

Abstract data types (ADT's)

Data Structures

- data – factual information
- structure – arrangement or relationship of elements
 - The New Merriam-Webster Pocket Dictionary

Data Type

- A data type is defined by two properties:
 - A Domain: set of values that belong to that type.
 - A Set of Operations: defines the behavior of that type.
- Example: **int**
 - What is the domain?
 - What are the operations?

Primitive (Atomic) C Data Types

Defined by the C language specification.

- Integer types: short, int, long
 - These can be preceded by unsigned
 - What is the size of int?
 - sizeof (int)
- Floating point types: float, double, long double
- Text types: char
 - What about string?
- What about Boolean?

Goal

- Build a useful data structure
- Test the data structure
- Hand that data structure off to a customer
 - future you
 - teammate
 - paying customer
 - your professor
- Profit / pass the class!

Data Structures

- A data structure can be thought of as a data type with values that:
 - Can be broken up into a set of component elements where each element is either atomic or another data structure
 - Include a set of relationships (structure) involving the component elements

Abstract Data Types (ADTs)

- An Abstract Data Type is defined in terms of its behavior rather than its representation
- An ADT has two qualities:
 - Irrelevant details are suppressed (hidden)
 - The data type being abstracted is isolated
- When defining ADTs you need:
 - The Domain
 - The Operations

Integer ADT

- Let us consider the specification for the integer ADT as follows:

ADT: Integer

Domain: All whole numbers i where
 $\text{INT_MIN} \leq i \leq \text{INT_MAX}$

`<limits.h>`

Integer ADT Specification

- **Operations:** Given i is an integer and f & g are expressions whose result is an integer, we define the following operations for C :

Operator	Results
Unary $+$	$+f$ is the same as f
Unary $-$	$-f$ changes the sign of f
Assignment $=$	$i = f$ assigns the integer value of f to i
Binary $+$	$f + g$ is the addition of two integer values

String ADT

- Integer is an atomic ADT.
- How might we specify a structured data type such as a String?
- Before specifying the String ADT, we need to answer certain questions.

String ADT Questions

- What are the domain of possible values
- What operations exist?

Language independent

Language specific

- What type are the component elements?
- What structure does the type have?

String ADT Specification

- **Elements:** Type char excluding the null terminating character.
- **Structure:** Characters are arranged linearly.
- **Domain:** All combinations of strings of length 0 to the max string length that can be formed from the character set.

String ADT Specification

- Operations
 - function `strLength (s)`
 - **results**: returns the number of characters in the string `s`
 - function `strEqual (s1, s2)`
 - **results**: returns true iff `strLength (s1)` equals `strLength (s2)` and the i th character of `s1` and `s2` are equal for all i where $1 \leq i \leq \text{strLength}(s1)$ *
 - function `strConcat (s1, s2)`
 - **results**: string `s2` is concatenated on the end of string `s1`; if the result exceeds the max string length, the characters are dropped

*Why 1 and not 0?

String ADT Specification

- Operations Continued
 - function strAppend (s, ch)
 - **requires:** strLength (s) < max string length
 - **results:** ch is added to the end of s increasing the length by 1
 - function strReverse (s)
 - **results:** the characters of s are reversed “abc” is “cba”
 - function strClear (s)
 - **results:** the string s is made empty
 - function strCopy (s1, s2)
 - **results:** string s2 is copied into string s1

ADT Implementation

- Now that the String ADT has been specified, we can focus on the best implementation choice.
- Before writing the code for each of the functions, we need to decide how we are going to represent a string.
- Code defensively! Your Data Structure should never crash the user's program.

String Representation

```
#define MAX_STR_LEN 256
typedef struct
{
    int length;
    char data[MAX_STR_LEN];
} String;
```


Problem

- For the given String representation, implement each of the following functions in C:
 - strlen
 - strcpy
 - strcat