Computational Thinking

Week 1

Flow Charts

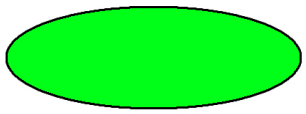
What is a Flowchart?

Flowchart is a graphical representation of an algorithm. Programmers often use it as a program-planning tool to solve a problem. It makes use of symbols which are connected among them to indicate the flow of information and processing.

The process of drawing a flowchart for an algorithm is known as “flowcharting”.

Basic Symbols used in Flowchart Designs

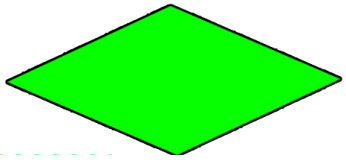
1. **Terminal:** The oval symbol indicates Start, Stop and Halt in a program’s logic flow. A pause/halt is generally used in a program logic under some error conditions. Terminal is the first and last symbols in the flowchart.



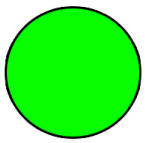
- **Input/Output:** A parallelogram denotes any function of input/output type. Program instructions that take input from input devices and display output on output devices are indicated with parallelogram in a flowchart.

- **Processing:** A box represents arithmetic instructions. All arithmetic processes such as adding, subtracting, multiplication and division are indicated by action or process symbol.

- **Decision** Diamond symbol represents a decision point. Decision based operations such as yes/no question or true/false are indicated by diamond in flowchart.



- **Connectors:** Whenever flowchart becomes complex or it spreads over more than one page, it is useful to use connectors to avoid any confusions. It is represented by a circle.



- **Flow lines:** Flow lines indicate the exact sequence in which instructions are executed. Arrows represent the direction of flow of control and relationship among different symbols of flowchart.

Advantages of Flowchart:

- Flowcharts are better way of communicating the logic of system.
- Flowcharts act as a guide for blueprint during program designed.
- Flowcharts helps in debugging process.
- With the help of flowcharts programs can be easily analyzed.
- It provides better documentation.
- Flowcharts serve as a good proper documentation.

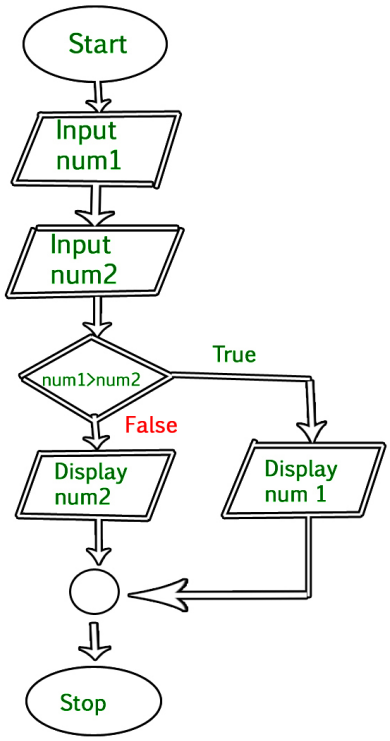
Disadvantages of Flowchart:

- It is difficult to draw flowchart for large and complex programs.
- In this their is no standard to determine the amount of detail.

- Difficult to reproduce the flowcharts.
- It is very difficult to modify the Flowchart.

Example : Draw a flowchart to input two numbers from user and display the largest of two numbers

Example:



Sanity of Data

The sanity of data: what we observed
• We organized our data set into cards, each storing one data item
• Each card had a number of elements, e.g.:
• numbers (e.g. marks)
• sequence of characters (e.g. name, bill item, word, etc)
• We observed that there were restrictions on the values each element can take:
• for example marks has to lie between 0 and 100
• name cannot have funny characters
• Constraints on the kinds of operations that can be performed:
• addition of marks is possible
• but a multiplication of marks does not make sense!

- compare one name with another to generate a boolean type (True or False)
- but cannot add a name with another!

Data Types

Data types are of 3 kinds

1. Charecter - Alpha-Numerics, Special Symbols - We can't perform any operations on this type of data - Result type - undefinded
2. Integers - Numerics range from Minus infinty to plus infinity - operations +,-,*,/,%, <,> - Result type: Integer or boolean
3. Boolean -True or False - operations AND, OR - result type Boolean

Subtypes:

▼ Integers:

Dates, Marks, Quantity, Ranks, count

▼ Charecter:

Gender

▼ Strings:

Names, City Words, Catagory

4. Record - Data type with multiple fields - each of which has a name and a value (Struct or Tuple)

▼ Examples of Record:

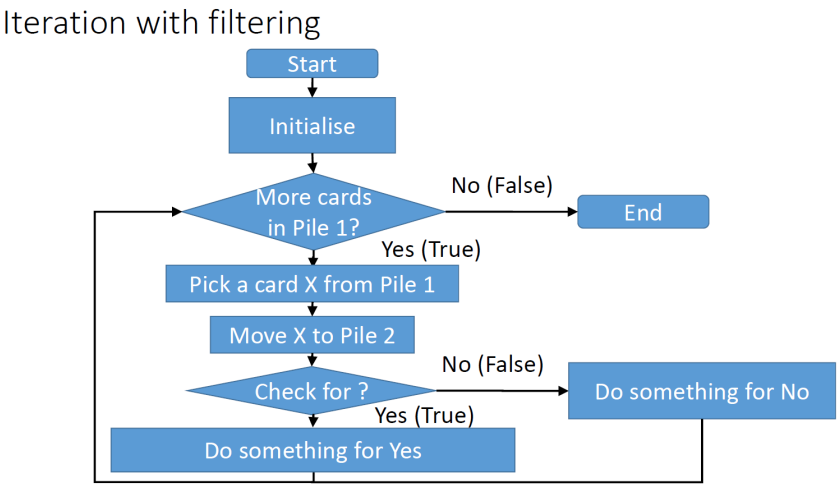
Marks card , Words in a Paragraph , Shopping bills

List

- A sequence of data elements (for example a sequence of records)
- MarksCardList - is the data type for our data set of all marks cards
- Each element in the sequence is of MarksCard Record data type
- ParagraphWordList - is the data type for our word data set
- Each element in the sequence is of WordInPara Record data type
- ShoppingBillList - data type for the shopping bill data set
- We need to define the Record data type for a shopping bill

Computational Thinking

Week 2



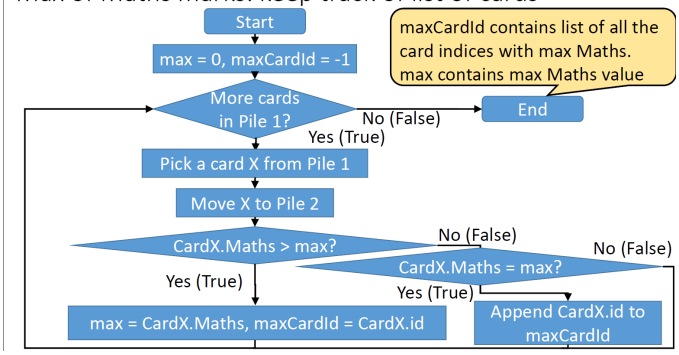
▼ To find Max marks

1. To Find max marks: Replace initialise with **Max=0**
2. Replace Check for with **Maths marks of Card X > max?** if so, **update max**

▼ To find Maths max marks

1. Initialise to **MaxCardId=-1**
2. Replace do something to **max = CardX.Maths, maxCardId = CardX.id**

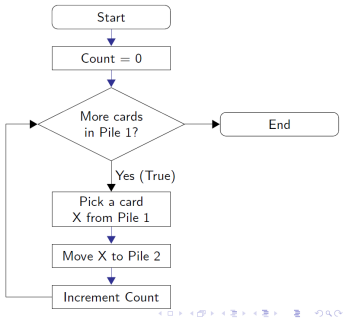
Max of Maths marks: keep track of list of cards



Pseudocode

Start
Count = 0
while (Pile 1 has more cards) {
  Pick a card **X** from Pile 1
  Move **X** to Pile 2
  Increment **Count**
}
End

1. Assign a value to a variable
2. Repeat steps while condition holds
3. Mark start and end of repeated block



Pseudocode: From pictures to text 6 / 7

Sum of Boys' Maths marks

```
Sum = 0
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  Move X to Pile 2
  if (X.Gender == M) {
    Sum = Sum + X.Maths
  }
}
```

- Conditional execution, once
- Equality (==) vs assignment (=)

Sum of Boys' and Girls' Maths mark

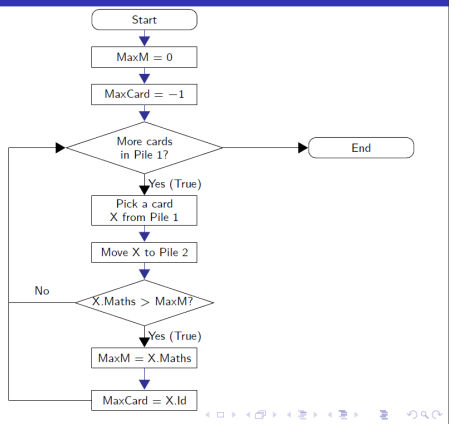
```
BoySum = 0
GirlSum = 0
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  Move X to Pile 2
  if (X.Gender == M) {
    BoySum = BoySum + X.Maths
  }
  else {
    GirlSum = GirlSum + X.Maths
  }
}
```

Finding the maximum Maths marks

```
MaxM = 0
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  Move X to Pile 2
  if (X.Maths > MaxM) {
    MaxM = X.Maths
  }
}
```

Finding the card with maximum Maths marks

```
MaxM = 0
MaxCard = −1
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  Move X to Pile 2
  if (X.Maths > MaxM) {
    MaxM = X.Maths
    MaxCard = X.Id
  }
}
```



Computational Thinking

Week 3

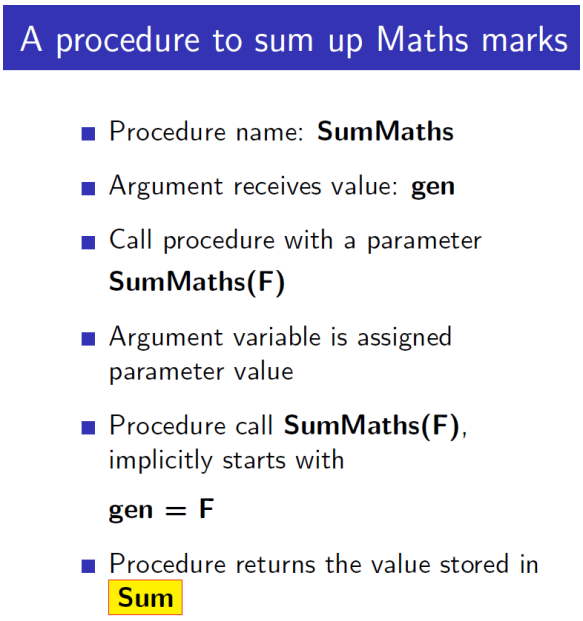
Extraction of data and Creation of tables

1.Data on cards can be naturally represented using tables
2.Each attribute is a column in the table
3.Each card is a row in the table
4.Difficulty if the cards has a variable number of attributes Items in shopping bill
5.Multiple rows | duplication of data
6.Split as separate tables and need to link via unique attribute
Tables

Procedures

A Procedure is a block of organized, reusable code that is used to perform a single, related action. Procedure provide better modularity for your application and a high degree of code reusing.

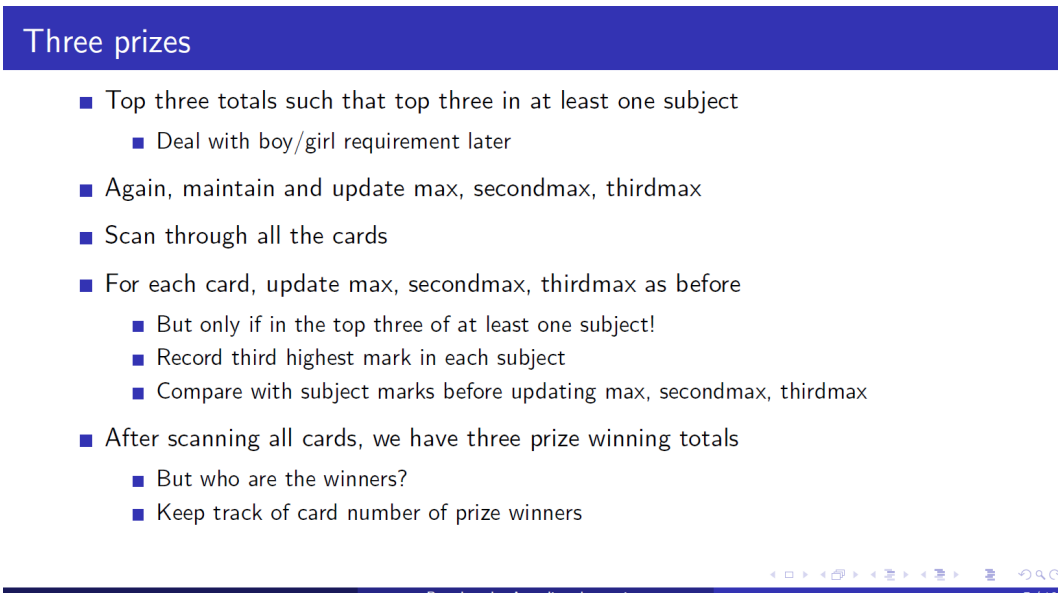
Example:



▼ To call a Procedure,

- use the Procedure name followed by parenthesis

1. A procedure may not return a value
2. Procedure call is a separate statement
3. Use a procedure when the same computation is used for differentsituations
4. Parameters fix the context
5. Use variables to save values returned by procedures
6. Keep track of the outcomes of multiple procedure calls
7. Procedures help to modularize pseudocode
8. Avoid descibing the same process repeatedly
9. If we improve the code in a procedure, benet automatically applies to all procedure calls



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Three prizes

- Maintain max, secondmax, thirdmax, as well as maxid, secondmaxid, thirdmaxid
- Record third highest mark in each subject
- Scan through all the cards
- Update max, secondmax, thirdmax as appropriate
  - Only if top three in some subject — new procedure **SubjectTopper(...)**
- In the end, we have what we need

```
⟨ Initialization of max, maxid etc ⟩
⟨ Record third highest per subject ⟩
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  ⟨ Update max, maxid etc ⟩
  }
}
```

Variables of interest

- maxid, max
- secondmaxid, secondmax
- thirdmaxid, thirdmax

Three prizes, in entirety

```
max = 0
secondmax = 0
thirdmax = 0
maxid = -1
secondmaxid = -1
thirdmaxid = -1
maths3 = TopThreeMarks(Maths)
phys3 = TopThreeMarks(Physics)
chem3 = TopThreeMarks(Chemistry)
while (Pile 1 has more cards) {
  Pick a card X from Pile 1
  if (SubjectTopper(X,math3,phys3,chem3)){
    if (X.Total > max) {
      thirdmax = secondmax
      thirdmaxid = secondmaxid
      secondmax = max
      secondmaxid = maxid
      max = X.Total
      maxid = X.Id
    }
    if (max > X.Total > secondmax) {
      thirdmax = secondmax
      thirdmaxid = secondmaxid
      secondmax = X.Total
      secondmaxid = X.Id
    }
    if (secondmax > X.Total > thirdmax) {
      thirdmax = X.Total
      thirdmaxid = X.Id
    }
  }
}
```

Boundary conditions

- What if all prize winners are of the same gender?
- Exclude the third prize winner and repeat the process
  - How many times?
  - Till we get three prize winners with at least one boy and one girls
  - Will this always given us three valid prize winners?
- What if there are ties?
  - How many ties can we tolerate?
  - Does it depend on first, second or third position?

- We have worked out a complex problem in full detail
- Identify natural units to convert into procedures
  - TopThreeMarks(Subj)
  - SubjectTopper(CardId,MMark,PMark,CMark)
- Shortcut for checking return value of a procedure that returns a Boolean value
  - if (SubjectTopper(CardID,Math3,Phys3,Chem3))
- Have to anticipate and account for unexpected situations in data
  - All toppers are same gender
  - Ties

Side effects

- What is the status of **Deck** after the procedure?
- Is each card the same as it was before?
  - We certainly expect so
- Is the sequence of cards the same as it was before?
  - Perhaps not
  - Depends what we mean by "restore" **Deck**
  - **SeenDeck** would normally be in reverse order
- Side effect Procedure modifies some data during its computation

Interface vs implementation

Each procedure comes with a contract

- Functionality
  - What parameters will be passed
  - What is expected in return
- Data integrity
  - Can the procedure have side effects?
  - Is the nature of the side effect predictable?
    - For instance, deck is reversed

Contract specifies interface

- Can change procedure implementation (code) provided interface is unaffected

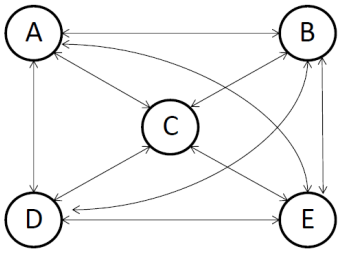
Computational Thinking

Week 4

Binning method is used to smoothing data or to handle noisy data. In this method, the data is first sorted and then the sorted values are distributed into a number of buckets or bins. As binning methods consult the neighborhood of values, they perform local smoothing.

Example

Comparing each element with all other elements



For 5 elements A, B, C, D, E:
The comparisons required are:

A with B, A with C, A with D, A with E	(4)
B with C, B with D, B with E	(3)
C with D, C with E	(2)
D with E	(1)

Number of comparisons: 4 + 3 + 2 + 1 = 10

- For N objects, the number of comparisons required will be:
  - (N - 1) + (N - 2) + ... + 1
  - which is = $\frac{N \times (N - 1)}{2}$
- This is the same as the number of ways of choosing 2 objects from N objects:
  - ${}^{N}C_{2} = \frac{N \times (N - 1)}{2}$
- From first principles:
  - Total number of pairs is N × N
  - From this reduce self comparisons (e.g. A with A). So number is reduced to: N × N - N
  - which can be written as N × (N - 1)
  - Comparing A with B is the same as comparing B with A, so we are double counting this comparison
  - So, reduce the count by half = $\frac{N \times (N - 1)}{2}$

Number of comparisons can be written as: ½ × N × (N - 1)

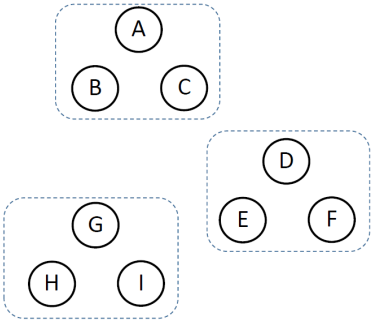
Calculation of reduction due to binning

- For N items:
- Number of comparisons without binning is: ½ × N × (N - 1)

- If we use K bins of equal size, number of items in each bin is: N/K
- Number of comparisons per bin is: ½ × N/K × (N/K - 1)
- Total number of comparisons is:
  K × ½ × N/K × (N/K - 1) = ½ × N × (N/K - 1)

- Factor of reduction is: [½ × N × (N - 1)] / [½ × N × (N/K - 1)]
  = (N - 1) / (N/K - 1)
- For N = 9 and K = 3, this is (9 - 1) / (3 - 1) = 4
  - So reduction is by a factor of 4 times.

Key idea: Use binning



- For 9 objects A,B,C,D,E,F,G,H,I:
  - The number of comparisons is ½ × 9 × (9 - 1)
    = ½ × 9 × 8 = 9 × 4 = 36

- If the objects can be binned into 3 bins of 3 each:
  - The number of comparisons per bin is:
    ½ × 3 × (3 -1) = ½ × 3 × 2 = 3
  - Total number of comparisons for all 3 bins is:
    3 × 3 = 9

- So, the number of comparisons reduces from 36 to 9 !
  - *Reduced by a factor of 4 times.*