A. Mirror Images

- Trivial
C. Interpreter

- Involved, but straightforward
E. Median Updates

- \textbf{Median} =
  - middle item in sorted list (odd length),
  - Or average of middle items (even length)
- Given a dynamic list, i.e., it allows
  - Inserts
  - Deletes
  - Report median after every successful operation
Augmented RB trees

• Augmented balanced RB tree is an efficient dynamic data structure
• Every insert in this problem involves
  1. Insert into RB tree, and
  2. Computing median in tree (Select)
• Every delete in this problem involves
  1. Delete from RB tree, and
  2. Computing median in tree (Select)
F. ACM Rank

• Data contains a stream of requests
  - $S$ minute teamID problemID result
  - $R$ teamID
  - $T$ rank

• Goal is to answer each query as efficiently as possible
Augmented RB Tree

- As with Rank and Select,
  - Augment RB tree with size (of subtree) info
- \textbf{S} translates to
  - insert or update operation
- \textbf{R} translates to
  - inorder tree traversal
- \textbf{T} translates to
  - Doing select operation on augmented tree
D. Balanced Lineup

- Given sequence of 1,000,000 cow heights (data) & list of 200,000 sublists of cows (queries)
  - Report difference in max and min height in group
  - Every sublist is specified by first and last cow
- Naïve:
  - Search every sublist
  - $10^6 \times 2 \times 10^5 = 2 \times 10^{11}$ O(Nk)
- What if we preprocess the data
Augment RB Trees

- What information to store?
- Can it be maintained?
- How do perform the new operation?
H. Median on the Plane

• Given N points on plane
  ▪ N is even
  ▪ No three points are collinear
• Select two points in such a way, that the infinite straight line on which they lie divides all remaining points into two equal-sized sets
• Naïve: Try every pair of points and check
  ▪ $O(N^2 \times N) = O(N^3)$
B. Tree Augmentation

• Examples
  ▪ Tree -> AugTree

• Examples
  ▪ AugTree -> Tree
  ▪ Challenges
Observation

• Every vertex forms a **star** with its neighbors
• Every **star** in Tree becomes a **clique** in the AugTree
• Thus identify the cliques
• Is that enough
• What about adjacent neighbors in Tree?
  - Cliques with common vertices
Algorithm for Augmented Tree?

- Use observations above to design an algorithm
G. Lights