Κόμπος: A Concurrency-Agnostic Debugger

An Example for Domain-Specific Online Debugging





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Research Foundation Flanders
Opening new horizons

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FWF Der Wissenschaftsfonds.

What am I doing?

A simple VM for all concurrency models

actors, CSP, STM, fork/join, data flow, threads+locks, …

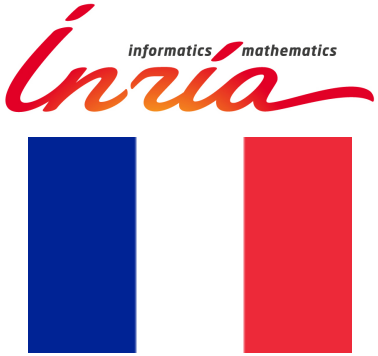
Ownership-based metaobject protocol

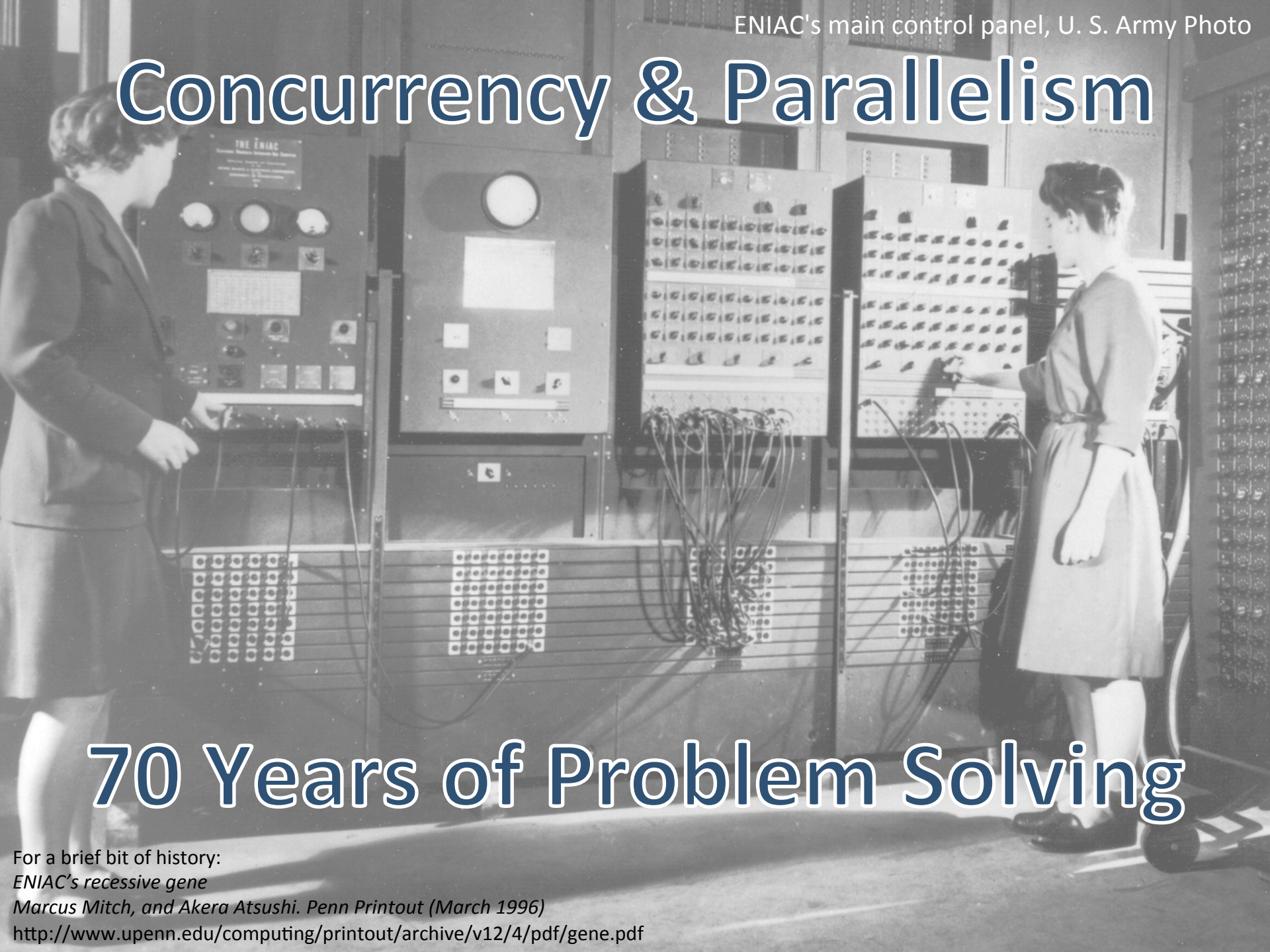
Making dynamic languages fast, easily! (incl. metaobject protocols)

Meta-Tracing vs. Partial Evaluation

Combining Concurrency Models

Tooling/Debugging





ENIAC's main control panel, U. S. Army Photo

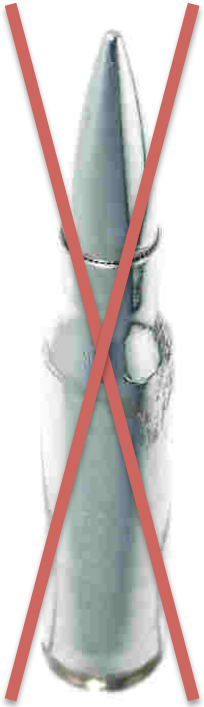
Concurrency & Parallelism

70 Years of Problem Solving

For a brief bit of history:
ENIAC's recessive gene
Marcus Mitch, and Akera Atsushi. Penn Printout (March 1996)
http://www.upenn.edu/computing/printout/archive/v12/4/pdf/gene.pdf

Decades of Research and Solutions for "*Everything*"

But no Silver Bullet



- **Actors**
- **CSP**
- **Locks, Monitors, …**
- **Fork/Join**
- **Transactional Memory**
- **Data Flow**
- …

In Practice: Concurrency Abstractions are Combined

- Uses Locks and Atomic*
- Multiple async. future/ task abstractions
- Multiple 'transaction' systems

> 4500 "deadlock" bugs

> 530 "race condition" bugs

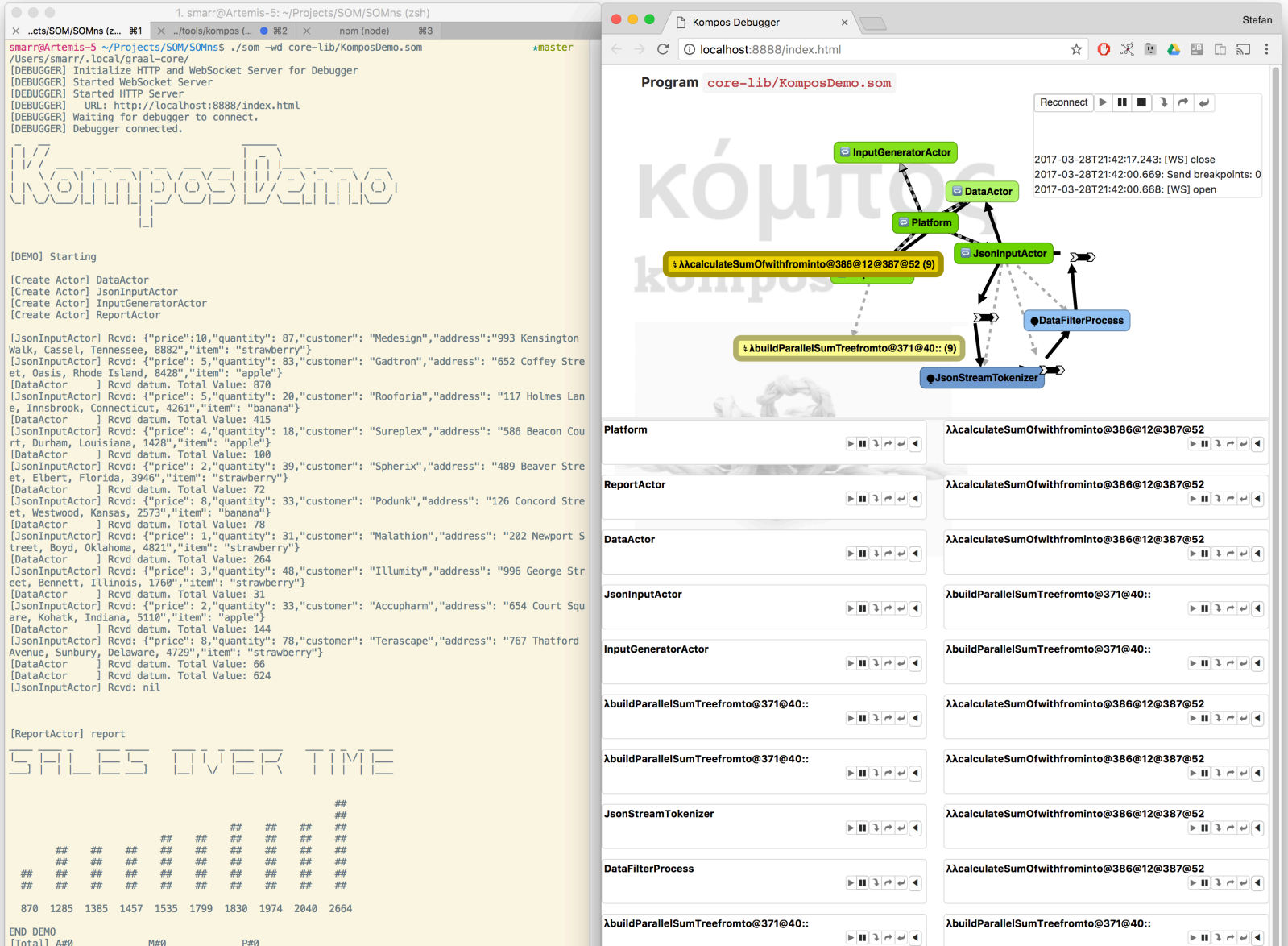
Study on Scala:
S. Tasharofi, P. Dinges, and R. E. Johnson. Why Do Scala Developers Mix the Actor Model with other Concurrency Models? In Proc. of ECOOP, volume 7920 of LNCS, pages 302–326. Springer, 2013.

I want to reason about actors, fork/join tasks, transactions…

And not some implementation-level shared memory

HOW TO DEBUG SUCH SYSTEMS?

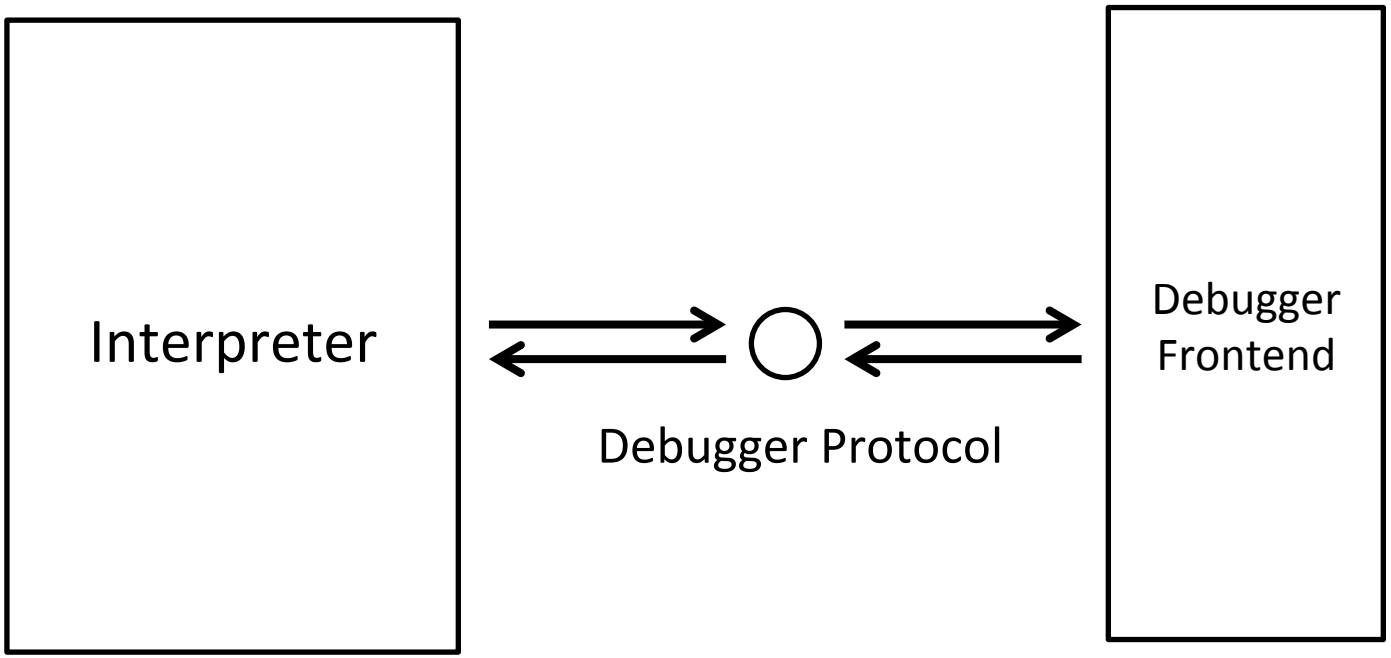
Demo of Kómpos



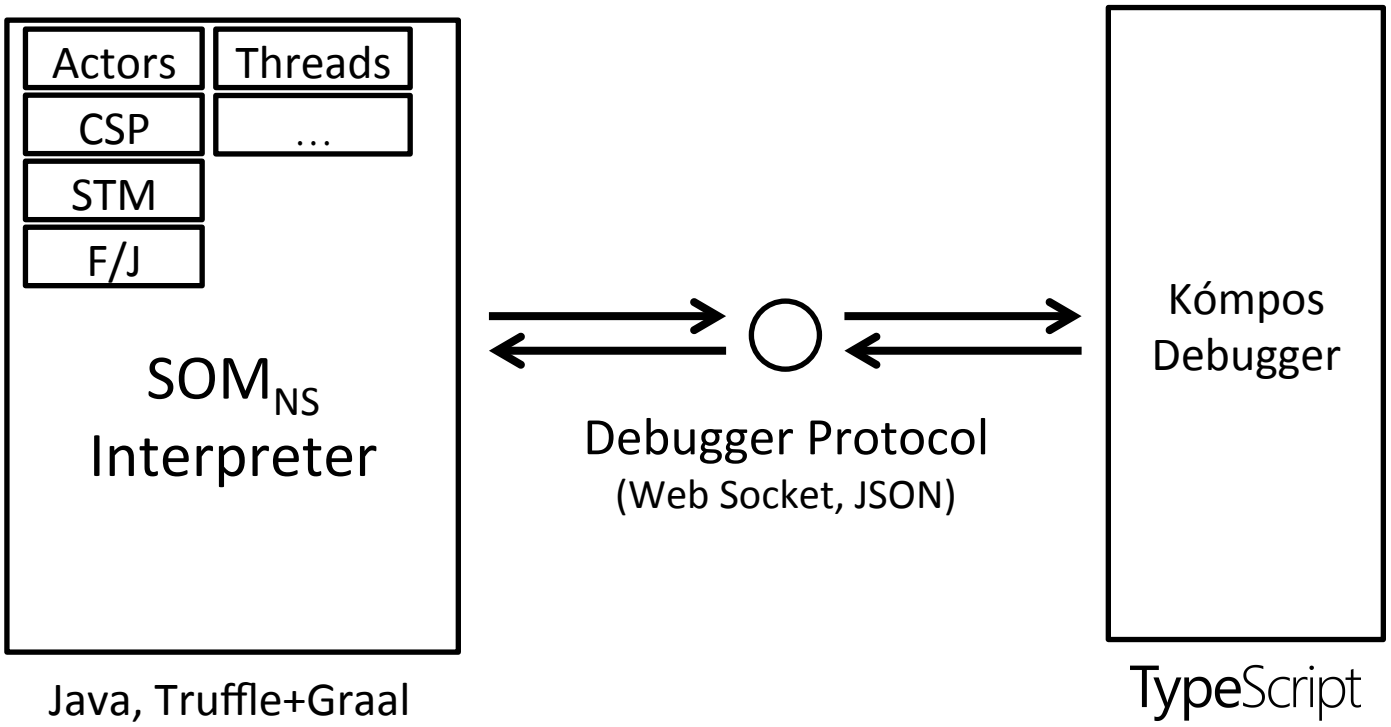
Custom Debugger Features

	Breakpoints	Stepping Operations
Sequential	1	5
Generic	4	2
Actors	6	5
CSP	4	2
STM	3	3
Threads&Locks	4	2
(not intended to be complete)	**22**	**19**

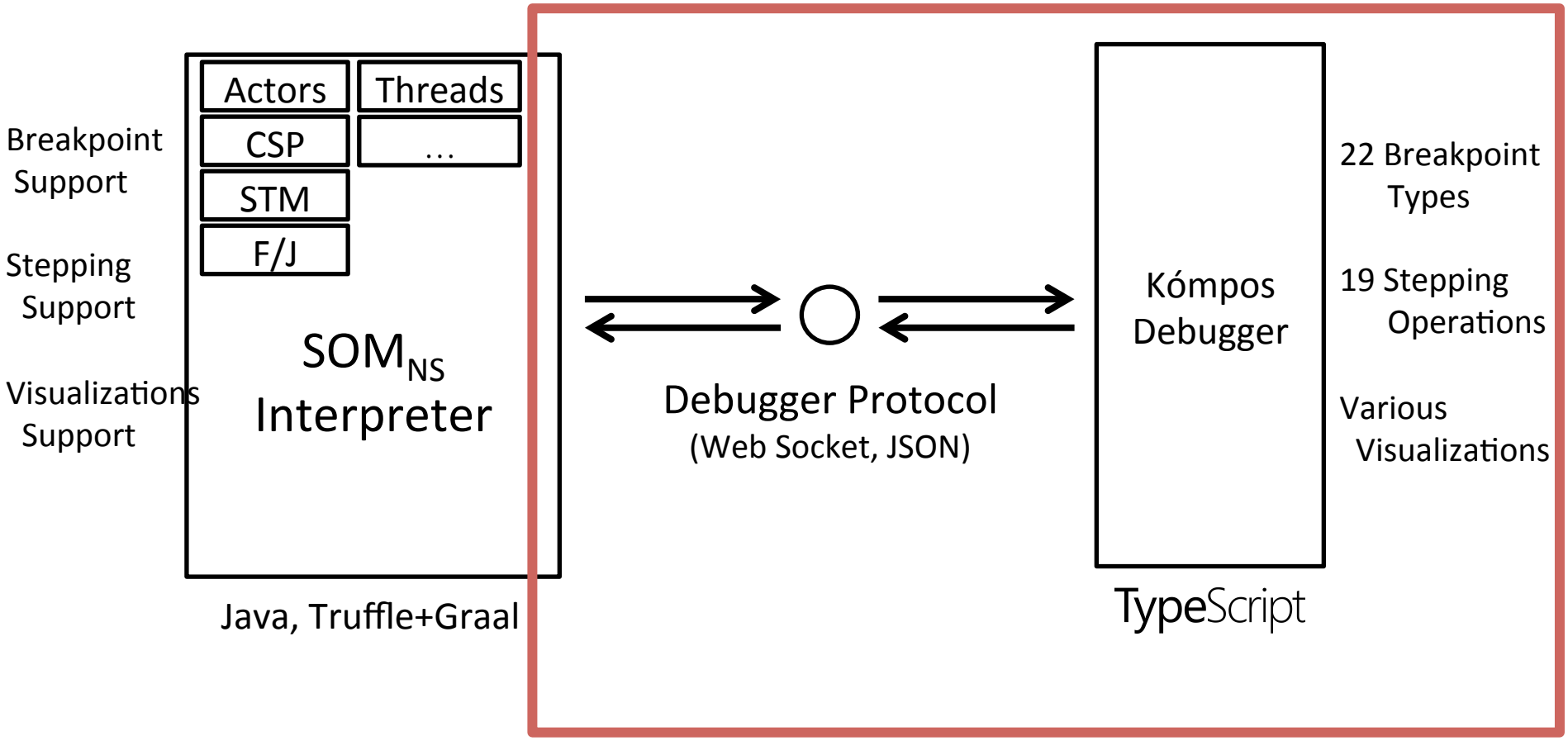
Debugger Architecture



Kómpos Architecture



Kómpos Architecture



How to Abstract from Concurrency Models?

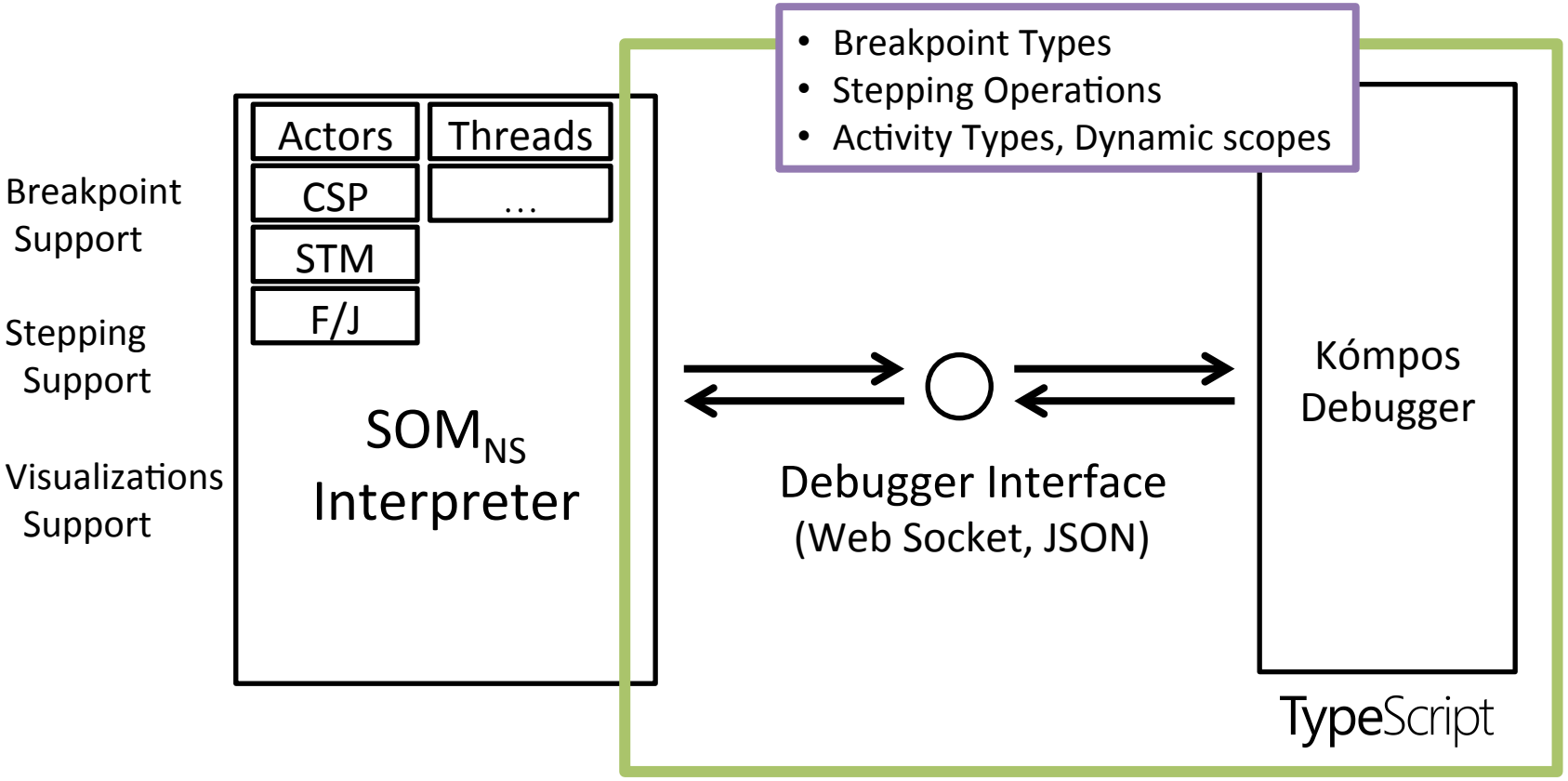
κόμπος

kompos

A Concurrency-Agnostic Debugger Protocol

THE KÓMPOS PROTOCOL

Abstract from Concurrency Models



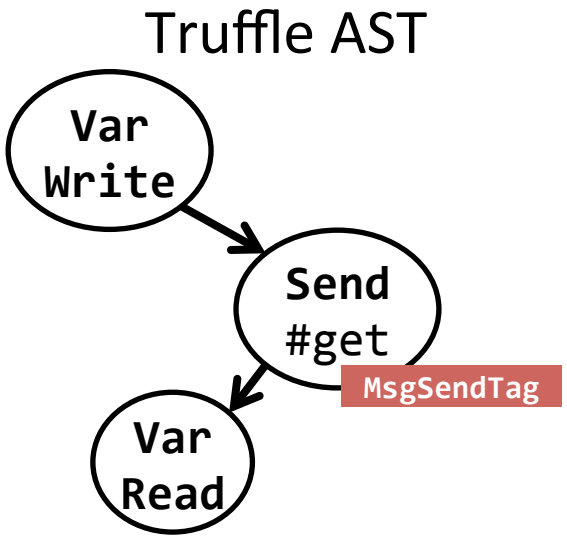
- Interactions modeled via data
- Debugger agnostic of concepts

What's a Breakpoint?

message send
message receive
promise resolver
promise resolution

```
prom := aResult <-: get.
```

- Name/Type
- Source Locations
  - Identified by Source Tags



Debugger Requirements

- Annotated AST

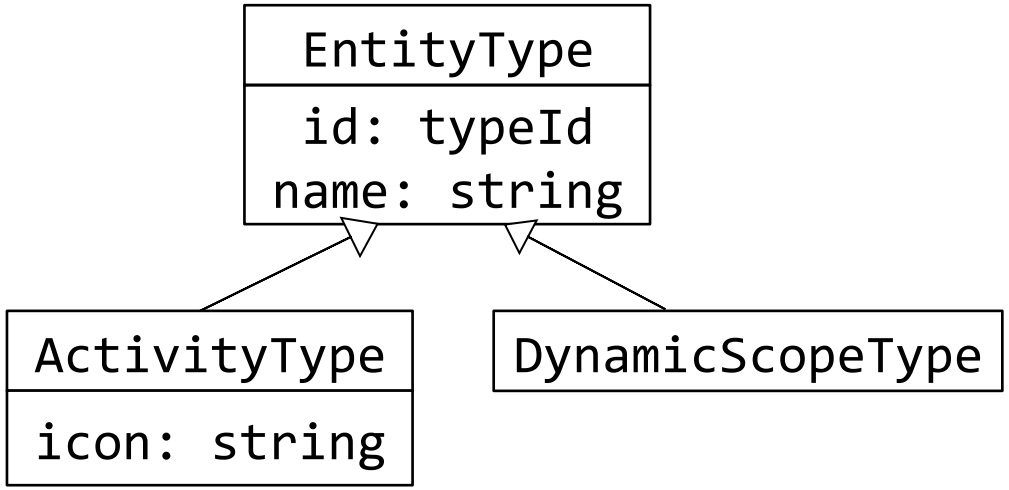
What's a Stepping Operation?

Step into
Step over
Return
Step to Receiver
Step to Promise Resolver
Step to Promise Resolution

```
prom :=
    aResult <-: get.
```

- Name/Type
- Source Locations
  - Identified by Source Tags
- Current Type of Activity
  - Actor, Process, Fork/Join Task, Thread
- Current Dynamic Scope
  - Held Monitor, Transaction

Kómpos Protocol Metadata



BreakpointType
name: string label: string applicableTo: Tag[]

SteppingType
name: string label: string applicableTo: Tag[] activities: ActivityType[] scopes: DynamicScopeType[]

Kómpos Protocol Messages

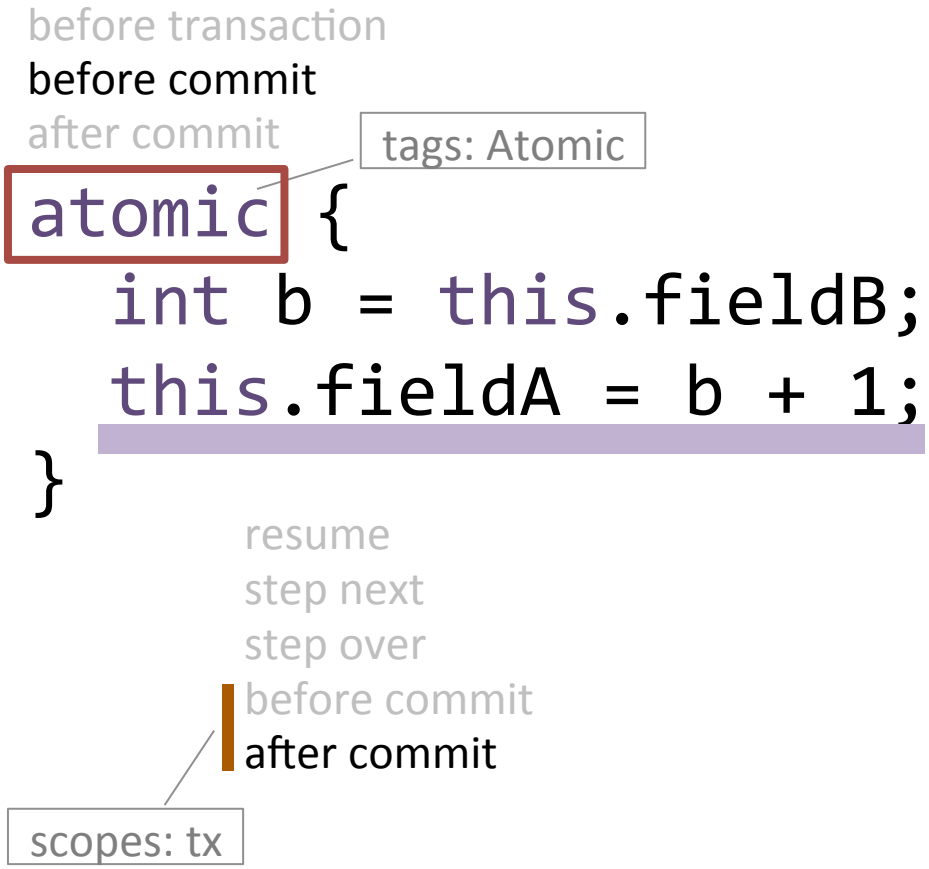
Source
URI: URI sourceText: string locations: TaggedCoord[]

BreakpointUpdate
location: Coord type: BreakpointType

Stopped
activityId: id location: Coord actType: ActivityType scopes: DynamicScopeType[]

Step
activityId: id type: SteppingType

Example for Transactions




```
to int: {BreakpointUpdate,
         loc: 1:1:6,
         type: beforeCommit}

from int: {Stopped,
           actId: 1,
           loc: 3:3:20,
           scopes: [tx]}

to int: {Step,
         actId: 1,
         type: afterCommit}
```

How concurrency-agnostic is the protocol design?

EVALUATION

Implemented Interactions
No changes to frontend required!

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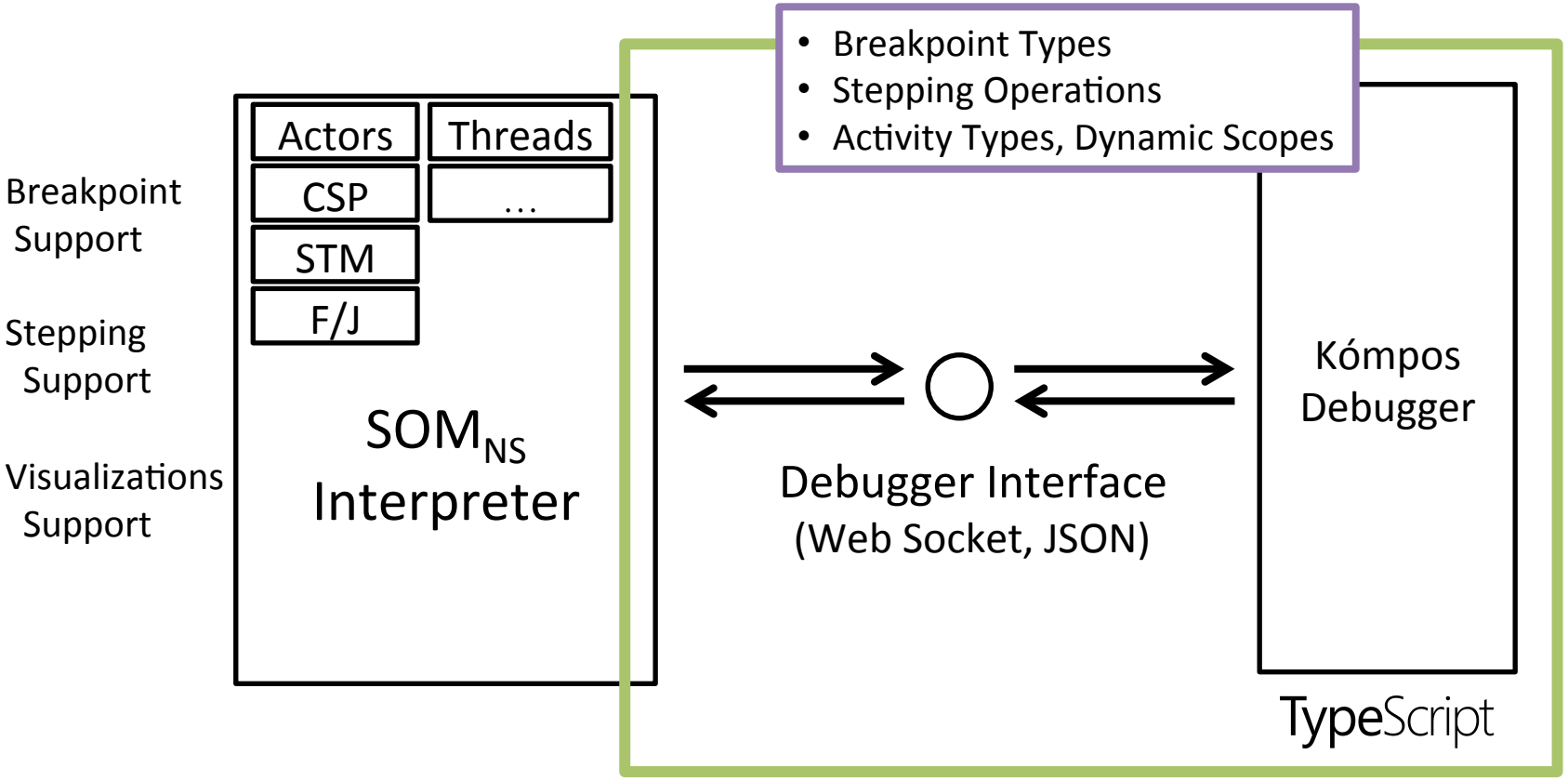
CONCLUSION

Too many Concepts, Too many Variations

Solution:
Model Domain with Metadata



META

Workshop on Meta-Programming Techniques and Reflection

Paper Submission: 14 Aug 2017
Late WIP Submission: 7 Sep 2017

Co-located with

SPLASH VANCOUVER 2017 OCTOBER 22–27

Paper Deadline: 14 August 2017

Workshop Proposals: 1 October 2017

Kómpos: Platform for Debugging Complex Concurrent Applications

- Concurrent Debugger
  - Concept-agnostic
- Visualization, Breakpoints, Stepping, Tracing
- Replay, Assertions,…
- For Actors, CSP, Fork/Join, STM, Locks&Threads,…