ADAAPHID – Ada and Aphids – Example I/O

https://www.spoj.com/problems/ADAAPHID/

$\oplus$ stands for logical operation XOR, that is true if and only if its arguments differ (one is true, the other is false).

Input	Process (Input after XOR)	Output
$Q = 7$		
$A = 1, V = 1,$ $L = 0$	$A \oplus L = 1 \oplus 0 = \mathbf{1},$ pseudoRand $= V \oplus L = 1 \oplus 0 = 1$	$\{\mathbf{1}, \underset{\text{new L}}{\mathbf{1}}\}$
$A = 3, V = 3,$ $L = 1$	$A \oplus L = 3 \oplus 1 = \overline{11}_2 \oplus \overline{01}_2 = \overline{10}_2 = \mathbf{2},$ pseudoRand $= V \oplus L = 3 \oplus 1 = \overline{11}_2 \oplus \overline{01}_2 = \overline{10}_2 = 2$	$\{2, 2+1\}=$ $\{\mathbf{2}, \underset{\text{new L}}{\mathbf{3}}\}$
$A = 4, V = 0,$ $L = 3$	$A \oplus L = 4 \oplus 3 = \overline{100}_2 \oplus \overline{011}_2 = \overline{111}_2 = \mathbf{7},$ pseudoRand $= V \oplus L = 0 \oplus 3 = \overline{00}_2 \oplus \overline{11}_2 = \overline{11}_2 = 3$	$\{7, 3+2+1\}=$ $\{\mathbf{7}, \underset{\text{new L}}{\mathbf{6}}\}$
$A = 3, V = 2,$ $L = 6$	$A \oplus L = 3 \oplus 6 = \overline{011}_2 \oplus \overline{110}_2 = \overline{101}_2 = \mathbf{5},$ pseudoRand $= V \oplus L = 2 \oplus 6 = \overline{010}_2 \oplus \overline{110}_2 = \overline{100}_2 = 4$	$\{5, 4+2+1\}=$ $\{\mathbf{5}, \underset{\text{new L}}{\mathbf{7}}\}$ (first number in ID is 5 and is not greater than 7, which is first in keyPair{7,6} and we skip pseudoRand=3 from keyPair{7,6} in the sum for calculating second int in current ID, that is why the second id is $4+\not{3}+2+1=7$)
$A = 5, V = 6,$ $L = 7$	$A \oplus L = 5 \oplus 7 = \overline{101}_2 \oplus \overline{111}_2 = \overline{010}_2 = \mathbf{2},$ pseudorand $= V \oplus L = 6 \oplus 7 = \overline{110}_2 \oplus \overline{111}_2 = \overline{001}_2 = 1$	$\{2, 1+2+1\}=$ $\{\mathbf{2}, \underset{\text{new L}}{\mathbf{4}}\}$ (we skip 4 and 3)
$A = 13, V = 13,$ $L = 4$	$A \oplus L = 13 \oplus 4 = \overline{1101}_2 \oplus \overline{0100}_2 = \overline{1001}_2 = \mathbf{9},$ pseudoRand $= V \oplus L = 13 \oplus 4 = 9$	$\{9, 9+1+4+3+2+1\}=$ $\{\mathbf{9}, \underset{\text{new L}}{\mathbf{20}}\}$
$A = 19, V = 19,$ $L = 20$	$A \oplus L = 19 \oplus 20 = \overline{10011}_2 \oplus \overline{10100}_2 = \overline{00111}_2 = \mathbf{7},$ pseudoRand $= V \oplus L = 19 \oplus 20 = 7$	$\{7, 7+1+4+3+2+1\}=$ $\{\mathbf{7}, \underset{\text{new L}}{\mathbf{18}}\}$ (we skip 9)

Observations: All operations we performed will took constant time, except for the search for aphids with first int from their ID's, which is not greater than first int from current aphid's ID. We need a data structure which can find us fast all those aphids. Treap can do that and even more – it can sum up all their second integers from their IDs fast: $O\big(\log(N)\big)$. That time complexity will result in total $O\big(N\ \log(N)\big)$ time complexity for the whole algorithm.