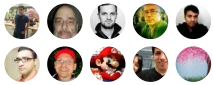


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How do splay trees balance themselves?

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2 Answers

**Ofir Nachum**, TA'ed MIT's advanced algorithms class

331 Views

Splay trees are not the standard 'balanced binary search trees' like AVL or red-black trees. In fact, it can be shown that any binary search tree can be converted to any other binary search tree (structure-wise) via a series of splays.

However, there is still a sense in which splay trees 'balance' themselves at each splay. Here's how to think about it (taken from MIT's 6.854 psets):

A rotation in splay trees involves 3 nodes: a node x , its parent y , and its grandparent z . Call this triple *biased* if over 9/10 of z 's descendants are below x , and *balanced* otherwise. Argue that along the given search path, there can be at most $O(\log n)$ balanced triples.

Argue that when a biased triple is rotated by a zig-zig or a zig-zag, the potential decreases by a constant, paying for the rotation (look at how the ranks of the three nodes change). Note that in splay trees, the potential is a sum of ranks of nodes $\sum r(x)$, where the rank $r(x)$ of a node is usually taken to be the logarithm of the size of the node's subtree.

Argue that when a balanced triple is rotated, the potential increases by at most $2(r(z) - r(x))$.

With this you can figure out that rotating biased triples is paid for by the potential drop, and thus the amortized cost consists of only the $O(\log n)$ rotations of balanced triples.

Thus, when a splay encounters a biased triple, it performs some work to make this triple more 'balanced.' In this sense, splay trees balance themselves.

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There is no guarantee a splay tree will be balanced, but it guarantees that often accessed nodes will be near the top. With random access, however, the tree becomes balanced. I happens because of "**Zig-zag Step**", which reduces tree height. Other splay operations don't change the tree height.

See [Splay tree](#) .

Written 24 Apr 2014

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