TIME-TRAVELING QUERIES

FOR FASTER DEBUGGING AND PROGRAM COMPREHENSION

Université de Lille

Inria — INVENTEURS DU MONDE NUMÉRIQUE

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RMod

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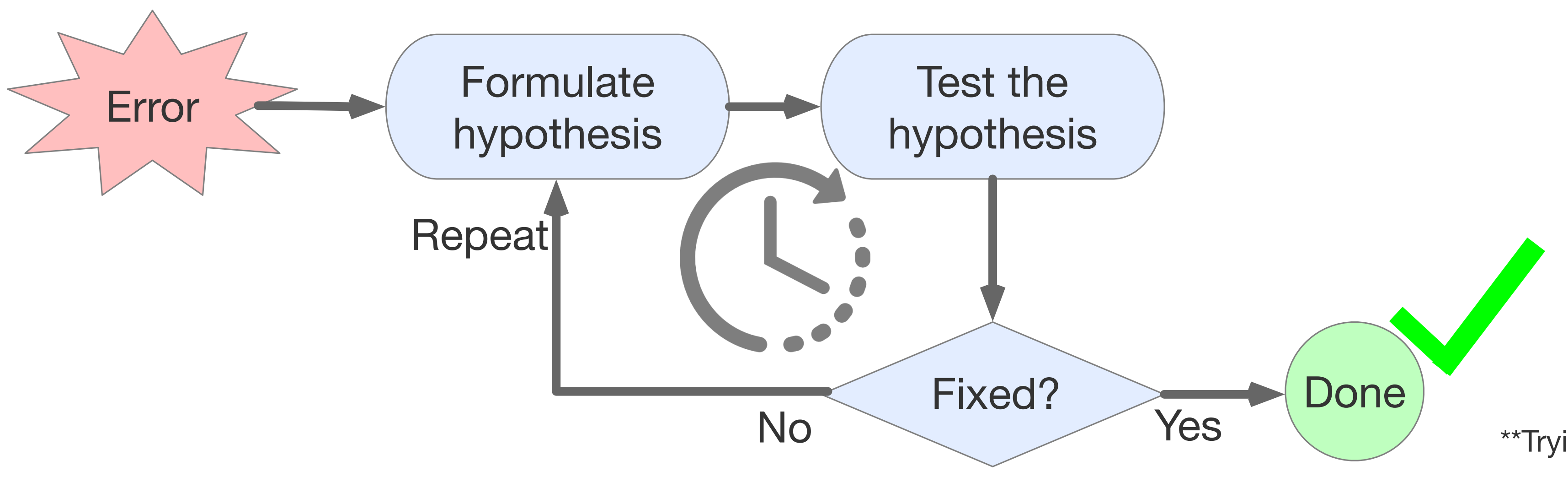
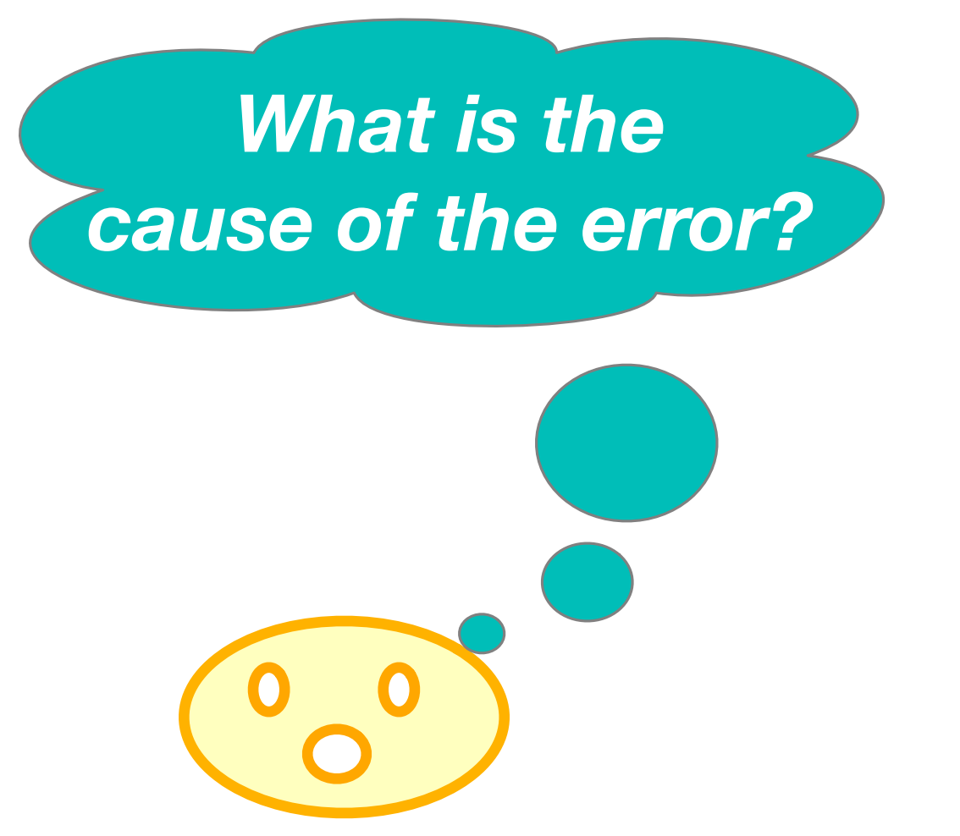
Context: The debugging process

Debugging is a time consuming iterative process:





Trying to understand the program emoji

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.*

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?

Step Over + Step Over + Step Into + Step Over + Step Into + Step Over + | + | + | + | + | + …

Breakpoint hit + Breakpoint hit + Breakpoint hit + Step Over + Step Into + Step Over + **Stepped too far!**

Tedious!

Missed the target!

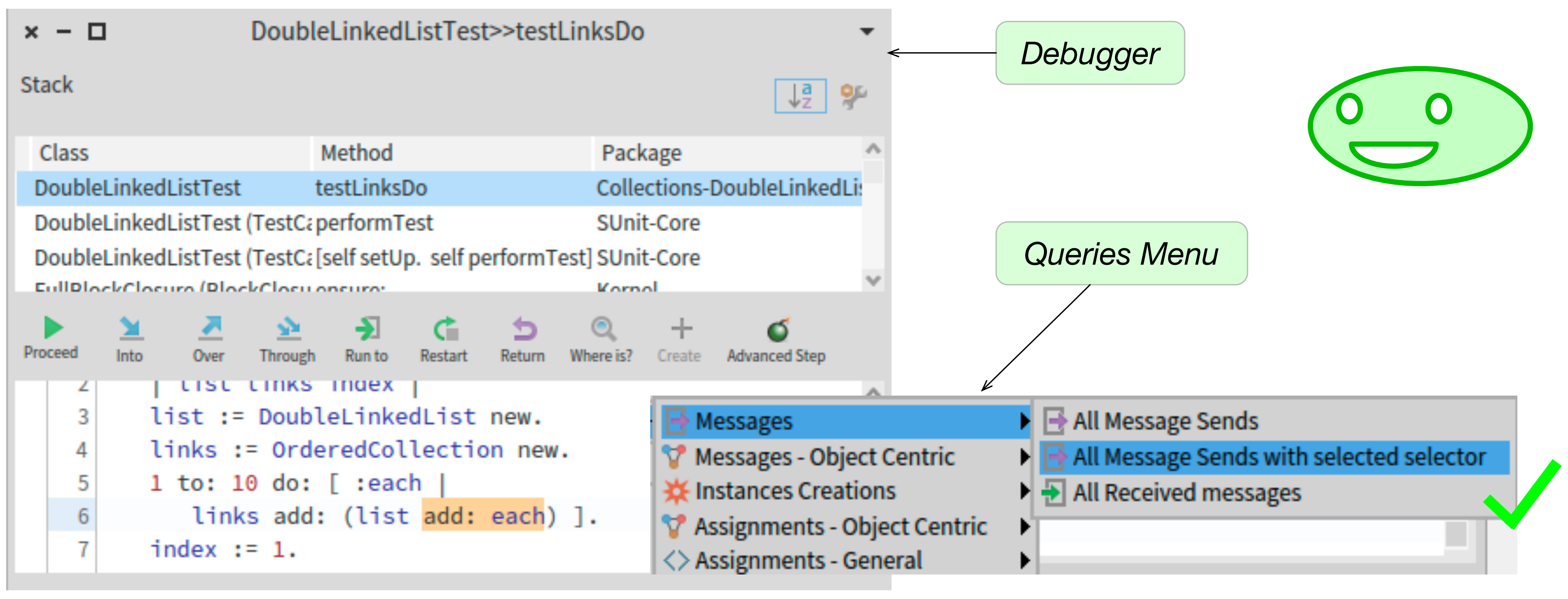
Can we do better?

Solution: Time-Traveling Queries

Time-Traveling Queries (TTQs)

Do you have a Debugging Question?

Select a Time-Traveling Query from the Queries Menu!

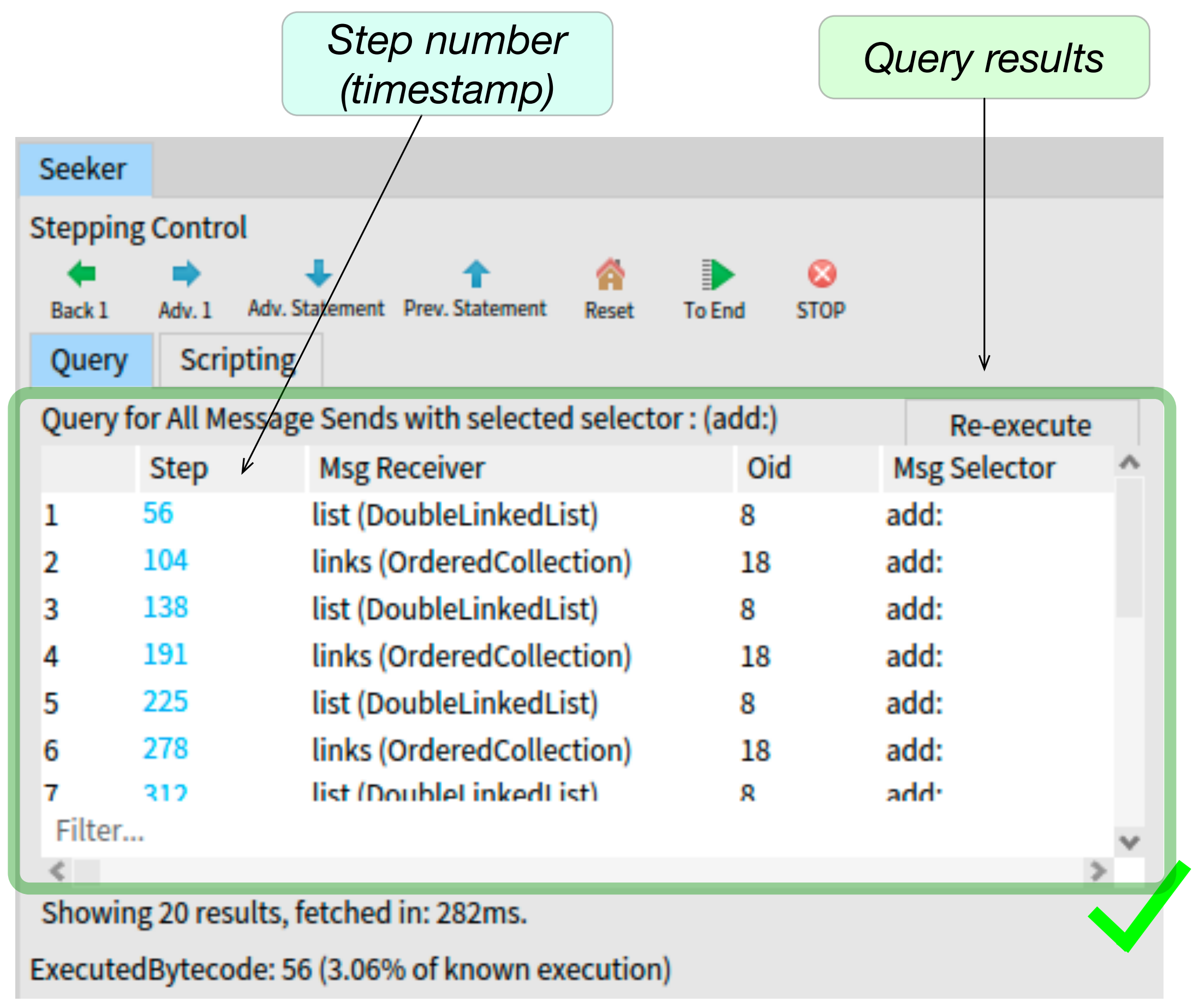


Class	Method	Package
DoubleLinkedListTest	testLinksDo	Collections-DoubleLinkedLi
DoubleLinkedListTest (TestCa	performTest	SUnit-Core
DoubleLinkedListTest (TestCa	[self setUp. self performTest]	SUnit-Core
FullBlockClosure (BlockClosu	ensure:	Kernel

```
| list links index |
list := DoubleLinkedList new.
links := OrderedCollection new.
1 to: 10 do: [ :each |
    links add: (list add: each) ].
index := 1.
```

- *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.***



Query for All Message Sends with selected selector : (add:)

	Step	Msg Receiver	Oid	Msg Selector
1	56	list (DoubleLinkedList)	8	add:
2	104	links (OrderedCollection)	18	add:
3	138	list (DoubleLinkedList)	8	add:
4	191	links (OrderedCollection)	18	add:
5	225	list (DoubleLinkedList)	8	add:
6	278	links (OrderedCollection)	18	add:
7	312	list (DoubleLinkedList)	8	add:

Showing 20 results, fetched in: 282ms.

ExecutedBytecode: 56 (3.06% of known execution)

Do you have different 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.

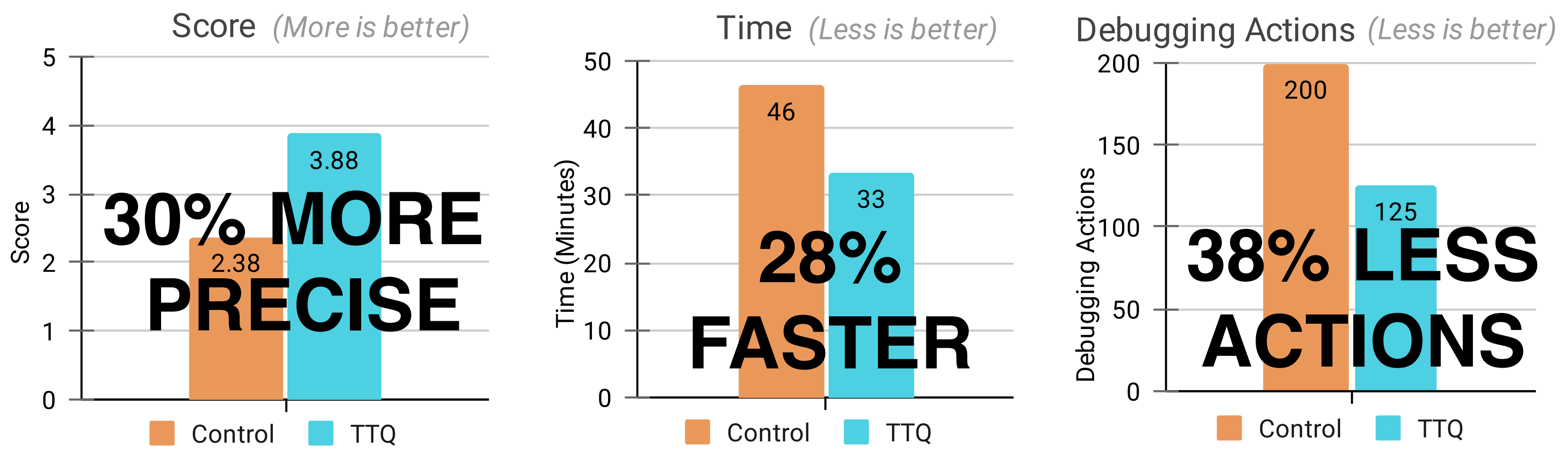
Controlled Experiment

- 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

Future work

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

Code and video demonstration available at: github.com/Willembrinck/TTQ-Debugging