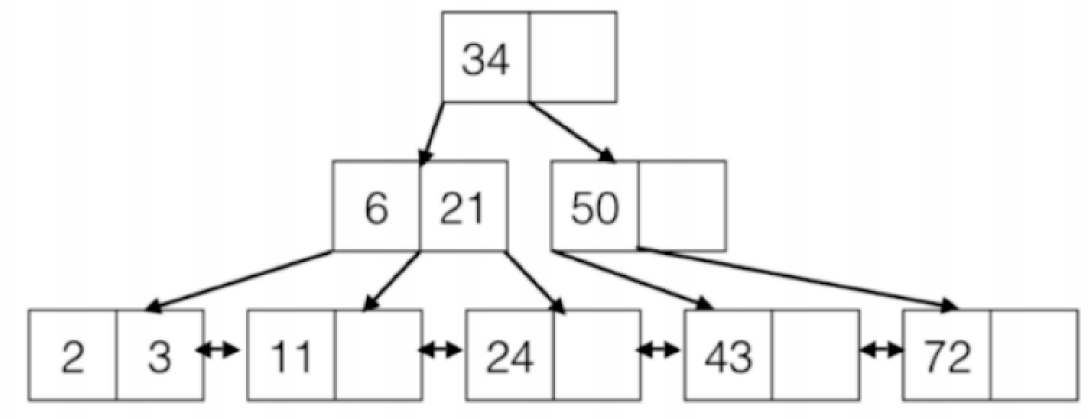
CS 186 Fall 2020 — Introduction to Database Systems — Alvin Cheung, Aditya Parameswaran — DIS 3

1 Indices (B+ Trees)

Assume we have the following B+ Tree of order 1. Each index node must have either 1 or 2 keys (2 or 3 pointers), and the leaf nodes can hold up to 2 entries.



(a) What is the maximum number of insertions we can do without changing the height of the tree?

(b) What is the minimum number of keys you could insert to change the height of the tree?

2 Indices

Two sets of terminology:

Clustered vs. unclustered

- In a clustered index, the data pages are sorted using the same index that build the B+ Tree. This means the keys are roughly sorted in the same order as the data pages, so it'd cost ~1 I/O per page of records wanted.
- In an unclustered index, the data pages are unsorted, meaning chances are it'd cost ~1 I/O per record wanted.

Three alternatives for storing underlying data:

- Alternative 1 (by value): the entire record is directly stored in the leaf page
- Alternative 2 (by reference): (key: ptr to rid) pairs are stored in the leaf pages, where each key may not be distinct
- Alternative 3 (by reference): (key: [ptr to rid1, ptr to rid2, ...]) pairs are stored in the leaf pages, where each key is distinct

(a) Is it possible to have two clustered indices on separate columns?

Suppose we have an alternative 2 unclustered index on `(assignment_id, student_id)` with a height of 3 (one must traverse 3 index pages to reach any leaf page).

Here's the schema:

```
CREATE TABLE Submissions (
    record_id integer UNIQUE,
    assignment_id integer,
    student_id integer,
    time_submitted integer,
    grade_received byte,
    comment text,
    regrade_request text,
PRIMARY KEY(assignment_id, student_id));

CREATE INDEX SubmissionLookupIndex ON Submissions (
    assignment_id, student_id);
```

Assume the table and its associated data takes up 12 MB on disk (1 MB = 1024 KB) and that page size is 64 KB. (This includes extra space allocated for future insertions.)

(b) We want to scan all the records in Submissions. How many I/Os will this operation take?

(c) UPDATE Students SET grade_received=85 WHERE assignment_id=20 AND student_id=12345; How many I/Os will this operation take?

(d) In the worst case, how many I/Os does it take to perform an equality search on grade_received?

3 Bulk-Loading

Suppose we were to create an order d=2 B+ tree via bulk-loading with a fill factor of 3/4. Here, fill factor specifies the fill factor for leaves only; inner nodes should be filled up to full and split in half exactly.

We insert keys with all integer values from 1-16 in order. Draw out the final B+ tree. What is its height?