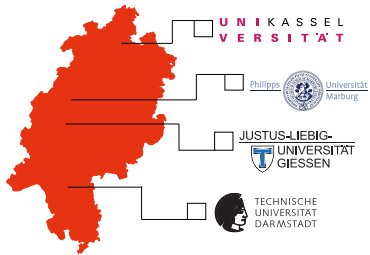
Excursion 1: Program Memory Layout

Hessisches Kompetenzzentrum für Hochleistungsrechnen (HKHLR)

Dr. Christian Iwainsky

V1.0



HKHLR is funded by the Hessian Ministry of Sciences and Arts

HESSEN

This segment's contents:

- Memory fundamentals, such as:
  - Head,
  - Stack (aka call-stack),
  - Variables and arguments, and
  - Pointers and allocated memory.
- Stack in context of multi-threading or OpenMP.

Two categories of variables:

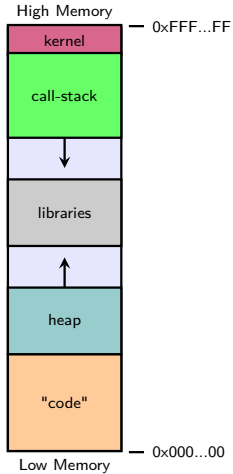
- Direct access:
  - `double i=pi;`
  - `int j=1;`
- Indirect access:
  - `double a[10];`
    `a[j]=i;`
  - `long int * data;`
    `data=(long int*) malloc(sizeof(long int)*100);`

Out of bound access:

- `a[11]=0;`
- `data[-1]=0;`

The virtual memory of any process is segmented with a structured defined by conventions:

- Call-stack,
- Heap,
- Static variables, constants, and code (called text-segment),
- Space for dynamic libraries,
- Kernel space,
- Other "reserved" memory as required.

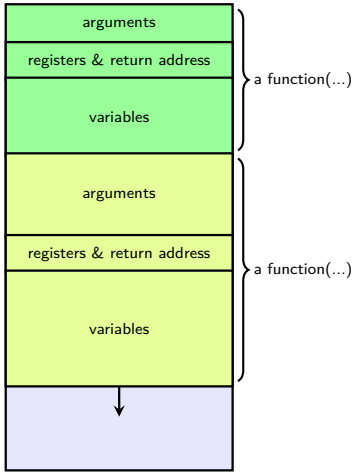


Stack-frame contents:

- Function arguments in reverse order,
- Return address,
- Saved registers, and
- Local variables.

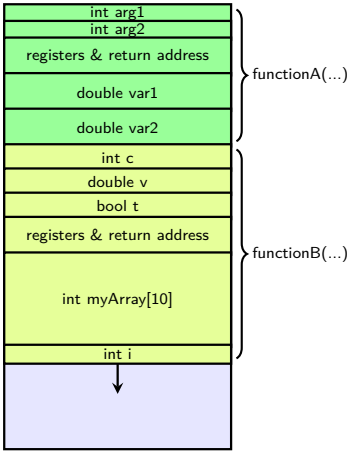
Local variables and fields can be:

- Rearranged,
- Padded,
- and aligned.



"Code example"

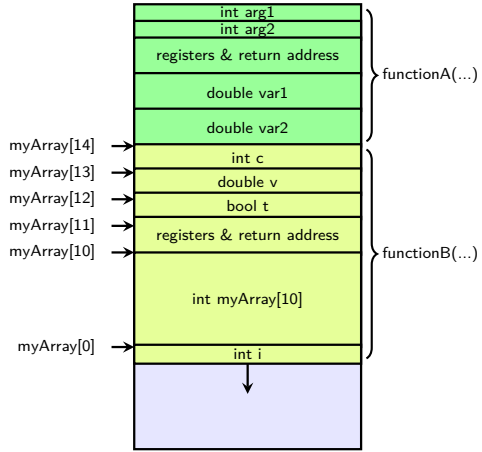
```
1  functionA(int arg1, int arg2){
2    double var1, var2;
3    functionB(var1,10.0,true);
4  }
5
6  functionB(int c, double v, bool t){
7    int myArray[10];
8    for (int i=0;i<15;++)
9      myArray[i]=0;
10 }
```



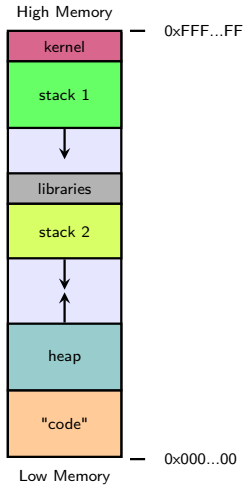
"Code example"

```
1  functionA(int arg1, int arg2){
2    double var1, var2;
3    functionB(var1,10.0,true);
4  }
5
6  functionB(int c, double v, bool t){
7    int myArray[10];
8    for (int i=0;i<15;++)
9      myArray[i]=0;
10 }
```

The out of bounds access of `myArray[]` writes to return address and saved registers.



- Multi-threading and OpenMP require a call-stack for each thread,
- Additional call-stacks usually located next to mapped memory, such as libraries,
- PThreads have a default stack size of 2 MB on 64bit systems,
- PThread stack size can be modified by RLIMIT_STACK or `ulimit -s`,
- Default OpenMP stack size is 4 MB (2 MB) on 64bit (32bit) systems,
- OpenMP thread stack size is specified by `OMP_STACKSIZE`.
- In **Multi-threading** there are multiple stacks.



This segments contents:

- Memory fundamentals, such as:
  - Head,
  - Stack (aka call-stack),
  - variables and arguments, and
  - pointers and allocated memory.
- Stack in context of multi-threading or OpenMP.