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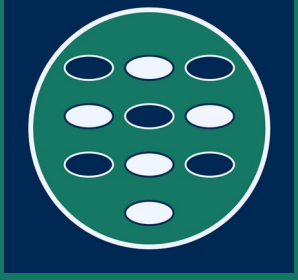

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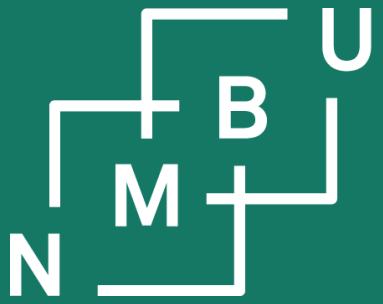
Ressurseffektiv programmering

2 Minnehandtering

2.1 Kallstakken og haugen



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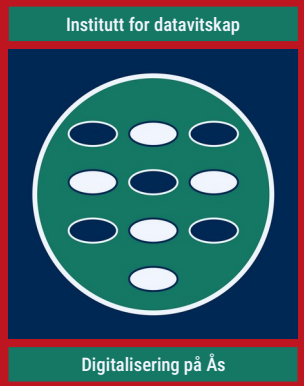

Eksempelproblem

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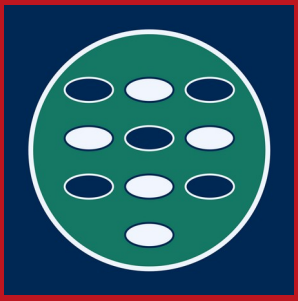

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2 Minnehandtering

2.1 Kallstakken og haugen

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Ordliste

Allocation	Allokering
Call stack	Kallstakk
Deallocation	Deallokering
Garbage collection	Søppeltømming
Heap	Haug
Stack frame	Stakkramme

Memory on the stack vs. memory on the heap

Allocation: Reserve memory to store data.
Deallocation: Release the memory.

On the stack

The stack is already handled completely and safely by the compiler. **Memory on the stack** (local variables of functions) is **allocated** as part of a **stack frame when the function is called**. It is **deallocated** again **when the function returns**.

On the heap

Memory on the heap is managed independent of the stack, at runtime, subject to **explicit allocation and deallocation** instructions that must come from the programmer. There is no garbage collection in C++!

initialization to *i = 42

- **Allocation** is done with **new**. Example: **int* i = new int(42);**
- **Deallocation** is done with **delete**. Example: **delete i;**

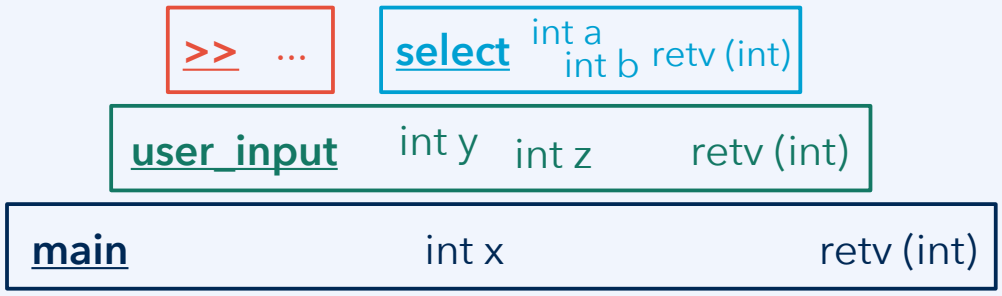
Functions and their stack frames

Stack-like memory management

When a function is called, a known amount of memory must be allocated for its variables (including parameters) "on top of the stack."

When the function returns, its memory can be released; the calling method and its variables become the top of the stack again.

The lifetime of local variables in a **stack frame** is limited to the function's runtime.




```
int select(int a, int b)
{
  if(a%2 == 0) return a;
  else return b;
}

int user_input()
{
  int y = 0, z = 0;
  std::cin >> y >> z;
  return select(y, z);
}

int main()
{
  int x = user_input();
}
```

Example file: three-functions.cpp; compile with "g++ -g3 -o …" and run using gdb.

Observations: Stack

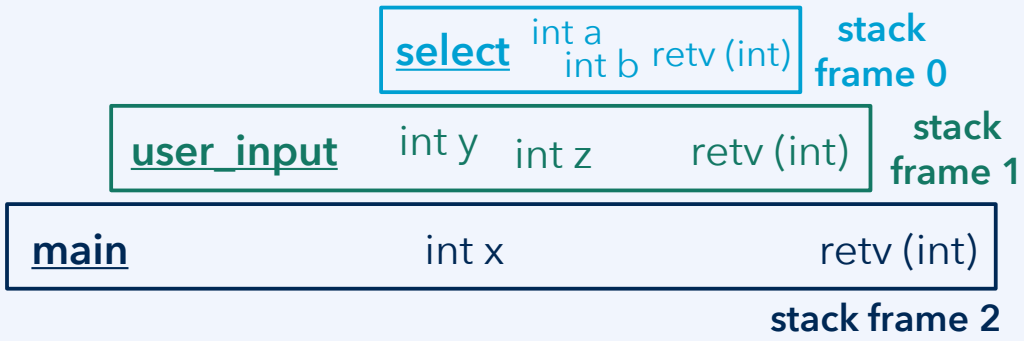
Backtrace and stack inspection using gdb

- Compile with "-g" or "-g3" option
- gdb three-functions
  - break three-functions.cpp:**6**
  - run

```
Breakpoint 1, select (a=4, b=3) at three-functions.cpp:6
6       if(a%2 == 0) return a;
```

  - bt ["backtrace"]

```
#0  select (a=4, b=3) at three-functions.cpp:6
#1  [...] user_input () at three-functions.cpp:14
#2  [...] main () at three-functions.cpp:19
```




```
1
2
3
4  int select(int a, int b)
5  {
6    if(a%2 == 0) return a;
7    else return b;
8  }
9
10 int user_input()
11 {
12   int y = 0, z = 0;
13   std::cin >> y >> z;
14   return select(y, z);
15 }
16
17 int main()
18 {
19   int x = user_input();
20 }
```

Summary: Allocation & deallocation (pointers)

How do we declare a pointer?

- Like any other variable. Its type is a pointer type; *e.g.*, int* my_int_pointer;

How do we initialize a pointer?

- Initialize to **nullptr** (pointer version of 0): int* my_int_pointer = **nullptr**;
- Initialize to **another variable's address**: int* my_int_pointer = &my_index;
- **Allocate memory** on the heap: int* my_int_pointer = **new** int(0);

How do we deallocate a variable if it is stored on the heap?

- Delete the pointer to it. Example: b = **new** BookIndex; …; **delete** b;

How to release the memory if it is a local variable that is stored on the stack?

- Don't do that! You can only call "delete" on memory allocated with "new".

What if we call **new**, but there is not enough free memory left on the system?

- **new** VeryBigObject may throw an exception (a high-level construct).
- **new(std::nothrow)** VeryBigObject may return **nullptr** (low-level construct).

Summary: Allocation & deallocation (arrays)

How do we declare a array?

- Give the size as constant expression in square brackets; *e.g.*, int values[6];
- Also possible: Just declare a pointer; *e.g.*, int* values;

How do we initialize an array?

- Explicitly give all the values: int values[ ] = {4, 2, 3, -7, 2, 3};
- Initialize to **all zeroes**, indicating the array size: int values[6] = { };
- **Allocate memory** with **default initialization**: int* values = **new** int[6]**()**;

How do we deallocate an array if it is stored on the heap?

- Use **delete[]**. Example: b = **new** BookIndex[100]**()**; …; **delete[]** b;
- **Pitfall:** If you use **delete** instead of **delete[]**, only b[0] will be deallocated!

What if we call **new**, but there is not enough free memory left on the system?

- **new** BigObject[100000]**()** may throw an exception.
- **new(std::nothrow)** BigObject[100000]**()** may return **nullptr**.

Glossar

Allokering

Definisjon: det å reservere minne på haugen for eit dataelement/objekt, datatabell eller annan datastruktur

- Vi kan òg seia at minnet på kallstakken blir «allokert», men det er alltid kompilatoren som tek vare på det;
- når programmeraren allokerer minne gjennom **new**, er det på haugen.

Glossar

Haug

Definisjon: minneområde der data blir allokert dynamisk, utan direkte tilknyting til kallstakken

Glossar

Stakkramme

Definisjon: element av kallstakken, som inneheld alle parametrane og dei lokale variablane til ein funksjon

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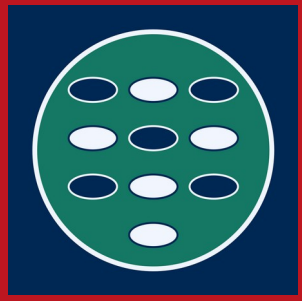

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Fast copying

Example: **std-copy.cpp**

Element-wise copying

```
for(int i = 0;  i < num_copy;  i++)  target[i] = source[idx_start + i];
```

This is slow! Don't do this for large numbers of elements adjacent in memory. Also, note that Core Guidelines recommend "size_t" instead of int.

C-style fast copying (apply this only to a traditional C/C++ array)

```
#include <cstring>
…
std::memcpy(target,  source + idx_start,  num_copy * sizeof(element_type));
```

Modern C++ style fast copying (can also be used for STL containers)

```
#include <algorithm>
…
std::copy(source + idx_start,  source + idx_start + num_copy,  target);
```

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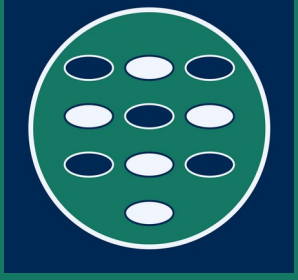

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