



Design and Analysis of Algorithms

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DESIGN AND ANALYSIS OF ALGORITHMS

Basic Efficiency Classes

Problems based on Asymptotic notations

Slides courtesy of **Anany Levitin**

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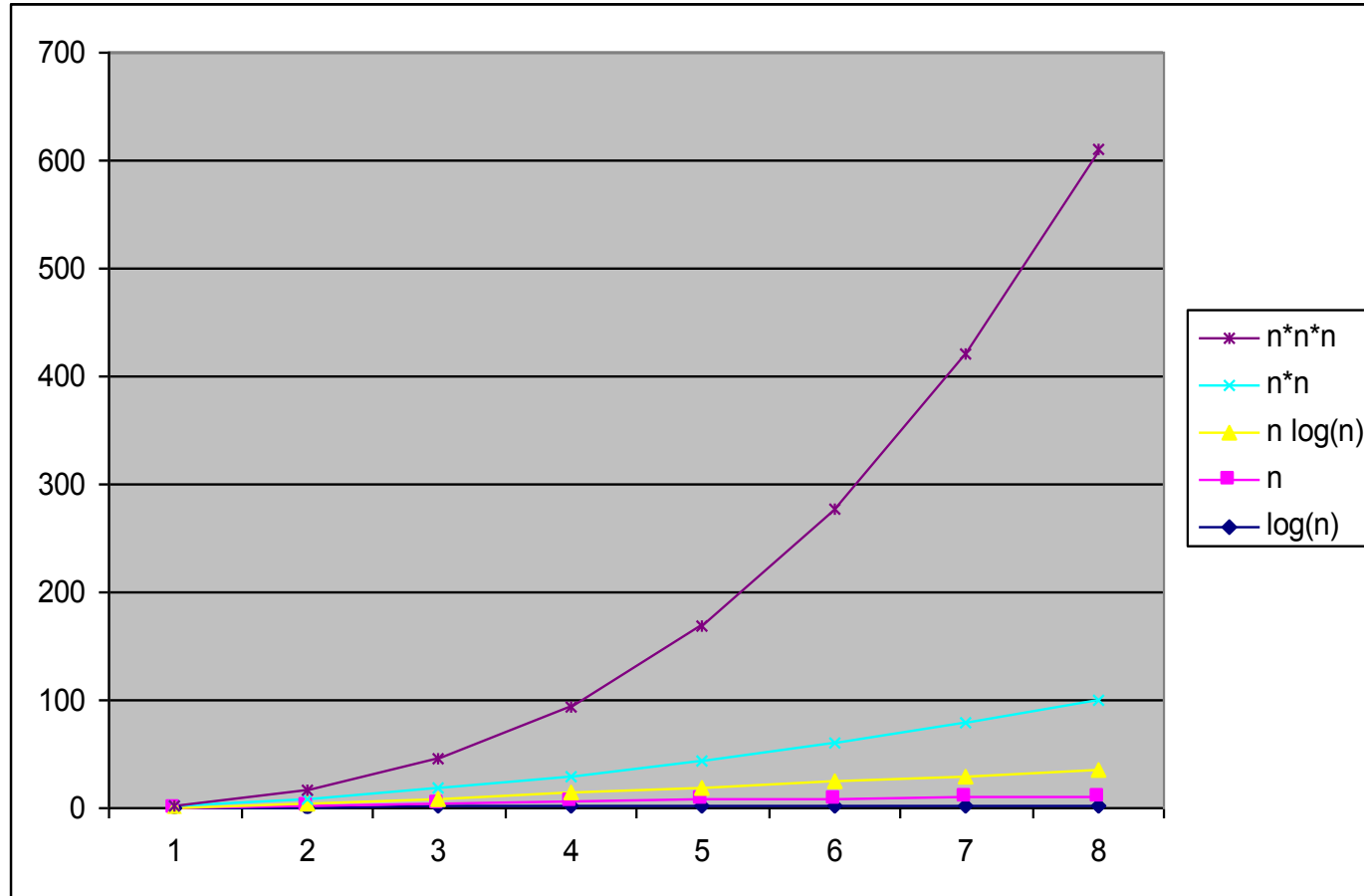
Design and Analysis of Algorithms

Basic Efficiency Classes

Class	Name	Example
1	constant	Best case for sequential search
$\log n$	logarithmic	Binary Search
n	linear	Worst case for sequential search
$n \log n$	n -log- n	Mergesort
n^2	quadratic	Bubble Sort
n^3	cubic	Matrix Multiplication
2^n	exponential	Subset generation
$n!$	factorial	TSP using exhaustive search

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Basic Efficiency Classes



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Basic Efficiency Classes

n	$\log_2 n$	n	$n \log_2 n$	n^2	n^3	2^n	$n!$
10	3.3	10^1	$3.3 \cdot 10^1$	10^2	10^3	10^3	$3.6 \cdot 10^6$
10^2	6.6	10^2	$6.6 \cdot 10^2$	10^4	10^6	$1.3 \cdot 10^{30}$	$9.3 \cdot 10^{157}$
10^3	10	10^3	$1.0 \cdot 10^4$	10^6	10^9		
10^4	13	10^4	$1.3 \cdot 10^5$	10^8	10^{12}		
10^5	17	10^5	$1.7 \cdot 10^6$	10^{10}	10^{15}		
10^6	20	10^6	$2.0 \cdot 10^7$	10^{12}	10^{18}		

Table 2.1 Values (some approximate) of several functions important for analysis of algorithms

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Asymptotic notations

O

$$f(n) = 3n+2 \quad g(n) = n$$
$$3n+2 \in O(n)$$
$$f(n) \leq c g(n) \text{ for some } +ve \ c \ \forall n \geq n_0$$
$$\Rightarrow f(n) \in O(g(n))$$
$$3n+2 \leq cn$$

Let $c = 4$

$$3n+2 \leq 4n$$

$n=1$ $n=2$ $n=3$

$5 \not\leq 4$ $8 \leq 8$ $11 \leq 12$

$3n+2 \leq 4n \quad \forall n \geq 2$

$$\Rightarrow 3n+2 \in O(n)$$

Ω

$$3n+2 \in \Omega(n)$$
$$f(n) \geq c g(n) \text{ for some } +ve \ c \ \forall n \geq n_0$$
$$f(n) \in \Omega(n)$$
$$3n+2 \geq cn$$

Let $c = 1$

$$3n+2 \geq n$$

$n=1$ $n=2$ $n=3$

$5 \geq 1$ $8 \geq 2$ $11 \geq 3$

$$3n+2 \geq n \quad n \geq 1$$
$$3n+2 \in \Omega(n)$$

Θ

$$3n+2 \in \Theta(n)$$
$$c_1 g(n) \leq f(n) \leq c_2 g(n) \quad \forall n \geq n_0$$

$c_1 = 1 \quad c_2 = 4$
 $n_{01} = 1 \quad n_{02} = 2$

$n_0 = \max(n_{01}, n_{02}) = 2$

$c_1 = 1 \quad c_2 = 4 \quad n_0 = 2$

$$3n+2 \in \Theta(n)$$
$$f(n) \in O(g(n))$$
$$\in \Omega(n)$$
$$\Rightarrow f(n) \in \Theta(g(n))$$



THANK YOU

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