NPTEL MOOC

# PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 3, Lecture 5

Madhavan Mukund, Chennai Mathematical Institute
http://www.cmi.ac.in/~madhavan

# Efficiency

- Measure time taken by an algorithm as a function $T(n)$ with respect to input size $n$
- Usually report worst case behaviour
  - Worst case for searching in a sequence is when value is not found
  - Worst case is easier to calculate than "average" case or other more reasonable measures

# O( ) notation

- Interested in broad relationship between input size and running time
- Is T(n) proportional to log n, n, n log n, $n^2$, …, $2^n$?
- Write T(n) = O(n), T(n) = O(n log n), … to indicate this
    - Linear scan is O(n) for arrays and lists
    - Binary search is O(log n) for sorted arrays

# Typical functions T(n)…

| Input | log n | n | n log n | $n^2$ | $n^3$ | $2^n$ | n! |
|---|---|---|---|---|---|---|---|
| 10 | 3.3 | 10 | 33 | 100 | 1000 | 1000 | $10^6$ |
| 100 | 6.6 | 100 | 66 | $10^4$ | $10^6$ | $10^{30}$ | $10^{157}$ |
| 1000 | 10 | 1000 | $10^4$ | $10^6$ | $10^9$ | | |
| $10^4$ | 13 | $10^4$ | $10^5$ | $10^8$ | $10^{12}$ | | |
| $10^5$ | 17 | $10^5$ | $10^6$ | $10^{10}$ | | | |
| $10^6$ | 20 | $10^6$ | $10^7$ | | | | |
| $10^7$ | 23 | $10^7$ | $10^8$ | | | | |
| $10^8$ | 27 | $10^8$ | $10^9$ | | | | |
| $10^9$ | 30 | $10^9$ | $10^{10}$ | | | | |
| $10^{10}$ | 33 | $10^{10}$ | | | | | |

Python can do about $10^7$ steps in a second

# Efficiency

- Theoretically $T(n) = O(n^k)$ is considered efficient
  - Polynomial time
- In practice even $T(n) = O(n^2)$ has very limited effective range
  - Inputs larger than size 5000 take very long