CSE 143

Abstract Data Types

[Chapter 3]

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Data Abstraction

What is *Abstraction*?

- An idealization
- A focus on essential qualities, disregarding the "details"
- An emphasis on the *what* rather than the *how*
  - `Specification vs. Implementation`
- A problem-solving technique

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Abstraction in Programming

- The type `int` is an abstraction for a way of interpreting bits in memory as a number
- A *struct* is an abstraction of a collection of related data items
- A *function* is a programmer-designed abstraction for some computation
- A *module* is a programmer-designed abstraction that groups related functions and data together and provides an interface

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Why Abstraction?

- Abstractions helps in managing complexity
  - Don't need to know details, just interface
- Treat abstractions as "black box" components to build upon
  - Know what inputs go into box, and what outputs come out, but not what goes on inside the box
  - Hierarchical or layered decomposition

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Review: Types vs. Instances

- Types
  - General category
  - Usually few in number
  - Some built in (`int`, `char`, `double`, etc.)
  - Programmer-defined (arrays, `structs`, `enums`, classes, etc.)
- Instances
  - Particular variables, parameters, etc.
  - May have many instances of a given type

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Abstract Data Types

- *ADTs* have two aspects:
  - Collection of *data*
  - *Operations* that can be applied to data
- Examples
  - Integers: arithmetic operations, printing, etc.
  - Boolean: `AND`, `OR`, `NOT`, test if `true`, etc.
  - Grade Transcript: Add, remove classes and grades, change grades, etc.

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Type = Data + Operations

- More Examples:
  - Automatic Teller Machine

    ```
    Data: cash available, machine status
    Operations: get account information, dispense
    cash, confiscate card, ...
    ```
  - Telephone network switch

    ```
    Data: line status, call information
    Operations: set up and break down calls, send
    billing information, test circuits,...
    ```

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Abstract Data Types

Two separate aspects:

- **Interface**
  - Name of new type
  - “Constructors” to make instances
  - Public operations on instances
- **Implementation**
  - Data representation of new type
  - Implementation of public operations, constructors
  - Additional private operations

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Implementer / Client / User

- Implementer (programmer)
  - writes the internal details of some part of the system
  - defines interface and implementation
- Client (programmer)
  - uses the interface of the "black box" provided by the Implementer
  - does not (directly) use the implementation!
- User (non-programmer)
  - sees only the exterior behavior of the system
- Related language for functions: Caller vs. called

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Textbook example: List ADT

- A list… names, groceries, numbers, etc.
- What do you need to do?
  - Create and destroy a list
  - Find out how long it is
  - Add (insert) new items to it
  - Delete items
  - Look at (retrieve) items
- Vector
  - A list where you can retrieve values by their index

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Great Ideas, but...

- How do we actually get modularity, abstraction, ADTs, black boxes, etc. in our programs?
- "Encapsulation": wrapping up the data and operations together in a clean package
- Historical note: for many years programmers have struggled to do this. Recent programming languages make it (much) easier.

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