

**Problem 1.** Suppose you need to sort 10 million integers, each in the range 0 to  $2^{40}$ . How would you do it? Which method, among the ones we have seen, gives the smallest tilde time complexity.

**Problem 2.** Describe an input instance for which MSD is much faster than LSD.

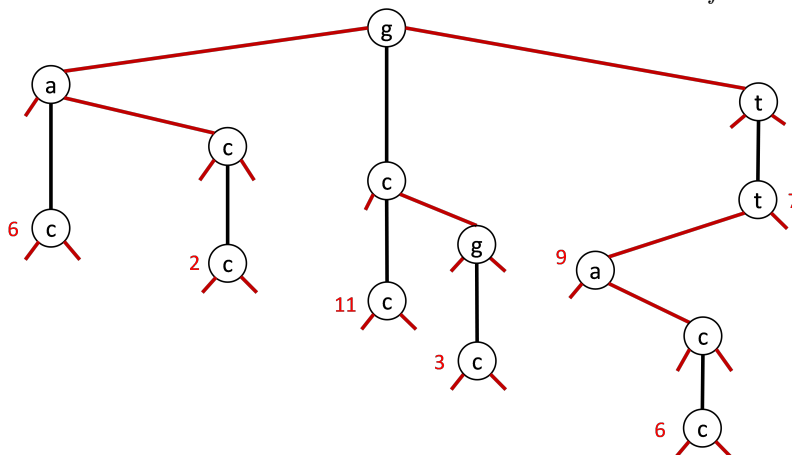
**Problem 3.** When is 3-way string quickSort the preferred sorting method?

**Problem 4.** Construct a set  $S$  of strings in lowercase ( $R = 26$ ) for which the  $R$ -way trie uses space (in words) less than the total number of characters in strings in  $S$ . (The number of characters in the set  $\{abc, bcd, aabd\}$  is 10.)

**Problem 5.** (Final exam 2018) Hakið við alla eiginleika sem gilda fyrir þríundatræ ( $R = 3$ ) sem inniheldur  $N$  strengi af meðallengd  $w$ . / Check all the properties that hold for a trinary trie ( $R = 3$ ) that contains  $N$  strings of average length  $w$ .

- Leit sem heppnast ekki tekur tíma (í fjölda stafasamanburða) sem er réttu hlutfalli við lengd leitarlykilsins. / A search hit takes time (in character comparisons) proportional to the length of the search key.
- Það er erfitt að eyða lykklum úr træinu. / Deleting a key is difficult.
- Plássnotkunin er mun meiri en hjá jafngildu TST. / The space usage is significantly larger than an equivalent ternary search trie (TST).
- Fjöldi tómra linka getur verið meiri en  $Nw$ . / The number of empty links can be larger than  $Nw$ .

**Problem 6.** (Final exam 2017) Consider the following Ternary Search Trie (TST), where the values are shown next to the nodes of the corresponding string keys.



- List the keys stored in the trie, in alphabetical order.
- Give one possible order in which the keys were inserted into the trie:

c) Insert the key tag into the trie, with value 5. Show or describe how the trie changes.

**Problem 7.** Suppose you have a set  $X$  of one million DNA strings of length 20, and a long string  $S$  (a genome) of length  $10^9$ . You want to answer which of the short strings occur in  $S$  as substrings.

- a) How long would it take to search for each string from  $X$  in  $S$  individually? (Assume, say, that your computer can perform  $10^9$  character comparisons per second.)
- b) Explain how to achieve this efficiently using a trie. Estimate the amount of time it would take.

#### CLASS EXERCISES

These questions will be addressed during exercise class. They are not to be turned in.

**Problem 8.** Suppose you have a trie with  $R = 26$  (lowercase letters) and insert into it the words: *tic*, *tac*, *toe*, *time*. How many null links will be stored in the nodes of the trie?