Week 05 Studio
Orders of Growth, Data Abstraction

CS1101S AY21/22 Semester 1
Studio 05E

Yan Xiaozhi (David)
@david_eom
yan_xiaozhi@u.nus.edu

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Admin

- Contact tracing (QR code + class photo)
- “RA1 is so bloody hard!”
  - NO BELL CURVE!!! If you meet criteria for A, you will get the A
  - Prof Martin is “mean” and wanted to challenge everyone
  - 6% only, please focus on mid-terms
- Mission Beyond the First Dimension due 6th September 2359
- Mastery check 1
  - Can PM me and try to book before all of us get busy with mid-terms :(((

Recap

Orders of Growth

What Is It?

- Limited resources for computational processes
  - Time and space
- Asymptotic analysis and notation
  - Provides abstraction / rough measures of resources used with respect to problem size
  - Big Omega (Ω) / Big Theta (Θ) / Big O (O)

Orders of Growth

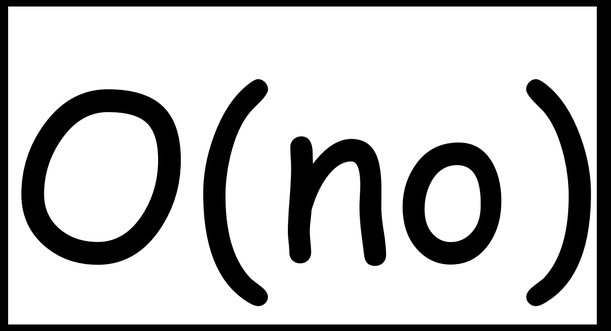
Textbook Definition

- Let n be a parameter that measures the size of the problem, and $R(n)$ be the amount of resources the process requires
- For sufficiently large value of n:
  - $\Omega(g(n))$ if $\forall\ n > n_0$, $\exists\ k \in \mathbb{R}^+$ such that $R(n) \geq k \cdot g(n)$
  - $\Theta(g(n))$ if $\forall\ n > n_0$, $\exists\ k_1, k_2 \in \mathbb{R}^+$ such that $k_1 \cdot g(n) \leq R(n) \leq k_2 \cdot g(n)$
  - $O(g(n))$ if $\forall\ n > n_0$, $\exists\ k \in \mathbb{R}^+$ such that $R(n) \leq k \cdot g(n)$
- Huh?

Orders of Growth

Summary

- Ω: lower bound (best case?)
- Θ: tight bound
- O: upper bound (worst case?)
- Every algorithm technically has Ω(1) and O(∞)
  - But that does not help with analysis!
  - Often interested in Big O notation
- Will be brought up again in CS2040S, CS3230, CS3233



Orders of Growth

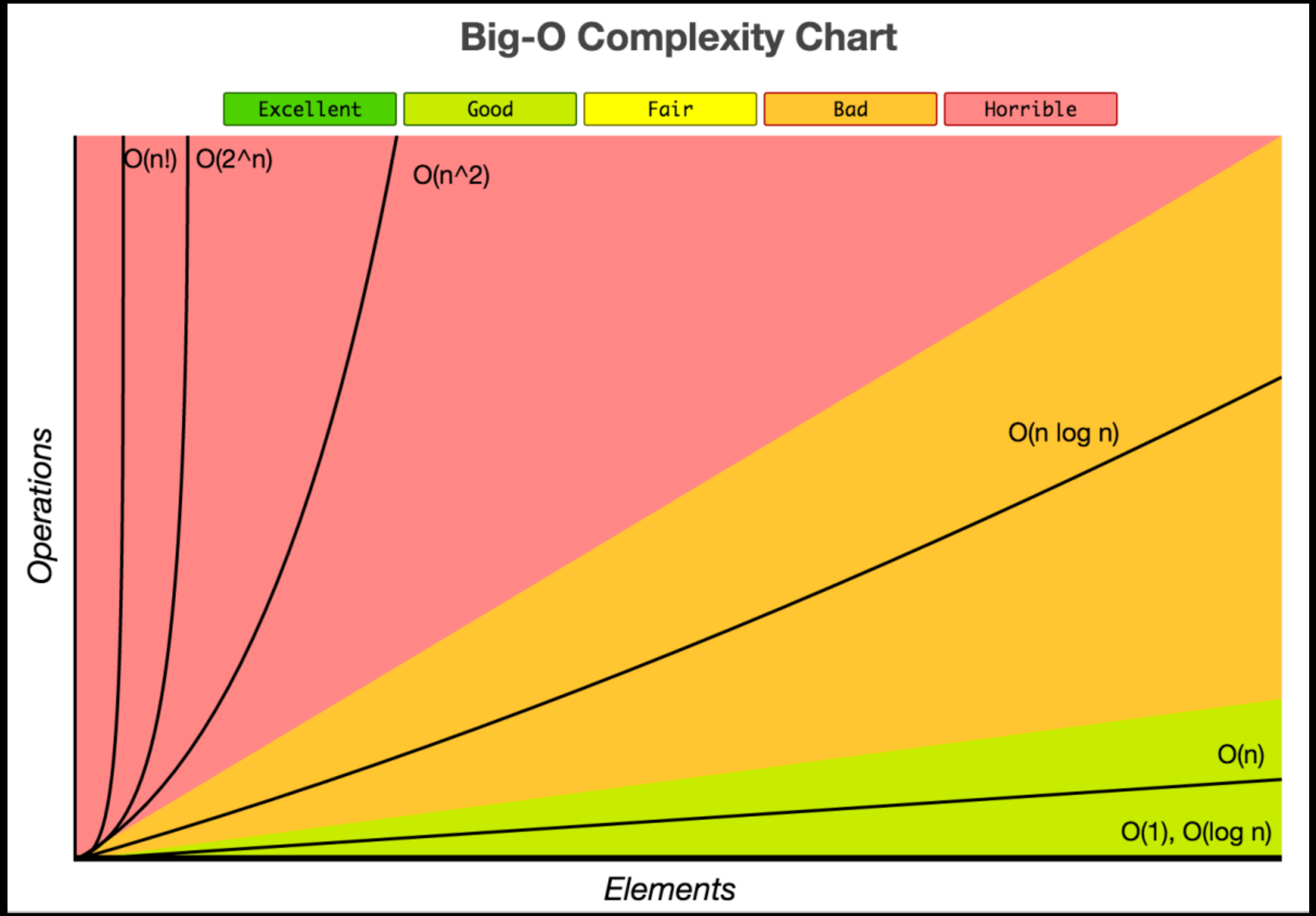
Things to Take Note

- Constants / Coefficients: disregard
  - $O(n) \equiv O(0.5n)$, $O(100000) \equiv O(1)$
- Addition: drop minor terms
  - $O(n^2 + 3n + 5) \equiv O(n^2)$
- Multiplication: take product
  - $O(n \cdot \log(n) \cdot n) \equiv O(n^2 \cdot \log n)$

Orders of Growth

Common Functions

Notation	**O(1)**	**O(log n)**	**O(n)**	**O(n log n)**	**$O(n^2)$**	**$O(n^c)$**	**$O(c^n)$**	**O(n!)**
Name	Constant	Logarithmic	Linear	Log-linear	Quadratic	Polynomial	Exponential	Factorial
e.g.	Look-up table	`fast_expt`, binary search	`expt`	Comparison-based sorting	Permutation, combination	Permutation, combination	Travelling salesman problem with DP	Travelling salesman problem with brute force


Big-O Complexity Chart
Excellent
Good
Fair
Bad
Horrible
O(n!)
O(2^n)
O(n^2)
O(n log n)
O(n)
O(1), O(log n)
Operations
Elements

Data Abstraction - Pairs

What Is It?

- A kind of data structure
- Does this seem familiar?
  - `function pair(x, y) { return f => f(x, y); }`
  - `function head(p) { return p((x, y) => x); }`
  - `function tail(p) { p((x, y) => y); }`
- Rational number

Data Abstraction - Lists

What Is It?

- Another kind of data structure
- “List” of things (number, string, boolean, pair, or even list itself)
  - `list(123, “hello”, true, list(1, 2, 3), pair(“head”, “tail”));`
- Linked list in C
- Python list, Java Array/ArrayList are not exactly a list


list
1
number
next
2
number
next
3
number
next
4
number
next
5
number
next
list
1
2
3
4
5

Data Abstraction - Lists

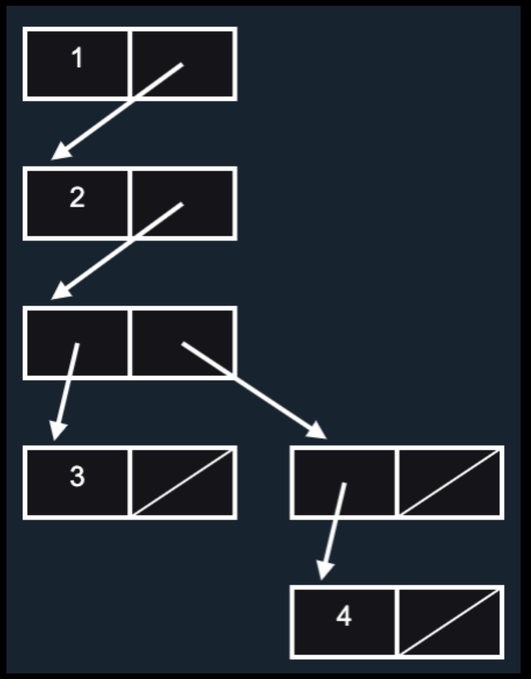
Definition

- Recursive in nature
  - A list is either null or a pair whose tail is a list
  - A list is either null or a pair whose tail is (either null or a pair whose tail is a list)
  - A list is either null or a pair whose tail is (either null or a pair whose tail is (either null or a pair whose tail is a list))
  - … you get it!

Data Abstraction - Lists

Notations

- `list(1, 2, list(3), pair(4, null));`
  - Box notation: `[1, [2, [[3, null], [[4, null], null]]]]`
    - `list_to_string`
  - List notation: `list(1, 2, list(3), list(4))`
    - `display_list` (display lists nicely if detected)
  - Box-and-pointer diagram: slash for `null`
    - `draw_data`
- `[null, null]` a pair or list?



Data Abstraction - Lists

Length

- Count the number of items in the list
- Nested list?
- Recursive / iterative?
- Head over to Source Academy!

Any Questions?