Introduction to Abstract Data Types

Κ08 Δομές Δεδομένων και Τεχνικές Προγραμματισμού
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Abstract Data Type (ADT)

- A collection of **data** and **operations** that
  - have precisely described behaviour (we know **what** they do)
  - but no precise implementation (we don't know **how** they do it)

- **ADTBookStore** (from the first lecture)
  - insert(title)
  - remove(title)
  - find(title)

- Do we know any such type?
Native types

- How is `int` implemented?
- What does `int a = -2;` store in memory?
  - 10...10 (sign-magnitude)
  - 1111101 (1-complement)
  - 1111110 (2-complement)
  - bit order? (little vs big endian)
  - size? (16, 32, 64 bits)
  - at least $3 \cdot 2 \cdot 3 = 18$ possibilities! The choice depends on the CPU.
- How is `a++` implemented?
Native types

• Even simple native types and operations are in reality **abstract**

• We know **what** they do but not **how**

• `int a = 1` stores **some representation** of 1 in `a`

• `a++` stores the representation of `a + 1` in `a`
  - where `a` is the number represented in `a`

• `printf("%d", a)` prints the number `a` represented in `a`
Why?

1. We can write programs without **thinking** (or even knowing) about how these operations are implemented
   - use complicated algorithms easily

2. We can **change the implementation** of `int` (eg change the CPU) without changing the code
   - easy maintenance

It would be impossible to write complex programs without these features!
Writing our own ADTs

- ADTFoo will be represented by the module `ADTFoo.h`
  - Declare a list of functions, constants, typedefs, etc
  - Describe **what** the module does, with documentation!

- To **use** ADTFoo
  - `#include "ADTFoo.h"
  - Call its methods, eg `foo_create()`
  - Link with `foo.o` (or some library containing it)

- To **implement** ADTFoo
  - Create `foo.c`, implementing all functions
  - The implementation should match the advertised behaviour
Containers

• The ADTs we learn in this class are containers
  - They allow to insert data (stored in the container)
  - Then retrieve it in different ways
  - And remove it

• Store values of any type: void*

• They have similar interfaces
  - Differ in the way data is inserted/removed/retrieved
# ADT Overview

<table>
<thead>
<tr>
<th>ADT</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADTVector</td>
<td>An abstract growable “array”</td>
</tr>
<tr>
<td>ADTList</td>
<td>Insert at any position, no “random access”</td>
</tr>
<tr>
<td>ADTQueue</td>
<td>First-in, First-out</td>
</tr>
<tr>
<td>ADTStack</td>
<td>Last-in, First-out</td>
</tr>
<tr>
<td>ADTPriorityQueue</td>
<td>Fast-access of the maximum element</td>
</tr>
<tr>
<td>ADTMap</td>
<td>Associate key =&gt; value (array with any type of index)</td>
</tr>
<tr>
<td>ADTSet</td>
<td>Ordered collection of unique items</td>
</tr>
</tbody>
</table>
Naming

• We use **different** names for **ADTs** and **Data Structures**
  - eg. **ADTVector** implemented by a **Dynamic Array**
• Loosely following the naming of the C++ standard library
• Be careful: each ADT/DS is known under many different names
  - also: the same name is often used for ADTs and DSs
• Remember the substance, not just the names!
A typical container ADTFoo

```c
typedef struct foo* Foo;
```

- We use an **incomplete struct** to hide the implementation
- The user cannot create `struct foo` variables or access their content
- We can only store **pointers** to `struct foo` created by the module
  - called **handles**
  - using the `Foo` typedef we forget that they are pointers!
- And pass them to other methods
A typical container ADT Foo

// Δημιουργεί και επιστρέφει ένα νέο foo
Foo foo_create();

// Επιστρέφει τον αριθμό στοιχείων που περιέχει το foo
int foo_size(Foo foo);

// Προσθέτει την τιμή value στο foo
void foo_insert(Foo foo, Pointer value, ...);

// Αφαιρεί και επιστρέφει μια τιμή από το foo
Pointer foo_remove(Foo foo, ...);

// Βρίσκει και επιστρέφει ένα στοιχείο από το foo
Pointer foo_find(Foo foo, ...);

// Ελευθερώνει όλη τη μνήμη που δεσμεύει το foo
void foo_destroy(Foo foo);
A typical use of ADTFoo

```c
#include "ADTFoo.h"

int main() {
    Foo foo = foo_create();

    // Προσθήκη στοιχείων στον ADT
    foo_insert(foo, int_pointer1);
    foo_insert(foo, int_pointer2);

    // Εύρεση στοιχείου
    int* value = foo_find(foo, ...);
    printf("found: %d", *value);

    // Αφαίρεση στοιχείου
    foo_remove(foo, ...);

    // Εκκαθάριση μνήμης
    foo_destroy(foo);
}
```
Many containers allow iterating

Using the concept of `node`.

```c
Foo foo = foo_create();
// ...insert...

// Διάσχιση όλων των στοιχείων (η σειρά εξαρτάται από τον ADT)
for(FooNode node = foo_first(foo); node != FOO_EOF; node = foo_next(foo, node)) {
    int* value = foo_node_value(foo, node); // η τιμή του συγκεκριμέν
    printf("value: %d\n", *value);
}
```