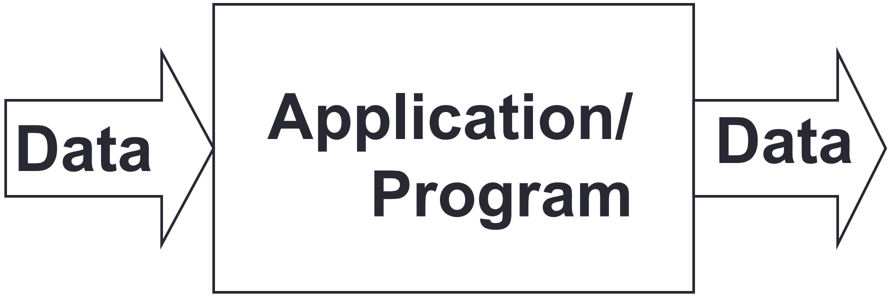
INTRODUCTION TO ADT

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

Application/ Program

Data

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.

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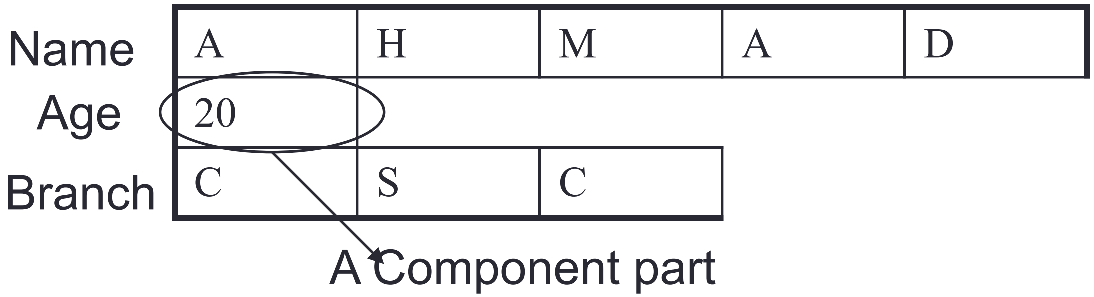
3.14

‘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.



Name	A	H	M	A	D
Age	20				
Branch	C	S	C		

A Component part

Data Types & Data Structures

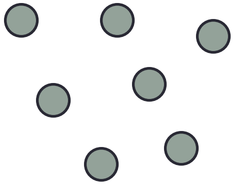
- A **data structure** is a data type whose values
  - (i) can be decomposed into a set of component elements each of which is either simple (atomic) or another data structure
  - (ii) include a structure involving the component parts.

Data Structures -> Data StructurING

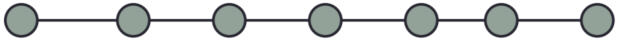
- A data structure is **a collection of data**, organized so that items can be stored and retrieved or removed by some fixed techniques.

Data Types & Data Structure

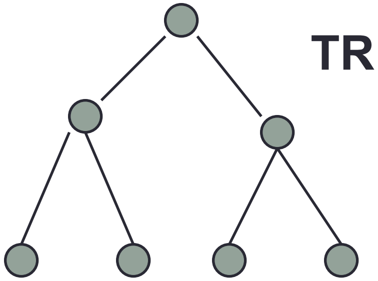
Possible Structures: Set, Linear, Tree, Graph.



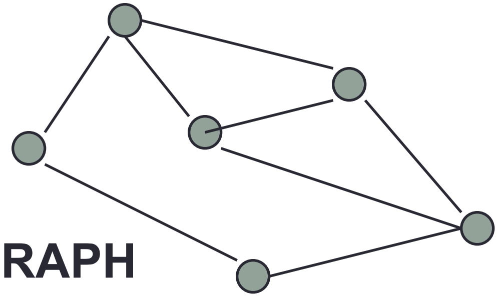
SET



LINEAR



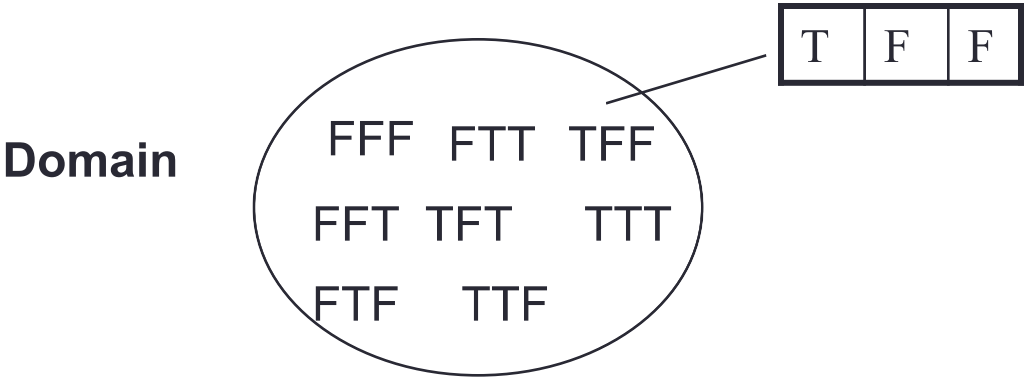
TREE



GRAPH

Data Types & Data Structures

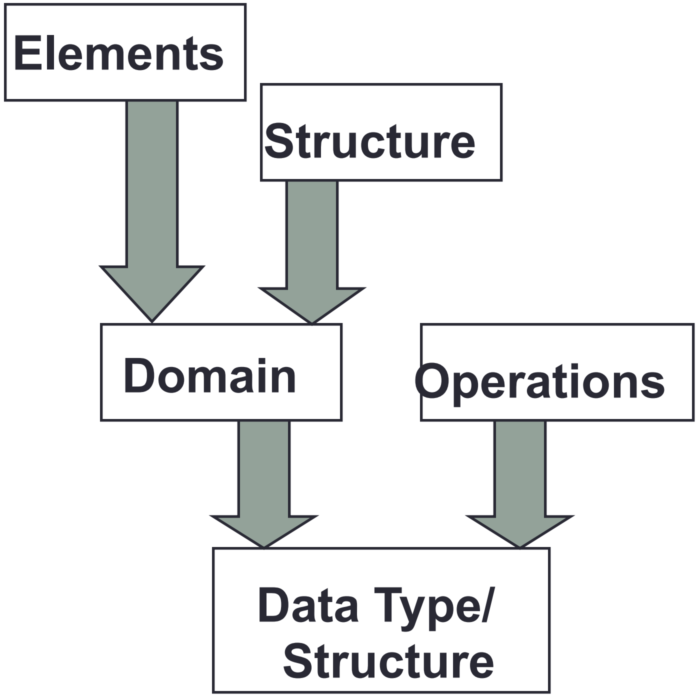
- What is the domain of a structured data type? Operations?
- Example: boolean[] Sample= new boolean[3];



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.
- 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…

ADTs

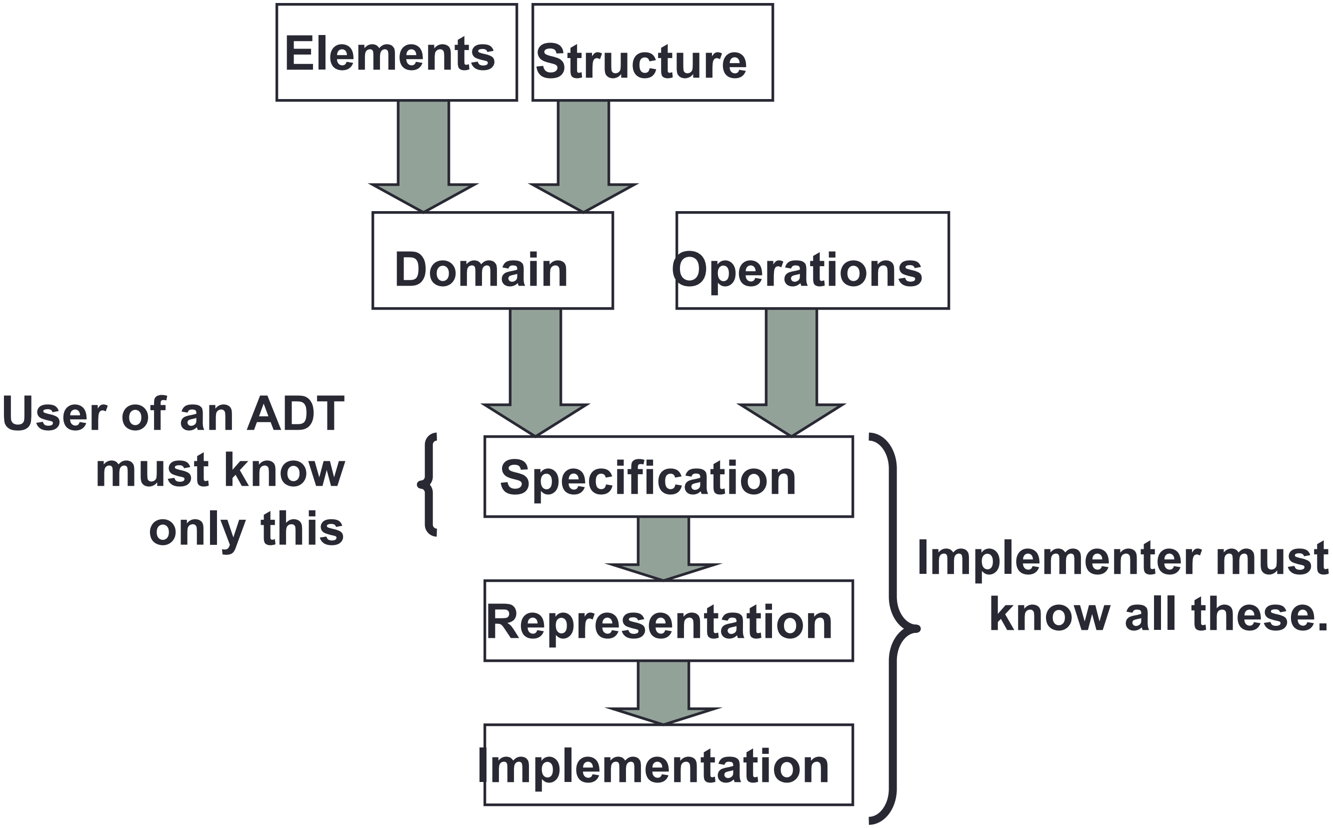
- While designing ADTs, a designer has to deal with two types of questions:
  - (i) **What** values are in the domain? **What** operations can be performed on the values of a particular data type?
  - (ii) **How** is the data type represented? **How** are the operations implemented?

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.

Graph, tree . . .

ADTs



Elements

Structure

Domain

Operations

Specification

Representation

Implementation

User of an ADT must know only this

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.

1.Procedure Append (c: char) → قد تكون بارامتر أو
رترن تايپ

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;   ← عشانه فيه إندكس ٠
   str = new char[80];
}
public void Append (char c) {
   size++;   لأننا نبدأ من -١
        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.