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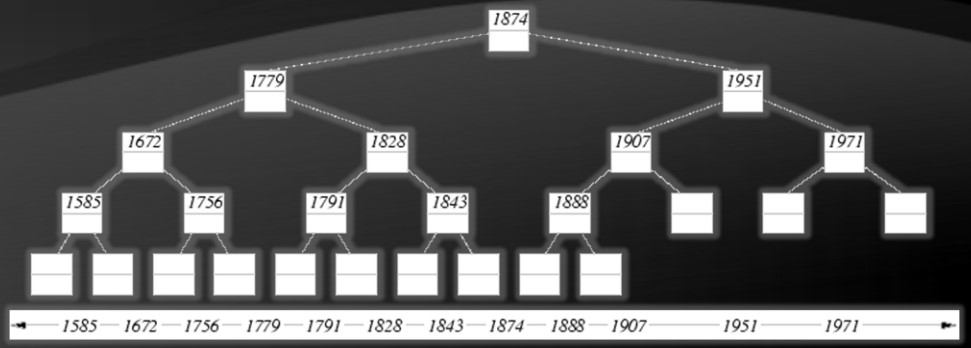

Data Structures Efficiency

Computational Complexity of Fundamental Data Structures, Choosing a Data Structure

Data Structures and Algorithms

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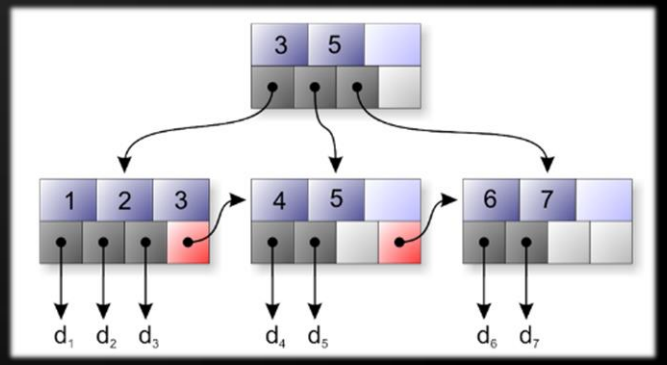

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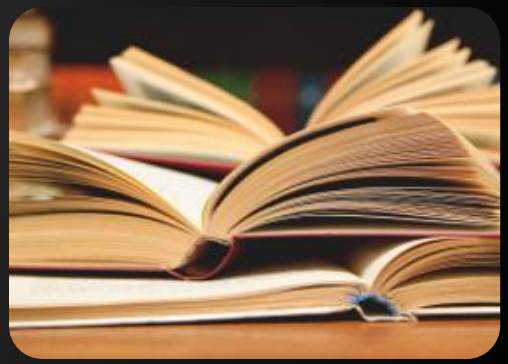
Table of Contents

1. Fundamental Data Structures – Comparison
   - Arrays
   - Lists
   - Trees
   - Hash-Tables
   - Sets
   - Bags
2. Choosing Proper Data Structure



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Comparing Data Structures

Time Complexity of Basic Operations

Data Structures Efficiency

Data Structure	Add	Find	Delete	Get-by-index
Array (T[])	O(n)	O(n)	O(n)	O(1)
Linked list (LinkedList<T>)	O(1)	O(n)	O(n)	O(n)
Resizable array list (List<T>)	O(1)	O(n)	O(n)	O(1)
Stack (Stack<T>)	O(1)	-	O(1)	-
Queue (Queue<T>)	O(1)	-	O(1)	-

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Data Structures Efficiency (2)

Data Structure	Add	Find	Delete	Get-by-index
Hash table (Dictionary<K,T>)	O(1)	O(1)	O(1)	-
Tree-based dictionary (Sorted Dictionary<K,T>)	O(log n)	O(log n)	O(log n)	-
Hash table based set (HashSet<T>)	O(1)	O(1)	O(1)	-
Tree based set (SortedSet<T>)	O(log n)	O(log n)	O(log n)	-

Choosing Data Structure

- Arrays (`T[]`)
  - Use when fixed number of elements should be processed by index
- Resizable array lists (`List<T>`)
  - Use when elements should be added and processed by index
- Linked lists (`LinkedList<T>`)
  - Use when elements should be added at the both sides of the list
  - Otherwise use resizable array list (`List<T>`)

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Choosing Data Structure (2)

- Stacks (`Stack<T>`)
  - Use to implement LIFO (last-in-first-out) behavior
  - `List<T>` could also work well
- Queues (`Queue<T>`)
  - Use to implement FIFO (first-in-first-out) behavior
  - `LinkedList<T>` could also work well
- Hash table based dictionary (`Dictionary<K,T>`)
  - Use when key-value pairs should be added fast and searched fast by key
  - Elements in a hash table have no particular order

Choosing Data Structure (3)

- Balanced search tree based dictionary (`SortedDictionary<K,T>`)
  - Use when key-value pairs should be added fast, searched fast by key and enumerated sorted by key
- Hash table based set (`HashSet<T>`)
  - Use to keep a group of unique values, to add and check belonging to the set fast
  - Elements are in no particular order
- Search tree based set (`SortedSet<T>`)
  - Use to keep a group of ordered unique values

Summary

- Algorithm complexity is rough estimation of the number of steps performed by given computation
  - Complexity can be logarithmic, linear, n log n, square, cubic, exponential, etc.
  - Allows to estimating the speed of given code before its execution
- Different data structures have different efficiency on different operations
  - The fastest add / find / delete structure is the hash table – O(1) for all these operations

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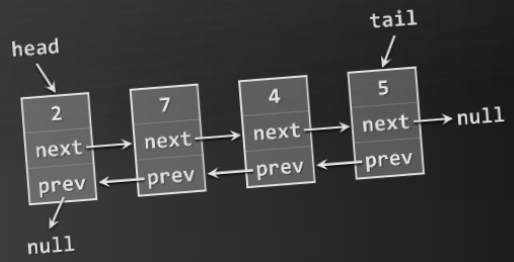
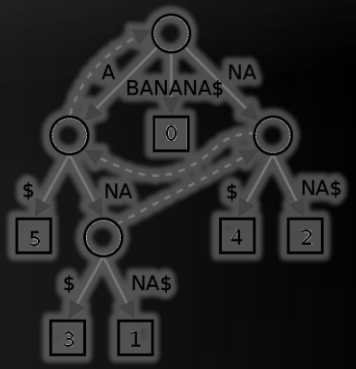
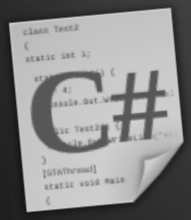
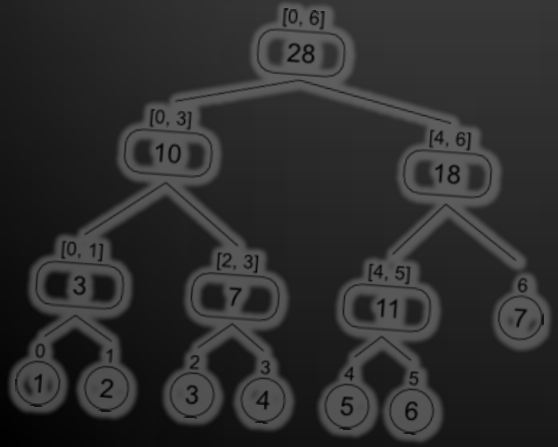
Data Structures Efficiency

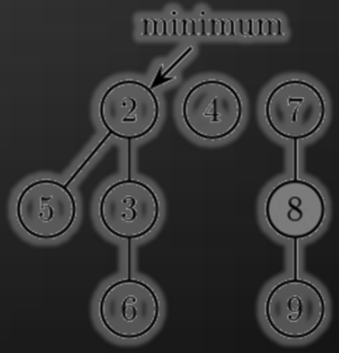


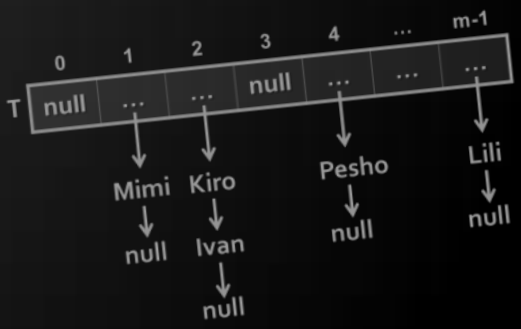




Questions?







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Exercises

1. A text file `students.txt` holds information about students and their courses in the following format:

```
Kiril   | Ivanov    | C#
Stefka  | Nikolova  | SQL
Stela   | Mineva    | Java
Milena  | Petrova   | C#
Ivan    | Grigorov  | C#
Ivan    | Kolev     | SQL
```

Using `SortedDictionary<K,T>` print the courses in alphabetical order and for each of them prints the students ordered by family and then by name:

```
C#: Ivan Grigorov, Kiril Ivanov, Milena Petrova
Java: Stela Mineva
SQL: Ivan Kolev, Stefka Nikolova
```

Exercises (2)

2. A large trade company has millions of articles, each described by barcode, vendor, title and price. Implement a data structure to store them that allows fast retrieval of all articles in given price range `[x…y]`. Hint: use `OrderedMultiDictionary<K,T>` from Wintellect's Power Collections for .NET.
3. Implement a class `BiDictionary<K1,K2,T>` that allows adding triples `{key1, key2, value}` and fast search by `key1`, `key2` or by both `key1` and `key2`. Note: multiple values can be stored for given key.

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