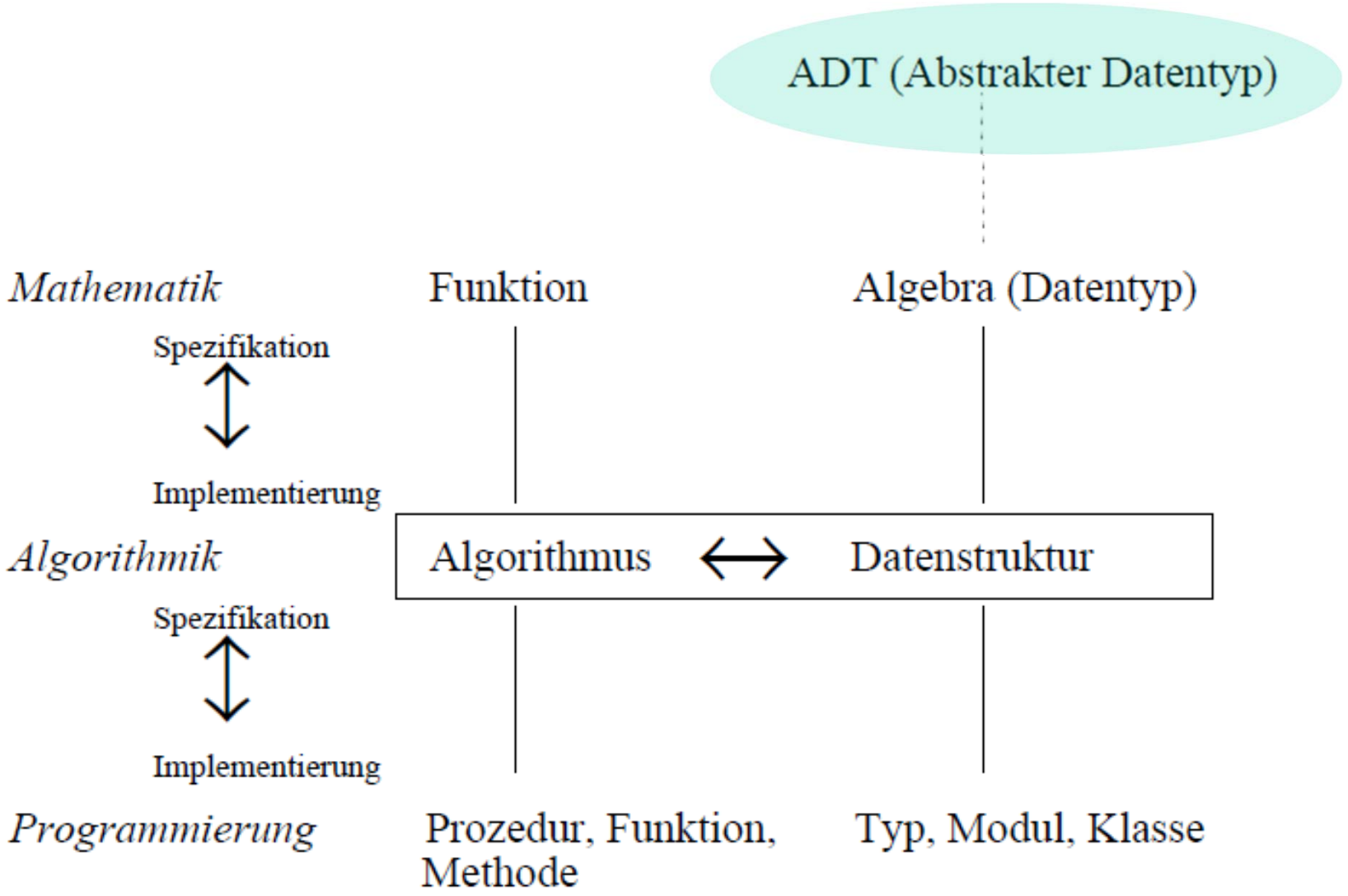


Datenabstraktion

- Im Gegensatz zu Datentypen und Datenstrukturen, die eher physikalisch definiert werden, gibt man bei einem **Abstrakten Datentyp** nur die Operationen an, die mit ihm ausgeführt werden können sollen.
- **Abstrakter Datentyp** (ADT)
  - Spezifikation durch seine (öffentlich bekannten) Operationen
  - Interne Darstellung und Implementierung bleiben verborgen



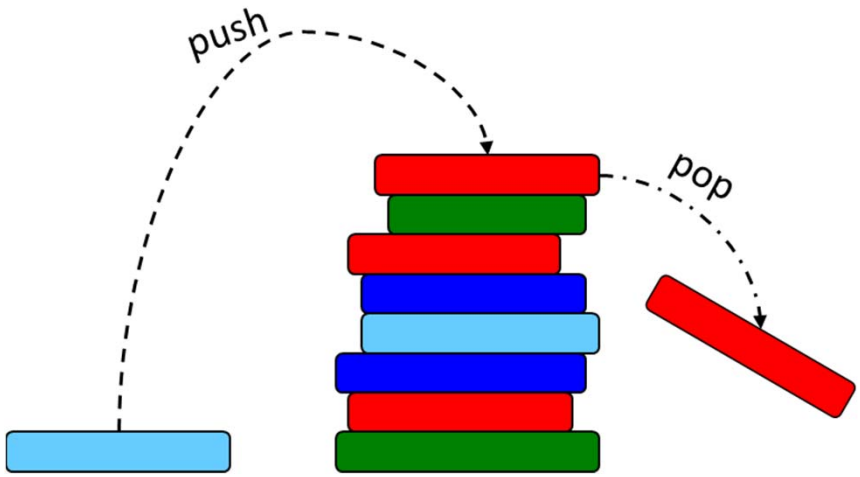
Abstraktionsebenen



Stack

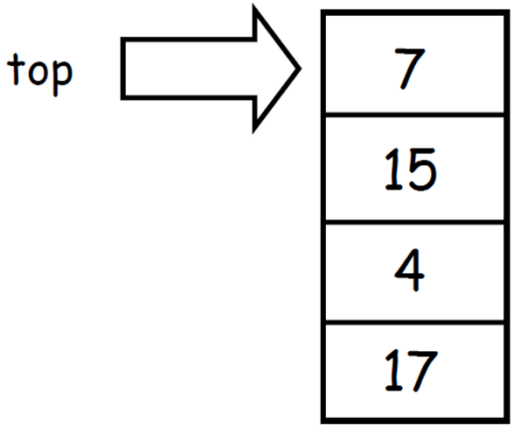
Stack (Stapel, Keller)

- Daten-Pufferung nach dem **LIFO-Prinzip**
- Anwendung: Parameterablage bei Funktionsaufruf, Syntaxprüfung, etc.
- Operationen: `push()` fügt ein Element ein
  `pop()` entfernt ein Element

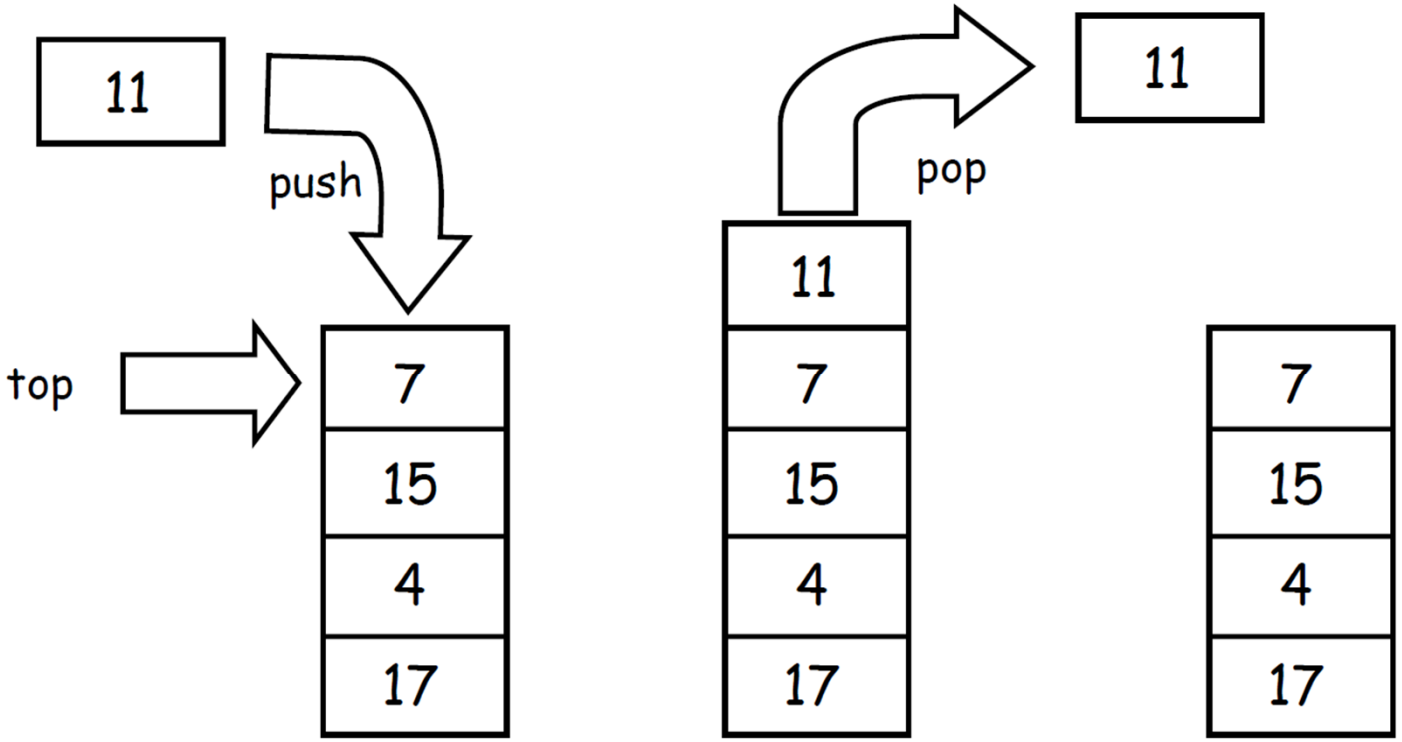


ggf. weitere: `init(), top(), empty()`

Stack (Stapel, Keller)



Stack (Stapel, Keller)



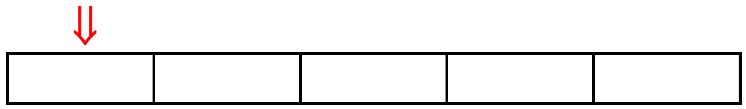
Stack: Beispiel-Implementierung

```
int stack[5], index = 0;
```

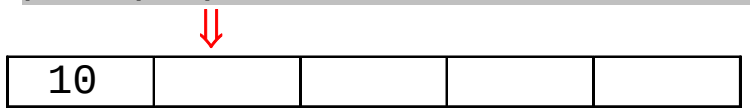
```
push(10);                                ⇐    10
push(14);                                ⇐    14
pop();                                   ⇒    14
pop();                                   ⇒    10
```

Stack: Beispiel-Implementierung

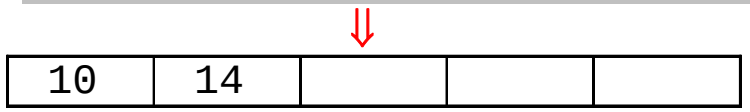
```
int stack[5], index = 0;
```



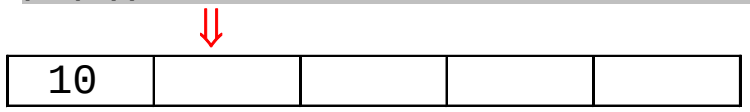
```
push(10);                                   ⇐ 10
```



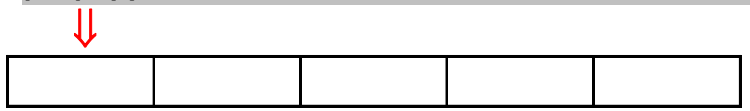

```
push(14);                                   ⇐ 14
```



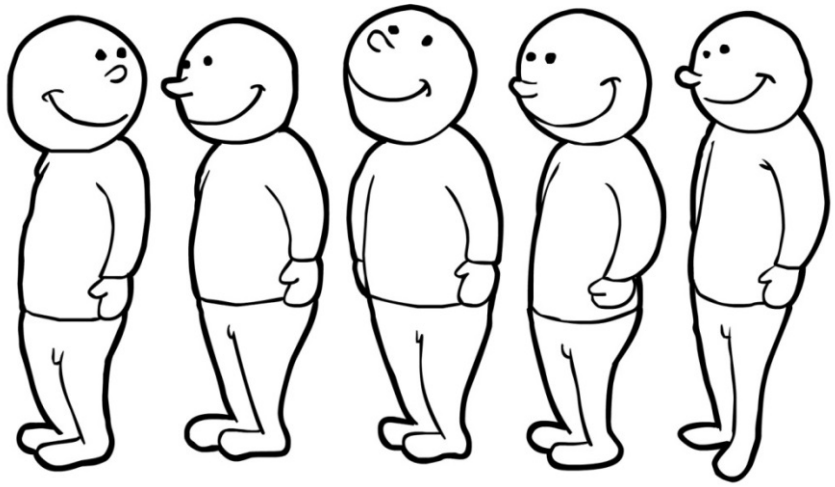

```
pop();                                      ⇒ 14
```




```
pop();                                      ⇒ 10
```

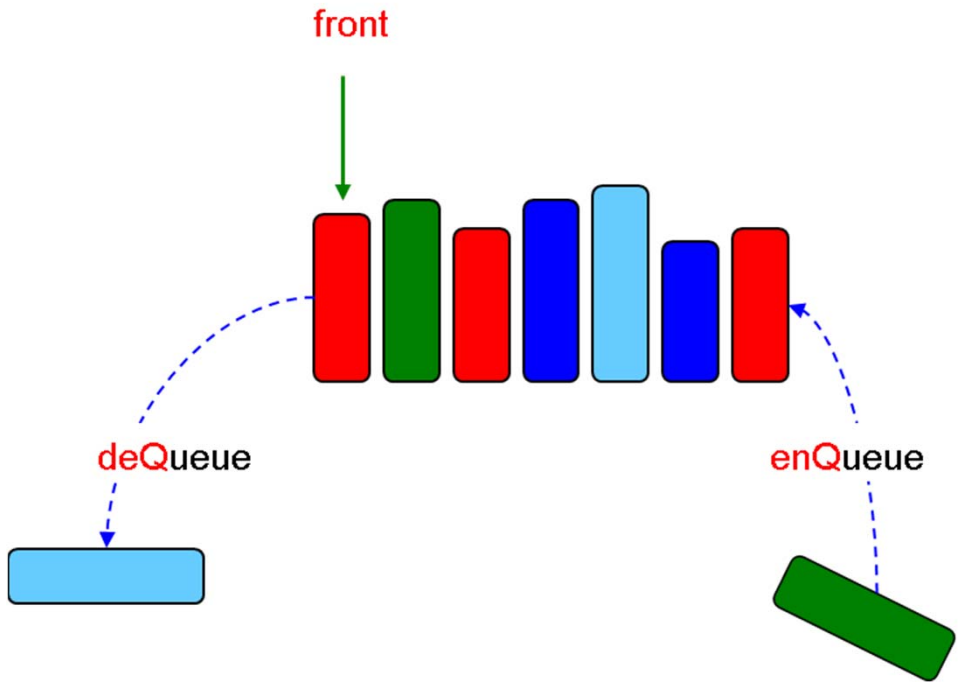


Queue

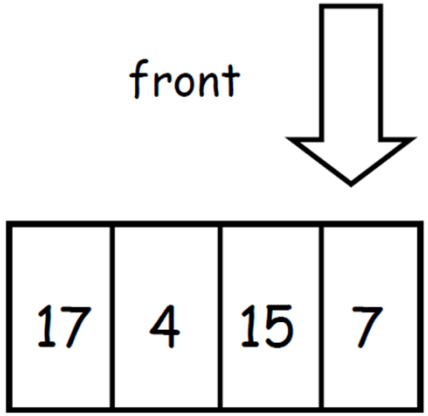


Queue (Reihe, Schlange)

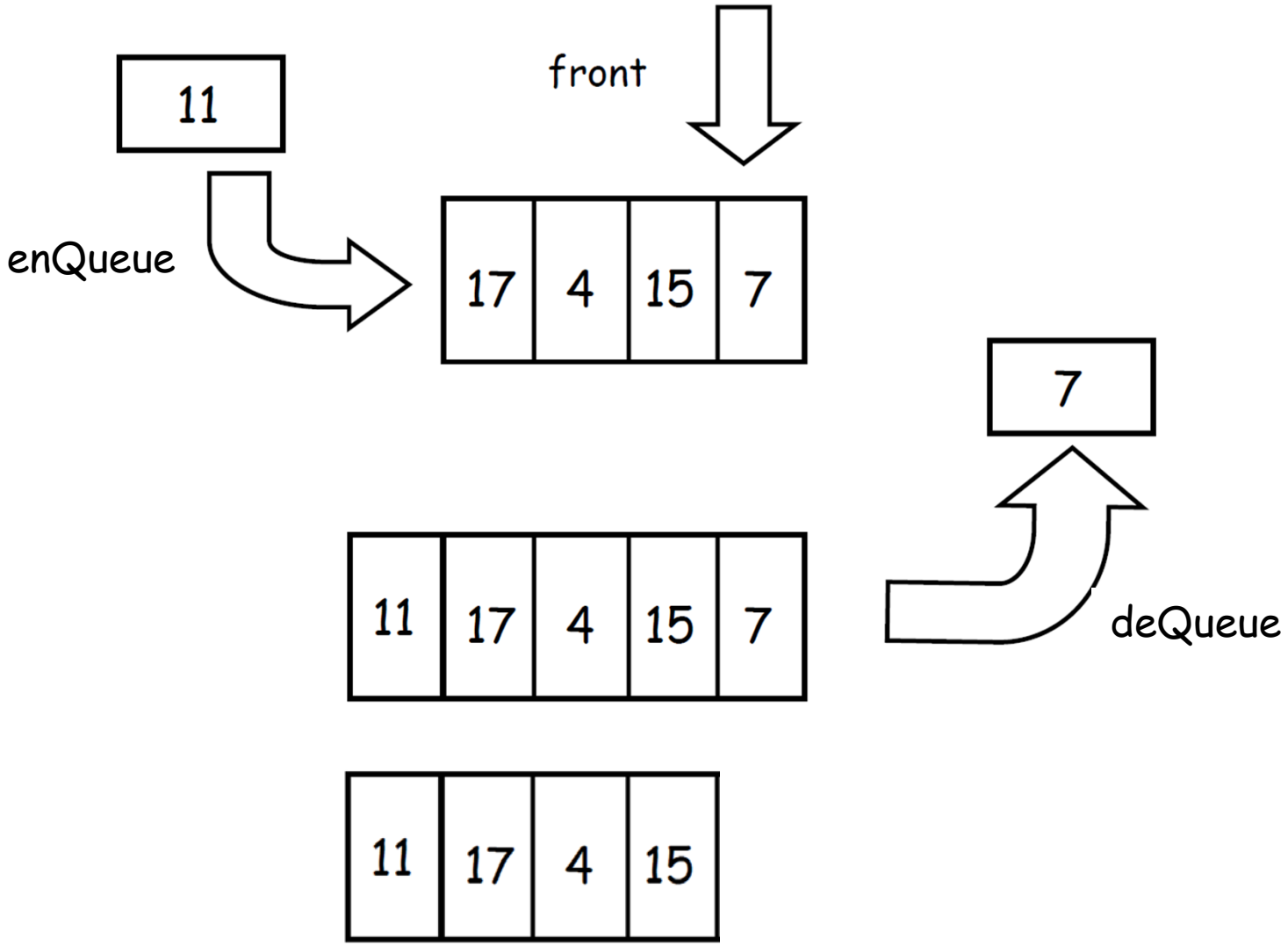
- Daten-Pufferung nach dem **FIFO-Prinzip**
- Bsp.: Ein-/Ausgabepuffer, Druckerwarteschlange
- Operationen: `enqueue()` fügt ein Element ein
  `dequeue()` entfernt ein Element



Queue (Reihe, Schlange)



Queue (Reihe, Schlange)

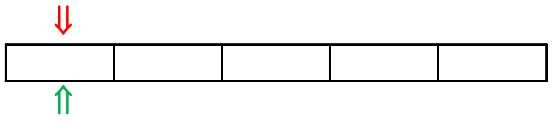


Queue: Beispiel-Implementierung

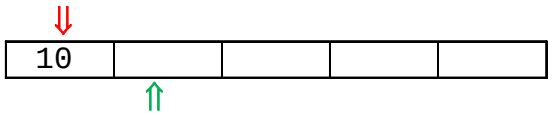
```
int queue[5], first = 0, last = 0;
enqueue(10);                                    ⇐ 10
enqueue(14);                                    ⇐ 14
enqueue(7);                                     ⇐ 7
dequeue();                                      ⇒ 10
dequeue();                                      ⇒ 14
```

Queue: Beispiel-Implementierung

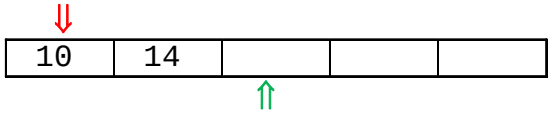
```
int queue[5], first = 0, last = 0;
```



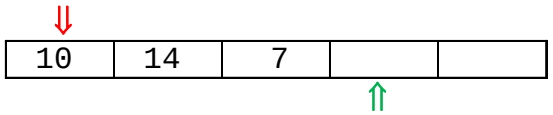

```
enqueue(10);                                    ⇐ 10
```



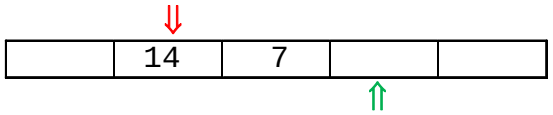

```
enqueue(14);                                    ⇐ 14
```



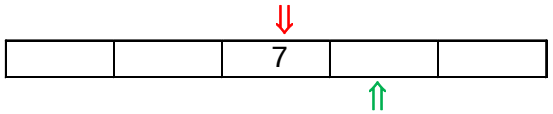

```
enqueue(7);                                     ⇐ 7
```




```
dequeue();                                      ⇒ 10
```




```
dequeue();                                      ⇒ 14
```



Verkettete Liste

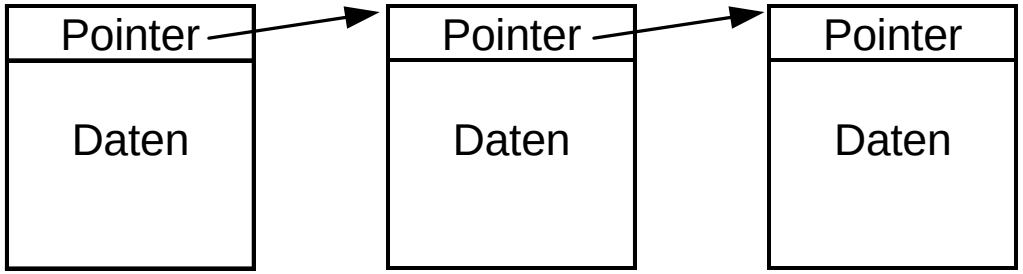
Verkettete Liste

- dynamische Struktur
- gleiche Listenelemente, beinhalten Verweis auf das nächste Element
- Datentyp eines Listenelements

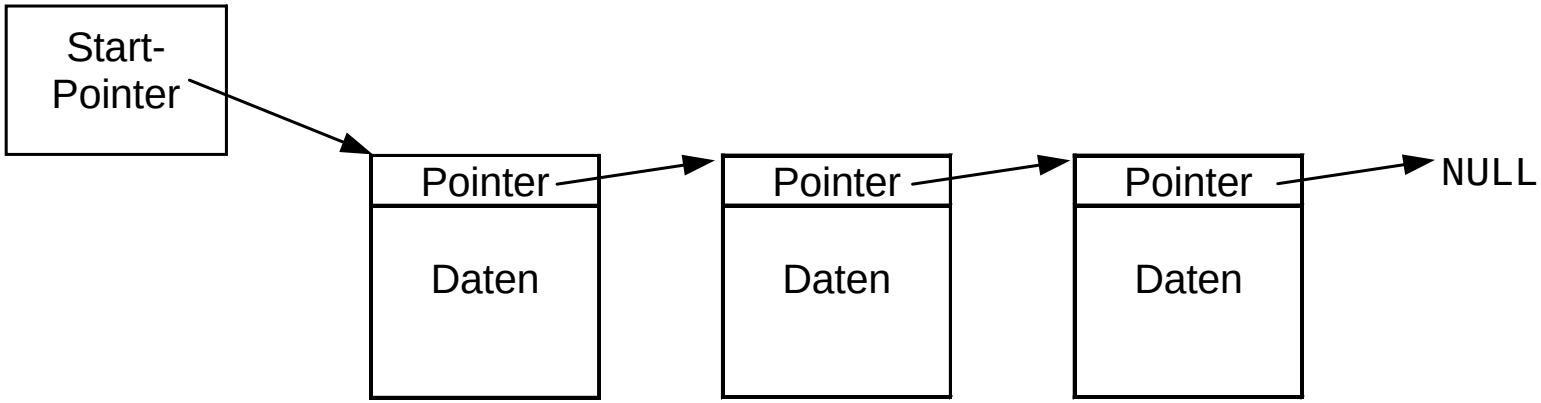
```
struct element
{
   float f;
   struct element *next;
};
```

- Operationen:
  - Liste initialisieren
  - Neues Listenelement einfügen
  - Listenelement löschen
  - Suchen eines bestimmten Listenelements

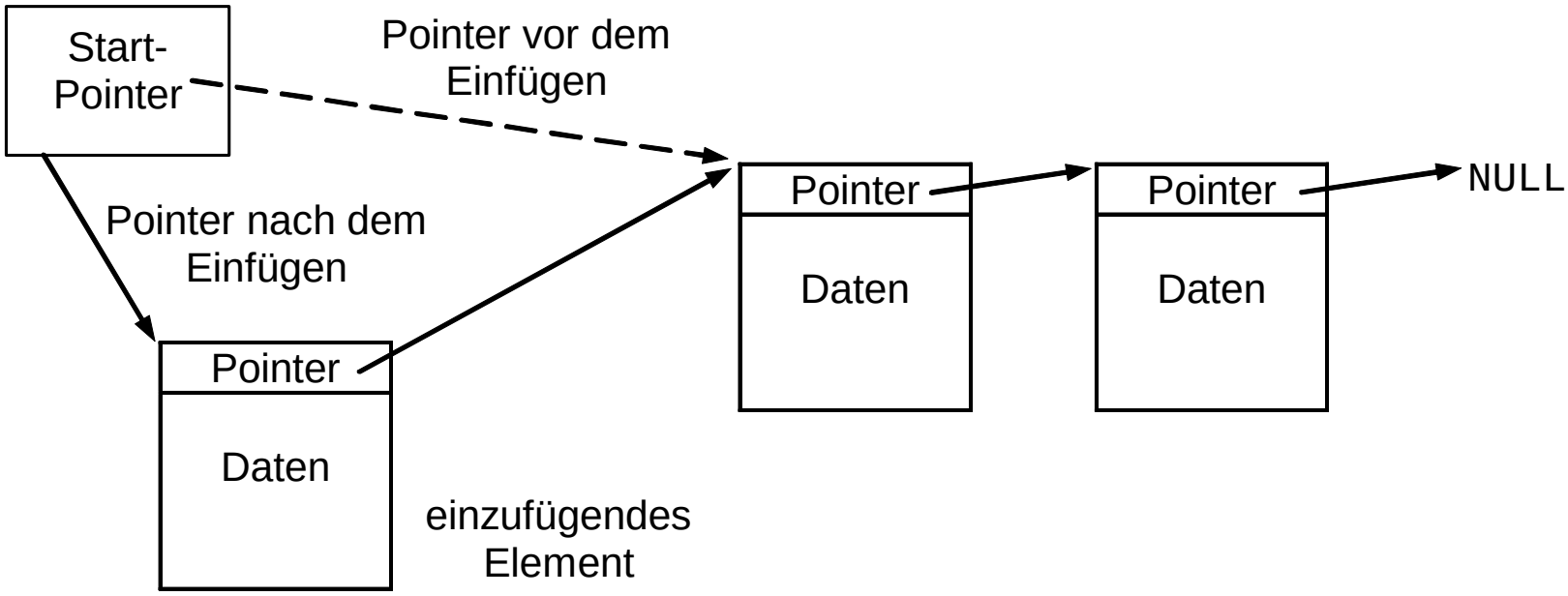
Einfach verkettete Liste



- mit Start-Pointer und Ende

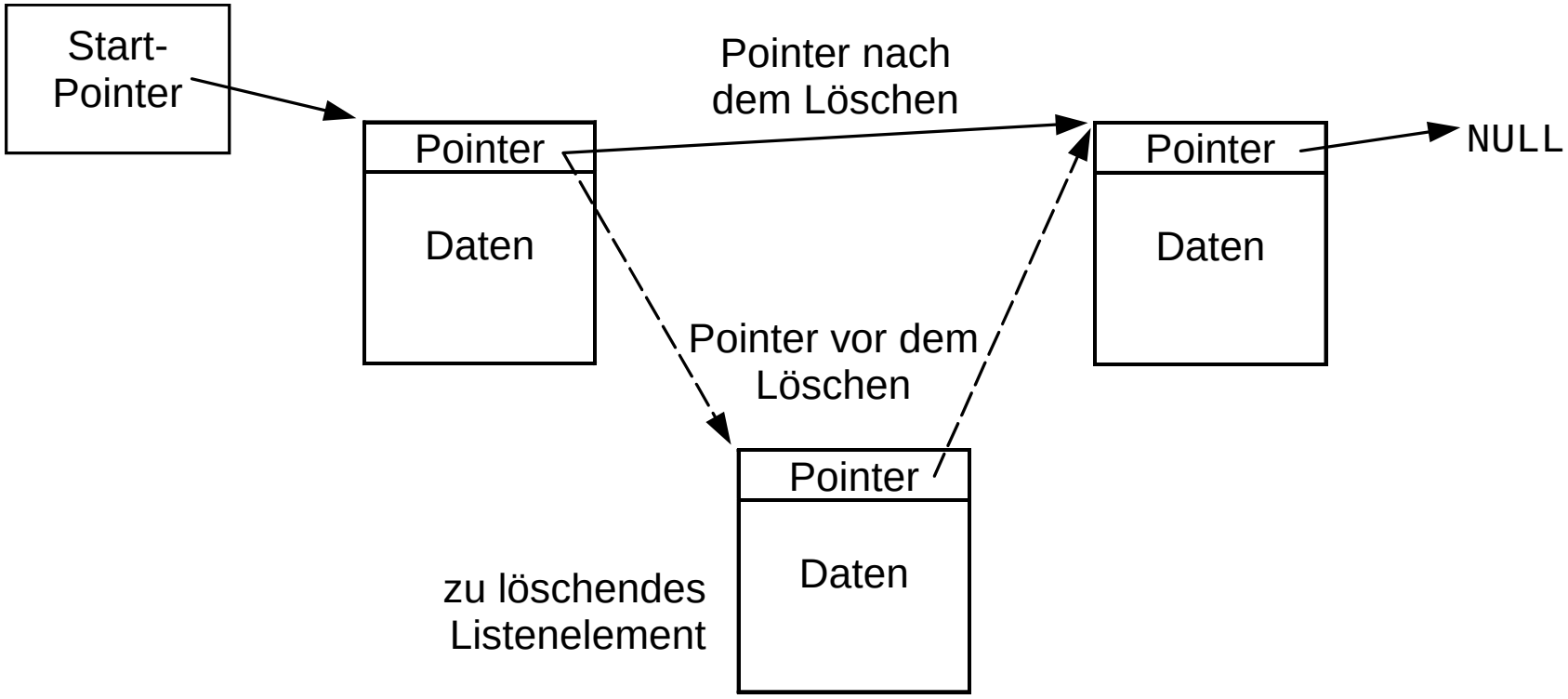


Implementierung: Neues Listenelement vorn einfügen




```
struct element
{
    float f;
    struct element *next;
};

struct element *start, *temp;
```

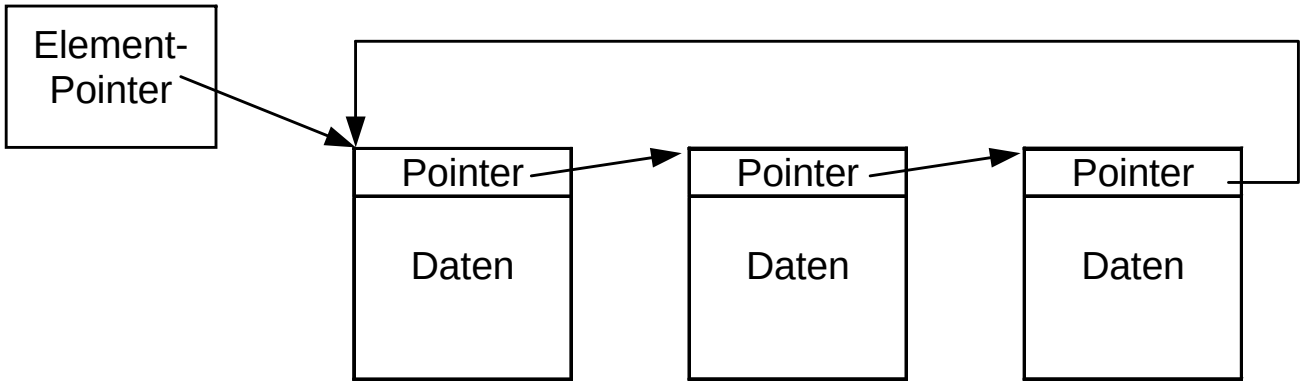
Implementierung: Listenelement löschen



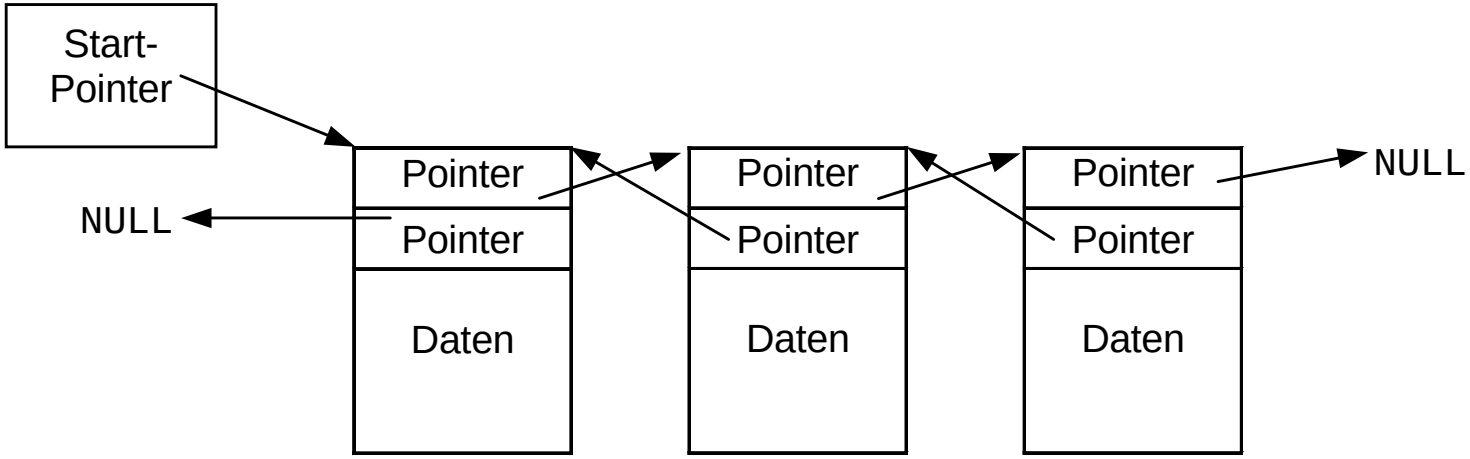

```
struct element
{
    float f;
    struct element *next;
};

struct element *start, *temp;
```

Varianten verketteter Listen

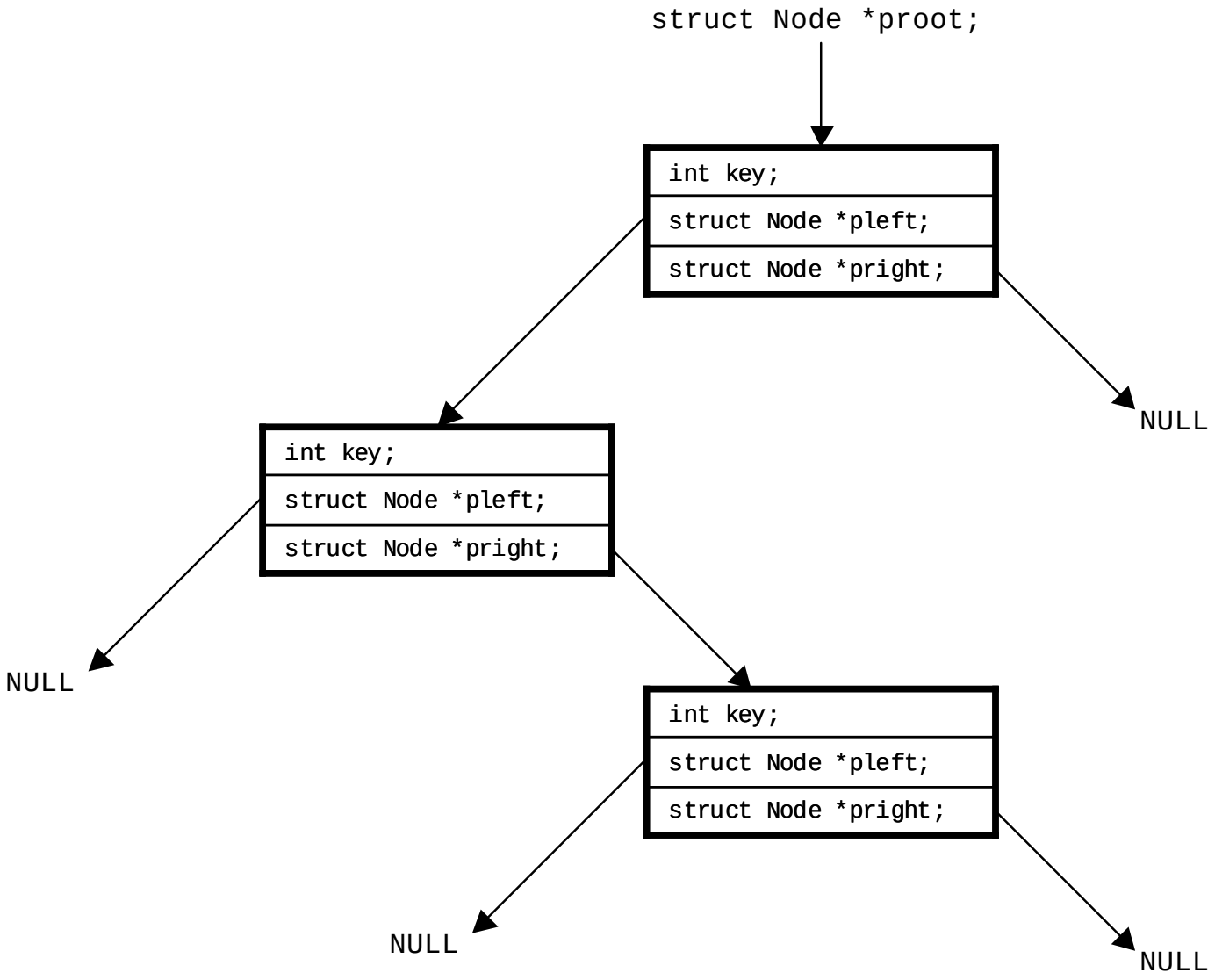
- Ringpuffer



- Doppelt Verkette Liste



Binärer Suchbaum



Effizienz: Binärbaum vs. Verkettete Liste

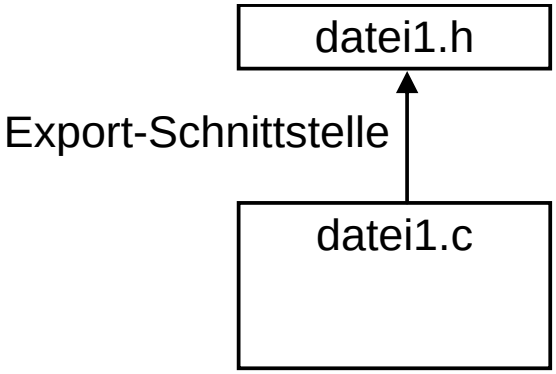
Effizienz beim Suchen von Elementen:

∅ Anzahl der Vergleiche: verkettete Liste ↔ ausgeglichener Binärbaum

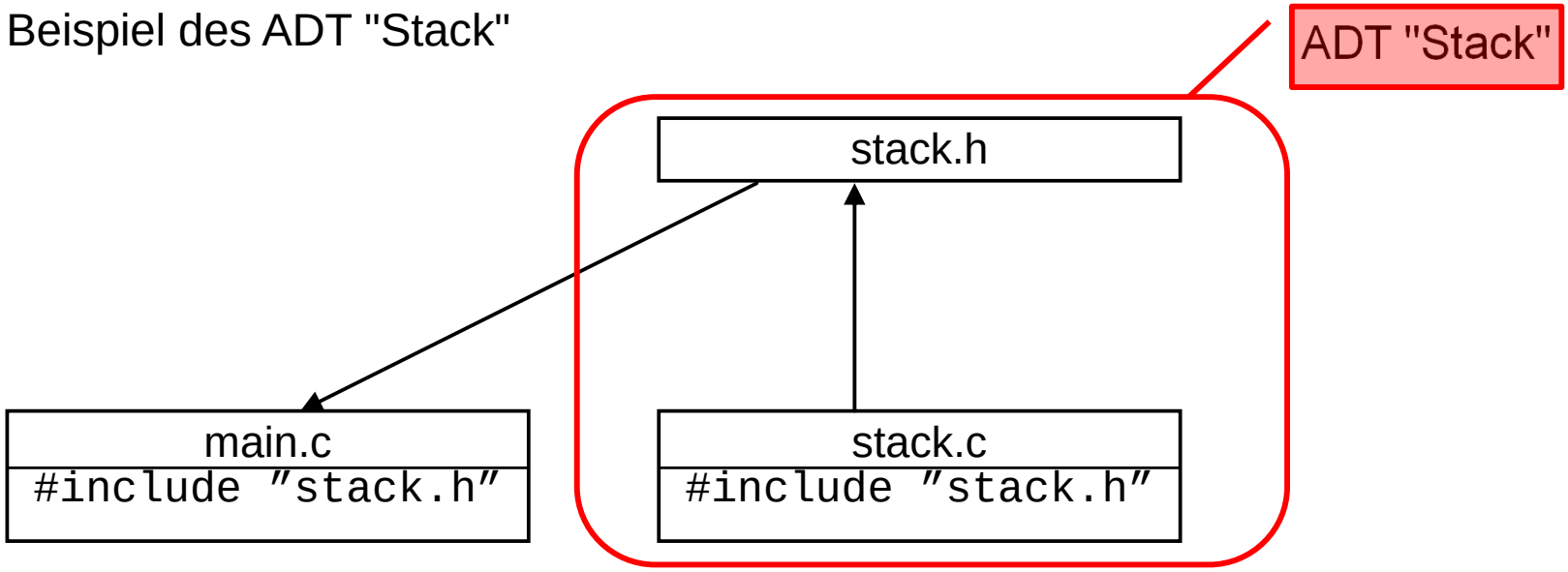
Anzahl der Elemente	# Vergleiche Liste	# Vergleiche Baum
1	1	2
3	2	4
15	8	8
63	32	12
255	128	16
511	256	18
...	...	...
1048575	524288	40

Implementierung eines ADT

- Allgemeines Schema



- Am Beispiel des ADT "Stack"



Vorwärtsdeklaration

```
struct B;

struct A
{
   int a;
   struct B *b;
};

struct B
{
   int b;
   struct A *a;
};
```