Programming in C

Week2

9.9.2015

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Meeting structure

- First week
  - Some notes
- Second week
  - Focus on pointers
- Slides related to first week topics – covered if time allows or some questions arise

First week tasks

- TMC problems
  - Some tests did not accept correct answers on the server
  - Difficulties configuring NetBeans properly
- Tasks
  - Uninitialized values: test failure information not useful
  - Printf: formatting problems, especially \n

Briefly about pointers

char *p; /* pointer to a character or string */

int *q;   /* pointer to one integer (or array) */

/*Memory allocated only for the pointer! */

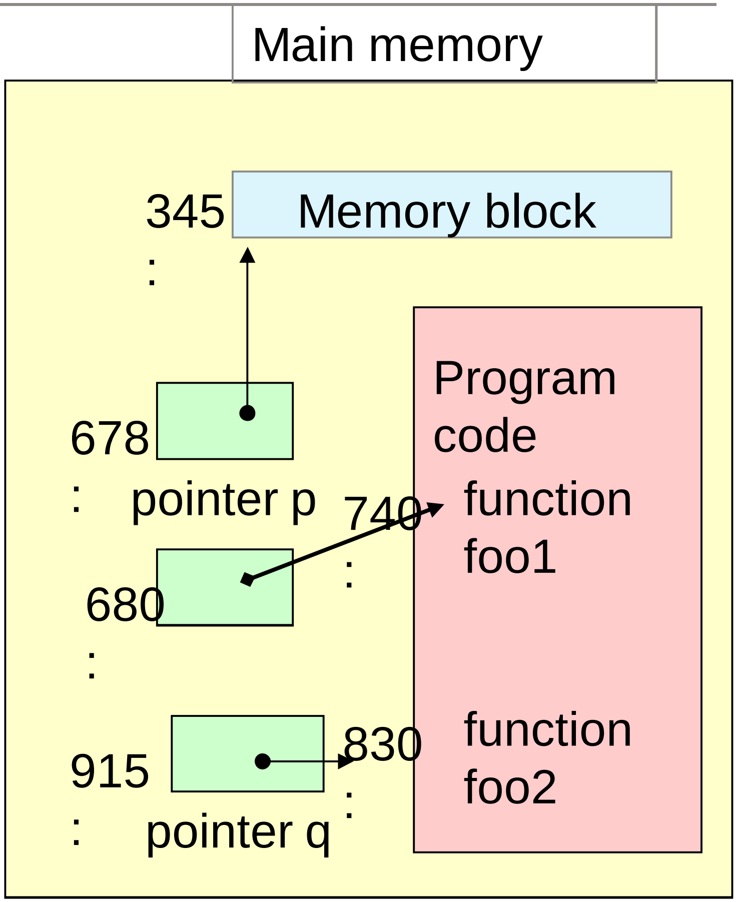
char *p = ”This string is allocated”;

int numbers[] = {1, 2, 3, 4, 5};

double table[100];

Allocate memory for the array and set the pointer to the array.

(No memory allocated for array name ”constant pointers”, only allocates the memory block containing the values!)



Pointers (and arrays)

- Array is just a sequence of values with a joint name.
  int a[15] is sequence of 15 integers.
- Array name is treated as a pointer, whose value is the address of the first element in the sequence.

```
pa = &a[0]
pa = a
```

- pointer arithmetic allows operations on array elements

```
 *(pa +3)   is the same as    a[3]
    pa+3     is the same as  &a[3]
```

Pointer arithmetics and operations

Remember:
NULL

p = &c   address of c
c = *p   value of the address pointed by p
c = **r   -”- (two ’jumps’)
p = q   allowed when p and q of same type

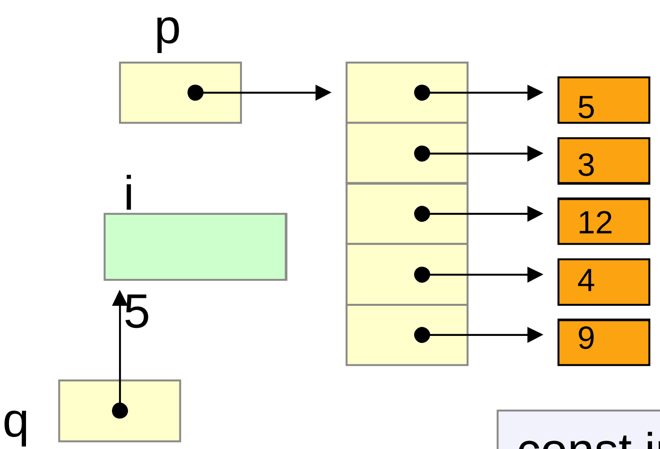
p+i, p-i   p is array, i has to be interger with suitable value
p-q,   p and q pointers of the same array and q<p
p < q,   p == q

*ip++   increments the address by ’one’

(*ip)++ increments the value in the address by one

Pointer arithmetics

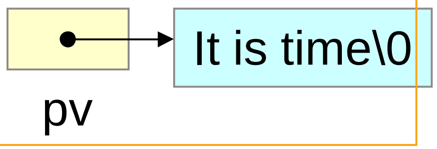
```
int  **p;
int    *q,r;
int     i;
i= **p
```



```
q = &i; /* q's new value is i's address
 i = *q+1;     i = ++*q;   /* i=6*/
 i = *q++;   /* ???? */
 r = q; *r = 3; /* i=3 */
```

```
const int  *p;
int  const *p;
const  int const  *p;
```

```
char msg [] = ”It is time”;   msg: It is time\0
char  *pv =”It is time”;
```

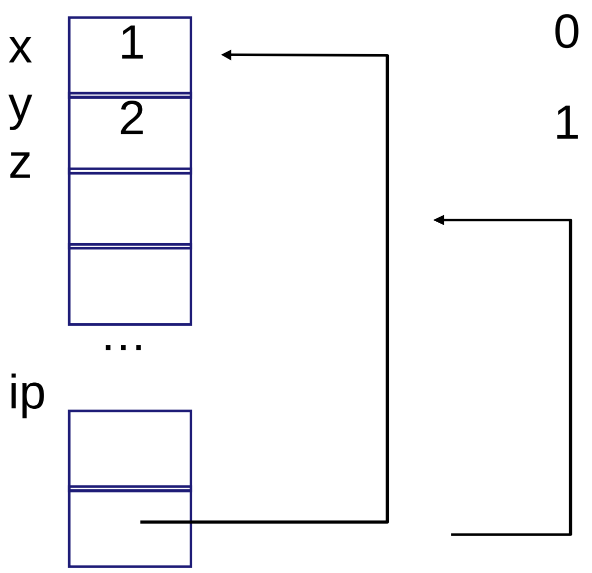


```
void *p;   i= *(int*) p;
```

Example code

```
int main(int argc, char**
argv)
{
 int x=1, y=2, z[10];
 int *ip;
int *p, q;
int *r, *s;

ip = &x;
y = *ip;  /* y = x =1 */
*ip = 0;   /* x = 0 */
ip = &z[0];
}

double atof(char * string);
```

p is a pointer variable and q is integer variable



Pointers as arguments for functions are very common. (Always used with arrays and needed for call by reference)

Memory allocation

- Explicit memory allocations!
- **malloc** – static data structures
- calloc – dynamic array
- realloc – change the size of already allocated object
- **free** – deallocate the memory

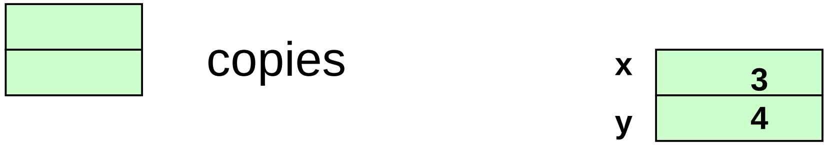
```
/* ALWAYS CHECK THE RETURN VALUE!!! */
if (k=malloc(sizeof(double)))
    error; /* allocation failed, do something else or terminate program */

/* memory allocation succeeded and k is the pointer to the new structure */
```

Functions:
Call by value, call by reference

C uses always call by value => function cannot change the value it receives as argument.

Call by reference done with pointers!!!

```
void swap(int x, int y) {
  int apu;
  apu=x;
  x=y;
  y= apu;
}
```



Addresses of x and y

```
void swap(int *x, int *y) {
      int apu;
      apu=*x;
      *x=*y;
      *y= apu;
   }
```

Call: swap (&x, &y);

double product (const double block, int size);

Make sure that function does not change the variable (ANSI standard!)

Example code: copy a string - Passing array to a function

```
#include <stdio.h>

void copy_string( char *s, char *t)
{
   int i =0;
  while (  (s[i] = t[i]) != ’\0’ )
    i++;
}

int main (void)
{
  char here [] =”This string is copied.”,
         there[50];
  copy_string ( here, there);    printf(”%s\n”, there);
  copy_string ( there, here);    printf(”%s\n”, there);
  return 0;
}
```

Strings (character arrays) as arguments. C is always passing only the address of the first element of any array.

Processing one character of each array

Example code: copy a string – Now with pointers

Version 1:

```
void copy_string( char *s, char *t)
{
  while (  (*s = *t) != ’\0’ )
    s++; t++;
}
```

Version 2:

```
void copy_string( char *s, char *t)
{
  while (  (*s++ = *t++) != ’\0’ )
    ;
}
```

Version 3:

```
void copy_string( char *s, char *t)
{
  while  ( *s++  =  *t++ )    ;
}
```

NOTE: The function prototype is identical with the previous slide

Minimalistic!

More about pointers and some good practices

- Generic pointer (void *p) can be used with type cast to handle a variable of that type.

```
*(double *)p
```

- Memory allocation for n integers

```
int *p;
if ((p=malloc(n*sizeof(int))) == NULL)
   error;
```

- Memory deallocation: remember to free(p); p=NULL;
- i'th element of array

```
p[i]     (preferred over *(p+i) )
```

- Handling an array p

```
for (pi = p;  pi < p+SIZE; pi++)
   remember to use pointer pi in the loop
```

Still more

- Call by reference
  1. Prototype’s argument – a pointer
     void func(int *pp)
  2. In the function use the pointed value.
     *pp
  3. In the function call: address of the variable
     func(&variable);
  4. In the function call: pointer
     func(pointer_variable);
- Array of struct

  for (p = block; p < block + n*elSize; p+= elSize)
- i. element of struct array

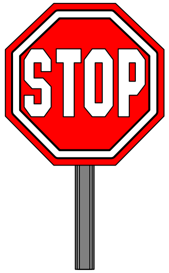
  p = block + i*elSize

Evaluation order
Preceedence

Same line - same priority

<table>
<tr><td></td><td>() [] . -></td></tr>
<tr><td></td><td>! ~ - ++ -- & * (tyyppi) sizeof</td></tr>
<tr><td>Arithmetical ops</td><td>* / %</td></tr>
<tr><td></td><td>+ -</td></tr>
<tr><td>Bitwise moves</td><td><< >></td></tr>
<tr><td>Value comparations</td><td>< <= > >=</td></tr>
<tr><td></td><td>== !=</td></tr>
<tr><td>Bitwise comparations</td><td>&</td></tr>
<tr><td></td><td>^</td></tr>
<tr><td></td><td>|</td></tr>
<tr><td>and</td><td>&&</td></tr>
<tr><td>or</td><td>||</td></tr>
<tr><td>Conditional op</td><td>?:</td></tr>
<tr><td></td><td>= *= /= %= += -= <<= >>= &= != ^=</td></tr>
<tr><td></td><td>,</td></tr>
</table>

Errors



Assosiativity

Expression

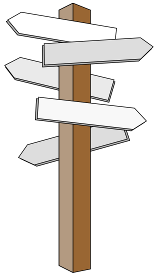
a < b < c

is interpreted as

(a < b) < c

And the meaning is different than expression

a < b && b < c



Style: using space

Do not use space with the following :

```
-> . [] ! ~ ++ -- -(sign)
*(pointer)&
```

Usually have space around these:

```
=    +=    ?:    +    <    &&
+ (addition)  and others
```

```
  a->b         a[i]        *c
            a = a + 2;
             a= b+ 1;
           a = a+b * 2;
```

Constants

Defined as variables, but with addition

- const

Usually constant names in capital letters

```
const float PI = 3.1412;
const int BIG_NUMBER = 0xFF7D;
const int  TRUE = 1;
const int FALSE = 0;
const char LETTER_A = ’a’;
const char [] MJONO = ”String has parenthesis around it”;
```

Macros

Preprocessor control – textual replacement!

Macro is a text that is replaced with other text before the actual compilation

NOTE: Whole end of the line is the replacement string as it is!!

Can be used to define ’constants’ but is more powerful

```
#define  MAKSIMI  30
#define  NAME “Tiina Niklander”
#define TRUE 1
#define FALSE 0
```

String vs character array

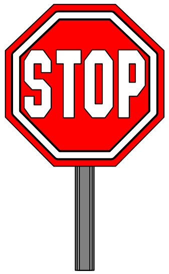
```
char letters[30];
char* char_pointer;
```

Array letters contains characters = character array

When the last character is ’\0’ then considered as string

Errors

Avoid mistakes



- `i = 8` different than `i == 8`

- Remember to set initial values to variables!
- Check the limits (avoid ‘off by one’)

- These are not logical operations!!!

```
e1 & e2
e1 | e2
if(x = 1) …
```

Errors

Overflow

NEVER test overflow with

```
i + j > INT_MAX
```

Why?

BUT do:

```
i > INT_MAX - j
```

Source:
Müldner

Slides related to first week

Simple types

Int 28, 074, 0x2A

char, one character, actually
a numerical value, do not
assume anything
’a’ ’\065’ ’\xA6’

float, double

NOTE: no boolean

- Use integer values
- 0 - FALSE and all other values TRUE

Size of these not fixed between systems (see: sizeof or limits.h)

signed, unsigned

- unsigned int
- signed char

short, long

- long char
- short int

Combined

- signed short int
- unsigned long int

Header file: limits.h

#include <limits.h>

Limits.h contains the maximum and minimum values of different types in this environment

At department the file is in /usr/include/

Always: INT_MAX >= 32767

Lots of values: eg. SHRT_MAX (singed short)

With ints you can define the type after value (U, L)

12U is unsigned int and 7L long int

sizeof(short) <= sizeof(int) <= sizeof(long)

Header file: float.h

```
#include <float.h>
```

Contains size and limit values for

- float
- double
- long double

sizeof(float) <= sizeof(double) <= sizeof(long double)

Type conversion

Implicit: operands with different types -> automatic type conversion for the arithmetic operation using the ’better quality’ type:

- `int  ja char`
- `unsigned`
- `long`
- `unsigned long`
- `float`
- `double`
- `long double`

Explicit:

```
(double)int_var;
(int) letter;
```

Statements

Conditional

```
if (cond)
    statement;
else
    statement;
```

```
If (cond) {
   statementS
} else {
   statementS
}
```

Loops

```
 for (;;)
statement
```

```
while (1) {
   statementS
   }
```

```
do {
   statementS
} while (cond);
```

Interrupting a loop

Break - continue from the statement AFTER the loop

Continue – continue with NEXT ROUND

Not named!!

Using break

```
While (1) {
   printf(“give two numbers a and b, a < b:”);
   if (scanf(“%d%d”, &a, &b) == 2)
      break;
   if (a < b)
      break;
   ...
}
/* break continues from here */
```

Several typical C features

- eternal loop while(1)
- error checks !!
- standard functions

Exiting from a deep loop structure

Exit over multiple loop levels must be done with goto (Avoid using for anything else!)

```
for(i = 0; i < length; i++)
     for(j = 0; j < length1; j++)
        if(f(i, j) == 0)
                    goto done;

done:
```

Break would continue the outer loop!

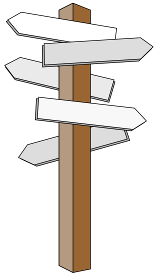
switch

```
.. /* Beginning of main and variable definitions */
Printf(”Please give at most %d chars\n”, LIMIT);
For (i = 1; i <= LIMIT; i++) {
   if ( (c=getchar()) == EOF)
      break;  /* end of file with CTRL-D */
   switch (c) {
   case ’ ’ : space++;
              break;
   case ’\t’: tabul++;
              break;
   case ’*’ : asterisk++;
              break;
   default  : if (c>=’a’ && c<=’z’)
                 lowercaseletters++;
   }
}
...  /* continues e.g. with printing */
```

```
/* Program that reads two integer values, and
 * outputs the maximum of these values.
 */
#include <stdio.h>
int main() {
   int i, j;
   printf("Enter two integers:");
   if(scanf("%d%d", &i, &j) != 2) {
     fprintf(stderr, "wrong input\n");
     return EXIT_FAILURE;
  }
   printf("Maximum of %d and %d is %d\n",
              i, j, i > j ? i : j);
   return EXIT_SUCCESS;
}
```

“Read two values”

Conditional operation



Control Statements

This loop

```
while(expr != 0)
        statement;
```

Is identical with this one

```
while(expr)
        statement;
```

Why?

Idioms

Read characters until sentinel

```
while(1) {
    if((aux = getchar()) == EOF || aux == SENTINEL)
        break;
      ...
}
```

or:

```
while(1) {
   if((aux = getchar()) == EOF)
      break;
   if(aux == SENTINEL)
      break;
   ...
```

Idioms

Read integers

```
while(1) {
    if (scanf("%d", &i) != 1 ||
       i == SENTINEL)
       break;
    …
}
```

Input and output briefly

Character at a time

```
int getchar()
int putchar(int)
```

Formatted

```
int scanf("format", &var)
int printf("format", exp)
```

```c
/* File: ex1.c
 * Program that reads a single character and
 * outputs it, followed by end-of-line
 */
#include <stdio.h>
#include <stdlib.h>
int main() {
   int c;   /* chars must be read as ints */

   if ((c = getchar()) == EOF)
      return EXIT_FAILURE;
   putchar(c);
   putchar('\n');

   return EXIT_SUCCESS;
}
```

NOTE: These header files are needed for the standard functions used

Printf & scanf: integer values

`d`	signed decimal
`ld`	long decimal
`u`	unsigned decimal
`o`	octal
`x, X`	hexadecimal

```
printf("%d%o%x", 17, 18, 19);
```

Printf and scanf: real number, floating point numbers

	default is 6 digits:
f	[-] ddd.ddd
e	[-] d.dddddde{sign}dd
E	[-] d.ddddddE{sign}dd
g	fe (f, e only if needed (e.g. sign <-4))
G	FE

```
printf("%5.3f\n", 123.3456789);
printf("%5.3e\n", 123.3456789);
123.346
1.233e+02
```

Printf and scanf: chars and string

`c`	one character
`s`	string

```
printf("%c", 'a');
printf("%d", 'a');

printf("This %s test", "is");
```

`scanf()` – return value

`scanf()` returns as its value the number of read items and `EOF`, if not item was read before the end-of-file occured

For example **`scanf("%d%d", &i, &j)`** `may return`:

2	If both values were read correctly
1	If only i was read
0	If reading failed completely
`EOF`	if file ended.