Building interactive strategy design assignments for game theory courses

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Advised by David Walker and Matt Weinberg

IW09: You Be the Professor!

Motivation: strategy design

- COS 445 strategy design and programming assignments
  - Students examine incentives in simple games representing real-world applications of course content
  - Simple interfaces for strategies
  - Focus on strategy (minimal implementation challenge)

Prisoner's Dilemma	Cooperate	Defect
Cooperate	(3, 3)	(0, 5)
Defect	(5, 0)	(1, 1)

```
public interface Prisoner {
    // true to cooperate, false to defect
    public boolean getAction();

    // callback to receive action
    public void addResult(boolean action);
}
```

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```
public interface Bidder {
    // Return your bid for the current day
    public double getBid(double dailyValue);

    // if you won,how much the winners paid
    public void addResults(List<Double> bids,
            int myBid, double myPayment
    );
}
```

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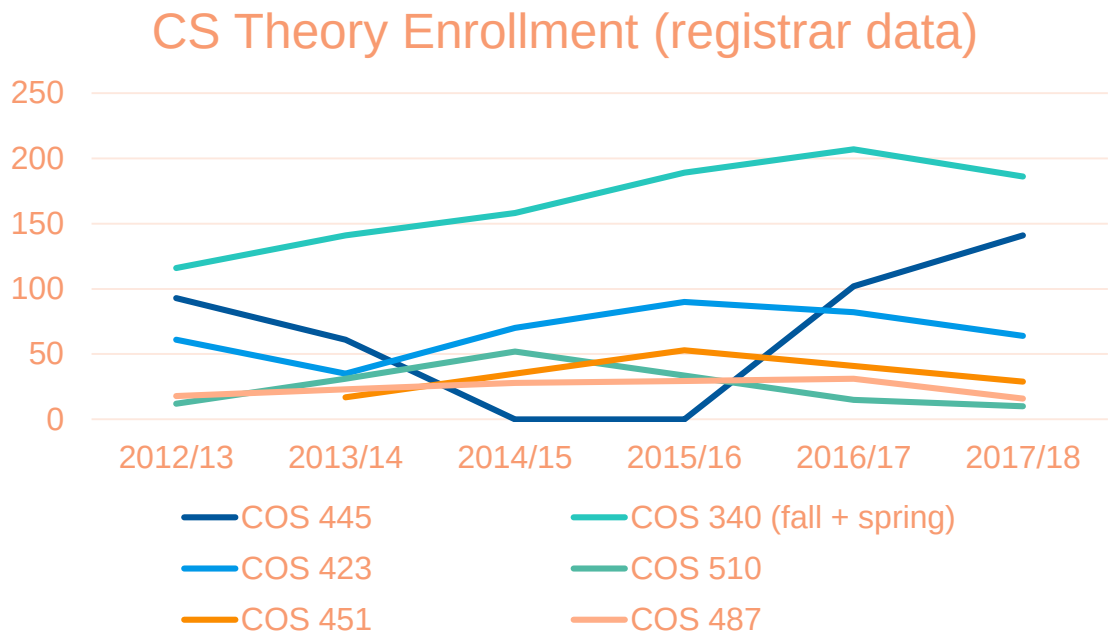
```
public interface Student {
    public int[] getApplications(int N,
            double max_SAT, double max_rank,
            double max_syn, double aptitude,
            double[] schools,
            double[] synergies
    );
}
```

Motivation: my work

- COS 445 needs course staff to rework these every year
  - Current assignments built by grad student no longer working on the course
  - Difficult to test - grad student had to copy in student names
  - Currently on COS 445 course staff as a grader

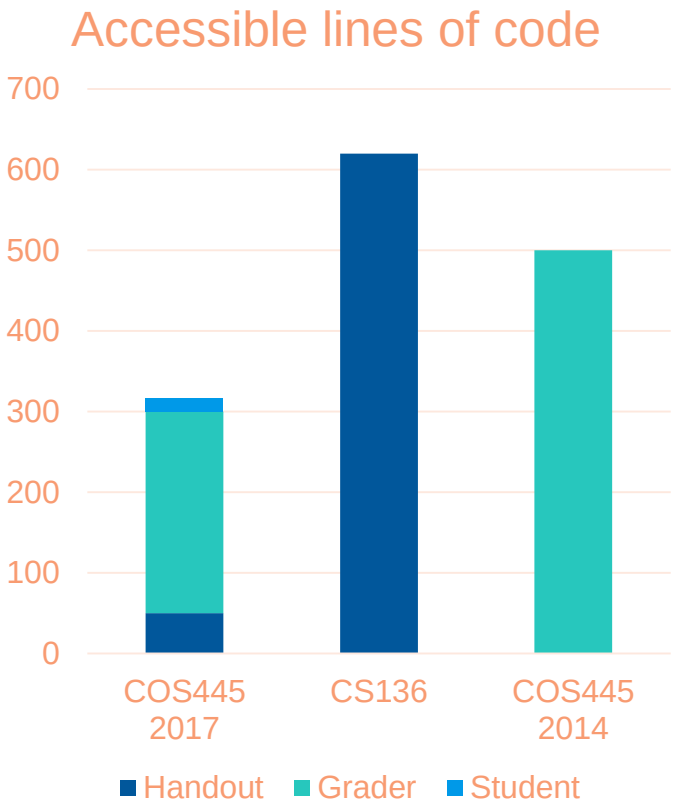


Goal

- Teach students how to use game theory to analyze a real world situation and work rationally
- Provide healthy incentive structures for grading to avoid students trying to hurt each others' performance

- Build infrastructure to develop assignments more easily
- Reduce wheel-reinvention by organizing resources
- Eliminate need for dedicated course staff member for 445 programming assignments

Related work



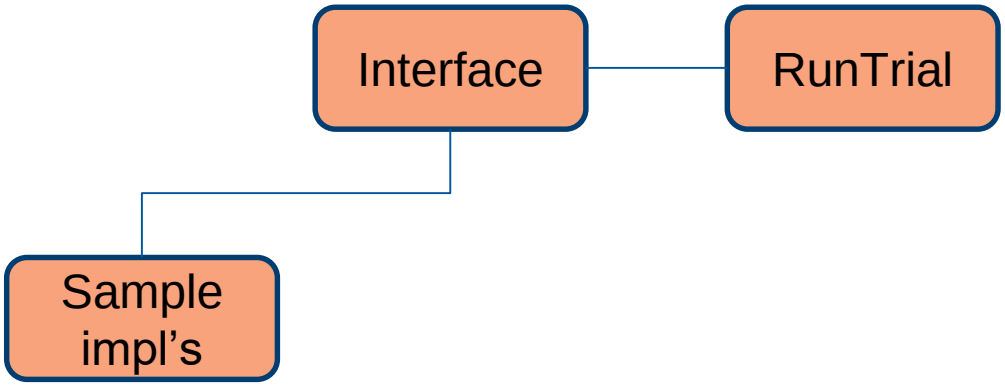
- COS 445 2017
  - Programming exercises run by Cyril Zhang
  - Interfaces and some handwritten testing code
- Harvard CS 136
  - Peer to peer bittorrent simulation
  - Sponsored search auctions
  - Python implementation of handout available
  - No grading code available
- COS 445 2014
  - Undocumented PHP backend
  - Prisoner's dilemma
  - Different assignment design

Approach

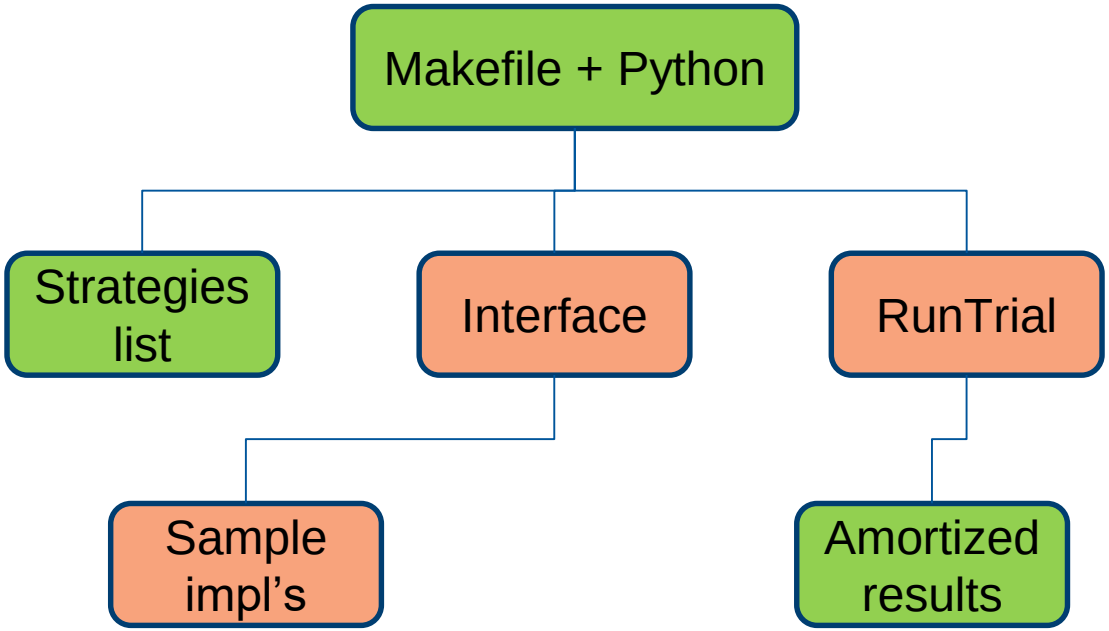
- Want to build a reusable codebase for the tasks which are repeated across assignments, i.e. evaluating student strategies against each other
- Built the modular, reusable codebase by building each assignment individually and refactoring reused code
- Take advantage of my role as a grader for COS 445 to test my project and receive feedback - from myself!
- Easily able to build extensions:
  - Student handout to evaluate strategies (vs. interface only)
  - Dropbox Check script
  - Leaderboard
- More extensions could be developed as needed

Implementation

Implementation



Implementation



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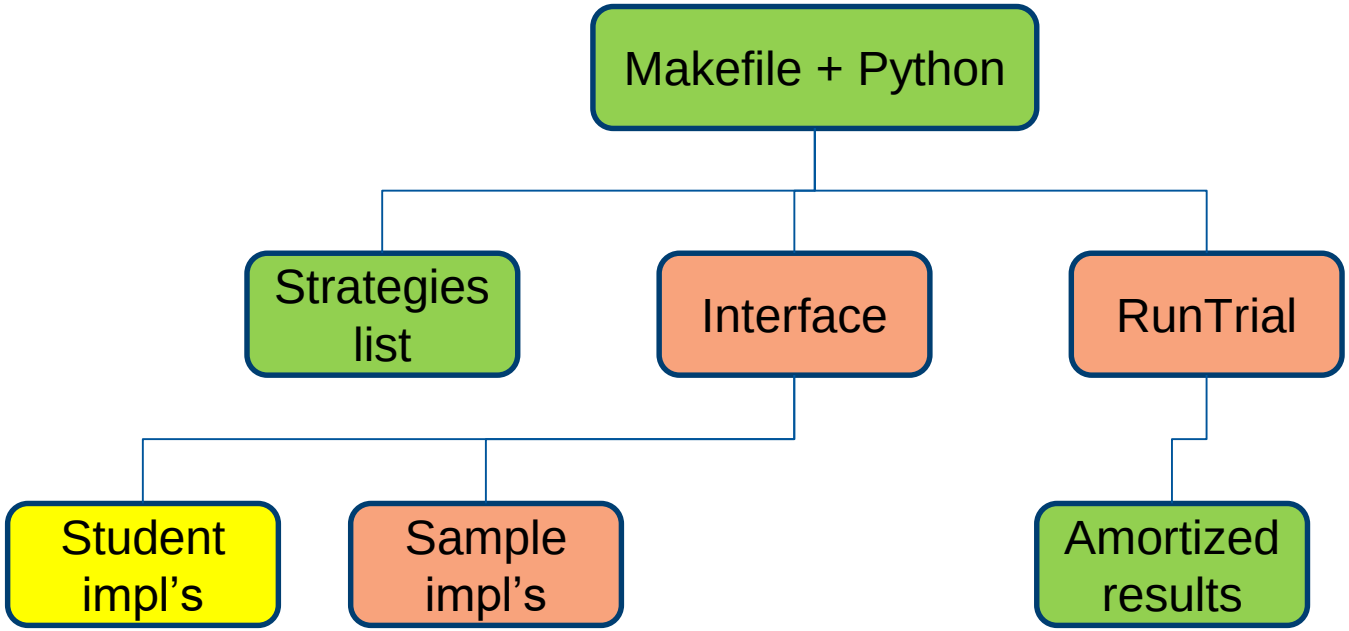

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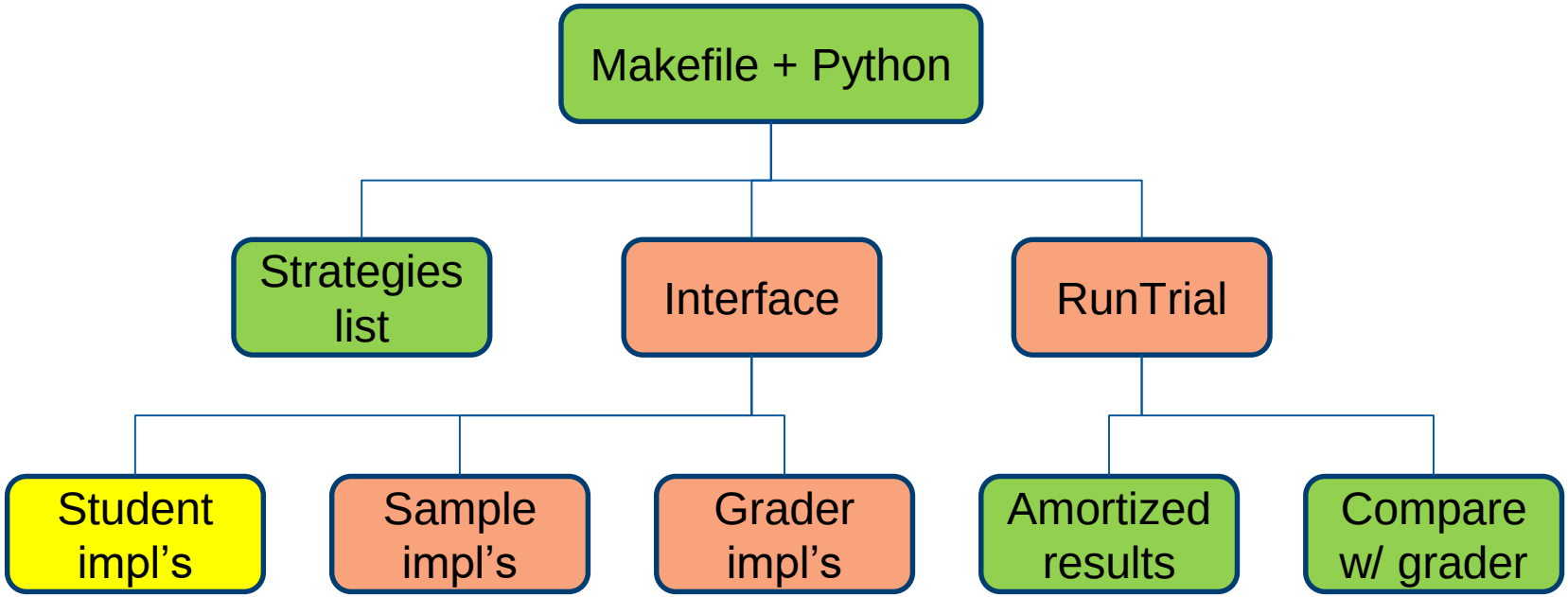
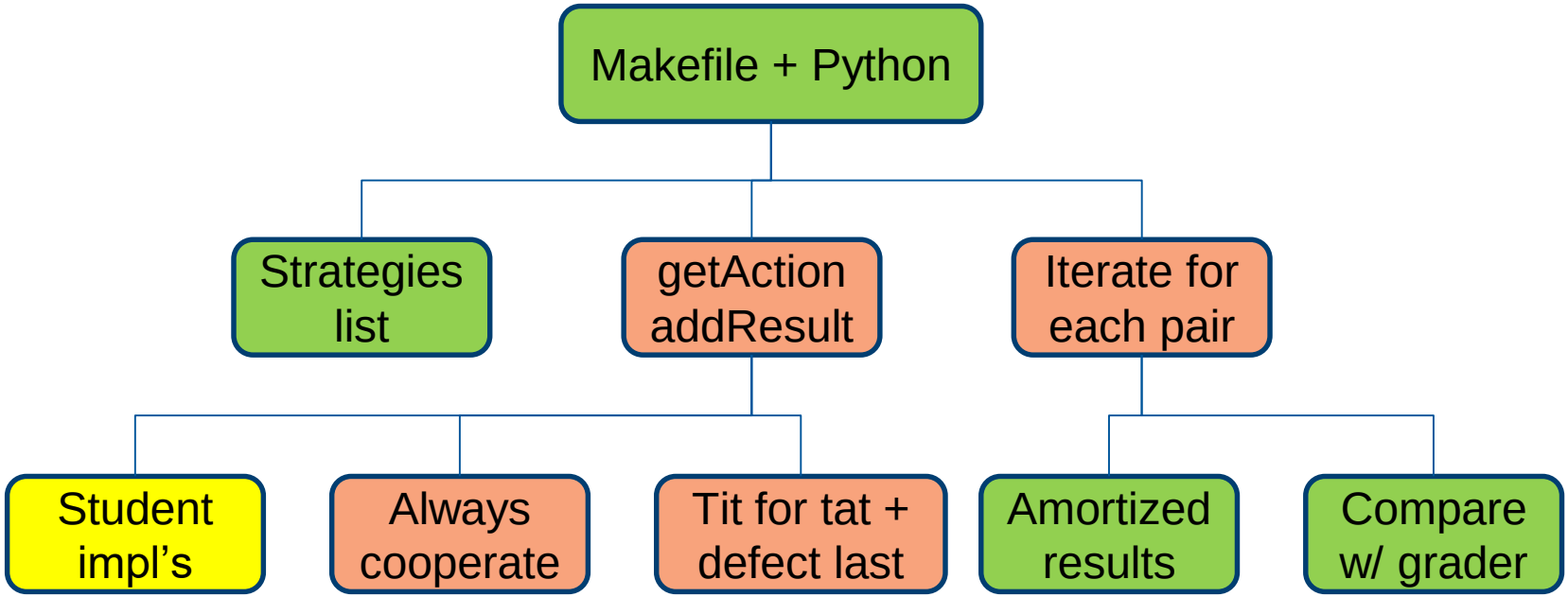
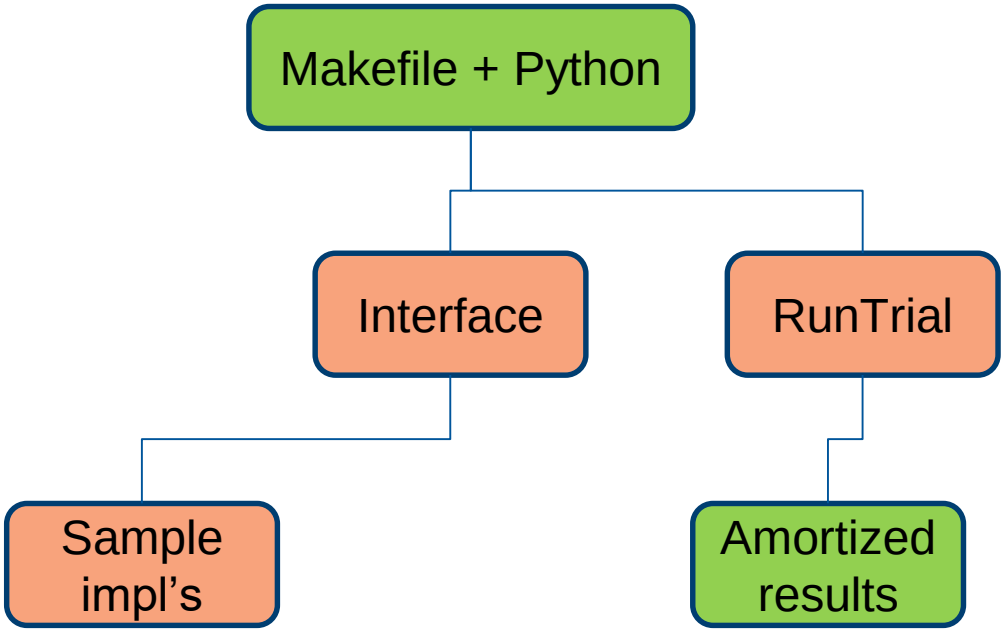


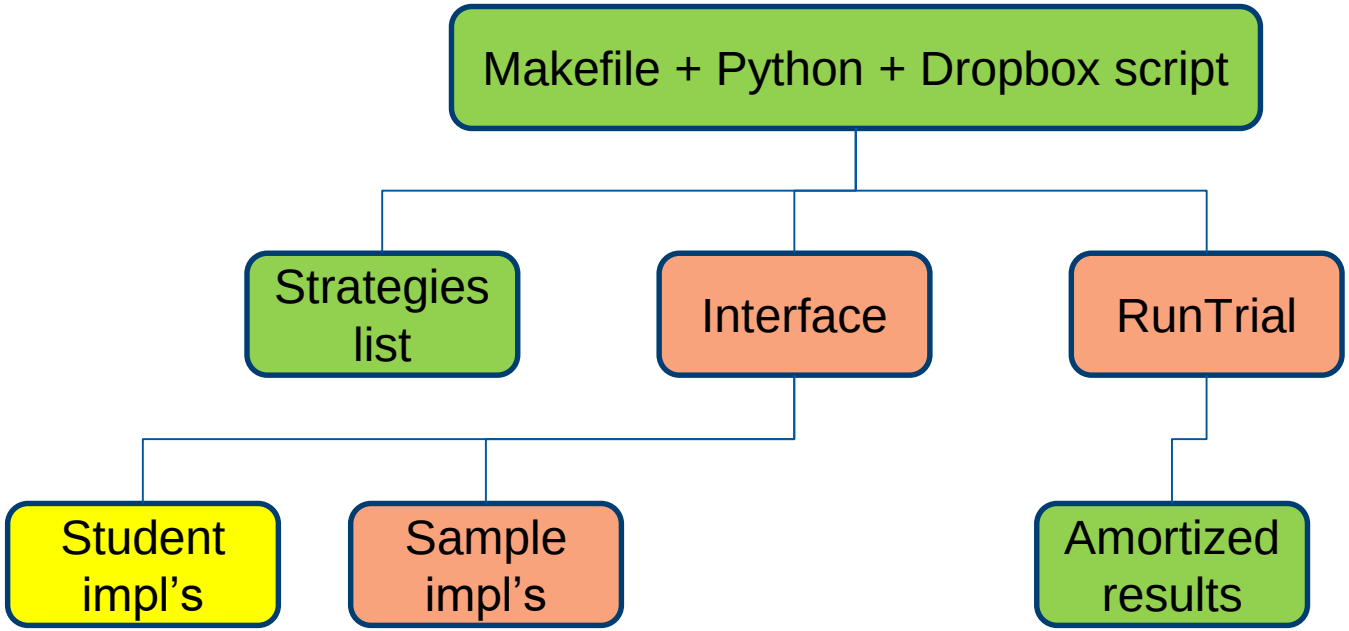
Implementation: Prisoner's dilemma



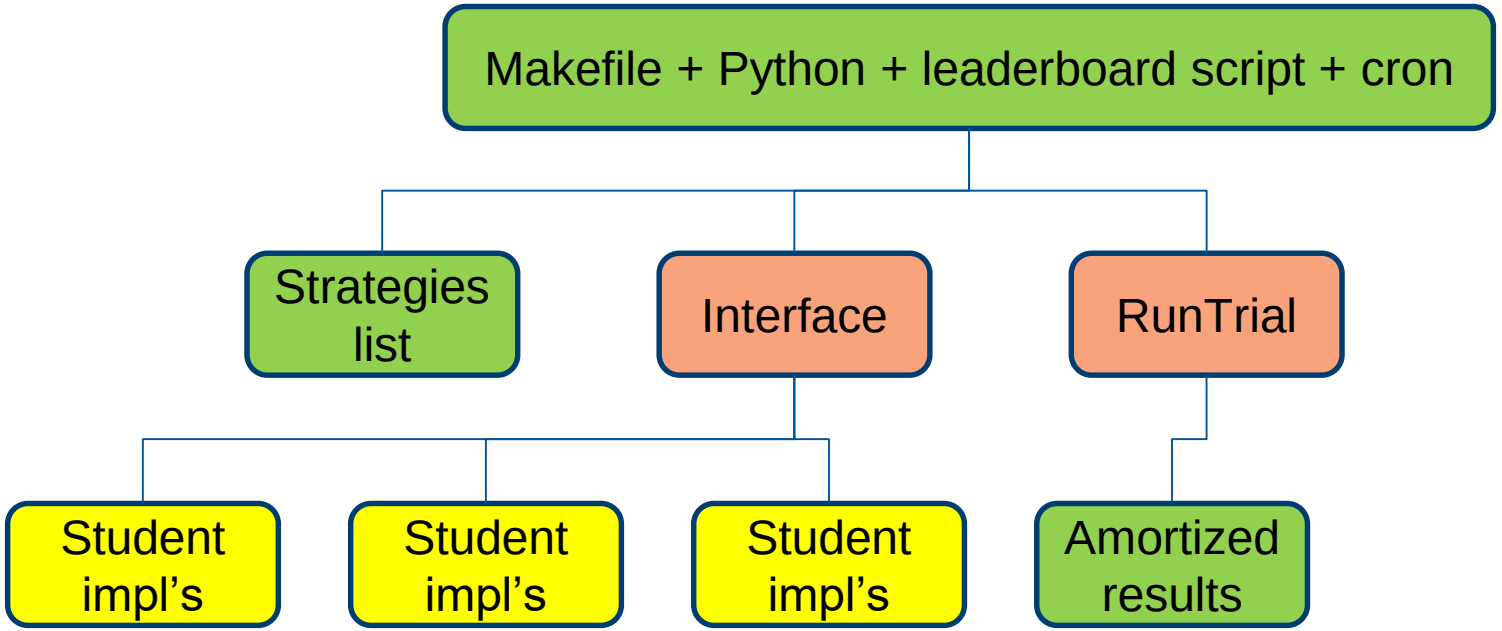
Implementation: Handout



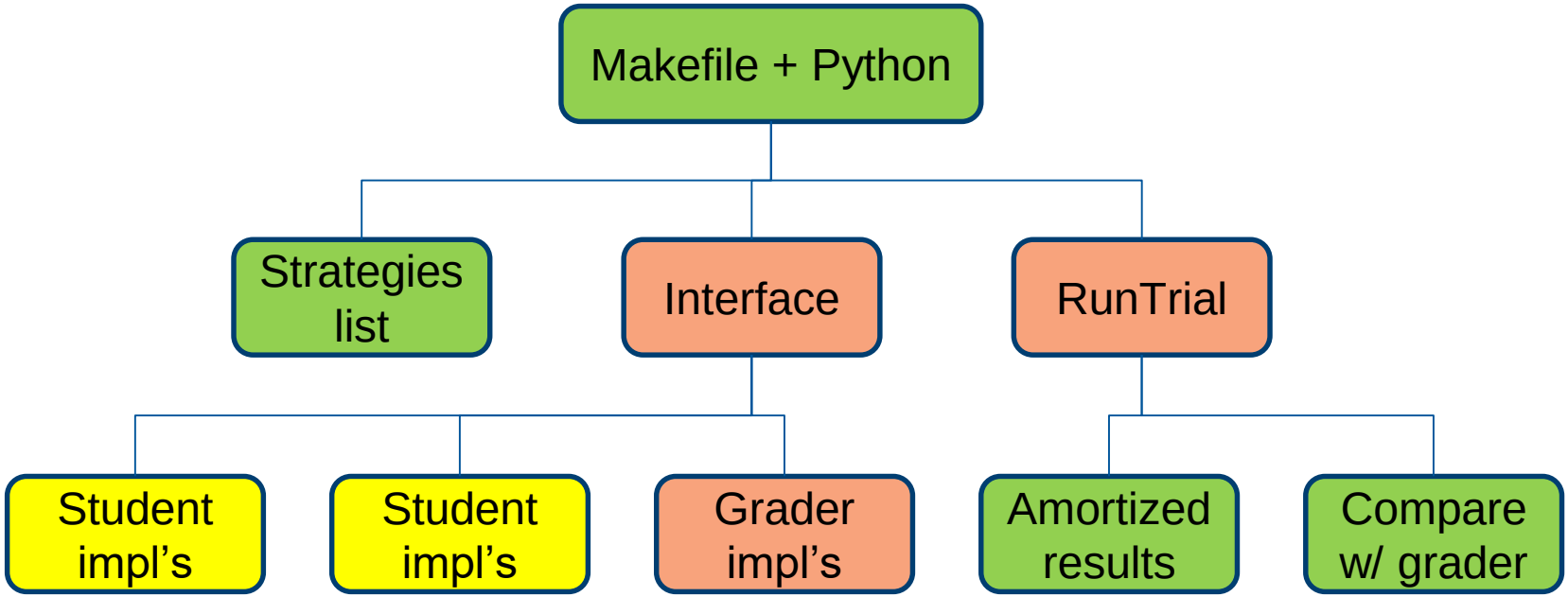
Implementation: Check Submit



Implementation: Leaderboard

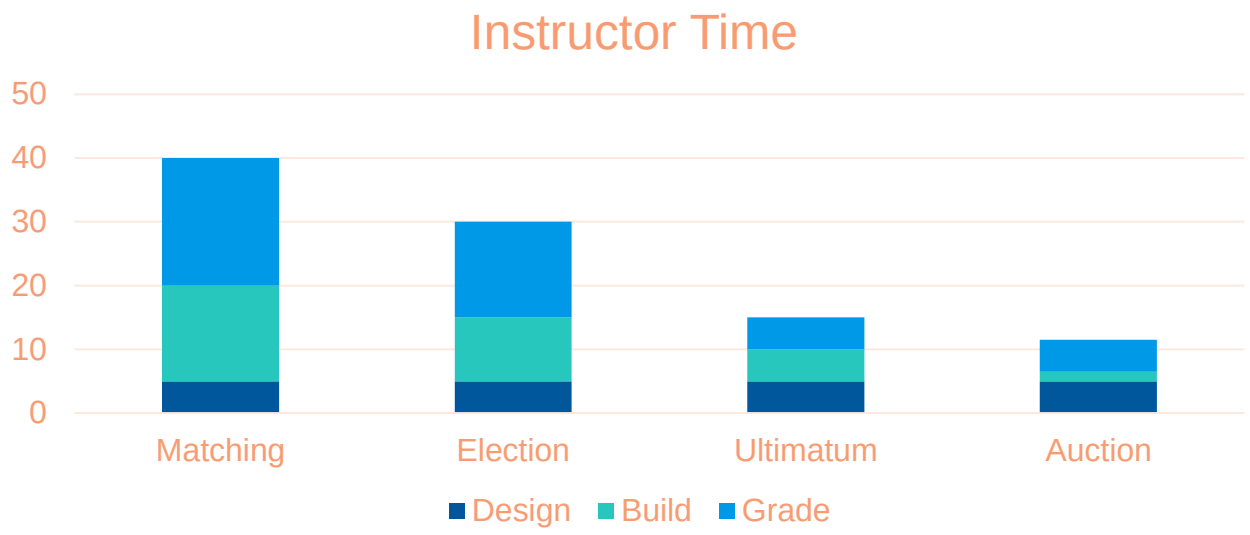


Implementation: Autograder



Results and Evaluation

- Used created infrastructure to build five assignments
  - Examine incentives in stable matchings, elections, a classical game, auctions, and gerrymandering



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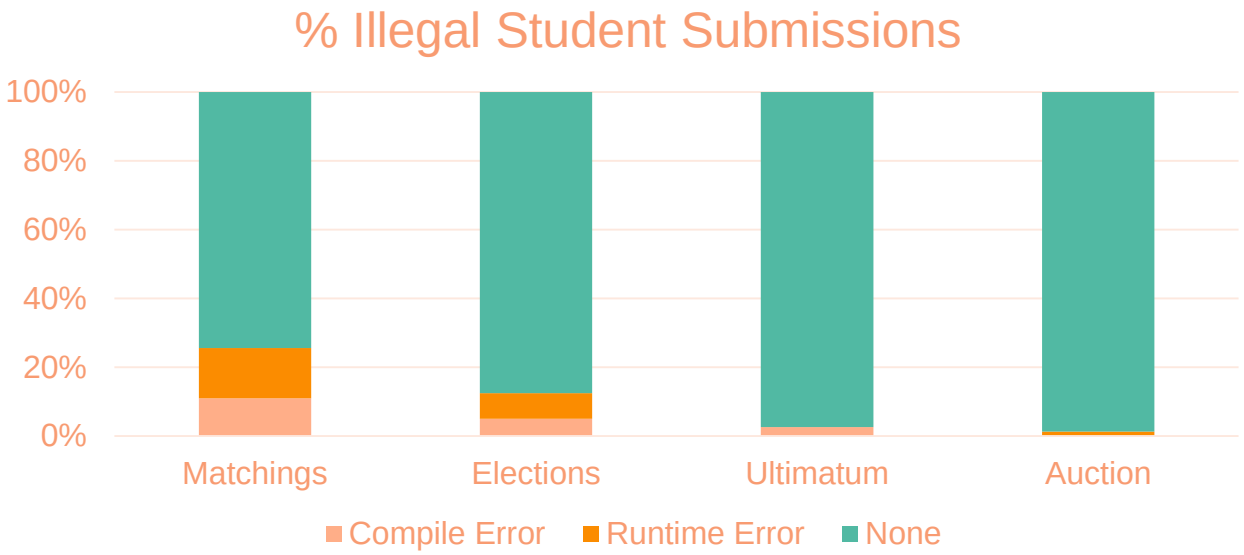

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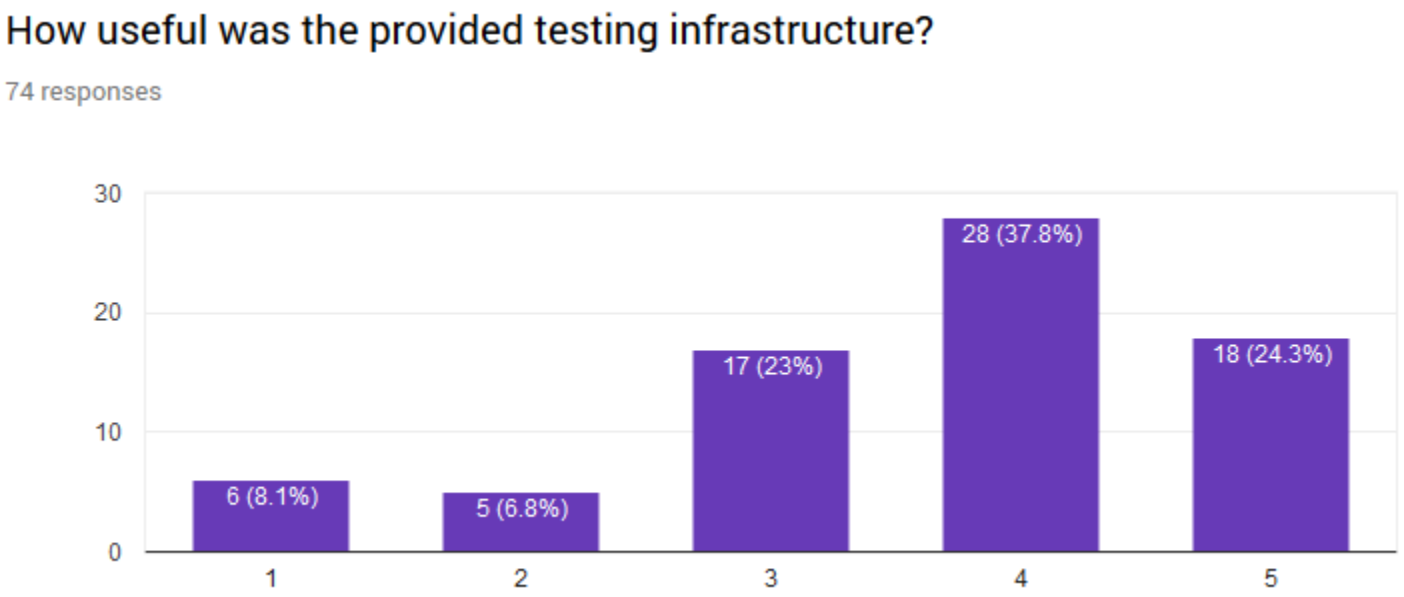

Conclusions and future work

- Students are enthusiastic to use provided tools
- We take advantage of that to make life easier for course staff
- Real students provided positive reviews for infrastructure
- Other course staff provided positive reviews for new tools

- Will verify reusability next year as a course grader
- The real evaluation will be two years from now

Thanks to

- Dave Walker for helping me structure this work to create a cohesive product
- My seminar classmates for their feedback
- Matt Weinberg for providing course resources and providing requests to shape the task at hand