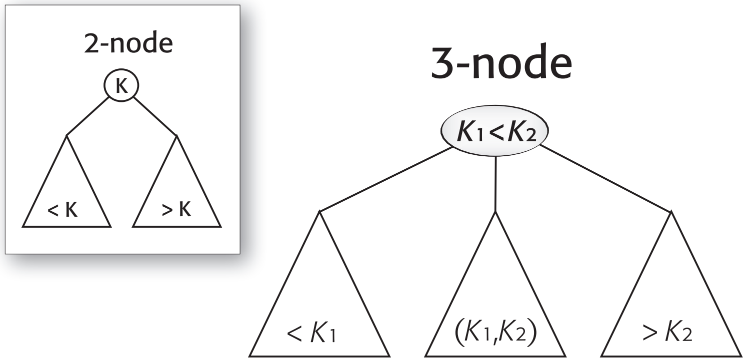
cs223fig31.cdr
Sunday, May 8, 2022 12:16:51 PM
Color profile: Disabled
Composite Default screen

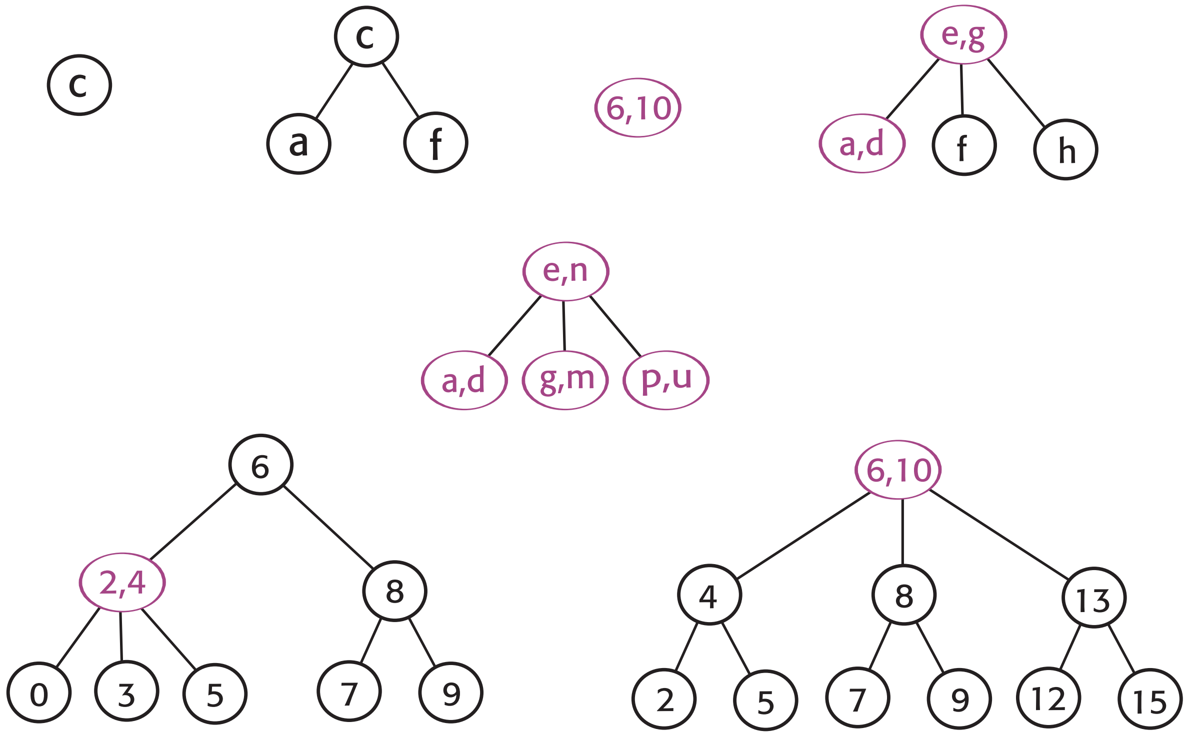
Balanced Search Trees
2–3 Trees

- Representation change



- **All leaves on same level**
- **Insert new key in a leaf**

2–3 Trees
Examples



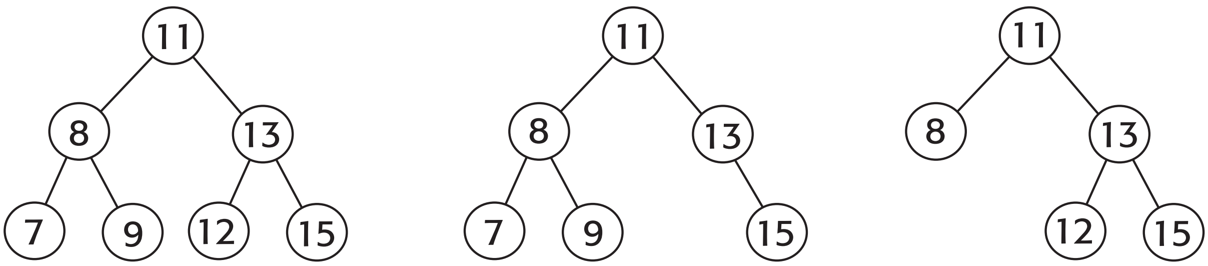
2–3 Trees
Definition Exercise

- ➪ **Full binary tree**
- ➪ **Complete tree**

Not every valid BST is a 2-3 tree. (Why?)

Which BST is also a valid 2–3 tree?

Definition-based questions are really about set membership. Check membership criteria in the definition to decide if it applies. (Note b is tricky).



(a) (b) (c)

Quiz
Is tree (c) an AVL? (Determine node balance factors).

Exercise
Show in a Venn diagram how BST, AVL, 2-3 trees relate.

Building 2–3 Trees

- **Empty: insert as root**
- **Not empty**
  - Find suitable leaf via key condition
  - Insert key in leaf (next)

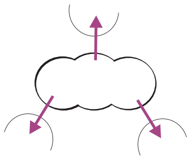
Building 2–3 Trees
Insert Key Procedure

➪ **Key promotion**

☺ ➪ **If leaf 2-node insert as 2nd key**

➪ **If leaf 3-node**

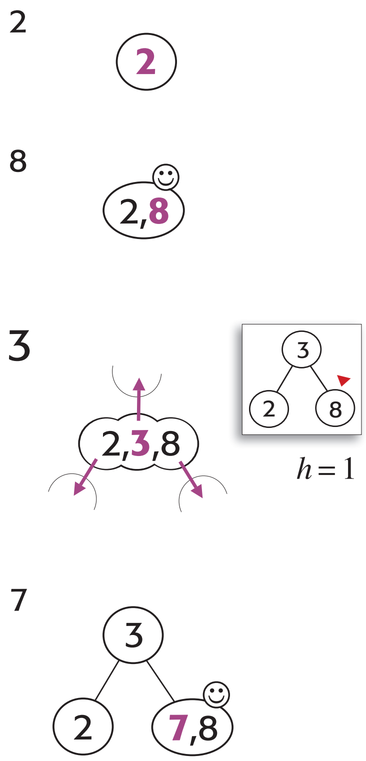
- ✎ Split to two 2-nodes: left, right
- ✎ Insert smallest key left, largest right
- ✎ Promote middle to parent
- ✎ If parent empty make middle new root else insert middle in parent



Basic insert procedure may repeat to restore 2-3 conditions.

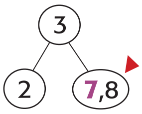
Building 2–3 Trees Example

2,8,3,7,5,6,4



Building 2–3 Trees Example (Cont.)

2,8,3,7,5,6,4



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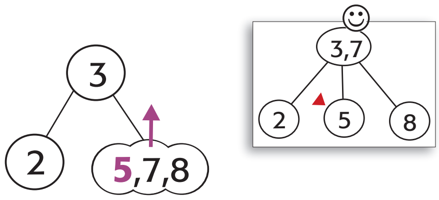

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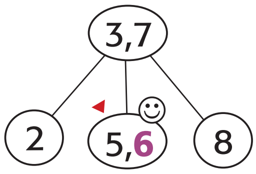
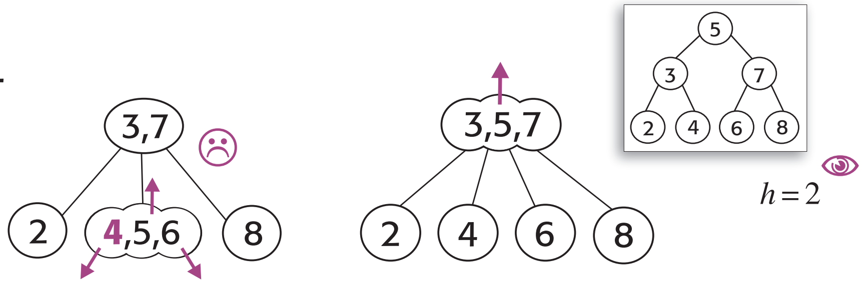
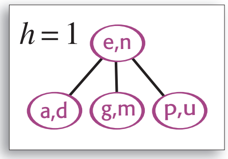


Quiz
How many times *insert* is called in each case?

4



2–3 Trees
Conclusions



7.4
- Importance

Quiz
In example, what is the shortest sequence of keys leading to a height of 2? What's the longest sequence? Hint: see final tree in previous slide and tree in this slide (fig).

- Dictionary operations (worst)
- Build efficiency

Exercise
In terms of practicality (implementation costs), efficiency of build and dictionary ops.

- Compare with BST, AVL