Algorithm/Running Time Analysis

Running Time

- Why do we need to analyze the running time of a program?
- Option 1: Run the program and time it
  - Why is this option bad?
  - What can we do about it?

Pseudo-Code

- Used to specify algorithms
- Part English, part code

```
Algorithm (arrayMax(A, n))
curMax = A[0]
for i=1 i<n i++
  if curMax < A[i]
    curMax = A[i]
return curMax
```

Math Review

- Summation – ∑
- Sum of n consecutive digits = n(n+1)/2

Counting Operations

```
Algorithm (arrayMax(A, n))
curMax = A[0]//1
for i=1 i<n i++ //n
  //1 or 2
  if curMax < A[i]
    curMax = A[i]
return curMax //1
```

- Best case – n+2
- Worst case – 2n + 2
- Average case – hard to analyze

Asymptotic Notation

- 2n + 2
- n=5 -> 12
- n=100 -> 202
- n=1,000,000 -> 2,000,002

- Running time grows proportionally to n
- What happens as n gets large?

Big-Oh

- f(n) is O(g(n)) if there is a real constant c>0 and an integer constant n_0>=1 such that f(n) <= cg(n) for every integer n>=n_0
- 2n+2 is O(n) n_0>=1 c=3

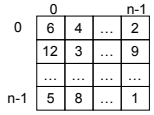
Examples

- $87n^4 + 7n$
- $3n\log n + 12\log n$
- $4n^4 + 7n^3\log n$

Terminology

- Logarithmic – O(log*n)*
- Linear – O(*n*)
- Linearithmic – O(nlogn)
- Quadratic – O(n^2)
- Polynomial – O(n^k) k>=1
- Exponential – O(a^n) a>1

Example



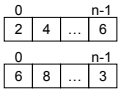
- Find maximum number in *n*x*n* matrix
- Algorithm:

Example

- What is the big-oh running time of this algorithm?

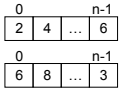
```
Algorithm:
Input: A, n
curMax = A[0][0]
for i=0 i<n i++
  for j=0 j<n j++
     if curMax < A[i][j]
          curMax = A[i][j]
return curMax
```

Another Example



- Determine how many elements of array 1 match elements of array 2
- Algorithm?

Another Example




```
Algorithm:
Input: A, B, n

for i=0 i<n i++
   for j=0 j<n j++
        if A[i] == A[j]
              matches++
              break
```

- What is the running time of the algorithm?