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## Time-Traveling Queries for Faster Debugging and Program Comprehension

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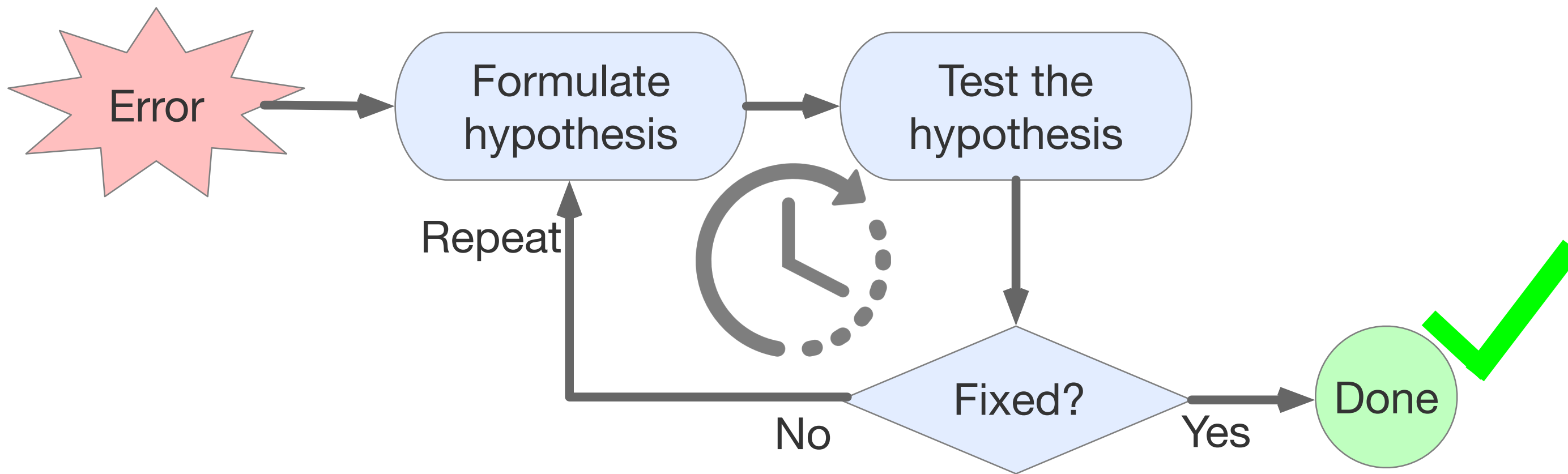
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## Context: The debugging process

Debugging is a time-consuming iterative process:



What is the cause of the error?

To understand the behavior of a program, developers ask program comprehension questions

- When during the execution is this method called?
- Where are instances of this class created?
- Where is this variable or data being accessed?
- Etc.

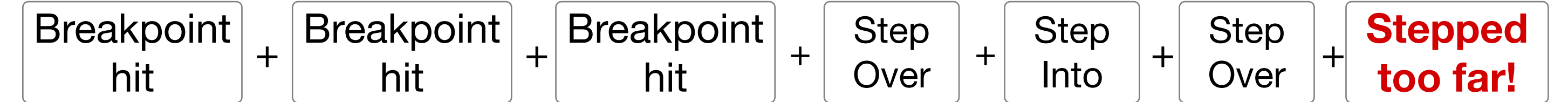
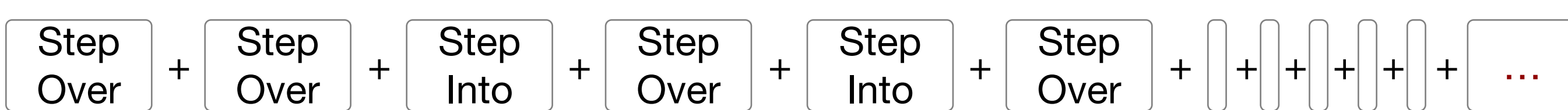
\*\*Trying to understand the program emoji\*\*

BETTER PROGRAM COMPREHENSION => SHORTER DEBUGGING PROCESS

## Problem: Understanding programs for debugging is difficult

To find answers, developers explore their program executions using debugging tools

Debugging question: What is the value of this variable during the execution?



Tedious! 😞

Missed the target! 😞

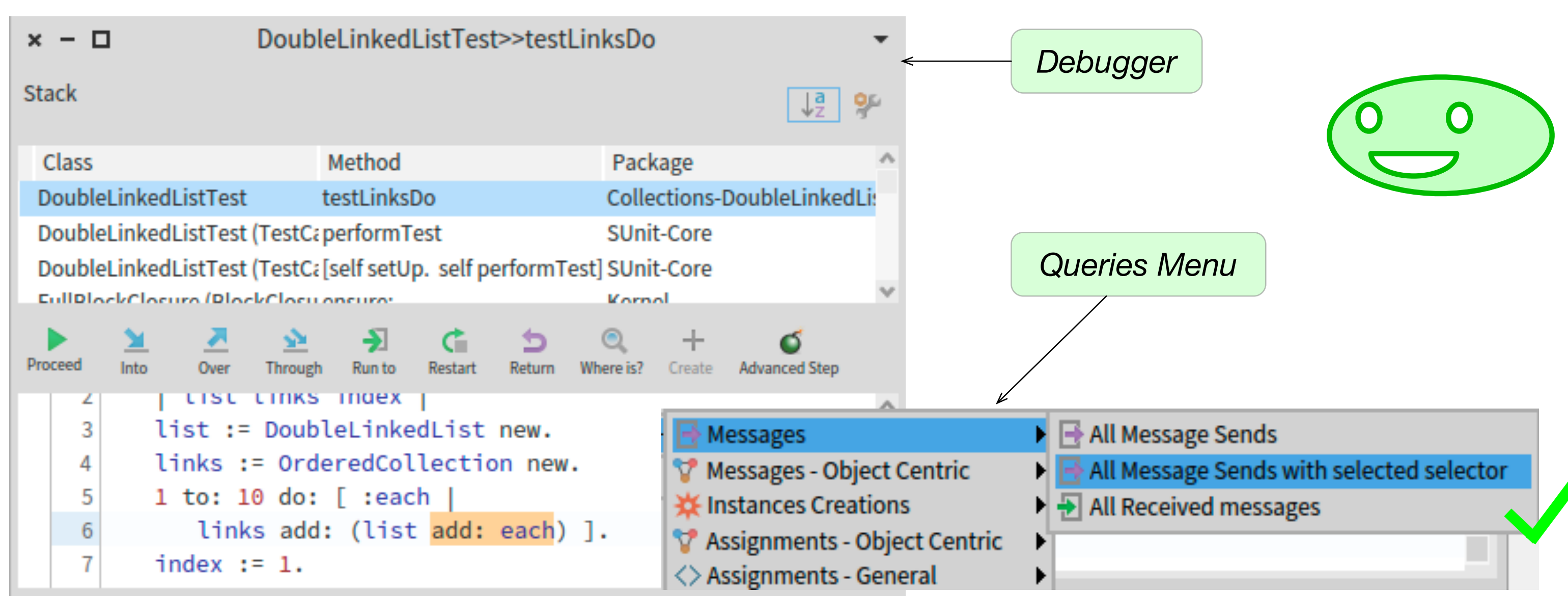
Can we do better?

## Solution: Time-Traveling Queries

### Time-Traveling Queries (TTQs)

Do you have a debugging question?

Select a Time-Traveling Query from the Queries Menu!



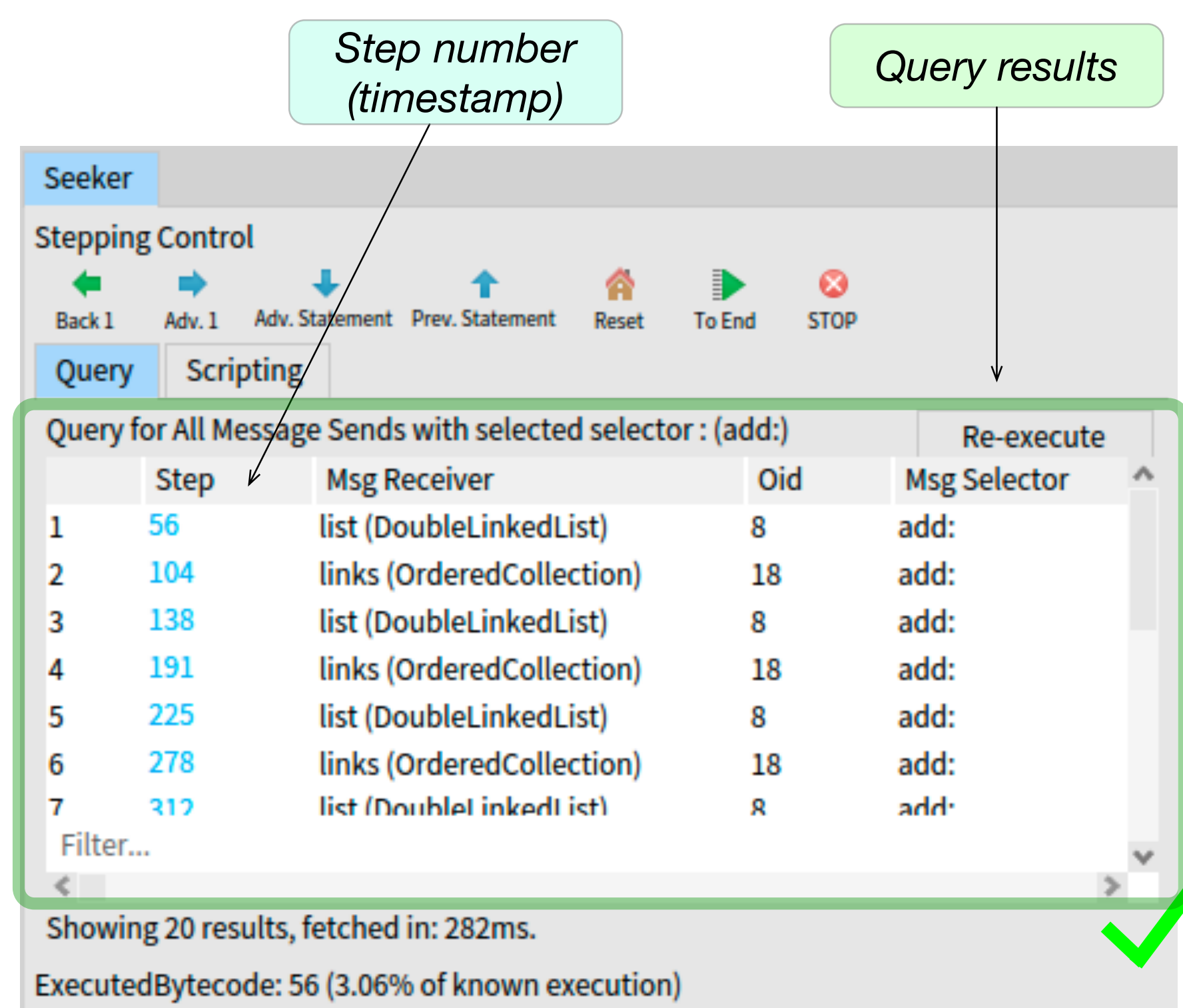
• TTQs request information of an execution related to **common debugging questions**.

• Find answers directly in your query result (Don't miss target!).

• "Click & Time-Travel"

Reverse or advance the execution jumping directly to any of the results timestamp (Less tedious!).

• Explore your execution states forward or backward.



Do you have another debugging question? Just select another query!

There is no query for your debugging question? Write your own TTQ!

Example:

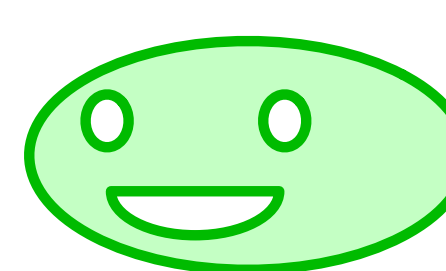
```

    "Lists global variables assignments"
    ^ UserTTQ from: programStates
      select: [ :state | state isAssignment and: [ state node variable isGlobalVariable ] ]
      collect: [ :state |
        ResultItem new
          bytecodeIndex: state bytecodeIndex;
          variableName: state assignmentVariableName;
          yourself ]
  
```

From where to extract the data?

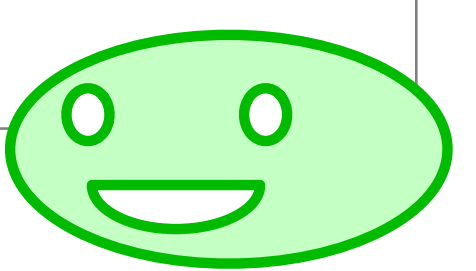
What program states are relevant?

What should be included in the results?



### Time-Traveling Queries Evaluation

With TTQs, developers perform program comprehension tasks more accurately, faster, and with less effort than with standard debugging tools\*.



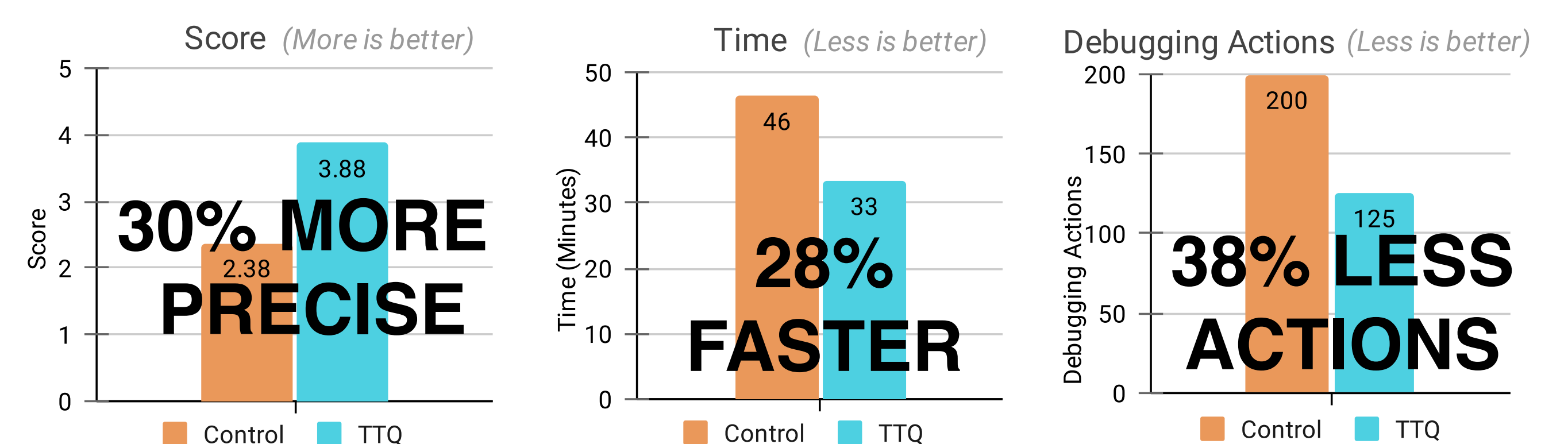
Controlled Experiment

- Repeated Measures Design (Within-subject)
- 34 Participants.

Research Question

Do TTQs improve program comprehension tasks of participants regarding precision, time spent and efforts? (vs. using standard debugging tools)

Results



Control: Without Time-Traveling Queries

TTQ: Using Time-Traveling Queries

(\*). M. Willebrinck, S. Costiou, A. Etien and S. Ducasse, "Time-Traveling Debugging Queries: Faster Program Exploration," 2021 IEEE 21st International Conference on Software Quality, Reliability and Security (QRS), 2021, pp. 642-653.

### Future work

- Scaling the solution to daily debugging scenarios.
- Studying new relevant queries.
- Research TTQs generalization to different programming languages.
- Designing new TTQs-based debugging tools.