Technische Universität München
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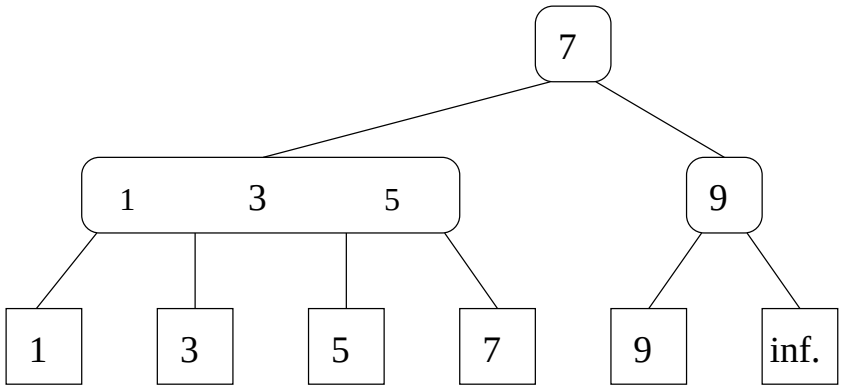
# Effiziente Algorithmen und Datenstrukturen I

## Aufgabe 1 (10 Punkte)

Carry out the following operations sequentially on the (2,4) tree shown below so that it remains a (2,4) tree and show what the tree looks like after each operation(always carry out each operation on the result of the previous operation):




1. Insert(4)
2. Delete(3)
3. Delete(1)

## Aufgabe 2 (10 Punkte)

Prove that there exists a sequence of $n$ insert and delete operations on a $(2, 3)$-tree s.t. the total number of split and merge operations performed is $\Omega(n \log n)$.

## Aufgabe 3 (10 Punkte)

Show how to maintain a dynamic set $Q$ of numbers that supports the operation MIN-GAP, which gives the magnitude of difference of the two closest numbers in $Q$. For example, if $Q = \{1, 5, 9, 15, 18, 22\}$, then MIN-GAP($Q$) returns 18-15=3, since 15 and 18 are the two closest numbers in $Q$. Make the operations INSERT, DELETE, SEARCH, and MIN-GAP as efficient as possible, and analyze their running times.