IF1210 Algoritma dan Pemrograman 1

Pointer dalam Bahasa C

Tim Pengajar IF1210

Sekolah Teknik Elektro dan Informatika

Tujuan

- Mahasiswa memahami sintaks dan pengertian pointer (dalam bahasa C)
- Mahasiswa mengerti penggunaan pointer dengan benar
- Mahasiswa memahami mekanisme kerja pointer dalam memory

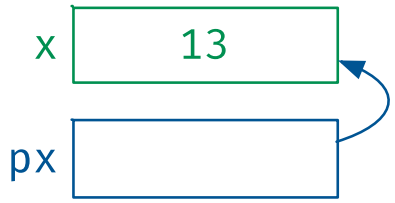
Referensi

- Materi diadopsi dari: Pointers and Memory, Nick Parlante ©1998-2000.
  - http://cslibrary.stanford.edu/102/PointersAndMemory.pdf

Prinsip Dasar Pointer

- Apakah **pointer** itu?
  - Adalah variabel yang menyimpan *reference* dari nilai lain.
  - Berbeda dengan variabel "biasa" yang menyimpan nilainya sendiri.

```
int x;
int *px;
x  = 13;
px = &x;
  /* reference to */
```

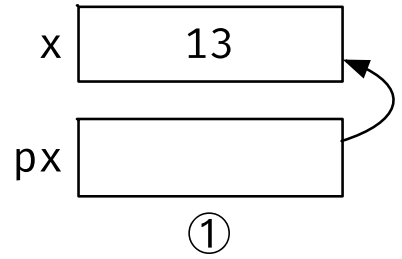


- Mengapa pointer?
  - Memungkinkan dua bagian/*section* dalam program berbagi akses informasi dengan mudah
  - Memungkinkan struktur data berkait/*linked* yang rumit (seperti *linked list*, *tree* berbasis *node*)

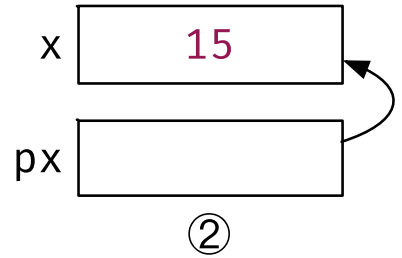
Pointer Dereference

- Operasi "*dereference*" adalah operasi untuk mendapatkan nilai yang diacu oleh sebuah pointer.

```
int x;
int *px;

①  x  = 13;
   px = &x;
     /* reference to */
```



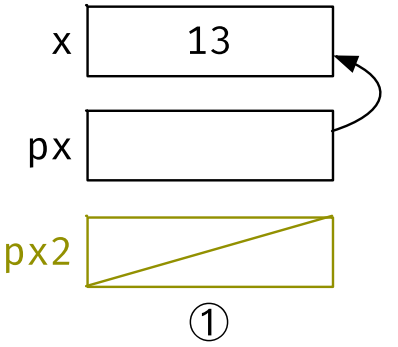

```
②  (*px) += 2;
     /* dereference */
```



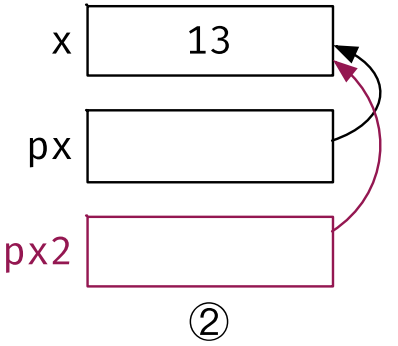
Null Pointer, Pointer Assignment

- **Null pointer**: nilai khusus untuk menyatakan bahwa sebuah pointer tidak menunjuk ke mana-mana.
- **Operator assignment** "="
  - Sebuah pointer di-assign **dengan pointer lain** untuk mengacu nilai yang sama

```
int x;
int *px, *px2;

①  x   = 13;
   px  = &x;
     /* reference to */
   px2 = NULL;
```




```
②  px2 = px;
```



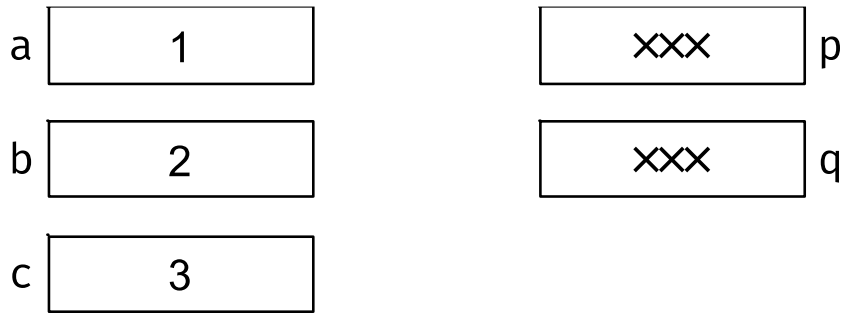
Bad Pointer

- Pointer yang belum diinisialisasi.
- *Dereference* terhadap bad pointer menyebabkan *runtime error*.

```
int *px;
```

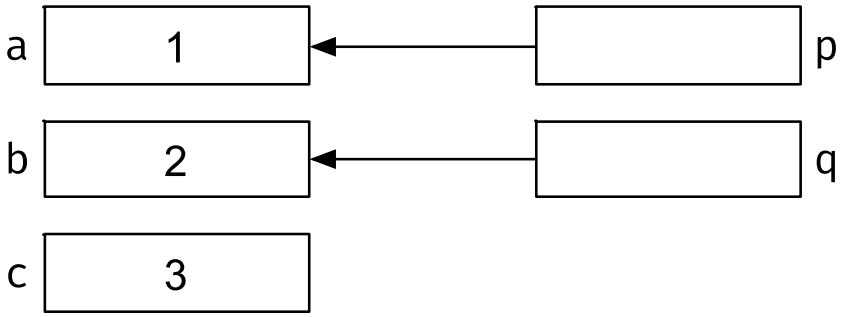
Contoh (1)

```
// allocate three integers and two pointers
int a = 1;
int b = 2;
int c = 3;
int* p;
int* q;

// Here is the state of memory at this point.
// T1 -- Notice that the pointers start out bad...
```



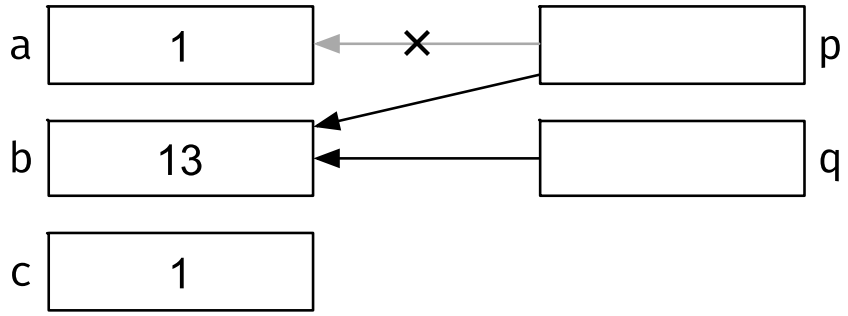
Contoh (2)

```
p = &a; // set p to refer to a
q = &b; // set q to refer to b

// T2 -- The pointers now have pointees
```



Contoh (3)

```
// Now we mix things up a bit...
c = *p;  // retrieve p's pointee value (1) and put it in c
p = q;   // change p to share with q (p's pointee is now b)
*p = 13; // dereference p to set its pointee (b) to 13
         // (*q is now 13)

// T3 -- Dereferences and assignments mix things up
```



Memori Lokal

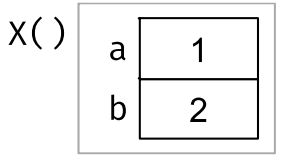
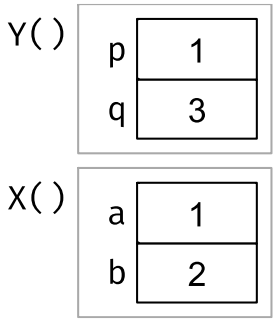
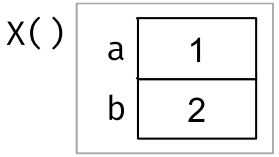
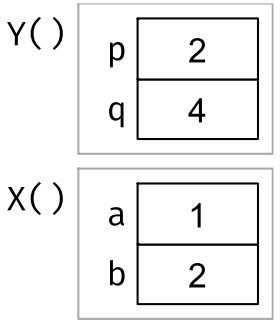
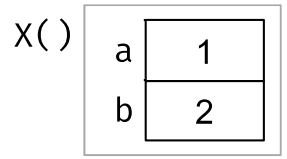
- **Alokasi** dan **Dealokasi**
  - Ketika variabel diberikan tempat pada memori untuk menyimpan nilai: ***allocated***.
  - Ketika variable tidak lagi memiliki tempat pada memori untuk menyimpan nilai: ***deallocated***.
  - Periode antara allocated-deallocated: ***lifetime***.

Alokasi, Dealokasi, Lifetime

```
void foo(int a) { // (1) Locals (a, i, scores) allocated when foo runs
    int i;
    float scores[100]; // This array of 100 floats is allocated locally.

    a = a + 1;      // (2) Local storage is used by the computation
    for (i=0; i<a; i++) {
        bar(i + a);    // (3) Locals continue to exist undisturbed,
    }                  // even during calls to other functions.

} // (4) The locals are all deallocated when the function exits.
```

Contoh

```
void X() {
  int a = 1;
  int b = 2;
  // T1

  Y(a);
  // T3
  Y(b);
  // T5
}

void Y(int p) {
  int q;
  q = p + 2;
  // T2 (first time through),
  // T4 (second time through)
}
```

T1 - X()'s locals have been allocated and given values..	**T2** - Y() is called with p=1, and its locals are allocated. X()'s locals continue to be allocated.	**T3** - Y() exits and its locals are deallocated. We are left only with X()'s locals.	**T4** - Y() is called again with p=2, and its locals are allocated a second time.	**T5** - Y() exits and its locals are deallocated. X()'s locals will be deallocated when it exits.
				

Contoh error

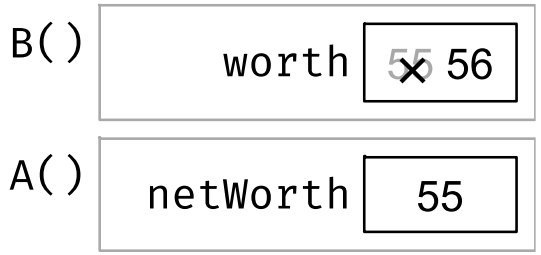
```
// T.A.B. -- The Ampersand Bug function
// Returns a pointer to an int
int* tab() {
  int temp;
  return(&temp); // return a pointer to the local int
}

void victim() {
  int* ptr;
  ptr = tab();
  *ptr = 42; // Runtime error! The pointee was local to tab
}
```

Function Call Stack

- Lihat materi Nick Parlante halaman 15-16
  - Passing parameter by value vs Passing parameter by reference

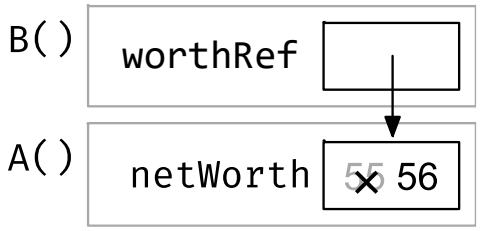
Passing Parameter: by Value

```
void B(int worth) {
  worth = worth + 1;
  // T2
}
void A() {
  int netWorth;
  netWorth = 55; // T1

  B(netWorth);
  // T3 -- B() did not change netWorth
}
```

T1 -- The value of interest `netWorth` is local to `A()`.	**T2** -- `netWorth` is copied to `B()`'s local worth. `B()` changes its local worth from 55 to 56.	**T3** -- `B()` exits and its local `worth` is deallocated. The value of interest has not been changed.
		

Passing Parameter: by Reference*

```
// B() now uses a reference parameter -- a pointer to the value of interest.
// B() uses a dereference (*) on the reference parameter to get at the value
// of interest.
void B(int* worthRef) {          // reference parameter
    *worthRef = *worthRef + 1; // use * to get at value of interest
    // T2
}
void A() {
    int netWorth;
    netWorth = 55; // T1 -- the value of interest is local to A()
    B(&netWorth);  // Pass a pointer to the value of interest.
                   // In this case using &.
    // T3 -- B() has used its pointer to change the value of interest
}
```

T1 -- The value of interest netWorth is local to A() as before.	**T2** -- Instead of a copy, B() receives a pointer to netWorth. B() dereferences its pointer to access and change the real netWorth.	**T3** -- B() exits, and netWorth has been changed.
		

Apakah “&” selalu diperlukan?

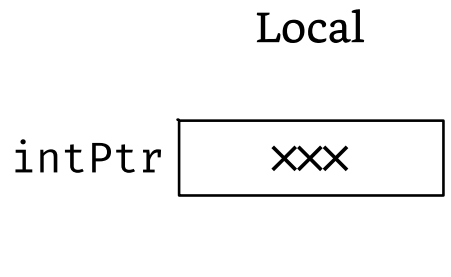
```
// Takes the value of interest by reference and adds 2.
void C(int* worthRef) {
  *worthRef = *worthRef + 2;
}

// Adds 1 to the value of interest, and calls C().
void B(int* worthRef) {
  *worthRef = *worthRef + 1; // add 1 to value of interest as
                             // before
  C(worthRef); // NOTE: no & required. We already have
               // a pointer to the value of interest, so
               // it can be passed through directly.
}
```

Heap Memory

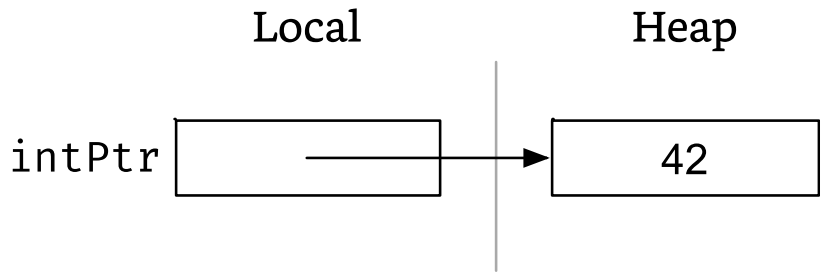
- Heap Memory == Dynamic Memory
  - Berbeda dengan Local Memory yang mengalokasi dan dealokasi memory secara otomatis saat function call
  - Pada Heap Memory, programmer harus melakukan alokasi dan dealokasi
- **Keuntungan** heap memory:
  - Lifetime
  - Ukuran
- **Kekurangan**:
  - more works
  - more bugs

Contoh Penggunaan Heap Memory (1)

```
void Heap1() {
    int* intPtr;
    // Allocates local pointer local variable (but not its pointee)
    // T1:
```

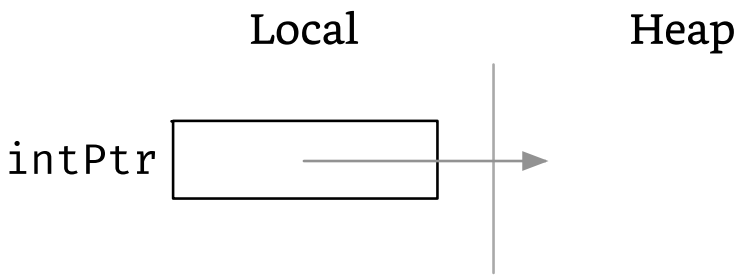



```
    // Allocates heap block and stores its pointer in local
    // variable.
    // Dereferences the pointer to set the pointee to 42.
    intPtr = malloc(sizeof(int));
    *intPtr = 42;
    // T2:
```



Contoh Penggunaan Heap Memory (2)

```
// Deallocates heap block making the pointer bad.
   // The programmer must remember not to use the pointer
   // after the pointee has been deallocated (this is
   // why the pointer is shown in gray).
   free(intPtr);
   // T3:
```




```
}
```

Referensi Tambahan

- Materi pointer, array dan string:
  A Tutorial on Pointers and Arrays in C, Ted Jensen, 2003.
  Bab 2, 3, dan 4
  - http://pweb.netcom.com/~tjensen/ptr/cpoint.htm
  - http://pw1.netcom.com/~tjensen/ptr/pointers.htm

Referensi Tambahan (*)

1.8 Arguments—Call by Value

One aspect of C functions may be unfamiliar to programmers who are used to some other languages, particularly Fortran. In C, all function arguments are passed "by value." This means that the called function is given the values of its arguments in temporary variables rather than the originals. This leads to some different properties than are seen with "call by reference" languages like Fortran or with `var` parameters in Pascal, in which the called routine has access to the original argument, not a local copy.

The main distinction is that in C the called function cannot directly alter a variable in the calling function; it can only alter its private, temporary copy.

Latihan Pointer

Latihan 1

Tentukan nilai s dan t pada 4 *statement* terakhir.

```
int f (void) {
  int s = 1;
  int t = 1;
  int *ps = &s;
  int **pps = &ps;//int **pps; pps=&ps
  int *pt = &t;

  **pps = 2;
  pt = ps;
  *pt = 3;
  t = s;
}
```

Materi dari: David Evans (CS216, lecture10, 2006, www.cs.virginia.edu/~evans/cs216/classes/lecture10.ppt)

Latihan 2

Tentukan nilai dan jelaskan apa yang terjadi terhadap ip setelah pemanggilan masing-masing fungsi.

```
int *value (void) {
  int i = 3;
  return &i;
}
void callme (void) {
  int x = 35;
}

int main (void) {
  int *ip;
  ip = value ();
  printf ("*ip == %d\n", *ip);
  callme ();
  printf ("*ip == %d\n", *ip);
}
```

Materi dari: David Evans (CS216, lecture10, 2006, www.cs.virginia.edu/~evans/cs216/classes/lecture10.ppt)

Latihan 3

```
int main() {
  char blocks[3] = {'I','T','B'}; // asumsi,alamat array blok adalah 4434
  char *ptr = &blocks[0];
  char temp;

  temp = blocks[0];
  temp = *(blocks + 2);
  temp = *(ptr + 1);
  temp = *ptr;

  ptr = blocks + 1;
  temp = *ptr;
  temp = *(ptr + 1);

  ptr = blocks;
  temp = *++ptr;
  temp = ++*ptr;
  temp = *ptr++;
  temp = *ptr;

  return 0;
}
```

Materi dari: David Evans (CS216, lecture10, 2006, www.cs.virginia.edu/~evans/cs216/classes/lecture10.ppt)