LN #5
(2 Hrs)

Data Organization: Lists, Arrays Multidimensional Arrays

CTPS 2018

Objectives

- To understand data organization.
- To learn to organize and access data using arrays.
- To understand concepts of single and multi indexing.

Organizing data

- Humans hate disorder.
- We try and organize our lives, our cities, our homes and even sometimes our desks and our bedrooms.
- There are many ways of organizing things, and we naturally organize different things in different ways.
- The organization we use depends on the things we are trying to organize and often more importantly, what we actually wish to do with them once they are organized.
  - Addresses are organized into postal areas so that it is easier for letters to be delivered.
  - A bookshop organizes its novels on the shelves usually alphabetically by author.
- The way we organize the things we must manipulate to achieve a task can make a massive difference to how quickly, easily or successfully the task can be done.

Is there a better way to store and access related items?

- *How should I store the details of all the student names of my class?*
  - *If 60 students in a class can I have 60 different variable names?*
    - E.g. name1,name2, name3 ……., name60.

- ✓ *Is it organized for efficient access?*
- ✓ *Is it easy to be remembered?*
- ✓ *What happens if number of students increase from 60 to 80?*

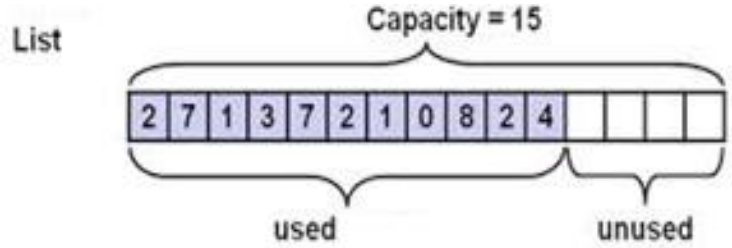
Is there a better way to store and access related items?… Answer

- *How should I store the details of all the student names of my class?*
  - *If 60 students in a class can I have 60 different variable names?*
    - E.g. name1,name2, name3 …….., name60.

- ✓ *Is it organized for efficient access?* No
- ✓ *Is it easy to be remembered?* No
- ✓ *What happens if number of students increase from 60 to 80?*

It becomes even more difficult to be handled and remembered

Lists



- A list is a sequence of items that are arranged in a particular order.
- Eg. list of your all time favorite records
    1. Bohemisn Rhspdody – Queen
    2. Stairway to Heaven – Led Zeppelin
    3. Your Song – Elton John
    4. Who made who – AC/DC
    5. Sweet Child of Mine – Guns 'n Roses
- Any item on the list can be identified by its position in the list.
- We denote the first item in the list as list [first_location] and the second item in the list as list[second_location].

Lists – Storage organization

- Data is stored at some location and each location has an address (Figure: Storage Organization).

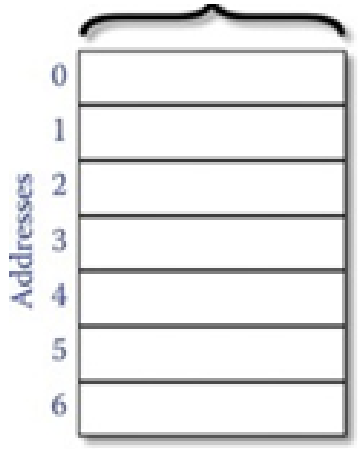


Figure : Storage Organization

Figure: List of Five painting records

- Each piece of data is located at an address (Figure: List of Five painting records).

Lists - Indices

- Addresses in lists are numbers (indices) as illustrated in Figure: List indices

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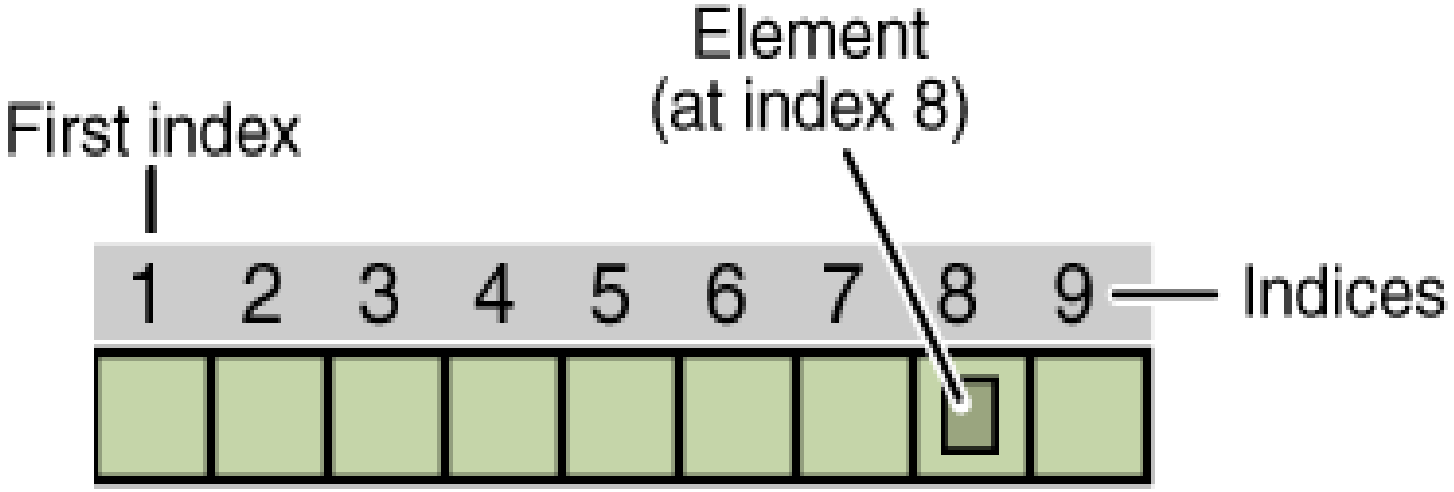


Figure: List indices

Adding Elements to list

- Lists can have new entries added anywhere, including in the middle, and their length can increase as needed.

Original List

1. *Bohemisn Rhspdody – Queen*
2. *Stairway to Heaven – Led Zeppelin*
3. *Your Song – Elton John*
4. *Who made who – AC/DC*
5. *Sweet Child of Mine – Guns'n Roses*

List after adding a new elements

1. *Bohemisn Rhspdody – Queen*
2. ***Every Breath you take - Police***
3. *Stairway to Heaven – Led Zeppelin*
4. *Your Song – Elton John*
5. *Who made who – AC/DC*
6. *Sweet Child of Mine – Guns 'n Roses*
7. ***The Ghost of Tom Jord – Bruce Springsteen***

Removing Elements from List

- Entries can be removed from lists.

Original List

1. *Bohemisn Rhspdody – Queen*
2. ***Every Breath you take - Police***
3. *Stairway to Heaven – Led Zeppelin*
4. *Your Song – Elton John*
5. *Who made who – AC/DC*
6. *Sweet Child of Mine – Guns 'n Roses*
7. ***The Ghost of Tom Jord – Bruce Springsteen***

List after deletion of two elements

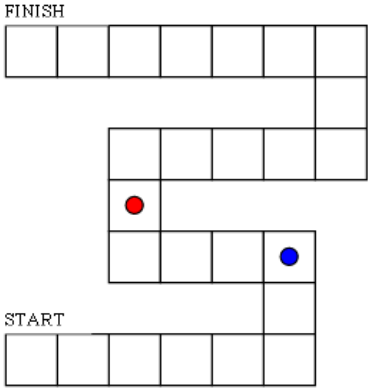
1. *Bohemisn Rhspdody – Queen*
2. *Stairway to Heaven – Led Zeppelin*
3. *Your Song – Elton John*
4. *Who made who – AC/DC*
5. *Sweet Child of Mine – Guns 'n Roses*

Real Time Applications of lists

We use lists all the time…

✓ Whenever I go shopping.

✓ The "To-Do" list is one of the most common ways that people use to organize their work or studies.



✓ Many simple children's board games are based on list-like structures.

Arrays

Array to the rescue!

Ordinary Variable

Like a box for storing one value

Array

Like a cabinet containing many drawers.

Each drawer stores one value.

We can refer to each drawer as 1st drawer, 2nd drawer, 3rd drawer, etc.

Arrays

- Array is a fixed sized list comprising of collections of variables, which we call elements.
- An array's elements are numbered using indices (Figure: Organization of array)
- The total number of elements in a given array is called as the length of an array.

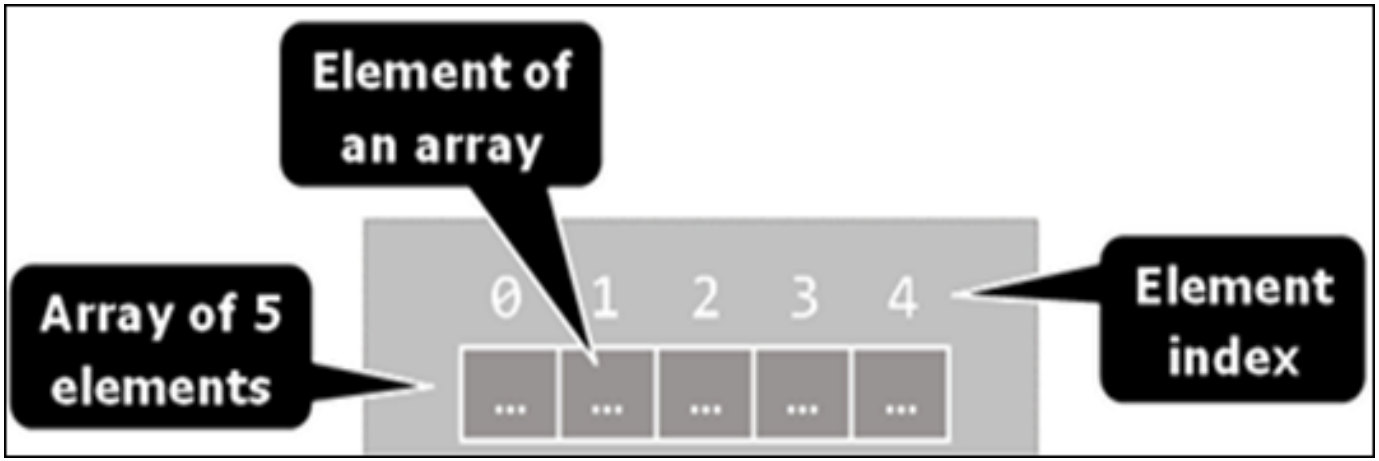


Figure: Organization of array

- All elements of a given array are of the same type.
- This allows one to represent a group of similar elements as an ordered sequence and work on them as a whole.
- Arrays can be in different dimensions (Figure: A 1-D and 2-D array), but the most used are the one-dimensional and the two-dimensional arrays.
- One-dimensional arrays are also called vectors.

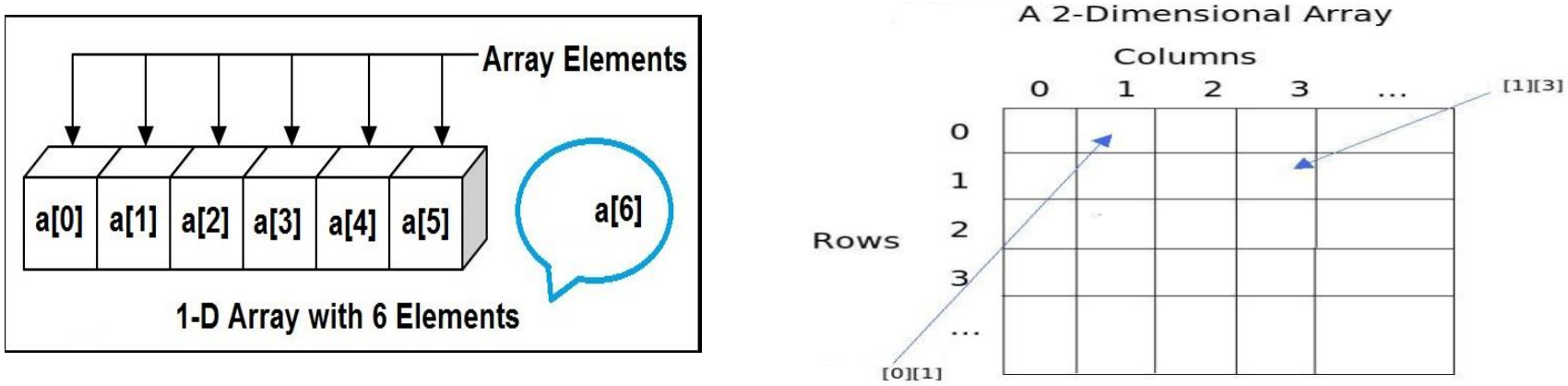


Figure: A 1-D and 2-D array

Array Properties

1. Arrays represent a **group of related data**.

(e.g. -- temperature for the last five days, or stock prices for the last 30 days.)

2. All data within a single array must share the **same data type.**

3. The **size of an array is fixed** once it is created.

Declaration/Creation of an Array

- Allocate an array with length of specified elements of mentioned type.
- During the creation/declaration of the array one must set the total number of the elements in the brackets (a non-negative integer number), defining its length.

  Eg. number mark[6], string name[5]
- The array cannot change its location nor can it change its length.
- The array cannot expand to fill more nor can it shrink to take up less storage.

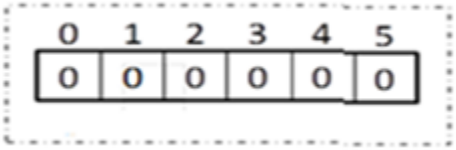


Figure: mark[6]

Boundaries of an Array

- Arrays are by default zero-based, which means the enumeration of the elements starts from 0.
- The index of the first element is 0, and that of the second element is 1, and so on.
- In an array of N elements, the last element has the index N-1.

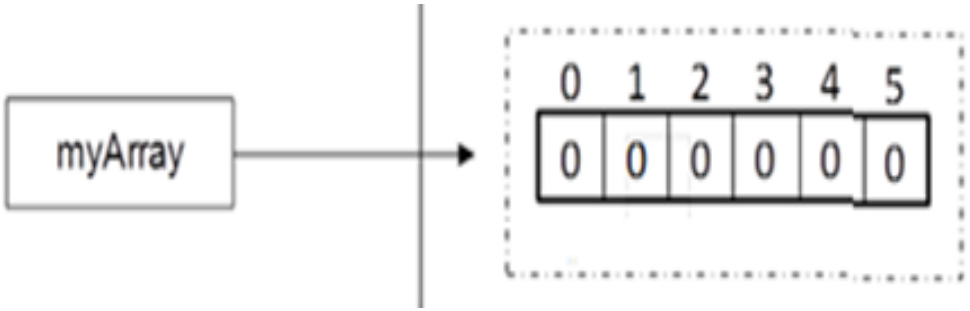


Figure: Boundary of myArray is 5

Array element access

- We access the array elements directly using their indices.
- Each element can be accessed through the name of the array and the element's index (consecutive number) placed in the brackets.
- For Eg. numberArray[2] produces the 3rd element, 6.

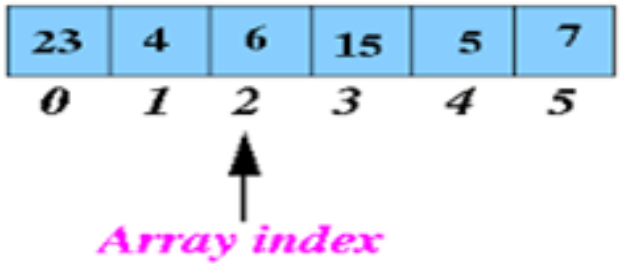


Figure: Elements of numberArray

Array element access *contd*---

- As long as we keep track of the location of the array, we will be able to access every item in the array.
- The location of the array is known as the base address or the anchor, and is the memory address of the first item in the array.
- From a computer's perspective, the name of an array corresponds to the anchor of the array.
  - If the name of the array is known, then the anchor is known and all of the array items can be accessed by their index.
  - Access elements by….(anchor of array A)+(i-1)

✓ *Can you show how can the elements (4,1, and 6) be accessed from the array Arr=[1,2,3,4,5,6] ?*

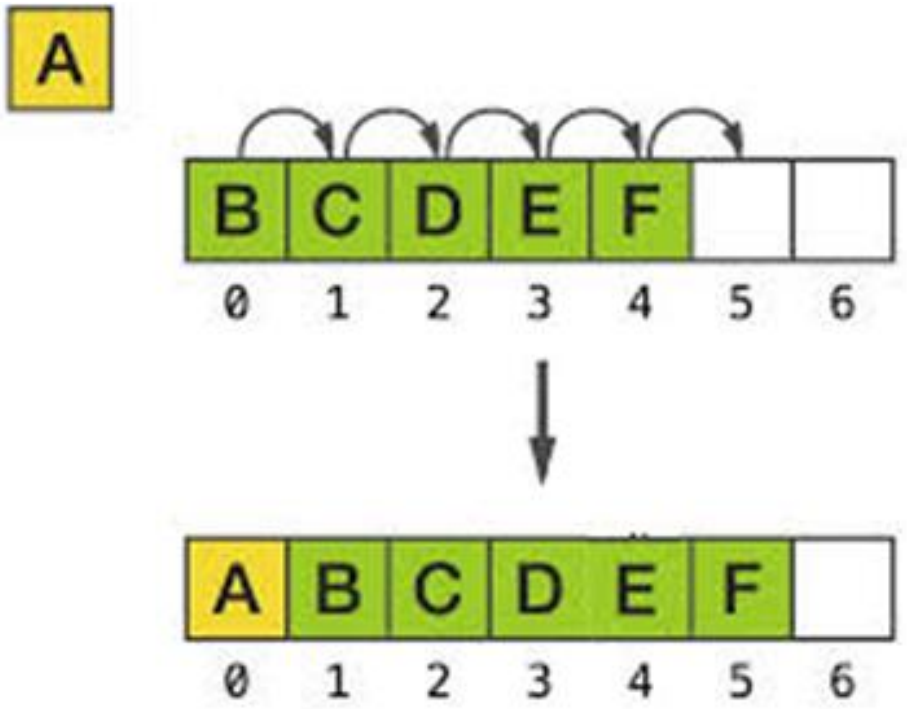
Answer……

4----------arr[3]

1----------arr[0]

6----------arr[5]

Inserting an element at the beginning



1. *Given the array scores,*

scores	79	87	94	82	67	98	87	81	74	91

Can you find

- ✓ *How many elements are there?*
- ✓ *What is the fifth element in the array?*
- ✓ *What is the result of mean = (scores[0]+scores[1])/2*

2. *Workout the average of Quiz1 and student0 with the following data?*

	Quiz1	Quiz2
Student0	95	85
Student1	89	80

Answers

How many elements are there? 10

What is the fifth element in the array? 67

What is the result of

```
mean = (scores[0]+scores[1])/2;
```

(79+87)/2 = 83

Can you workout the average of Quiz1 and student0 with the following data??? 92,90

- *Consider the payroll task, that requires several pieces of information (hours worked, rate of pay, and regular and over time pay) for the employees of an organization.*

✓ *Can we organize such data as individual arrays, one for each of the piece of information?*

✓ *Is this an efficient approach?*

Answer….

- *Consider the payroll task, that requires several pieces of information (hours worked, rate of pay, and regular and over time pay) for the employees of an organization.*

✓*Can we organize such data as individual arrays, one for each of the piece of information? Yes*

✓*Is this an efficient approach? No because individual single D Arrays of say… 2 attributes do not capture the relationship between the two attributes… A Multi D array is a better choice*

Read and display array elements

1. Start
2. Declare A[10], i
3. Set i = 0
4. While (i < 10)
    4.1 Read A[i]
    4.2 i = i + 1
5. Set i =0
6. While (i < 10)
    6.1 Print A[i]
    6.2 i = i + 1
7. Stop

Find sum of array elements

1. Start
2. Declare A[10], sum, i
3. Set sum = 0, i = 0
4. While (i < 10)
    - 4.1 Read A[i]
    - 4.2 sum = sum + A[i]
    - 4.3 i = i +1
5. Print sum
6. Stop

Find average of array elements

1. Start
2. Declare A[10], sum, I, average
3. Set sum = 0, i = 0
4. While (i < 10)
    - 4.1 Read A[i]
    - 4.2 sum = sum + A[i]
    - 4.3 i = i +1
5. average = sum / 10
6. **Print average**
7. Stop 4.3

Display odd array elements

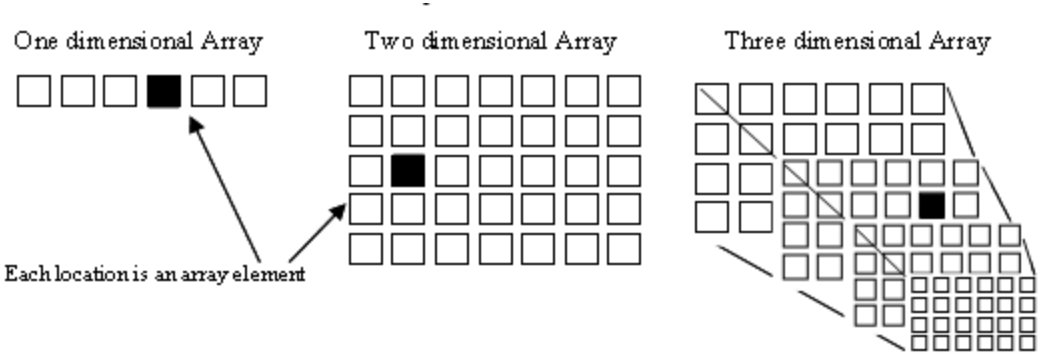
1. Start
2. Declare A[10], i
3. Set i = 0
4. While (i < 10)
   - 4.1 Read A[i]
   - 4.2 i = i + 1
5. Set i =0
6. While (i < 10)
   - 6.1 if (A[i] mod 2 is NOT equal to 0)
     then Print A[i]
   - 6.2 i = i + 1
7. Stop

Maximum array element

1. Start
2. Declare A[10], i,MAX
3. Set i = 0
4. While (i < 10)
   - 4.1 Read A[i]
   - 4.2 i = i + 1
5. Set i =1,MAX = A[0]
6. While (i < 10)
   - 6.1 if (A[i] >MAX)
     - then MAX= A[i]
   - 6.2 i = i + 1
7. Print MAX
8. Stop

Multi Dimensional Arrays

- Although it is useful to have data in one-dimensional arrays, it is sometimes useful to arrange data into rows and columns (two dimensional arrays), rows columns and ranks (three-dimensional), or even higher dimensionality.



- A particular cell in a five-dimensional array may be accessed as follows:

  Arr_name[*dim*1][*dim*2][*dim*3][*dim*4][*dim*5].

Multi Dimensional Arrays *contd*---

- For eg., if there are eight students and ten questions, and the answers can be stored in a two-dimensional array as given.

Students' Answers to the Questions:

	0	1	2	3	4	5	6	7	8	9
Student 0	A	B	A	C	C	D	E	E	A	D
Student 1	D	B	A	B	C	A	E	E	A	D
Student 2	E	D	D	A	C	B	E	E	A	D
Student 3	C	B	A	E	D	C	E	E	A	D
Student 4	A	B	D	C	C	D	E	E	A	D
Student 5	B	B	E	C	C	D	E	E	A	D
Student 6	B	B	A	C	C	D	E	E	A	D
Student 7	E	B	E	C	C	D	E	E	A	D

- Similarly, the distances between the cities can be represented using a two-dimensional array as given.

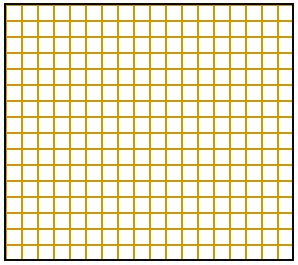
Distance Table (in miles)

	Chicago	Boston	New York	Atlanta	Miami	Dallas	Houston
Chicago	0	983	787	714	1375	967	1087
Boston	983	0	214	1102	1763	1723	1842
New York	787	214	0	888	1549	1548	1627
Atlanta	714	1102	888	0	661	781	810
Miami	1375	1763	1549	661	0	1426	1187
Dallas	967	1723	1548	781	1426	0	239
Houston	1087	1842	1627	810	1187	239	0

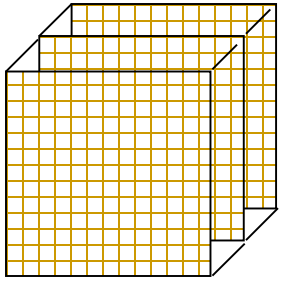
Multi Dimensional Arrays *contd*---

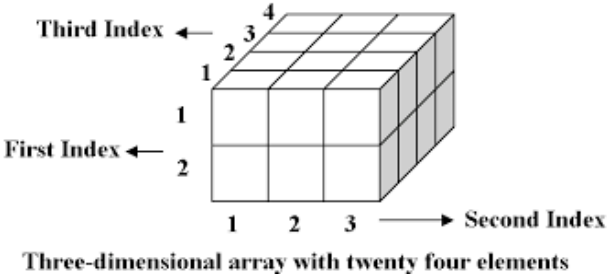
- An array can be declared with multiple dimensions.

2 Dimensional



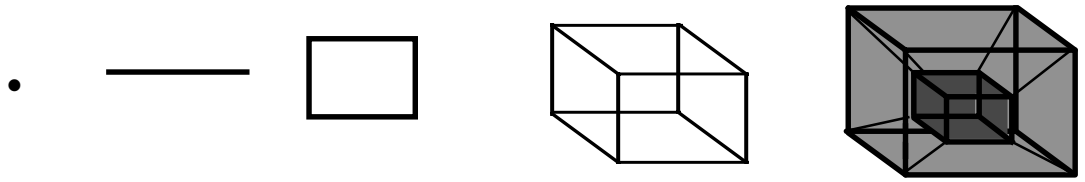
3 Dimensional





Three-dimensional array with twenty four elements

- Multiple dimensions get difficult to visualize graphically (say, from a dot to a cube within a cube) .



Read and display 2D array elements

1. Start
2. Declare A[3][2], i, j
3. Set i =0
4. While (i < 3)
   - 4.1 Set j = 0
   - 4.2 While (j < 2))
     - 4.2.1 Read A[i][j]
     - 4.2.2 j = j + 1
   - endwhile
   - 4.3 i = i+1
   - endwhile

5. Set i =0

6. While (i < 3)

6.1 Set j = 0

6.2 While (j < 2)

6.2.1 Print A[i][j]

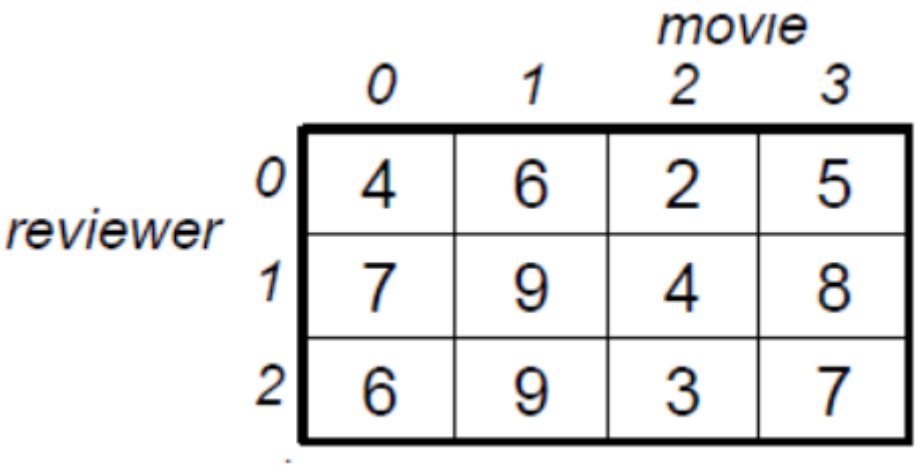
6.2.2 j = j + 1

endwhile

6.3 i = i +1

endwhile

7. Stop



EXAMPLE

Find average rating by the 3rd reviewer

i =2, j = 0,sum=0

while(j < 4)

sum = sum + A[i][j]

j = j +1

endwhile

avg_rating = sum/ 4

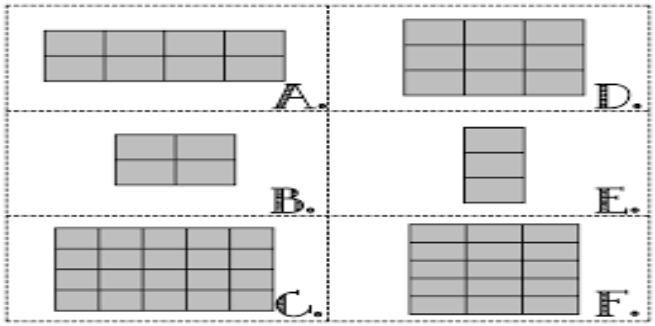
Print avg_rating

Find average rating of reviewers

reviewer \ movie	0	1	2	3
0	4	6	2	5
1	7	9	4	8
2	6	9	3	7

```
i =0, sum=0
while(i < 3)
        j=0
        while(j < 4)
                sum = sum + A[i][j]
                j = j +1
        endwhile
        i = i +1
        avg_rating = sum/ 4
        Print avg_rating
        sum =0
endwhile
```

- ✓ *Can you specify the dimension of the array and show how individual elements can be accessed?*

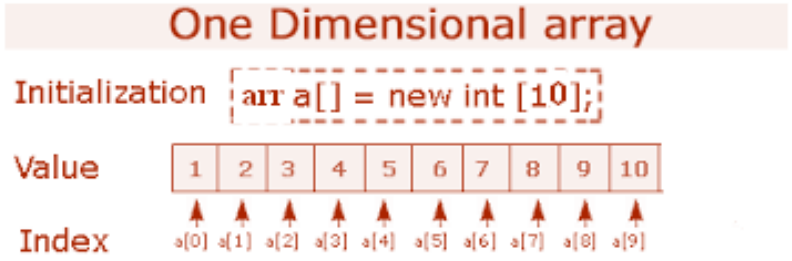


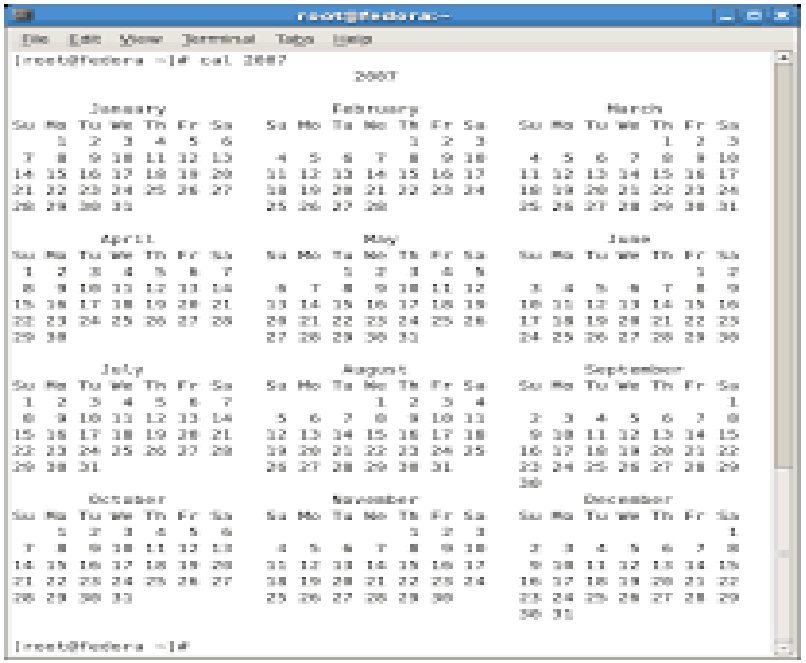
- ✓ *Can you show the pictorial representation of the memory associated with an array named a containing 10 integers?*

- ✓ *Can you model an array to store the datebook information (specify the dimension, number of indices, show how to access, modify a particular entry of the datebook)?*

Answer….

A. 2X4 D. 3X3
B. 2X2 E. 1X3
C. 4X5 F. 5X3





Model using one 2D array for storing days of a particular month

Locate an entry using 3 dimensions and update …..

E.g. cal[2015][10][3]

Game of *Spit Not So (Berlekamp et al, 1982)*

The game is played as follows by two players:

- *Write the nine words: SPIT NOT SO FAT FOP AS IF IN PAN* on separate pieces of cards.
- The cards are placed face up.
- Each player takes it in turns to take a card.
- To win you must get all the cards that have the same letter.
  - For example if you had picked up the cards SPIT, IF and IN, you would have all the cards containing the letter I so would win.
- If all the cards are taken with no one having all of a particular letter then the game is a draw.

- *Play a few games to get then idea, then turn the page to see how a suitable organisation will help you play better.*

- Before you start to play draw up the following grid, with the words that are on the cards written in the squares shown.
- The position of each word is important.
- They have been organised so that there is a single letter in common in each row, column and diagonal.
- All the F-words run along the bottom, for example.

NOT	IN	PAN
SO	SPIT	AS
FOP	IF	FAT

- Keep this hidden from your opponent – otherwise they may see the secret.
- Play the game exactly as before, except, now each time you pick up a card, put a cross in the square that corresponds to that word.
- Put a nought in the squares corresponding to the cards your opponent takes.
- For example, the above game will end with your table looking like the following:

NOT **O**	IN	PAN **X**
SO **O**	SPIT **X**	AS
FOP **X**	IF **O**	FAT **X**

What has been described?

- Arrays and their importance.
- Operations on arrays(create, add, delete, locate).
- The properties of arrays.
- Multi-dimensional arrays.

Credits

- ***Software Solution, Foundation for program design, Lewis and Loftus***
- ***Computing Without Computers, A Gentle Introduction to Computer Programming, Data Structures and Algorithms, Version 0.15, Paul Curzon***
- ***Google images***