Rules

- Enemy ships cancel each other out in battle.
- Planet produce some ships pre turn.
- Neutral planets: short term sacrifice for long term gain.

Stealing

- Taking over a neutral planet costs as many ships as there are defenders.
- It is an often-used tactic to wait for the enemy to take a neutral planet and lose ships, and then take the planet from him on the next turn.

Redistribution

- If ships stay put until they are needed for defense or attack, then they may be too far from the action when they are finally needed.

Multi-Planet Moves

- By combining forces of multiple planets, the target planet can be taken earlier or defended later.

Difficulties

- Position evaluation.
- Practically unbounded number of possible moves.
- How to test playing strength.

Future

- Future is a possible sequence of states of a planet.
- In the simplest case the future is calculated from ships already in route in the game.

Future Based Evaluation

- Strength is a piecewise linear function of time.
- Assume that there are no hidden changepoints.
- Score: difference of accumulated growths.

Full Attack Evaluation

- **Full Attack Lemma:** Assuming that there are no neutral planets and Player 2 can take none of the planets of Player 1 when both players continuously send all possible ships to the contested planet, then Player 2 can take none of the planets of Player 1 even if allowed to attack multiple planets simultaneously in any pattern.

Move Generation

- A smallish number of candidates moves must be selected.
- Moves are assembled from per-planet *steps*.
- **Steps:** A step is a set of orders targeting the same planet.

Steps

- The need of a planet is the number of ships per turn needed to take over or defend that planet.
- Try to satisfy the need of the target planet from the surpluses of friendly planets.
- Once we have steps for all planets, they are scored by the normal evaluation function and the most promising ones combined inti a composite move (subject to validity).

Surplus

- Try to control non-linearity.
- Most notable non-linearity is at ownership changes.
- **Surplus:** The surplus of player P at planet A at a time t is the number of ships that can be sent away on that turn from the defending army without:
    - Making any scheduled order from planet A invalid.
    - Causing the planet to be lost anytime after that (observing only the fleets already in space).
    - Bringing an imminent loss closer in time.

Alpha-Beta?

- The neutral planets are the blind spot of the position evaluator.
- If the bot cannot take and keep a high growth planet it may go and take a low growth one leaving the first on to the opponent.
- This can lead to quick losses.
- The solution is Alpha-Beta.

Search

- A walk on states of solution space (often need to record states too).
- Guided by heuristics in non-trivial cases.
- States get evaluated.

Solution Space

- There are practically infinite possible actions to take.
- A very good move generator is needed.
- Fast evaluation of moves is needed.