Verification Games
Making Verification Fun

Werner Dietl

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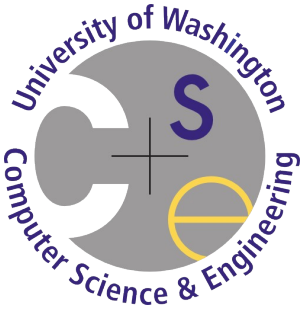
http://cs.washington.edu/verigames



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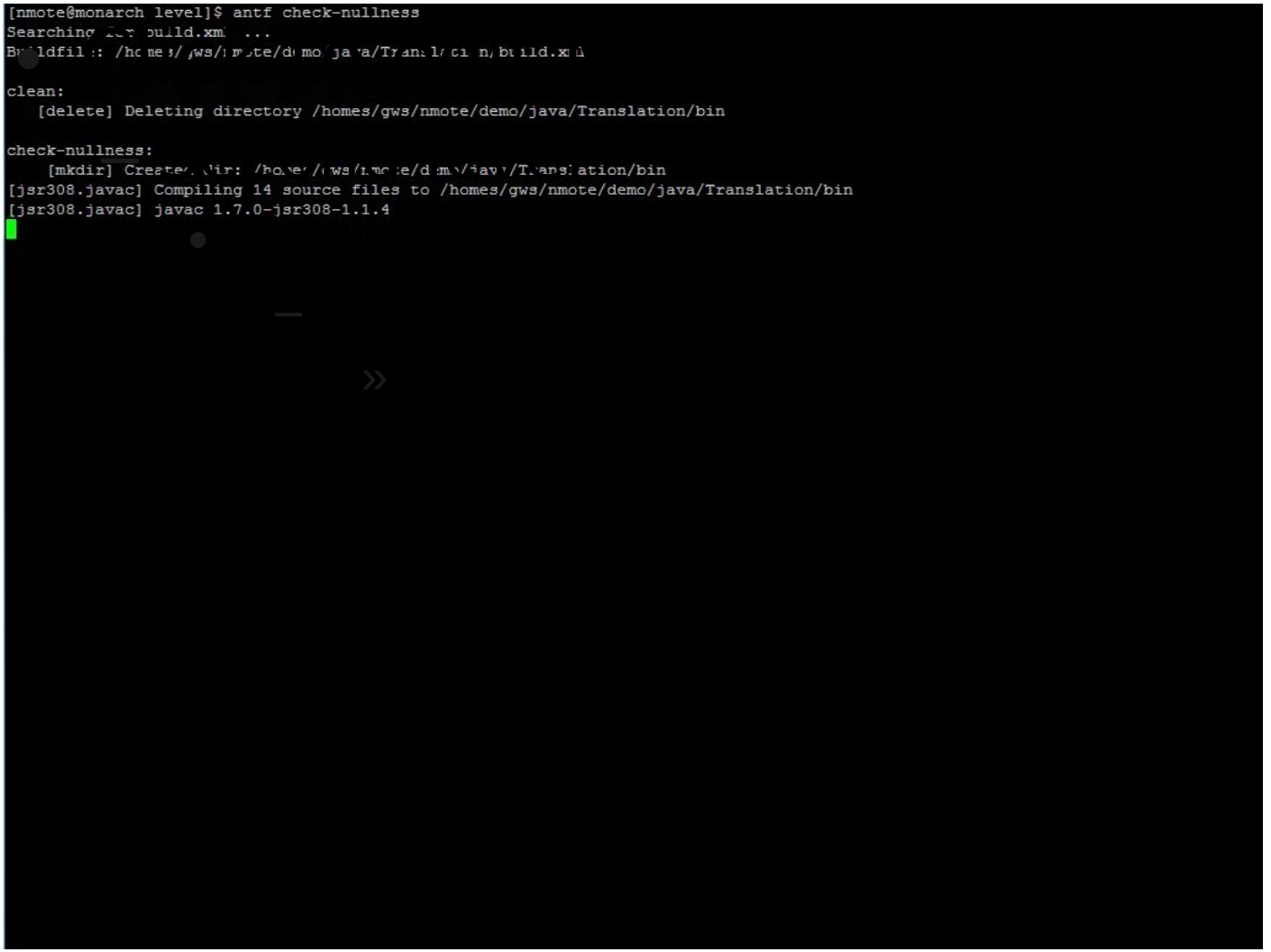
Angry Birds

Software verification



Which is more fun?

- Play games
- Prove your programs correct

Angry Birds:

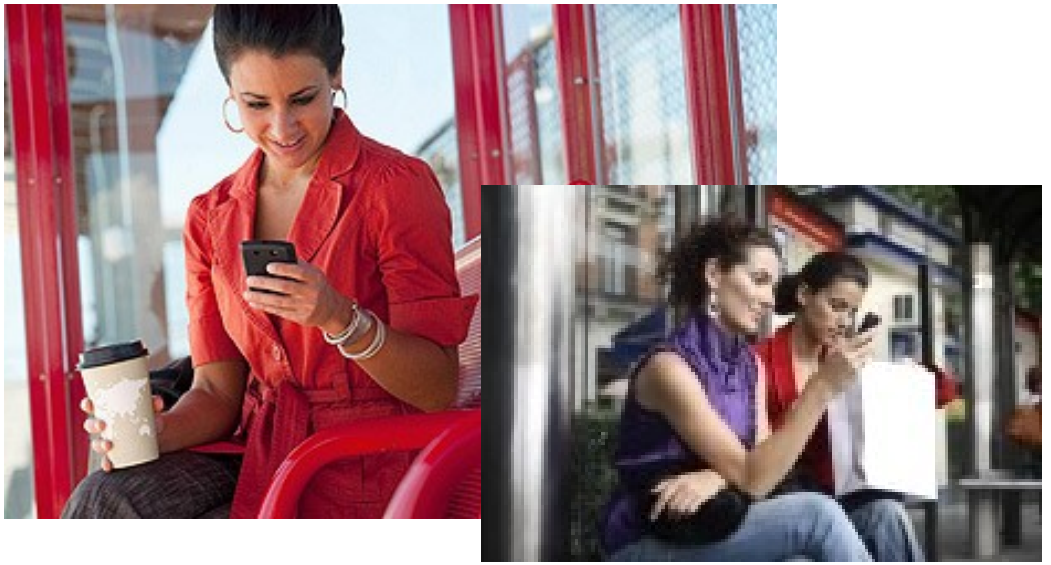
02 Nov 2011: 200000 years play-time

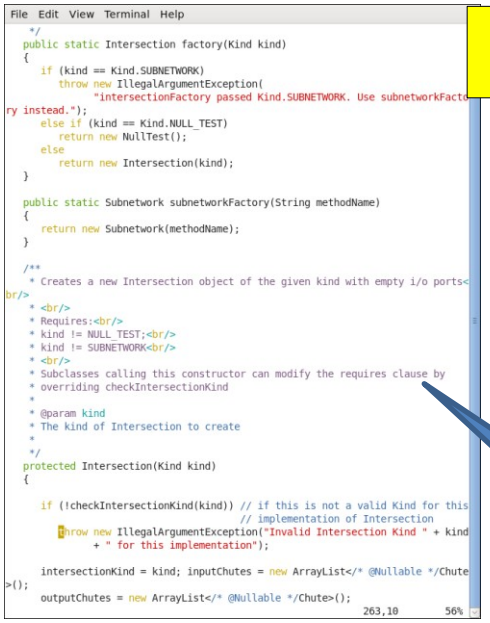
11 May 2012: downloaded one billion times

Crowd-sourced verification

1. Make software verification **easy** and **fun**
2. Make the game **accessible** to everyone
3. Harness the power of the **crowd**

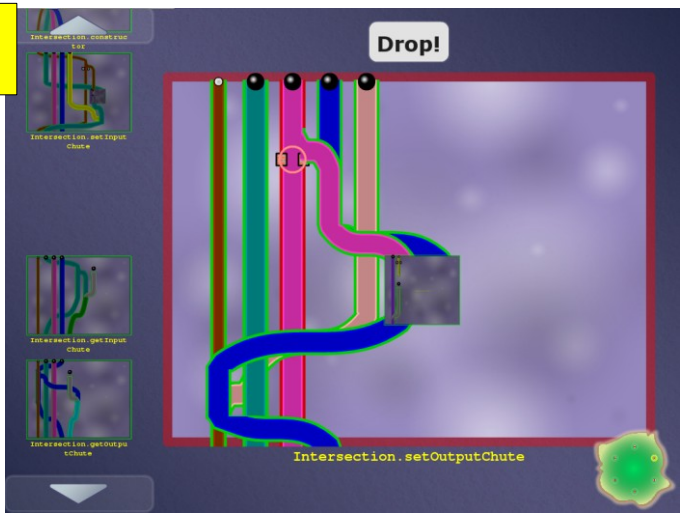
Goal: Verify software while you wait for the bus





Code

Automatic translation



Game

Encodes a constraint system

Highly-skilled, expensive labor

Volunteers

Verified software (with proof/ annotations)

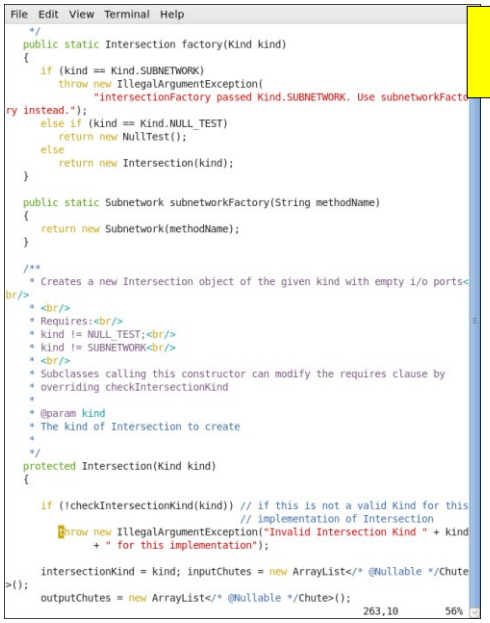
Automatic translation

Completed game

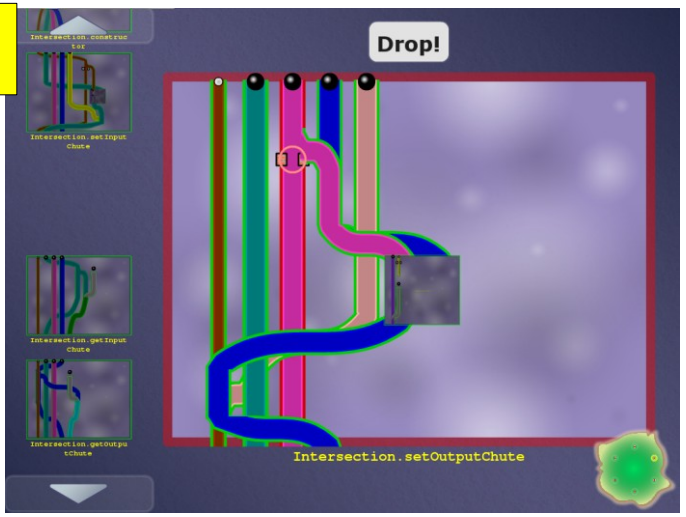

SAVE
BACK
SUBMIT
World 1 Map
SCORE
2727
DROP!
Connection-vulture--GET
Connection-vulture--SET
Connection-in--GET
Connection--init--Ljava-net-Socket-Ljava-lang-ThreadGroup-ILVulture---V
Connection-run---V
Connection
Connection-vulture--GET
Connection-vulture--SET
Connection-client--GET

Code

Game



Automatic translation

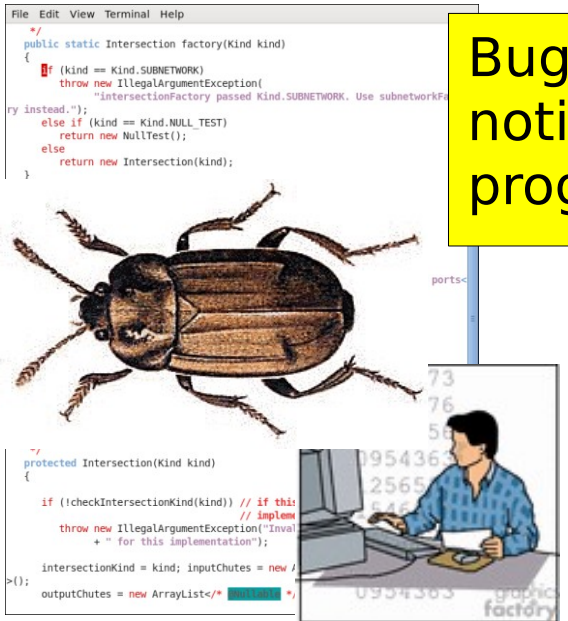


Volunteers

Completed game with buzzsaws

Automatic translation

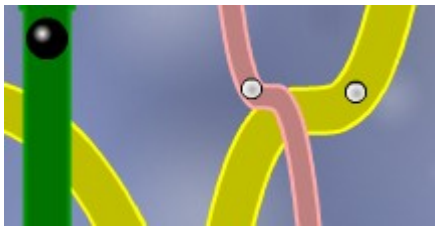
Bug detected, notify programmer

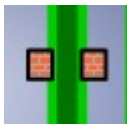


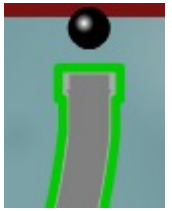
Example: null pointer errors

Goal: no dereference of null

Pipe	↔ a variable
Pipe width	↔ narrow: non-null wide: maybe null
Ball	↔ a value
Ball size	↔ small: non-null large: maybe null
Pinch point	↔ dereference
Unmodifiable pipe/ball	↔ literal **null**, object creation



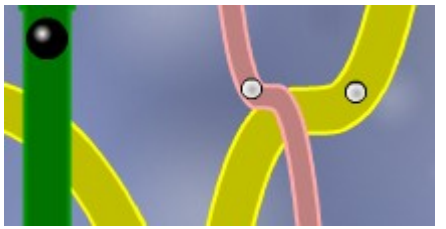




Program ↔ game correspondence

Pipe ↔ a variable

Pipe width ↔ type of the variable

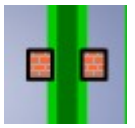


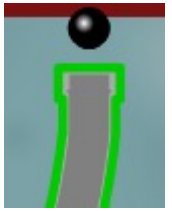
Ball ↔ a value

Ball size ↔ a property of the value

Pinch point ↔ requirement

Unmodifiable pipe/ball ↔ requirement





Intuition: dataflow

Other examples

SQL injection

unintended side effects

format string and regexp validation

incorrect equality checks

race conditions and deadlocks

units of measurement

aliasing

...

Challenges

Will the game be fun?

- Better than waiting for the bus

Do people outperform verification algorithms?

- Inference is undecidable

- Hypothesis:
  - no for correct, verifiable programs
  - yes for incorrect or unverifiable programs

- Game players only have to reduce overall verification cost, not fully verify the program

Scoring & Collaboration

1. Game score influenced by
   - Collisions (verifiability)
   - Use of buzzsaws (trusted assumptions)
   - Pipe widths, distinguishing input and output pipes (re-usability of modules)
2. Collaboration & competition between players
   - High-score boards
   - Collaborative teams solve challenges
   - Social aspects (chats, forums, ...)

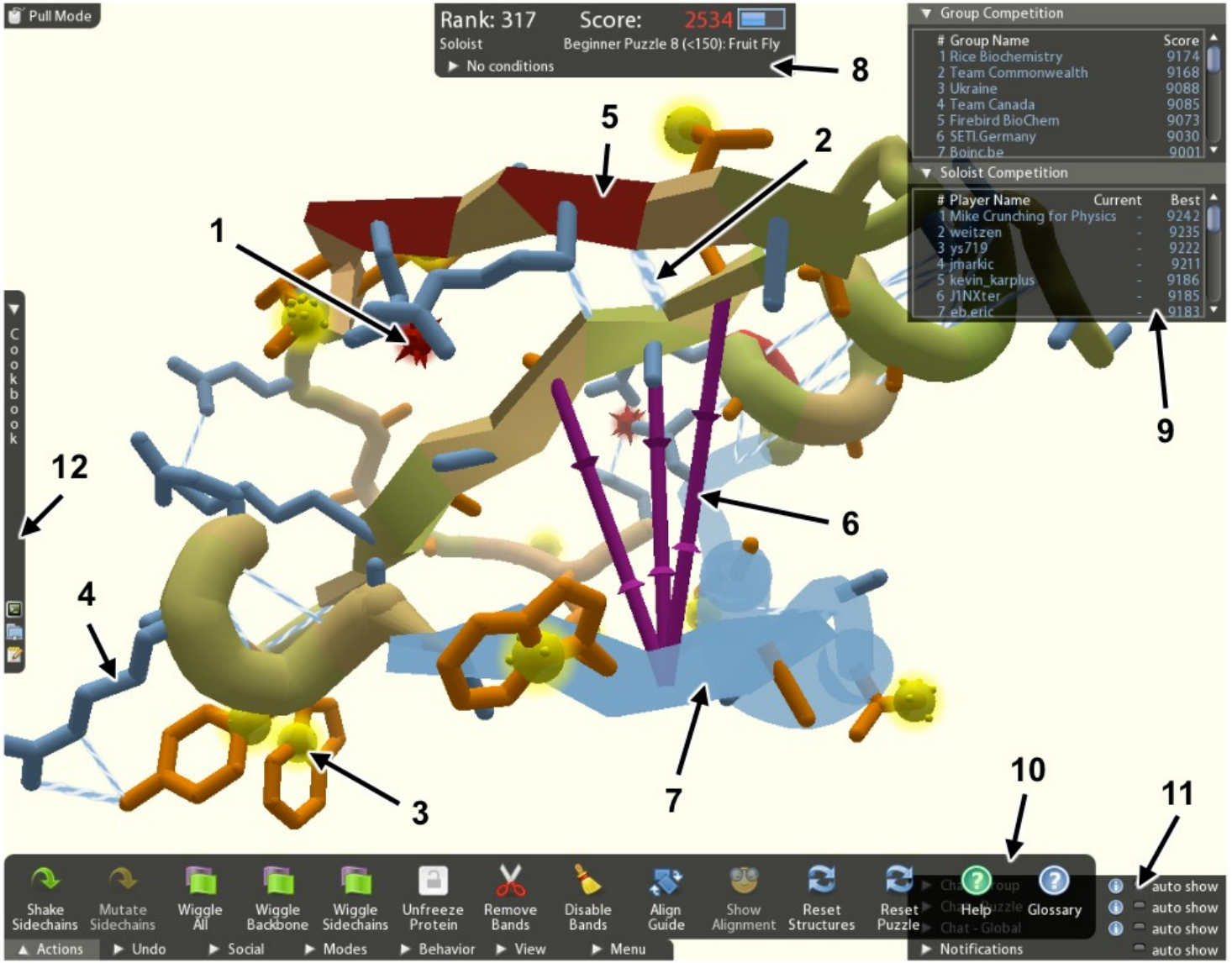
Scalability & Optimization

1. Brute force not feasible for large programs
2. Scale-up verification by
   - Crowdsourcing games
     1. Distribute games to humans
     2. Reconfigure games to adjust difficulty
     3. Redundancy
   - Automatic inference and optimizations
     1. How many easy challenges should be left for humans to feel good about progress?

FoldIt

1. Proteomics game at UW
2. Effectively created the genre of games that solve hard problems
3. Three Nature papers in under 2 years
4. Over 240,000 players, 200+ new per day

FoldIt


Pull Mode
Rank: 317
Score: 2534
Soloist
Beginner Puzzle 8 (<150): Fruit Fly
No conditions
8
Group Competition
Group Name Score
1 Rice Biochemistry 9174
2 Team Commonwealth 9168
3 Ukraine 9088
4 Team Canada 9085
5 Firebird BioChem 9073
6 SETI.Germany 9030
7 Boinc.be 9001
Soloist Competition
Player Name Current Best
1 Mike Crunching for Physics - 9242
2 weitzen - 9235
3 ys719 - 9222
4 jmarkic - 9211
5 kevin_karplus - 9186
6 J1NXter - 9185
7 eb.eric - 9183
9
Cookbook
12
1
2
5
6
4
3
7
10
11
Shake Sidechains
Mutate Sidechains
Wiggle All
Wiggle Backbone
Wiggle Sidechains
Unfreeze Protein
Remove Bands
Disable Bands
Align Guide
Show Alignment
Reset Structures
Reset Puzzle
Help
Glossary
auto show
auto show
auto show
auto show
Actions
Undo
Social
Modes
Behavior
View
Menu
Notifications

Contributions

Gamification of program verification

Game...

- encodes correctness conditions
- utilizes human intuition & insight
- is playable by anyone

Goal: cheaper verification $\Rightarrow$ more verification

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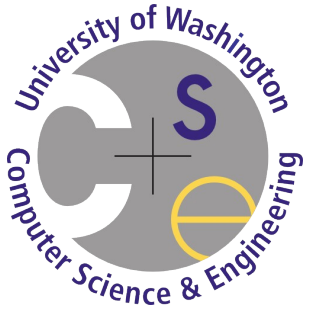

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Conference 9