Improving Community-Participated Patrol for Anti-Poaching

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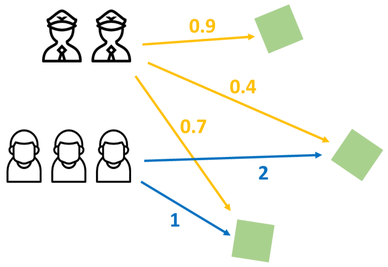
Resources Allocation of Community Participated Patrol



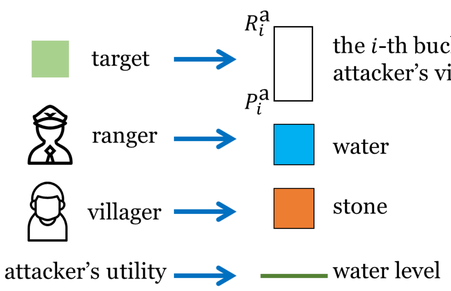
Professional rangers: distribute efforts among multiple targets
Community members: patrol a single target
Goal: maximize the defenders' expected utility by adjusting defensive strategy

Mixed-Integer Linear Program Solution

Stackelberg Game:

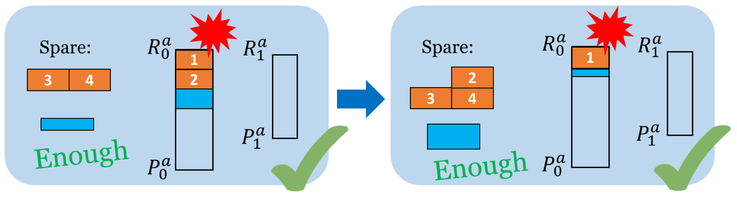
Integer Constraint ➡ **MILP** ➡ **Exponential Time**

Monotonicity

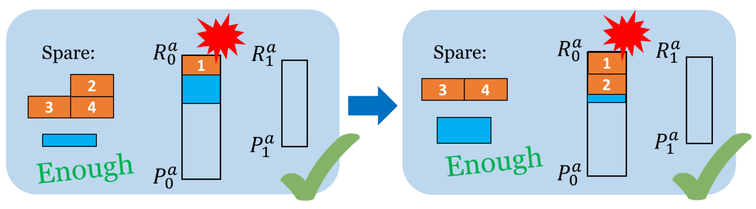


Stone: thrown into buckets as a whole
Water: poured into buckets at will
Goal: Adjust resources to lower the water level of bucket i^* (the one with the highest water level)

Lemma: When bucket i^* is chosen to be attacked, reducing its stones and water still allows a defensive strategy that makes it be attacked.

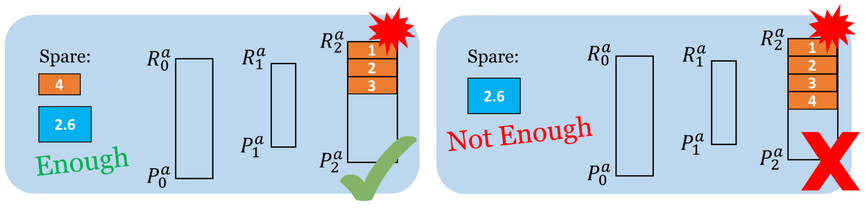


Lemma: When bucket i^* is chosen to be attacked, replacing its water with stones of equal volume still allows a defensive strategy that makes it be attacked.

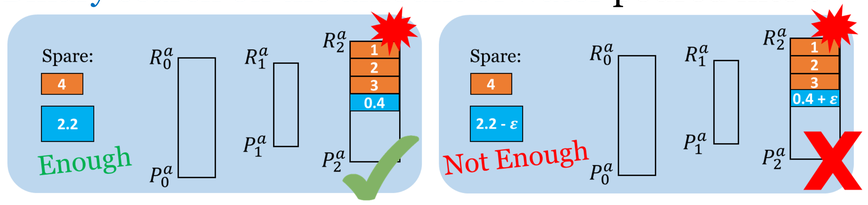


Two-Dimensional Binary Search

1. Iterate over all buckets as the attacked bucket i^*
2. Binary search on the max number of stones thrown into i^*



3. Binary search on the amount of water poured into i^*



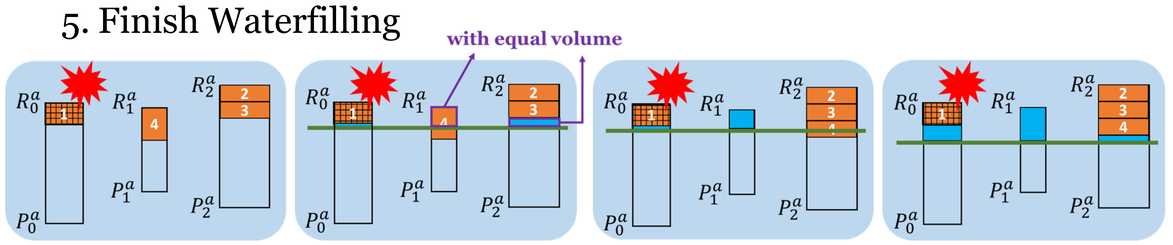
To any desired accuracy

Complexity: $O(n^2 \log \frac{M}{\varepsilon})$

M is the maximum absolute reward or penalty

Hybrid Waterfilling

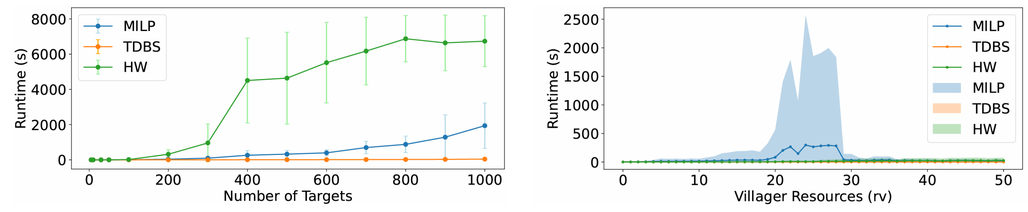
1. Iterate over all buckets as the attacked bucket i^*
2. Binary search on the max number of stones thrown into i^*
3. Greedy for spare stones
4. Waterfilling to a critical point and trigger a swap
5. Finish Waterfilling



Exact

Complexity: $O(n^4 \log n)$

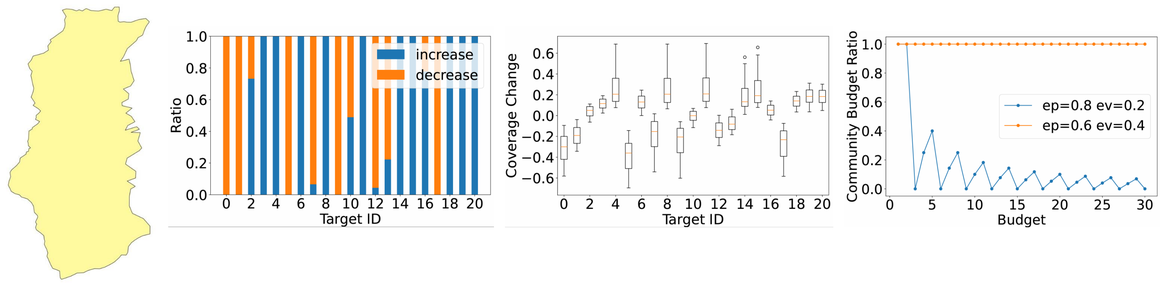
Experiments



1. The runtime of TDBS is significantly lower.
2. TDBS results at precision 10^{-3} are accurate enough for practical use.
3. The performance of TDBS and HW are more stable than MILP.

Case Study

We applied RACPP to a protected area in Northeast China



1. If the generated defensive strategies are followed, defenders' utility is expected to improve 25.9%-152.6%, with an average of 83.1%.
2. When there are extra funds to recruit more rangers or villagers, defenders should decide based on their cost-effectiveness ratio.