

# Outline

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- Binary Trees
- Traversing Binary Tree
- Red-Black Trees
- Red-Black Tree Insertions
- **2-3-4 Trees**

# Introduction to 2-3-4 Trees

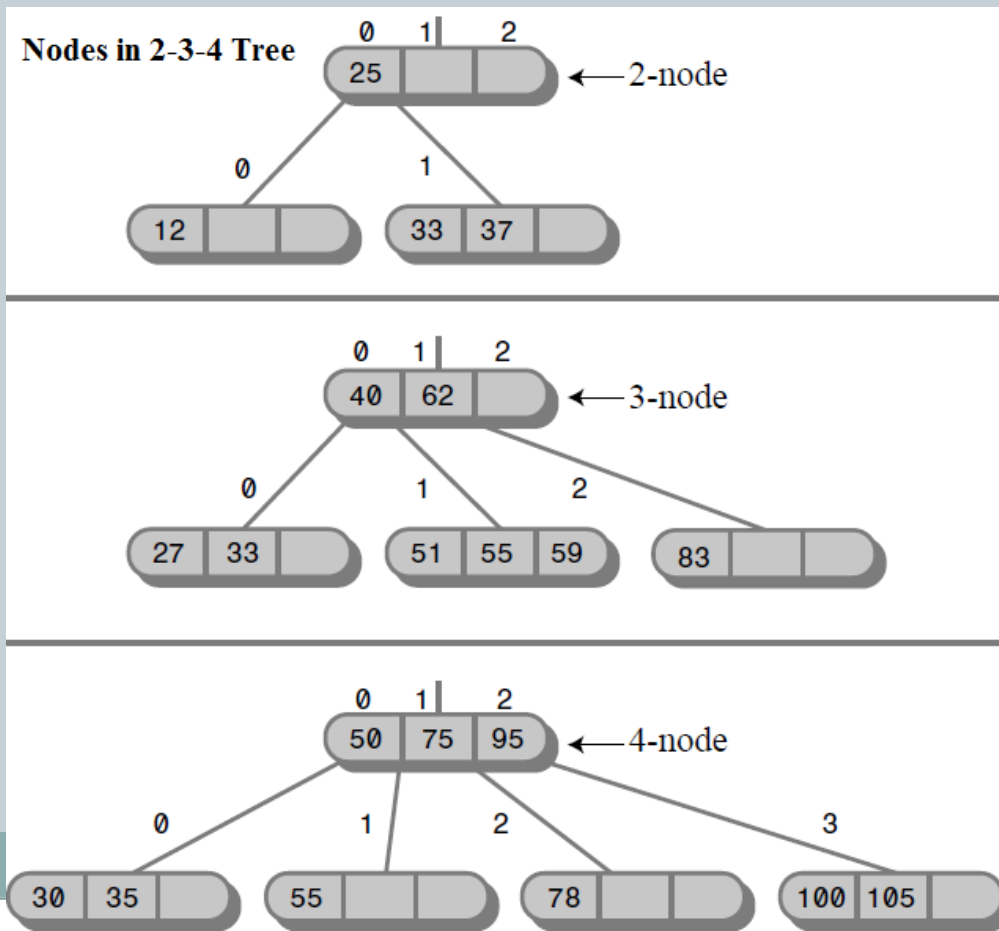
2

- The 2, 3, and 4 in the name 2-3-4 tree refer to how many links to child nodes can potentially exist in a given node.
- For nonleaf nodes, the following three arrangements are possible:
  - A node with one data item always has two children
  - A node with two data items always has three children
  - A node with three data items always has four children
- Thus, if  $L$  – number of child links, and  $D$  – number of data items.  $L = D + 1$

# Introduction to 2-3-4 Trees (Cont.)

3

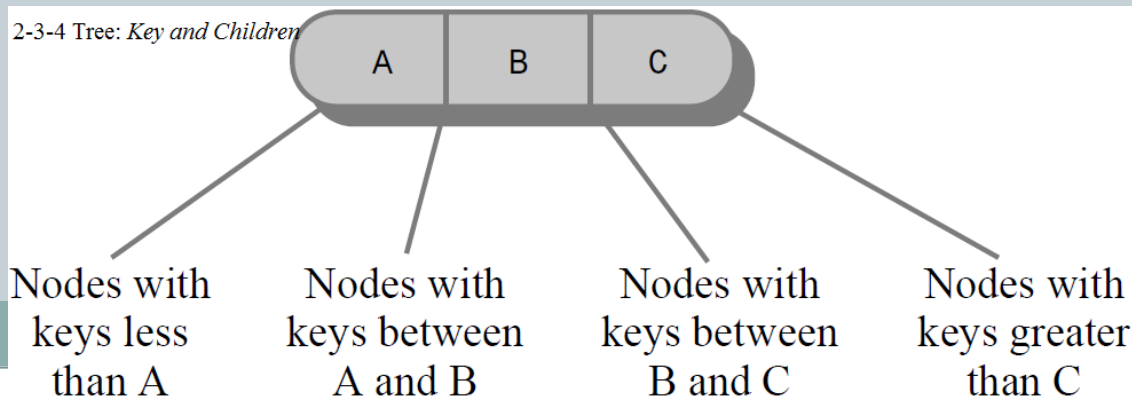
- Why a 2-3-4 tree is not called a 1-2-3-4 tree? Because a node cannot have only one child.



# 2-3-4 Tree Organization

4

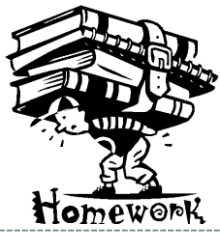
- Data items in a link were numbered from 0 to 2, and the child links from 0 to 3.
- The data items in a node are arranged in ascending key order from left to right.
- 2-3-4 tree characteristics:
  - All children in the subtree rooted at child 0 have key values less than key 0.
  - All children in the subtree rooted at child 1 have key values greater than key 0 but less than key 1.
  - All children in the subtree rooted at child 2 have key values greater than key 1 but less than key 2.
  - All children in the subtree rooted at child 3 have key values greater than key 2.



# Searching for a Data Item in 2-3-4 Tree

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- Finding a data item with a particular key is similar to the search routine in a binary tree.
- You start at the root, and, unless the search key is found there, select the link that leads to the subtree with the appropriate range of values.



## Homework 23 submit to:

[fe.assignment@gmail.com](mailto:fe.assignment@gmail.com)



Mon., 7-March-201  
@ 15:00

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1. Create a 2-3-4 Tree.
2. Create a function for searching a data item in 2-3-4 Tree



Late submission: the score will be **minus** 10% for every hour

To be continued...