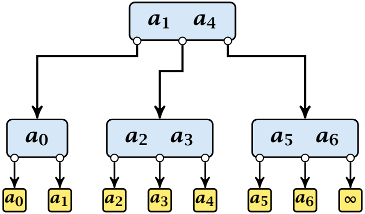
4.5 Inserting into a $(2, 3)$-tree

Given a $(2, 3)$-tree with n elements, and a sequence $x_0 < x_1 < x_2 < \cdots < x_k$ of elements. We want to insert elements $x_1, \dots, x_k$ into the tree ($k \ll n$).

time: $\mathcal{O}(\log n)$; **work:** $\mathcal{O}(k \log n)$



4.5 Inserting into a $(2,3)$-tree

1. determine for every x_i the leaf element before which it has to be inserted

   time: $\mathcal{O}(\log n)$; work: $\mathcal{O}(k \log n)$; CREW PRAM

   all x_i's that have to be inserted before the same element form a chain
2. determine the largest/smallest/middle element of every chain

   time: $\mathcal{O}(\log k)$; work: $\mathcal{O}(k)$;
3. insert the middle element of every chain

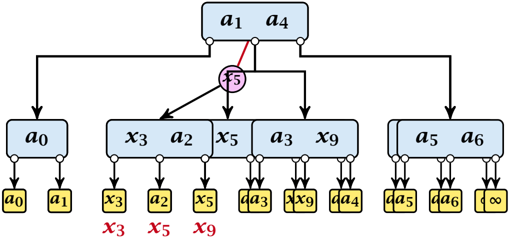
   compute new chains

   time: $\mathcal{O}(\log n)$; work: $\mathcal{O}(k_i \log n + k)$; k_i= #inserted elements

   (computing new chains is constant time)
4. repeat Step 3 for logarithmically many rounds

   time: $\mathcal{O}(\log n \log k)$; work: $\mathcal{O}(k \log n)$;

Step 3



- each internal node is split into at most two parts
- each split operation promotes at most one element
- hence, on every level we want to insert at most one element per successor pointer
- we can use the same routine for every level

4.5 Inserting into a $(2, 3)$-tree

- Step 3, works in phases; one phase for every level of the tree
- Step 4, works in rounds; in each round a different set of elements is inserted

Observation

We can start with phase i of round r as long as phase i of round $r - 1$ and (of course), phase $i - 1$ of round r has finished.

This is called Pipelining. Using this technique we can perform all rounds in Step 4 in just $\mathcal{O}(\log k + \log n)$ many parallel steps.