Range counting

Count (or enumerate) objects in a given range (many times)
Use array: $O(\log n)$ to place $L,R \rightarrow$ to count.
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$O(k + \log n)$ to enumerate/report.
USE ARRAY: \( O(\log n) \) to place \( L, R \) → to count.
\( O(k + \log n) \) to enumerate/report.

but this is not dynamic \[ \text{insert/delete data: } O(n) \]
Store size of each subtree
\[ k = 6 \]

\[ \text{count 1} \]
\[ k = 6 \]

- \[ [ \quad ] \]
- \[ L \]
- \[ R \]

- \[ \square \rightarrow \text{count } 1 \]

Diagram with nodes labeled from 1 to 6 and arrows indicating connections.
\[ k = 6 \]

- **\( \square \)** → count 1
- **\( \bigcirc \)** → count subtree

Diagram of a tree with nodes labeled from 1 to 6, showing the counting process.
$O(\log n)$ nodes visited

- 2 paths root→leaf
- 1 neighbor off path per node

○ "inside"
× "outside"
Can we update subtree sizes when inserting/deleting data?
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Use a RB tree

when are subtree sizes affected?
Can we update subtree sizes when inserting/deleting data?

Use a RB tree

When are subtree sizes affected? Rotations