Algorithms and Data Structures

Data Structures + Algorithms = Programs

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Our Algorithms & Data Structures Journey

Create overview of Data Structures and Algorithms and Timeline

Expectations

1. Get overview of fundamentals
2. Know when to use them
3. Practice Practice Practice !!!

First Phase of Our Journey

- Why Algorithms & Data Structures
- Arrays and Linked Lists
- Stacks, Queues and Deques
- Sorting and Selection Algorithms
- Exercises

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Why Algorithms?

- Akshaya’s example on making a cup of coffee
  - What is the algorithm?
- Use notes from Princeton slides
  - http://www.cs.princeton.edu/~rs/AlgsDS07/00overview.pdf
  -

Why Algorithms: Web Search

Why Algorithms: Biology and Health

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Why Algorithms: Packet Routing

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Examples of Algorithms

- Google’s Page Rank Algorithm (Web Page Ranking)
- National Center for Biotechnology Information’s BLAST Algorithm
- Needleman Wunsch Algorithm (Protein Alignment)

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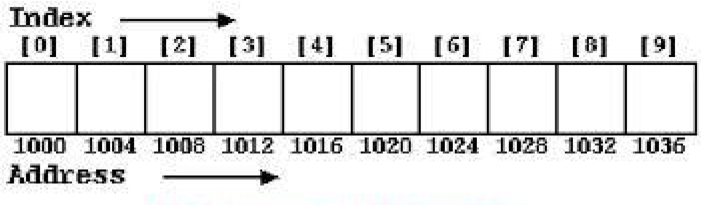
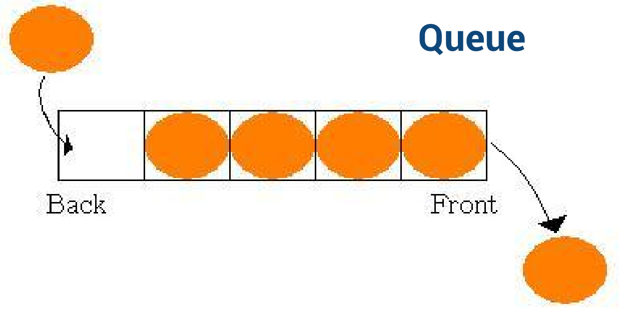
  -

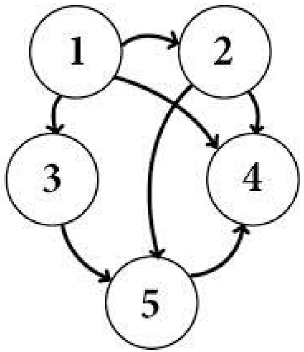
Examples of Data Structures



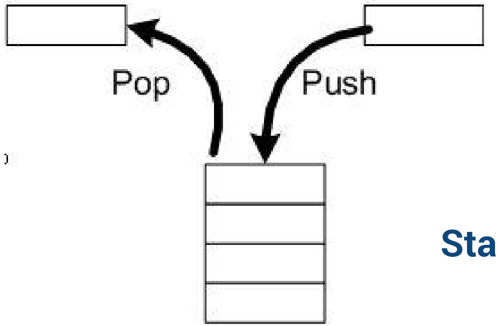
Array



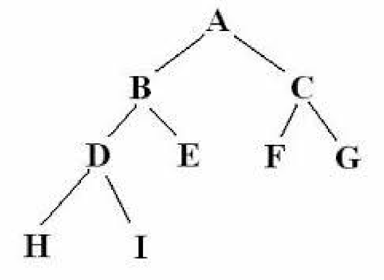
Queue



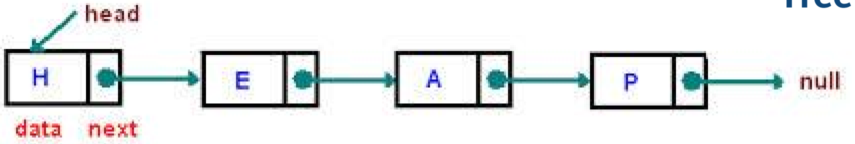
Graph



Stack



Tree



Linked List

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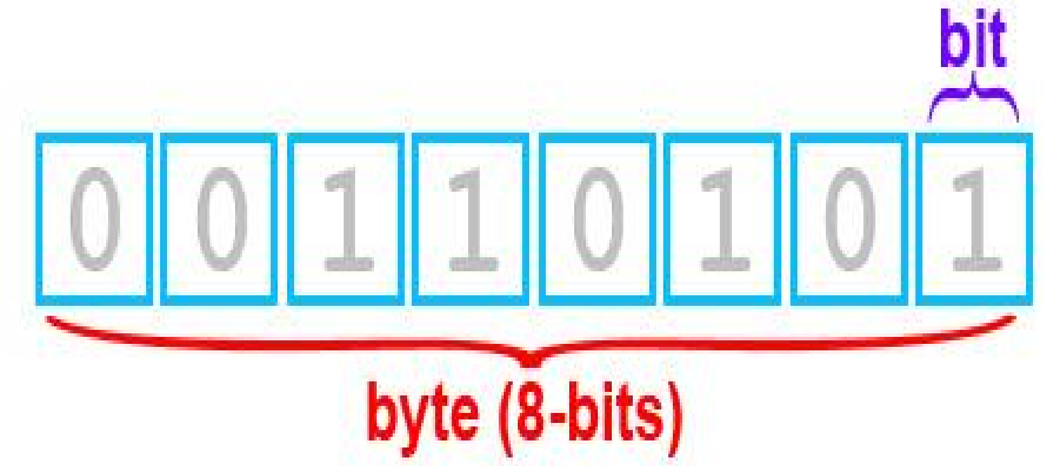
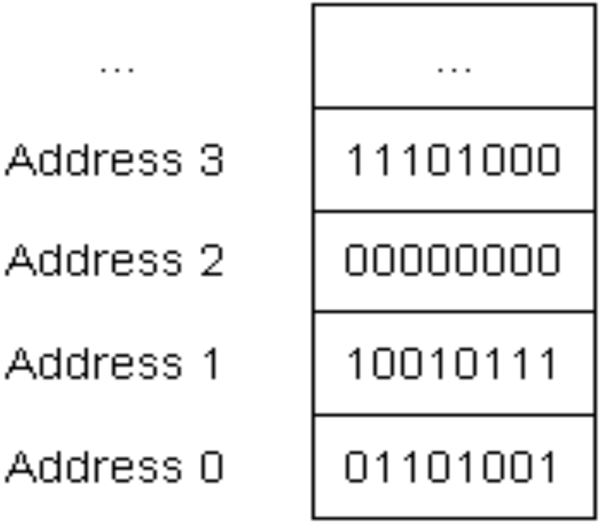
Arrays

If you Byte something, you will get Bitten 8 times



There’s a joke in there somewhere. LOL!

Memory Address



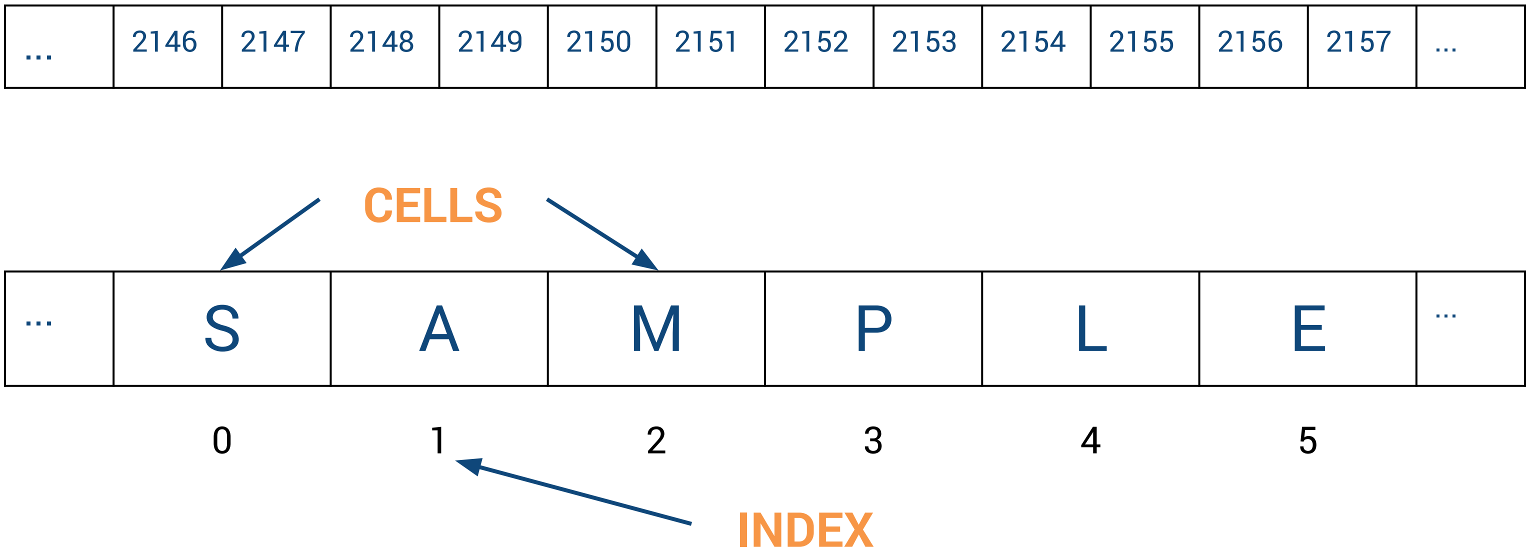
...	...
Address 3	11101000
Address 2	00000000
Address 1	10010111
Address 0	01101001

Memory Addresses

Each byte of memory -> unique number

Computer system can refer specifically to data in Address 3 or Address 0

An Array



...	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	...

...	S	A	M	P	L	E	...
	0	1	2	3	4	5	

Stores a group of related variables one after another in a contiguous portion of memory

Array Properties

Array Operations

Given an array, here are some operations:

0	1	2	3	4	5
S	A	M	P	L	E

- array[index]
- Size
- Insert
- Remove
- Resize

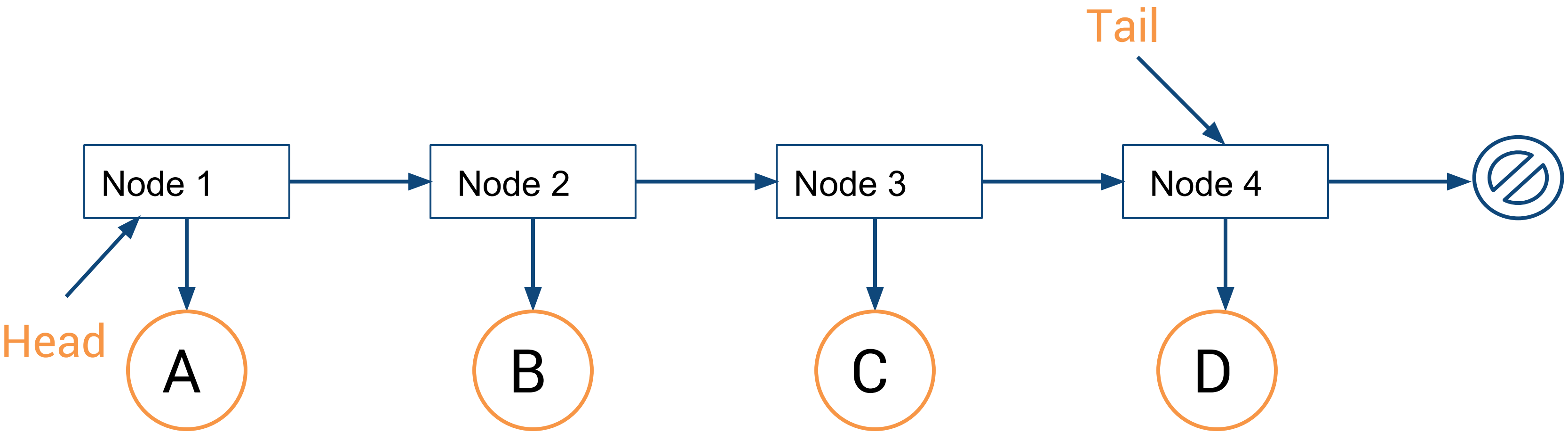
Linked Lists

- Singly Linked Lists
- Doubly Linked Lists
- Circularly Linked Lists

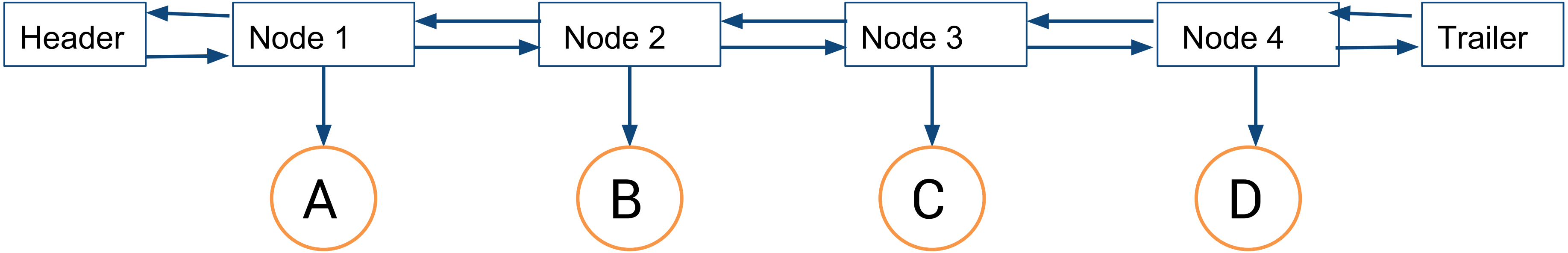
Linked List: Properties

1. Elements kept in certain order
2. More distributed representation
3. Core representation is a node
4. Maintains reference to its element
5. Maintains reference to neighbouring node(s)
6. Head and Tail nodes

Linked List: Singly Linked

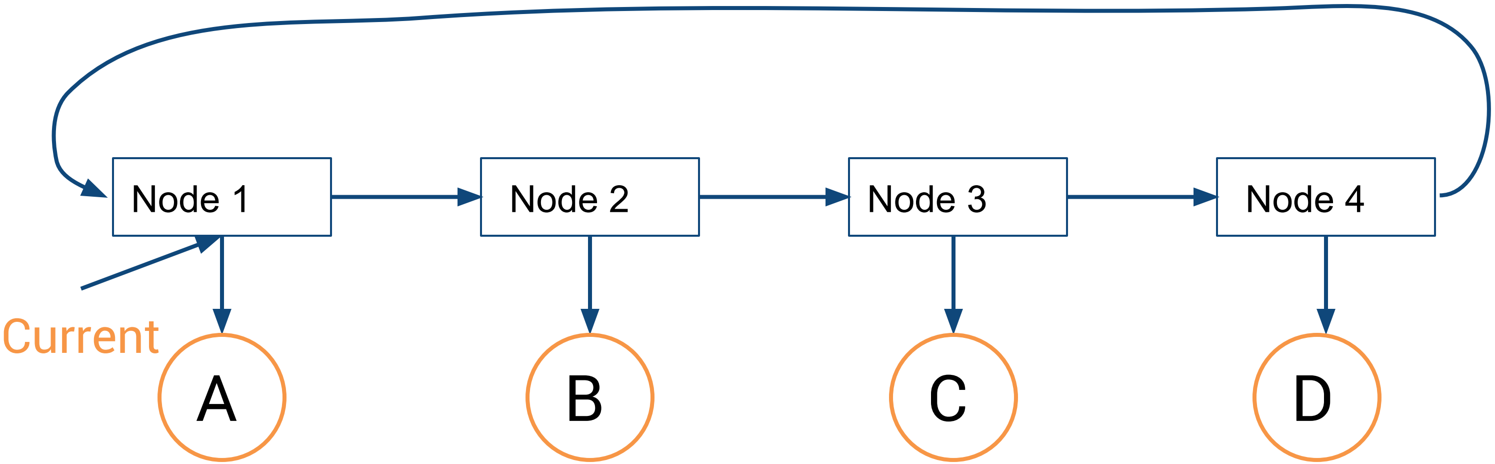


Linked List: Doubly Linked



Header and Trailer are “dummy nodes” known as SENTINELS (or guards)

Linked List: Circularly Linked



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Group activity: Array-Based vs Linked Lists

1. Break up into groups of 3-4 people
2. Discuss the benefits and costs of array-based lists
3. Discuss the benefits and costs of linked lists
4. For 2 and 3 think about ease of element access, memory use, insertion and deletions at arbitrary positions
5. You can use any resource available to you including your group members

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Stacks

Stacks: Common Examples

- How you pack plates after washing them
- When you use the Back button on your web browser
- When your study for a final exam last minute
- When use the undo button after you accidentally delete your unsaved 15 page essay

Stack Operations

- Push: insert a new item to stack
- Pop: remove and return most recently added item
- isEmpty: is the stack empty?

Stack Implementations: Which is better ?

Array-based Stack

or

Linked List Stack

Queues

Queues: Common Examples

- Printing order on a network printer
- Voting lines during elections
- What happens at petrol stations when there is fuel shortage
- What you encounter when waiting for your banku during lunch
- When Jerry creates a playlist for an upcoming party

Queue Operations

- Enqueue: insert a new item onto queue
- Dequeue: delete and return most recently added item
- isEmpty: is the queue empty?

Queue Implementations: Which is better ?

Array-based Queue

or

Linked List Queue

Double-Ended Queues (Deques)

Pronounced Decks in order not to mix it up with DEQUEUE Operation

Deques Operations

- First
- Last
- Add last
- Add first
- Delete first
- Delete last
- Is empty

Device Break

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Big “Oh” Notation

Mini Activity: Order these from lowest to highest

logN	a^N	N^2	1	NlogN	N^3	N	N!

Average Algorithms

Average 1

```
n = len(S)
A = [0] * n
for j in range(n):
    total = 0
    for i in range(j +1):
        total += S[i]
    A[j] = total / (j+1)
return A
```

Your Turn: Which Average Algorithm is Better ?

Average 2

```
n = len(S)
A = [0]*n
for j in range(n):
    A[j] = sum(S[0:j+1])/ (j+1)
return A
```

Average 3

```
n = len(S)
A = [0] * n
total = 0
for j in range(n):
    total += S[j]
    A[j] = total / (j+1)
return A
```

Sorting Algorithms

Real-life Applications of Sorting

Why Sorting?

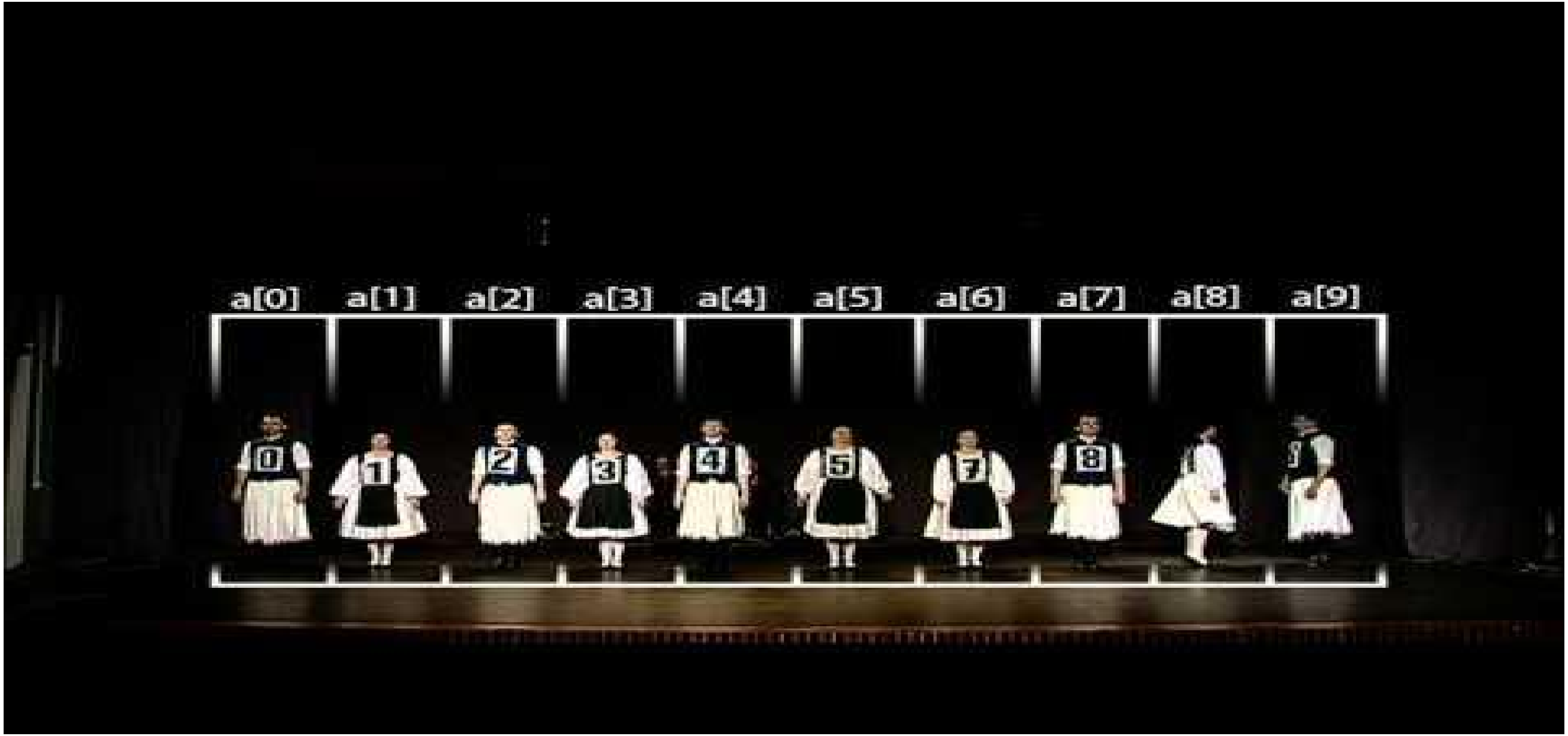
Some Sorting Algorithms

- Merge-Sort
- Quick-Sort
- Insertion-Sort
- Heap-Sort
- Bucket-Sort
- Radix Sort

Sorting: Insertion Sort

1. 1st element: already sorted
2. 2nd element: if smaller than 1st swap them
3. 3rd element: swap leftward until in proper order with first 2 elements
4. 4th element: swap leftward until in proper order with first 3 elements
5. 5th to last element: continue leftward swapping manner above
6. Sorted!!!

Insertion Sort Video



Merge Sort

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Quick Sort

Selection Algorithms

Real-Life Applications of Selection

Why Selection?

Some Selection Algorithms

Labs