Computer Science

Pointers

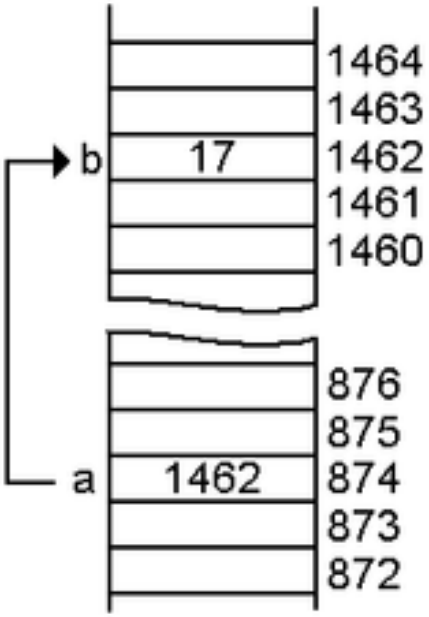
Pointers in C language

- Definition
- Pointers operators: «*» and «&»
- Declaration and initialization
- Operations with pointers
  - Assignment operations
  - Pointer arithmetic
- Pointers types
  - Generic
  - Null
  - Constant
- Arrays and pointers
  - Pointer to array
  - Arrays of pointers
- Pointer to pointer
- Pointers to structures and unions

Pointer definition (I)

- A **pointer** is a *variable* that contains the *memory address* of another *variable*
  - It is an *indirection*: the variable can be accessed *indirectly*
  - It is said that a pointer *points* to the variable
  - Example:

    Pointer **`a`** *points* to variable **`b`**



From wikibooks.org

Pointer definition (II)

- Pointers are a very important tool in C language
  - They provide fast and efficient access to arrays
  - They facilitate working with linked lists
  - They facilitate information exchange between functions
  - They are essential to
    - Assign memory dynamically
    - Manage files
- Pointers must be used with a lot of care to avoid making serious mistakes very difficult to find

Pointers operators: «*» and «&»

- The **address operator «&»** returns the *memory address* of its operand
  - It can just be applied to variables and array elements

```
punt = &var;
```

- The **indirection operator** «*» applied to a pointer accesses the value of the variable the pointer points to
  - It can be used as any other variable without limitations

```
*punt = 7.98
```

- Both operators «*» and «&»
  - Are associated from left to right
  - Have higher precedence than arithmetic/logic operations

Pointers declaration and initialization (I)

- The declaration of a pointer variable assigns the necessary memory to store an address

```
datatype *pointername;
```

  - `datatype` is the type of the variable to which the pointer points
  - `pointername` is the label of the memory position that stores the variable address
  - `*pointername` refers to the value of that variable
  - The declaration does not reserve any memory for the variable

- The memory size required to store an address is always the same, independently of the data type contained in the address

Pointers declaration and initialization (II)

- To **initialize** a pointer is to make it point to a valid variable
  - Variable must exist prior to pointer initialization
  - This does not mean that the variable must contain valid data

```
float *punt;        /* Pointer declaration */
float var;          /* Variable declaration. They
                       must be of  the same type*/
punt = &var;        /* Pointer initialization. var
                       still without valid data*/
*punt = 7.98;         /* Variable initialization
                      Equivalent to var = 7.98; */
```

Operations with pointers (I)

- Just operations that can be made with addresses:
  - **Assignment** operations
  - **Arithmetic:** addition, subtraction, increment and decrement

- **Assignment** operations
  - Pointer to pointer:
    - Both will point to the same address
    - Both must be of the same type

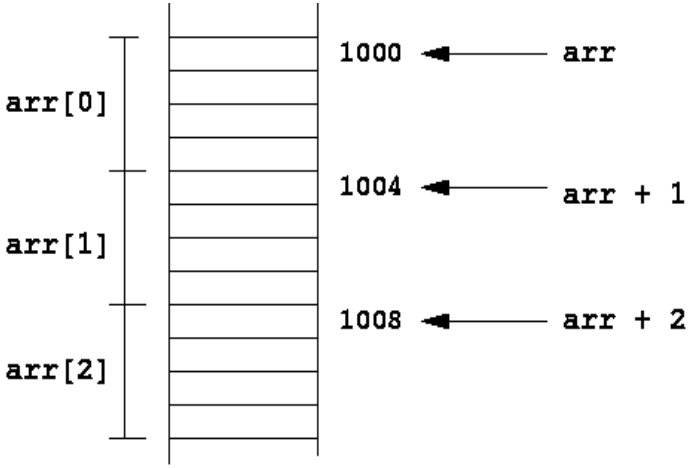
```
int data, *punt1, *punt2; /* Declarations */
punt1 = &data;    /* punt1 initialization */
punt2 = punt1;          /* punt2 points to data*/
```

Operations with pointers (II)

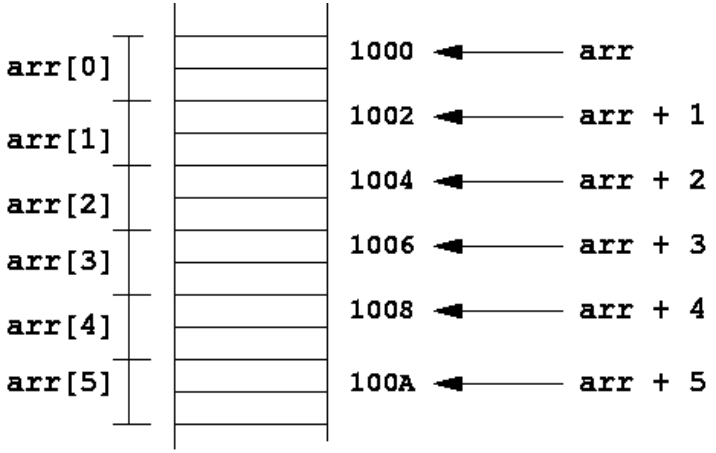
- **Arithmetic** operations: Let `arr` be a pointer and `n` an integer
  - **Addition, Subtraction, Increment/Decrement**

    `arr+n, arr-n, arr++, arr--`

  - **Pointer arithmetics just considers addresses**
    (pointer arithmetic != ordinary arithmetic)



`arr` is `int` type (4 bytes)



`arr` is `short int` type (2 bytes)

from www.cs.umd.edu

Pointer types

- **Generic pointer** does not point to any data type yet

```
void *pointername;
```

  - It is declared generic and later can point to any kind of data

- **Null pointer** points to address NULL (= 0)

```
datatype *pointername = NULL;
```

  - `NULL` is a constant defined in `stdio.h`
  - It is used because address 0 is not valid

- **Constant pointer** always points to the same address

```
datatype *const pointername;
```

  - The content of the address do may change though

Arrays and pointers (I)

- Every thing that can be done with arrays can also be done with pointers
  - Pointer versions are generally faster and more used
- The array identifier is a pointer to its first element
- To access element `M` in an array of `N` elements, $0 \leq M < N$
  - With arrays

```
elementM = arrayname[M];
```

  - With pointer

```
elementM = *(arrayname+M);
```

Since the name of an array is a synonym of the location of the initial element

Arrays and pointers (II)

- A **pointer to an array of characters** points to the first element
  - It can be initialized in declaration

```
char *pointername = "string";
```

    - `pointername` contains the address of the first character
    - `string` is a string of characters ending with `'\0'`

- Functions receive a string as a pointer to the first element of the string (pass by reference)

```
char *message = "Reading error";
puts(message);
```

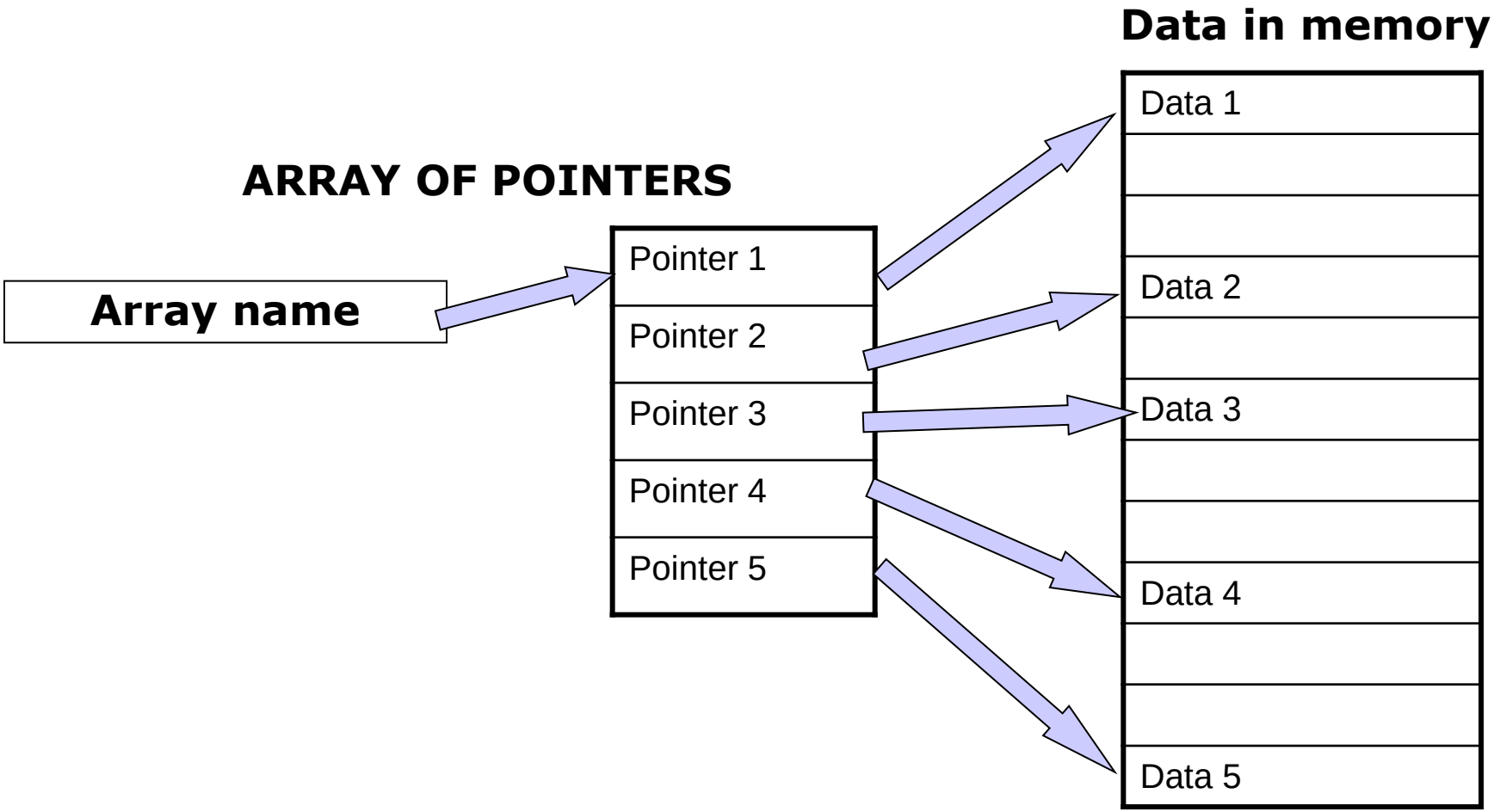
Arrays and pointers (III)

- An **array of pointers** is declared as

```
datatype *arrayname[size];
```

  - Its elements are addresses where `datatype` elements are contained
    - All elements must be initialized pointing them to a valid data
  - An array of pointers to character is similar to a array of strings

Arrays and pointers (IV)



Arrays and pointers (V)

- Examples:
  - 2D array of characters

```
char mssg[3][80] ={“Initial”, “Central”, “Last”};
puts(mssg[1]);   /* “Initial” to screen */
```

  - Array of pointers to character

```
char *mssg [3];  /* Array of 3 pointers to char */
mssg[0]= “Initial”;  /* Initialization*/
mssg[1]= “Central”;
mssg[2]= “Last”;
puts(mssg[1]);
```

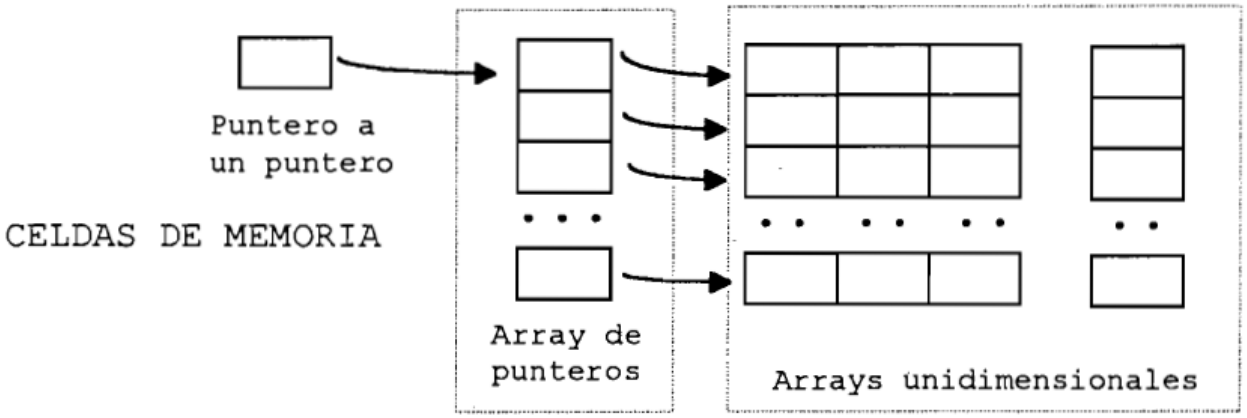
Pointer to pointer

- A **pointer to pointer** is a double indirection:

```
datype **pointername;
```

  - `pointername` contains the address of `*pointername` whose contains the address of `**pointername`

- Particularly important in **dynamical memory allocation of multidimensional arrays** (unit 4.10)
  - Element `matrix[i][j]` of 2D-array can be accessed `*(*(matriz+i)+j)`



ARRAY BIDIMENSIONAL CREADO MEDIANTE ASIGNACIÓN DINÁMICA DE MEMORIA

Pointers to structures and unions

- Pointer to structure/union declaration (unit 4.9)

```
struct structuretypename *pointername;
union uniontypename *pointername;
```

  - The types must be previously defined

- To access one members using pointers
  - Usual notation: `*pointername.membername`
  - With «->» operator: `pointername -> membername`