Praktikum: Entwicklung interaktiver eingebetteter Systeme

C++-Labs

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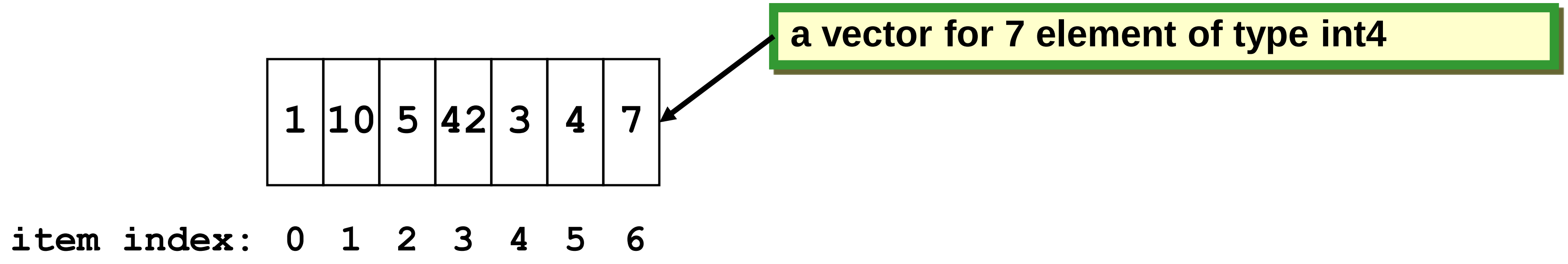
Agenda

- Writing a Vector Class
- Constructor, References, Overloading
- Templates, Virtual Functions
- Standard Template Library (ADVANCED)
- Smart Pointer (ADVANCED)

Writing a Vector Class

- Writing a simple vector class
  - a vector is an one-dimensional array of objects
  - start with a simple object
  - integer values - type int
  - to make future changes easier use a typedef - t_vector
  - provide methods to
    - create a vector of given size
    - read/write to/from that vector (implemented later)
    - destroy a vector without memory leakage


a vector for 7 element of type int4
1
10
5
42
3
4
7
item index: 0 1 2 3 4 5 6

Vector Class| Header

```
#ifndef _INCLUDED_VECTOR_HPP
#define _INCLUDED_VECTOR_HPP

#include <iostream>

typedef int t_vector;

// class declaration
class vector {
public:
  vector(int size = 16);
  ~vector();

protected:
  t_vector *_buf;
  int       _size;
}; // Note the semicolon
#endif // _INCLUDED_VECTOR_HPP
```

avoid multiple inclusion

data type to be stored in vector

constructor and destructor

member variables to store the vector elements and the size of the vector

Vector Class| Implementation

```
// use header from previous slide
#include "vector.hpp"

vector::vector(int size) { // constructor
   _size = size;
   _buf = new t_vector[_size];

   for(int idx = 0;idx < _size;++idx) {
     _buf[idx] = -1;
   }
   std::cout << "vector of size: "
             << _size << " created [ ";
   for(int idx = 0; idx < _size;++idx) {
     std::cout << _buf[idx] << " ";
   }
   std::cout << "]" << std::endl;
}

vector::~vector() { // destructor
   delete[] _buf;
   std::cout << "vector of size: "
             << _size << " deleted”
             << std::endl;
}
```

allocate storage for vector elements

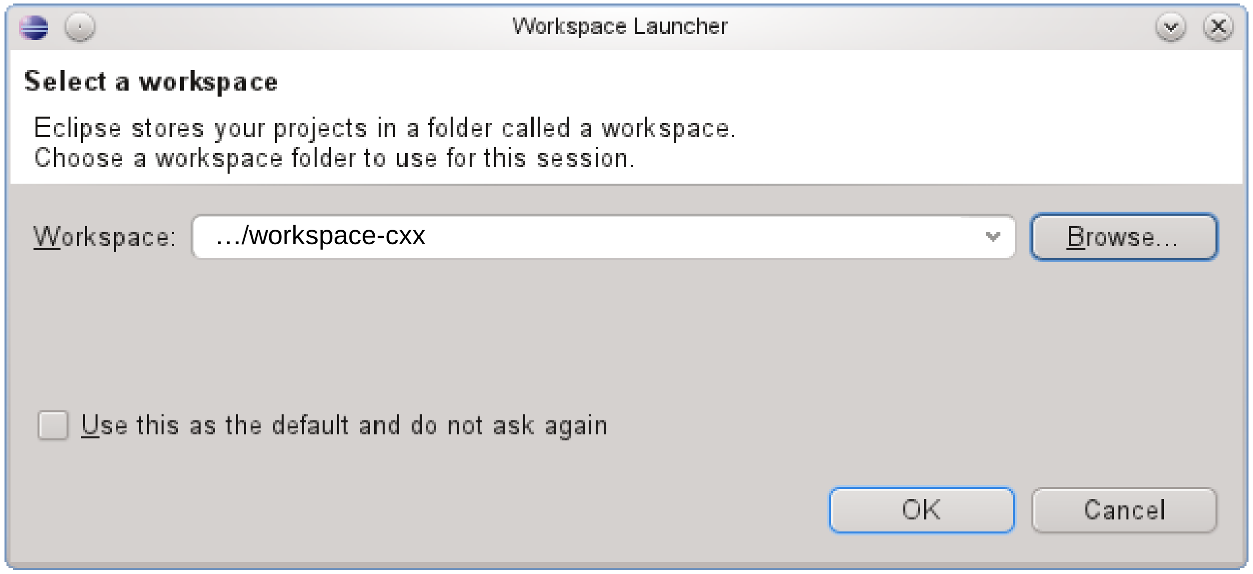
data type to be stored in vector

initialize vector elements to known value

free the storage allocated by the vector elements

Vector Class| Compile and Run

- Open the Eclipse workspace “workspace-cxx”



Select a workspace

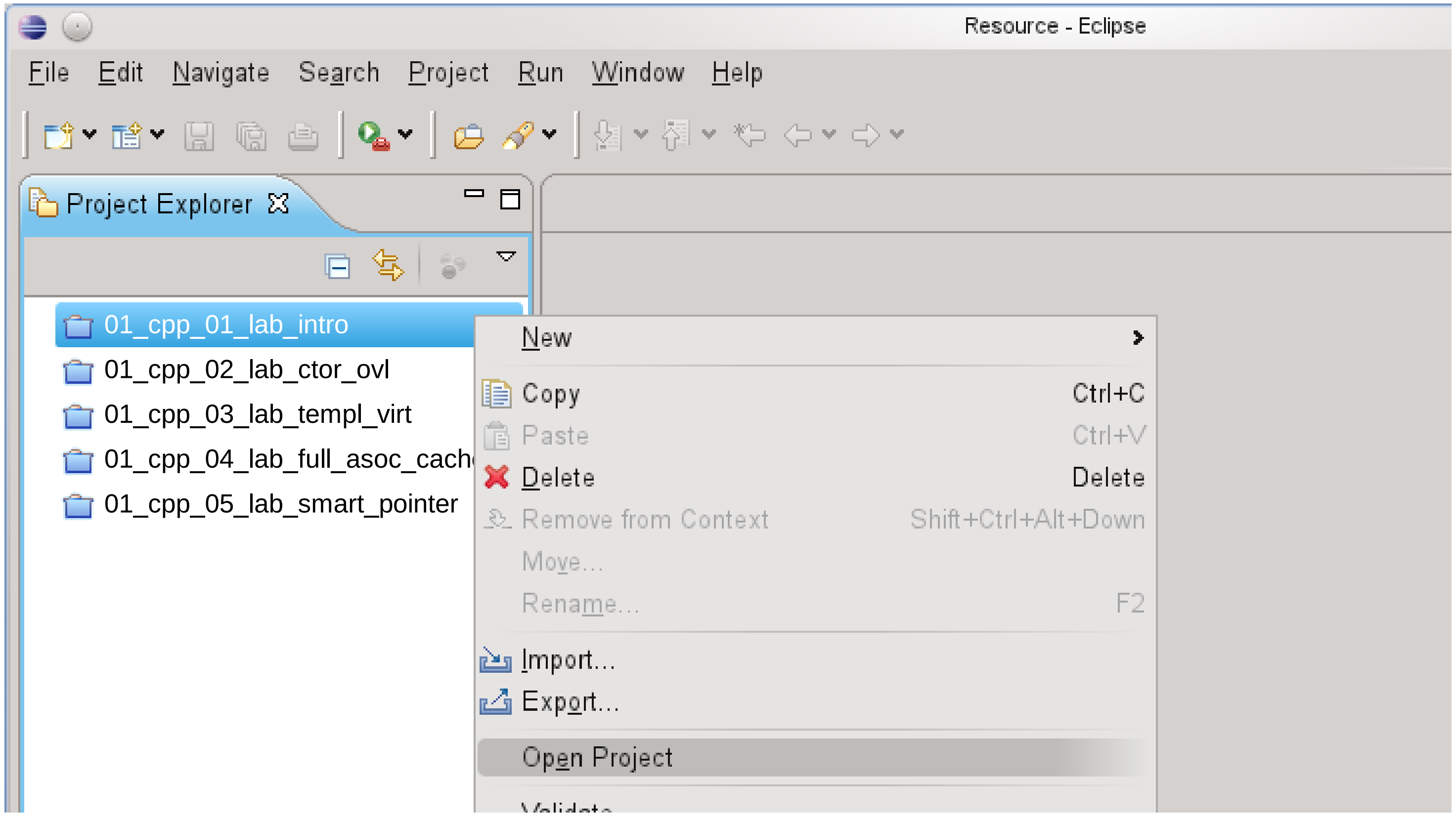
Eclipse stores your projects in a folder called a workspace.
Choose a workspace folder to use for this session.

Workspace: …/workspace-cxx

Use this as the default and do not ask again

Vector Class| Compile and Run

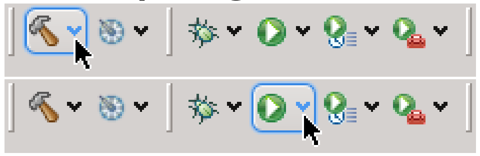
- Then open the 01_cpp project in there



Lab “01_cpp_01_lab_intro” 1/1

- Modify main.cpp to
  - instantiate vectors of size 2,5 and 10
  - explicitly call the destructor of one vector

- Compile and Run the program using the eclipse
  - “Build” menu
  - “Run” menu



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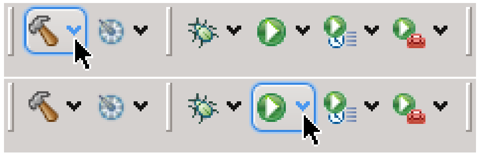
Lab “01_cpp_02_lab_ctor_ovl”

- For the vector class
  - a constructor with an optional parameter for the initial value is needed (default = 0)
  - a function with two arguments that reads values from the vector is needed
    - Argument 1: a reference to the value to be read
    - Argument 2: the index of the value to be read
    - The function has to implement a range check for the index argument
  - two operators have to be implemented
    - vector &operator =(const vector &rhs);
    - vector &operator +=(const vector &rhs);
      (implements pointwise addition; check if both vectors are of equal length)

Lab “01_cpp_02_lab_ctor_ovl” 1/1

- Constructor, References and Overloading
  - in **vector.h**
    - extend the function prototype of the constructor to take two arguments (vector size and initial value)
    - give the function prototype for the new read() function that takes two arguments (value and index)
  - in **vector.cpp**
    - implement the element initialization in the constructor
    - implement the new **read**() method
    - implement the **operator=**()
    - implement the **operator+=**()

- Compile and Run the program using the eclipse
  - “Build” menu
  - “Run” menu



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- Writing a Vector Class
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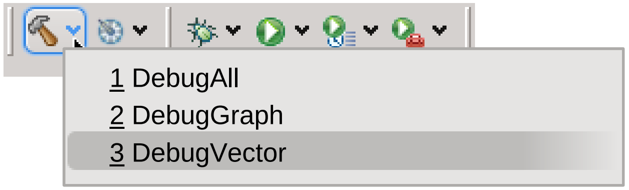
Lab “01_cpp_03_lab_templ_virt”

- Making the vector class a template class
  - modify the vector class to be a template class that can store an arbitrary data type
- Create a class hierarchy for graphical objects
  - pure virtual base class graph_obj
    - declares a method **area**() to return the area
  - concrete implementations derived from **graph_obj** (e.g. a **rectangle** and a **circle**) have to implement that method
- Store graphical objects within the **vector** class
- Use the new template version of the vector class to store graphical objects (e.g. rectangles and circles)

Lab “01_cpp_03_lab_templ_virt” 1/3

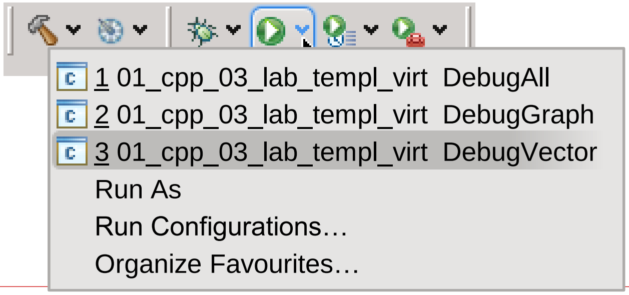
- Class Templates, Virtual Methods and Classes
  - in **vector.h**
    - modify the code to make vector a template class **vector**<T>
    - **Hint: In our original code we used t_vector as a typedef for the data type to store in the vector!**
    - **Hint: Have a look at the constructor, as it has already been transferred to a template style!**
    - **Hint: Remember that the complete class implementation of a template class has to reside in the header file!**

- Compile and Run the program using the eclipse
  - DebugVector “Build” menu entry



1 DebugAll
2 DebugGraph
3 DebugVector

  - DebugVector “Run” menu entry

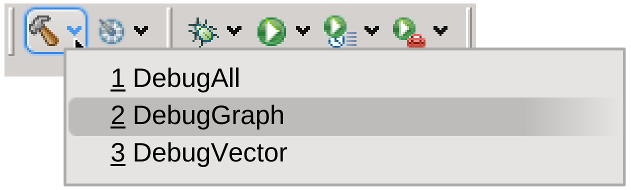


1 01_cpp_03_lab_templ_virt DebugAll
2 01_cpp_03_lab_templ_virt DebugGraph
3 01_cpp_03_lab_templ_virt DebugVector
Run As
Run Configurations…
Organize Favourites…

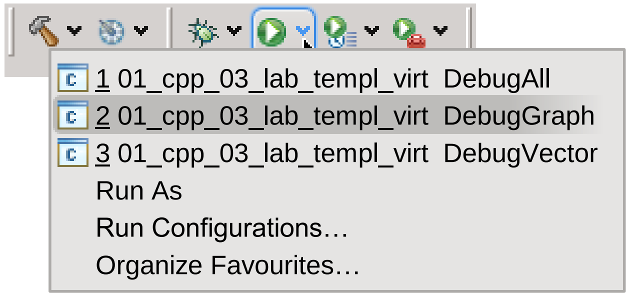
Lab “01_cpp_03_lab_templ_virt” 2/3

- Class Templates, Virtual Methods and Classes
  - in **graph_obj.h**
    - implement a class circ (for circle) that inherits from the virtual base class graph_obj
    - the constructor should take the radius as an optional argument (default = 0.0)
    - implement the method **area**()
    - **Hint: Don't forget to implement a destructor as well!**

- Compile and Run the program using the eclipse
  - DebugGraph “Build” menu entry



  - DebugGraph “Run” menu entry

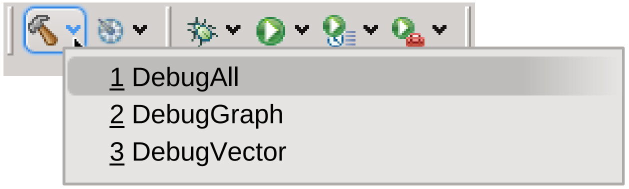


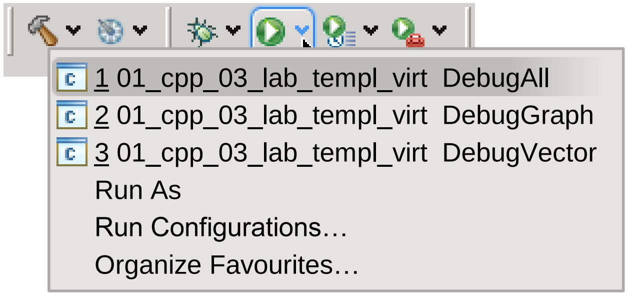
1 01_cpp_03_lab_templ_virt DebugAll
2 01_cpp_03_lab_templ_virt DebugGraph
3 01_cpp_03_lab_templ_virt DebugVector
Run As
Run Configurations…
Organize Favourites…

Lab “01_cpp_03_lab_templ_virt” 3/3

- Class Templates, Virtual Methods and Classes
  - in **main.cpp**
    - instantiate a vector of **rect** with 2 elements, the elements should have width=1, height=2
    - instantiate a vector of **circ** with 3 elements, the elements should have radius=2

- Compile and Run the program using the eclipse
  - DebugAll “Build” menu entry
  - DebugAll “Run” menu entry




1 01_cpp_03_lab_templ_virt DebugAll
2 01_cpp_03_lab_templ_virt DebugGraph
3 01_cpp_03_lab_templ_virt DebugVector
Run As
Run Configurations…
Organize Favourites…

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Lab "…04_lab_full_asoc_cache"

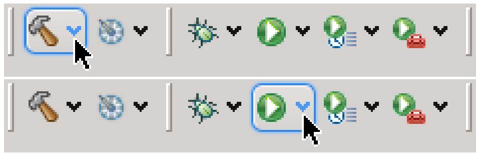
- Problem
  - Associative hardware caches have fixed sizes and given replace strategies
  - The C++ STL provides associative container classes, but these do not have a fixed size and no replace strategy

- Idea
  - Implement a fully associative cache as a template class **full_asoc_cache**<>, that uses the **map**<> container class from the STL
  - The data types for the key and for the entry are given as template parameters
  - The size of the cache (the number of cache-lines) is given as constructor parameter
  - To simplify the implementation, inserting a new entry into a full cache replaces a random cache line

Lab "…04_lab_full_asoc_cache" 1/1

- Standard Template Library
  - in **full_asoc_cache.h** implement following methods
    - bool get(const TAG_T&, ENTRY_T&);
      Hint: Use the method find() from the class map<>
    - void insert(const TAG_T&, const ENTRY_T&);
      Hint: Use the operator[] from the class map<>
    - void erase(const TAG_T&);
    - void clear();

- Compile and Run the program using the eclipse
  - "Build" menu
  - "Run" menu



Output:
```
re:10.1  im:0
re:12.1  im:0.2
re:14.1  im:0.4
Re:15.1  im:0.5
```

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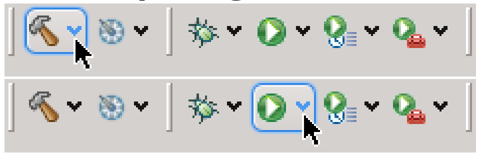
Lab “01_cpp_05_smart_pointer”

- Problem
  - Unlike Java, C++ provides no built-in garbage collector that deletes unreferenced objects, thus eliminating memory leaks
  - Smart pointers that manage reference counts for every allocated object are able to know when the last reference to an object is gone and thus delete the object
- Idea
  - Implement a template class **smart_ptr**<> that represents a pointer to a given object type **T**
  - The Copy Constructors and the Assignment Operators have to manage the reference counts
  - The Destructor and the Assignment Operators may delete the referenced object
  - A **smart_ptr**<> can be created from a pointer to an object of type T
  - A common reference count value is allocated if the pointer is not 0 (what is the default value)

Lab "01_cpp_05_smart_pointer"

- Smart Pointer
  - in **smart_ptr.h**
    - implement a constructor to create a **smart_ptr**<T> from a pointer **T***
    - implement the copy constructors and the assignment operator with reference counting
    - implement the destructor and avoid memory leaking
    - implement the missing operators to create a complete smart pointer

- Compile and Run the program using the eclipse
  - "Build" menu
  - "Run" menu



Output:

```
*ptr3 = black-colored car with speed 12.0416
*ptr4 = silver-colored jet with speed 100.125
*ptr5 = 42
```