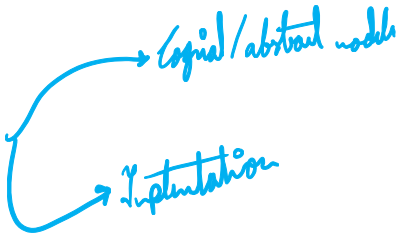
INTRODUCTION TO ADT

CS212:Data Structure

Data Types & Data Structures

- Applications/programs read data, store data temporarily, process it and finally output results.
- What is data? Numbers, Characters, etc.

Data Types & Data Structures



- Data is classified into **data types**. e.g. char, float, int, etc.
- A data type is:
  - (i) a **domain** of allowed values and
  - (ii) a set of **operations** on these values.
- Compiler signals an error if wrong operation is performed on data of a certain type.
  - For example,
    - `char x,y,z;`
    - `z = x*y` is not allowed.

Data Types & Data Structures

- Examples

Data Type	Domain	Operations
boolean	0,1	and, or, =, etc.
char	ASCII	=, <>, <, etc.
integer	-maxint to +maxint	+, _, =, ==, <>, <, etc.

Data Types & Data Structures

- `int i,j;` i, j can take only integer values and only integer operations can be carried out on i, j.

- **Built-in** types: defined within the language e.g. `int`,`float`, etc.

- **User-defined** types: defined and implemented by the user e.g. using `typedef` or `class`

Data Types & Data Structures

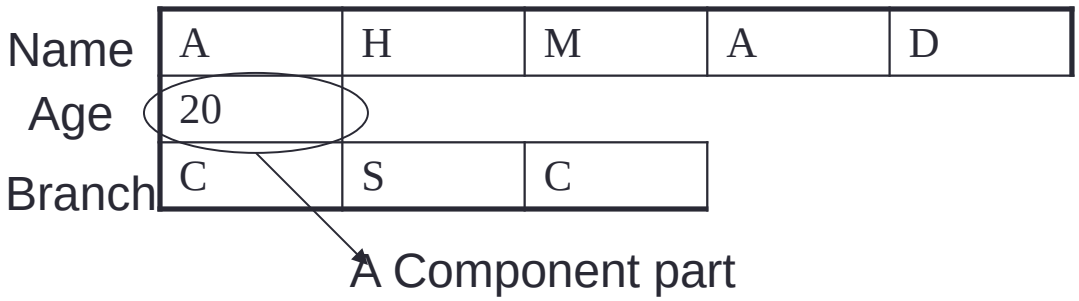
- **Simple Data** types: also known as atomic data types have no component parts. E.g. int, char, float, etc.

Primitive?

21 3.14 ‘a’

Data Types & Data Structures

- **Structured Data** types: can be broken into component parts. E.g. an object, array, set, file, etc. Example: a student object.



Data Types & Data Structures

- A **data structure** is a data type whose values
  - (i) can be decomposed into a set of component elements each of which is either simple (atomic) or another data structure
  - (ii) include a structure involving the component parts.

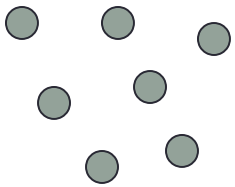
Data Structures -> Data StructurING

- A data structure is **a collection of data**, organized so that items can be stored and retrieved or removed by some fixed techniques.

Data Types & Data Structure

↳ stored in undo when using undo-redo

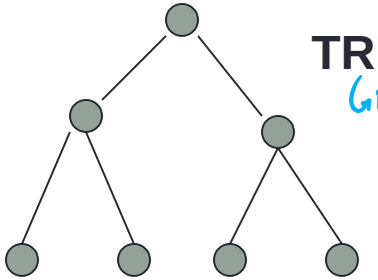
Possible Structures: Set, Linear, Tree, Graph.



SET

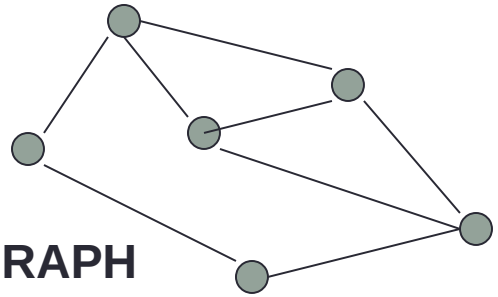
LINEAR → a string is a set of linear characters

↳ (linked list?



TREE

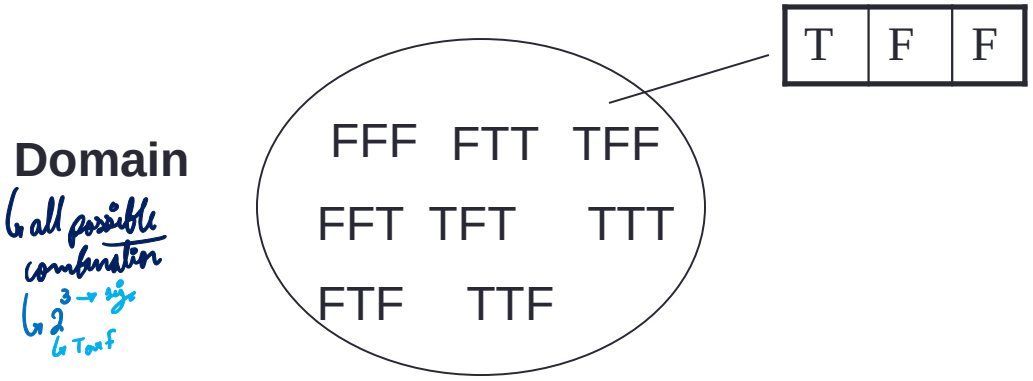
↳ BST



GRAPH

Data Types & Data Structures

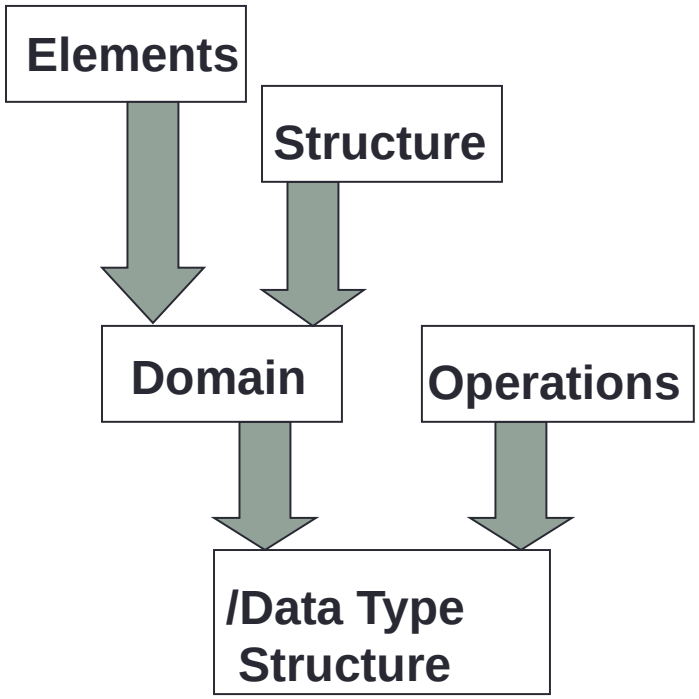
- What is the domain of a structured data type? Operations?
- Example: `boolean[] Sample= new boolean[3];`



Data Types & Data Structures

- Example: Operations:

```
Sample[0] = True;
boolean C = Sample[1];
```



Abstract Data Types (ADTs)

- **Abstraction**? Anything that hides details & provides only the essentials. → gives you a skeleton or a template
- Examples: an integer 165 = $1.10^2+6.10^1+5.10^0$, procedures/subprograms, etc.
- **Abstract Data Types (ADTs):** Simple or structured data types whose implementation details are hidden… → independent of the implementation; integer, strings, characters

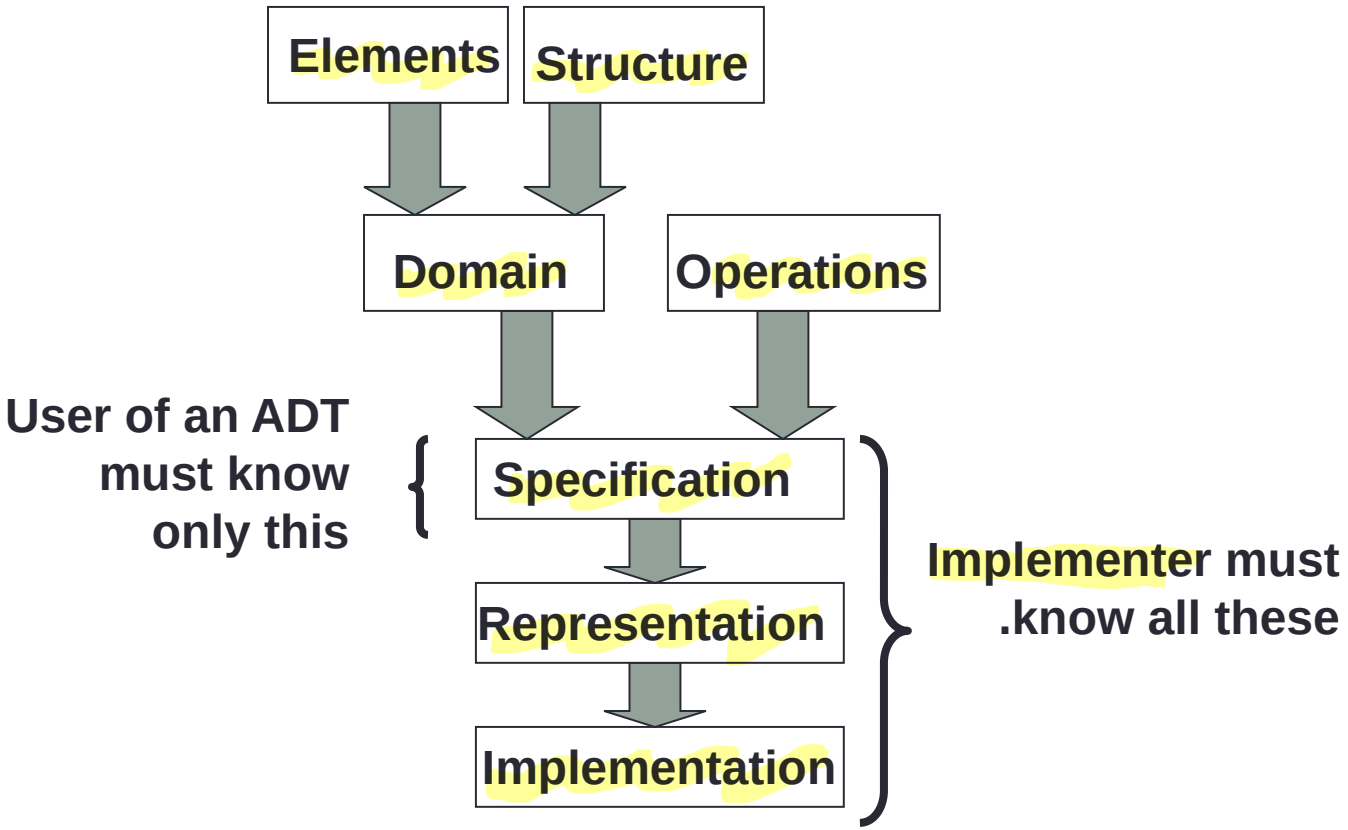
ADTs

- While designing ADTs, a designer has to deal with two types of questions:
  - (i) **What** values are in the domain? **What** operations can be performed on the values of a particular data type?
  - (ii) **How** is the data type represented? **How** are the operations implemented?

ADTs

- ADTs **specification** answers the ‘what’ questions. Specification is written first.
- ADTs **implementation** answers the ‘how’ questions. Done after specification.
- Users & Implementers:
  - Users of an ADT need only know the specification …. No implementation details. advantage
  - Programmer (Implementer) who implements ADT is concerned with..specification, representation, implementation.

ADTs


Elements
Structure
Domain
Operations
User of an ADT must know only this
Specification
Representation
Implementation
Implementer must know all these

ADT: Example

ADT String1
:Specification
.**Elements:** type char
.**Structure:** elements (characters) are linearly arranged
Domain: type String, finite domain, there are 0 to 80 chars in a string, therefore $1+128+128^2+\ldots..+128^{80}$ possible .stings in the domain
.**Operations:** Assume that there is a string S
Procedure Append (c: char).1
.Requires: length(S) < 80
.Results: c is appended to the right end of S

ADT: Example

2. Procedure Remove (c: char)

   Requires: length(S) > 0.

   Results: The rightmost character of S is removed and placed in c, S's length decreases by 1.

3. Procedure MakeEmpty ()

   Results: all characters are removed.

4. Procedure Concatenate (R: String)

   Results: String R is concatenated to the right of string S, result placed into S.

5. Procedure Reverse ()
6. Procedure Length (L: int)
7. Procedure Equal (S: String, flag: boolean)
8. Procedure GetChar (int i)

Remember

- In Java the *class* construct is used to declare new data types.
- In Java operations are implemented as function members of classes or methods.

ADT String: Implementation

```
} public class String1 extends Object
;private char[] str
;private int    size

} () public String1
;size = -1
;str = new char[80]
{
} public void Append (char c)
;++size
if (size<80)
;str[size] = c
 else
System.out.println("Character"+c +" is not
;appended ")
{
```

Representation

Implementation

ADT String: Implementation

```
public char Remove (){
   char c = str[size];
   size--;
   return(c);
}
public char GetChar(int i){
 if(i>=0 && i<size+1)
   return(str[i]);
 return ‘’;
}
public void MakeEmpty (){
   size = -1;
}
public int Length (){
   return(size+1); }
```

ADT String: Implementation

```
public void Concatenate (String1 s){
     for (int i = 0; i<=s.Length(); i++) {
       char c = s.GetChar(i);
       Append(c);
      }
  }
  public boolean Equal (String1 s){
  }
  public void Reverse () {
  }
}
```

Using ADT String

```
import java.lang.*;
public class Test {
  public static void main(String[] args) {
        String1 s = new String1();
        String1 s1 = new String1();
        System.out.println("Hello, World");
        s.Append('a');
        s1.Append('b');
        s.Concatenate(s1);
        System.out.print(s.GetChar(0));
        System.out.println(s.GetChar(1));
}
```

ToDo

- Read 2.1, 2.2, 2.3 of the Textbook.
- Program the String1 ADT.
- Implement the reverse and equals operations.
- Test This ADT using a test Class.

* Data Types:
  1. define a domain of value
  2. define operations allowed

* User-defined Data Types:
  1. the operations and values are not specified in the language but by the user
     ↳ example a user defines a point type that consists of 2 integers x, y

* ADT:
  1. similar to user-defined data types which defines operations on values using functions w/o specifying what is inside and how it performs.
  2. acts as a blueprint or an outline
     ↳ a black box that hides the inner structure and design from the user.
  3. there are multiple ways to implement ADT.
  4. a user can use ADTs operations w/o knowing the implementation
     ↳ example: we use the method .length() with String w/o knowing the code!