AIOCJ: a Choreographic Framework for Safe Adaptive Distributed Applications

Mila dalla Preda[1], **Saverio Giallorenzo**[2], Ivan Lanese[2], Jacopo Mauro[2], and Maurizio Gabbrielli[2]

[1]Department of Computer Science - Univ. of Verona
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Conference on Software Language Engineering, 2014

Why Choreographic?

Bob	**Alice**
`msg = “Want to dance?”;`	`sendMessage: msg from Bob;`
`sendMessage: msg to Alice;`	`response = show( msg );`
`ok: response from Alice`	`ok: response to Bob`

Why **Choreographic**?

```
sendMessage: Bob( “Want to dance?” ) -> Alice( msg );
response@Alice = show( msg );
ok: Alice( response ) -> Bob( response )
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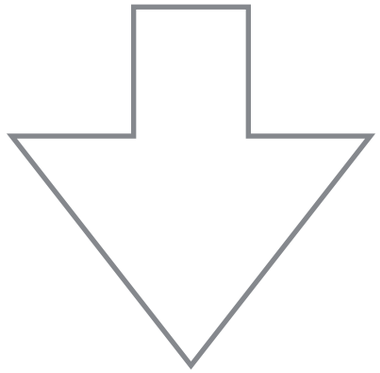

Projects to

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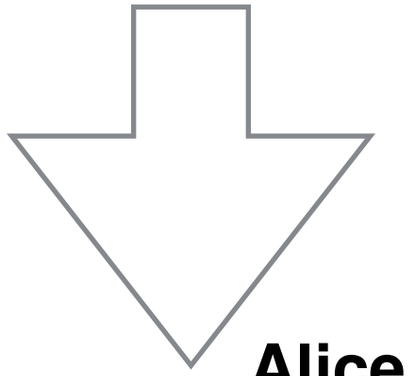

Projects to

Bob

```
msg = “Want to dance?”;
sendMessage: msg to Alice;
ok: response from Alice
```

Alice

```
sendMessage: msg from Bob;
response = show( msg );
ok: response to Bob
```

Why **Choreographic**?

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sendMessage: Bob( “Want to dance?” ) -> Alice( msg );
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```

What if we want to change (parts of it) at runtime?

Safe Adaptive Choreographies

Choreographies are suitable for programming safe distributed systems.

Can we make them suitable for programming **safe** and **adaptable** distributed systems?

AIOCJ is our attempt at giving a positive answer to this question.

Safe Adaptive Choreographies

We deem **AIOCJ** suitable because:

1. It gives a general and neat overview of the (interaction in the) whole system;

2. It injects “good” (desirable) properties on distributed systems;

3. It has proven to be a feasible implementation of formal results. (We ensure “good” properties to hold on the distributed system at runtime and after any step of adaptation).

1. Neat overview

Neat overview | The **AIOC** Language

```
sendMessage: Bob( “Want to dance?” ) -> Alice( msg );

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- **Interactions** (synchronous)**;**

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sendMessage: Bob( “Want to dance?” ) -> Alice( msg );
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```

- Interactions (synchronous);
- **Local Computation**;

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- Interactions (synchronous);
- Local Computation;
- **Participants**;

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- Interactions (synchronous);
- Local Computation;
- Participants;
- **Operations**;

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sendMessage: Bob( “Want to dance?” ) -> Alice( msg );
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- Interactions (synchronous);
- Local Computation;
- Participants;
- Operations;
- **Functions**;

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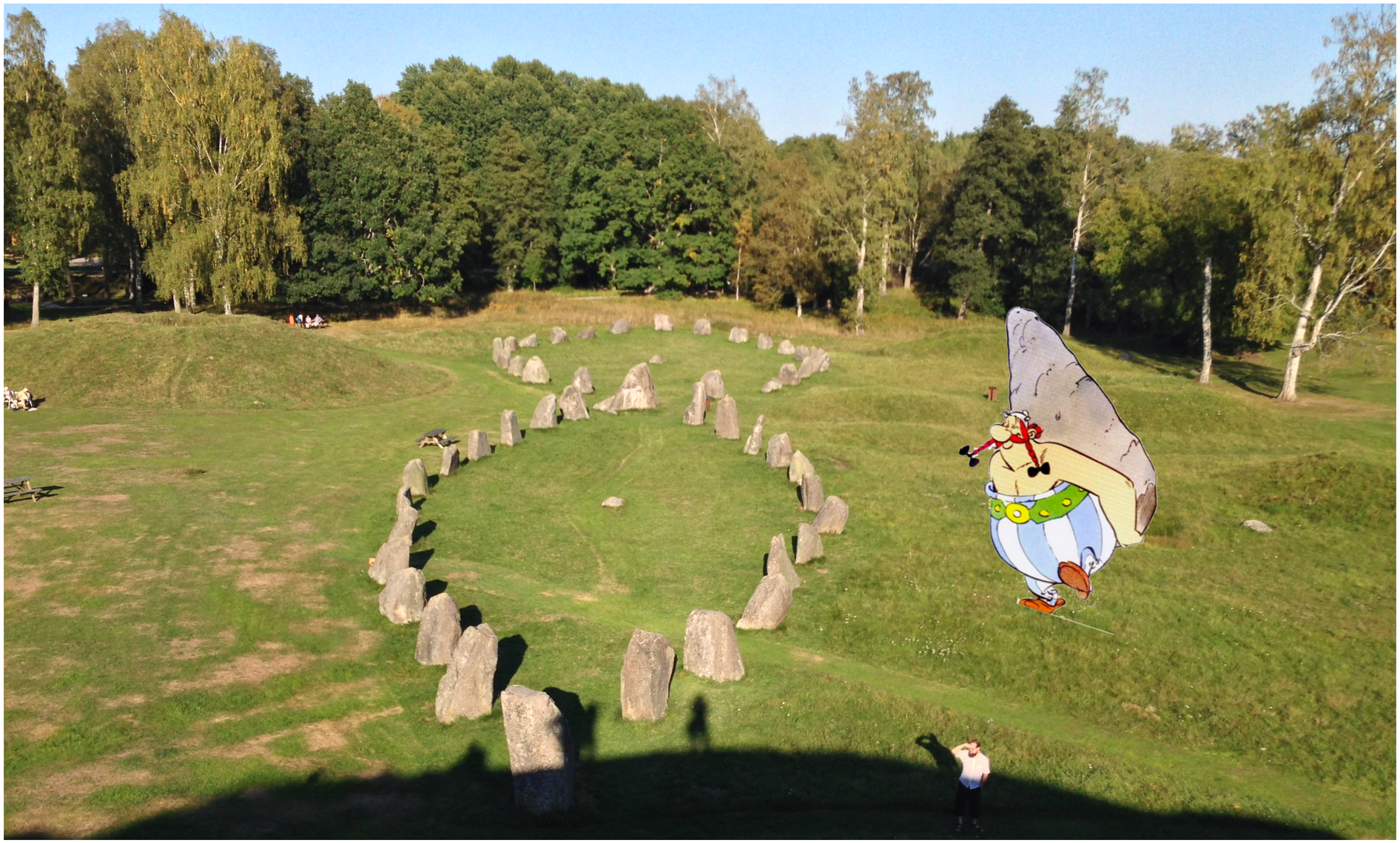
ok: Alice( response ) -> Bob( response )
```

- Interactions (synchronous);
- Local Computation;
- Participants;
- Operations;
- Functions;
- **Data**.

1. Neat overview,



1. Neat overview,

also when programming adaptation

Neat overview | The **AIOC** Language

Scopes

Neat overview | The **AIOC** Language

A **scope** defines a part of the interaction
that can be replaced (adapted).

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```
scope @Bob {
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} prop { N.scopename = “hangout” }
```

- **Scope Declaration**;

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- Scope Declaration;
- **Scope Leader**;

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- Scope Declaration;
- Scope Leader;
- **Sub-choreography**;

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- Scope Declaration;
- Leader;
- Sub-choreography;
- **Scope properties**;

Neat overview | The **AIOC** Language

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Rules

Neat overview | The **AIOC** Language

A **rule** defines a choreography that
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A **rule** defines a choreography that can replace a scope.

```
rule {
 on { N.scopename == “hangout” }
 do {
  sendMessage: Bob( “What about Movies?” ) ->
   Alice( msg )
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}
```

- **Rule Declaration**;

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rule {
  on { N.scopename == “hangout” }
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```

prefixes
N. - properties of the scope;
E. - environmental variables;
non prefixed variables are local to the leader.

- Rule Declaration;
- **Applicability Condition**;

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- Rule Declaration;
- Applicability Condition;
- **New Choreography**.

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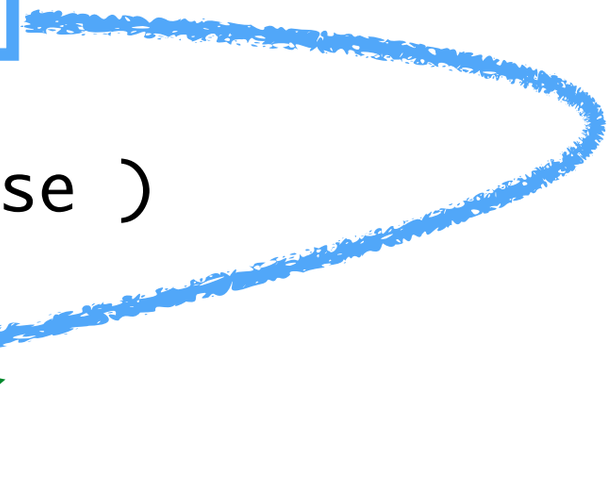

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2. “Good” properties

“Good” Properties

|

Deadlock- and Race-freedom by construction.

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock- and race-free by construction.

1. **Interactions are atomic**
2. We enforce **well-formed choreographies** both in AIOCJ programs and rules.
3. **Correctness of projection**

“Good” Properties

II

Consistency of Adaptation

“Good” properties | **consistency of adaptation**

When a scope of an AIOCJ program adapts, the adaptation is **consistent** among the participants.

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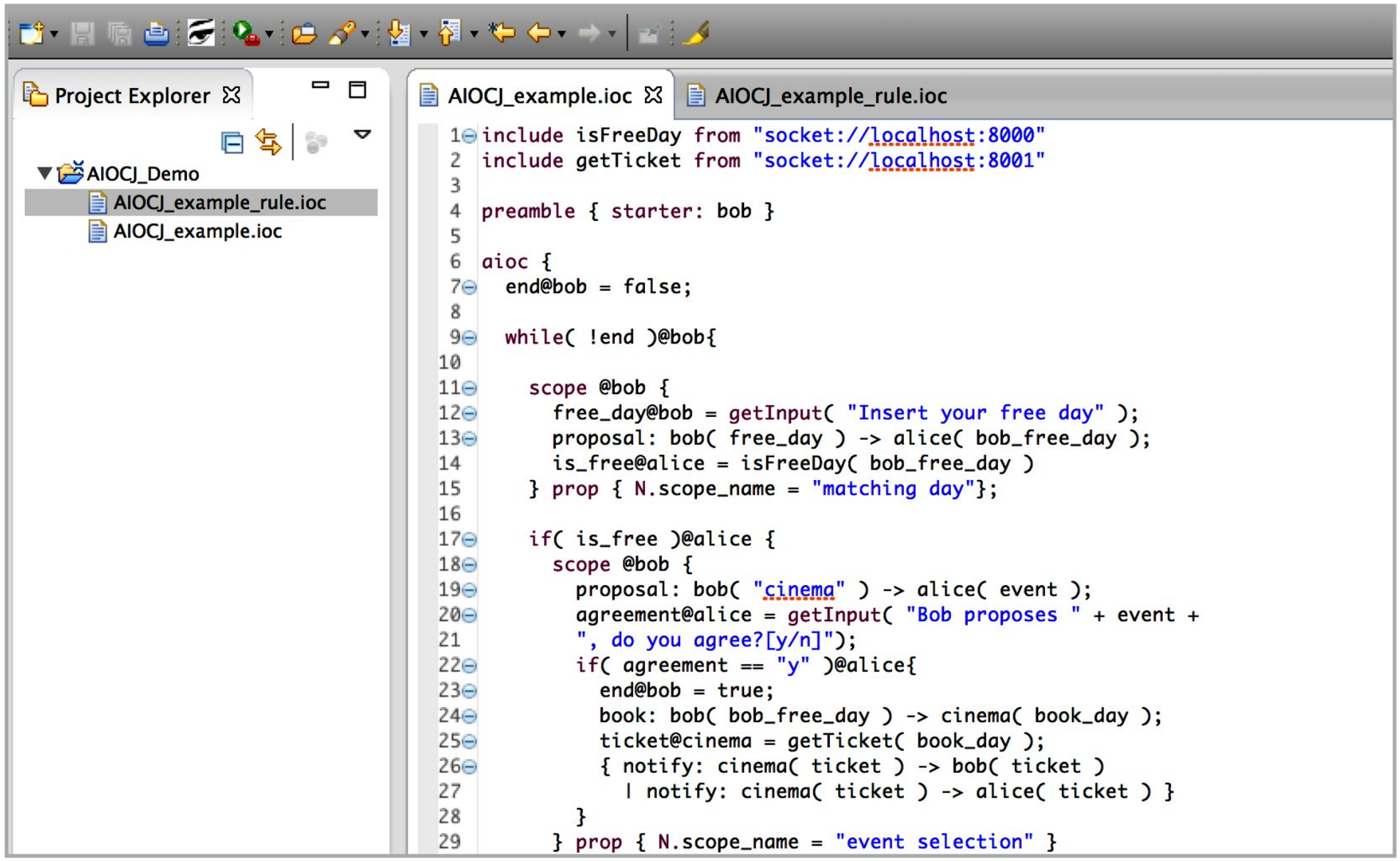
Only Bob can query the repositories of rules.
He decides whether to adapt and which rule applies.

This allows rules to change at runtime!



3. Feasible

Website: http://bit.do/**aiocj**

Feasible | **The AIOCJ Framework**

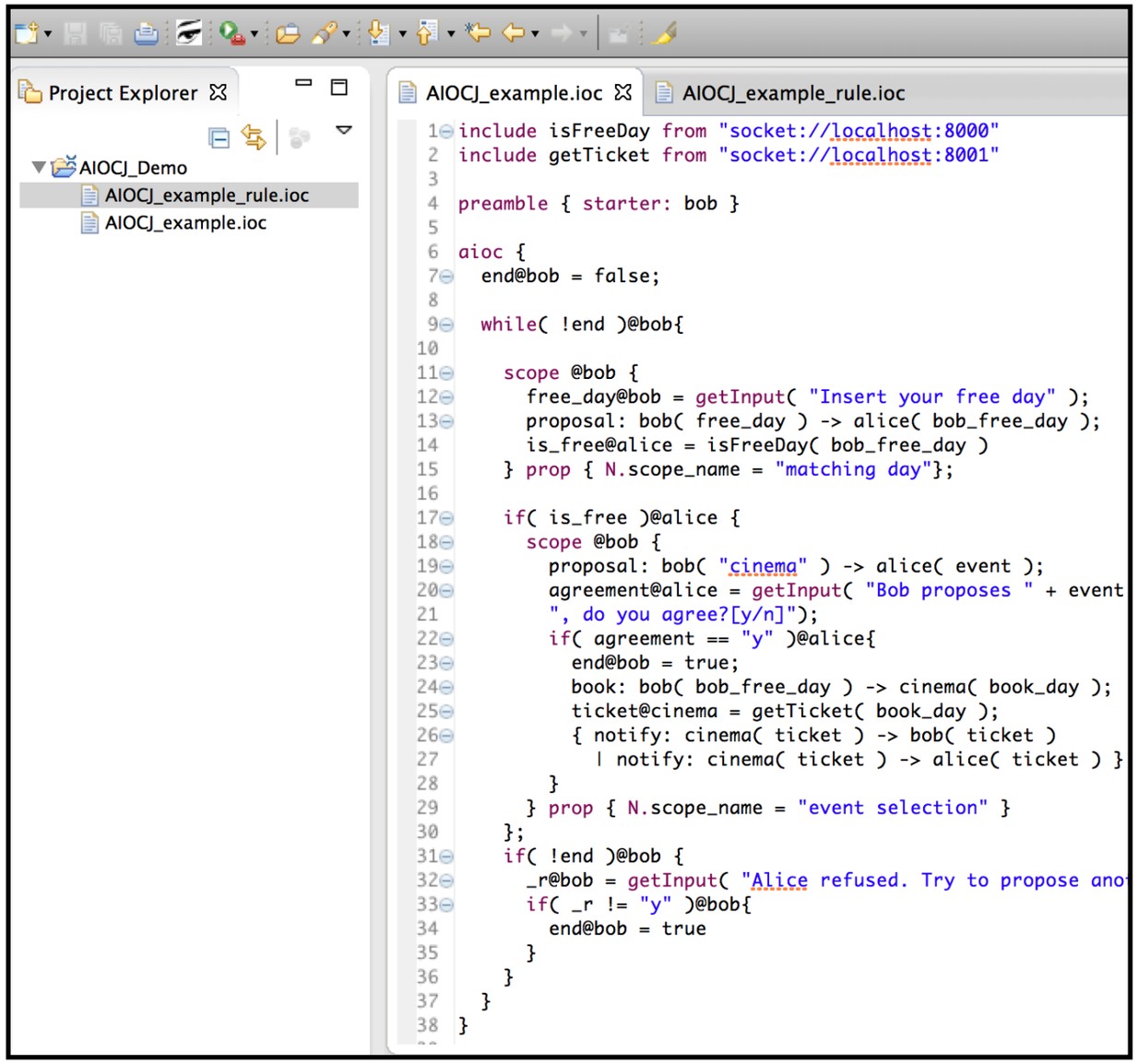
AIOCJ-ecl.

Plug-in for Eclipse.

Provides:

- syntax highlighting;
- syntax checking;
- online correctness checking;
- Projection to Jolie

www.jolie-lang.org



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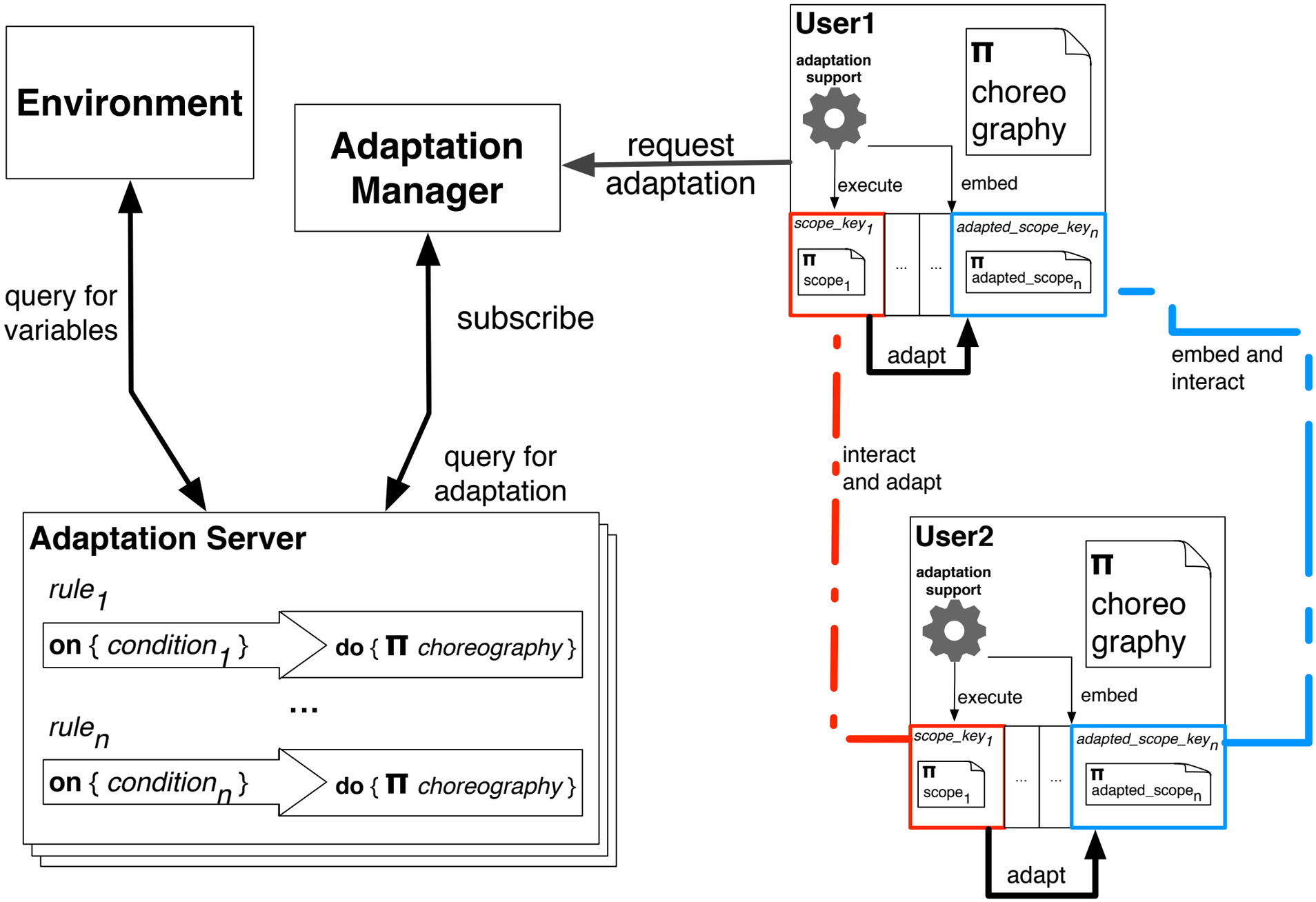
Feasible | **The AIOCJ Framework**

AIOCJ-mid



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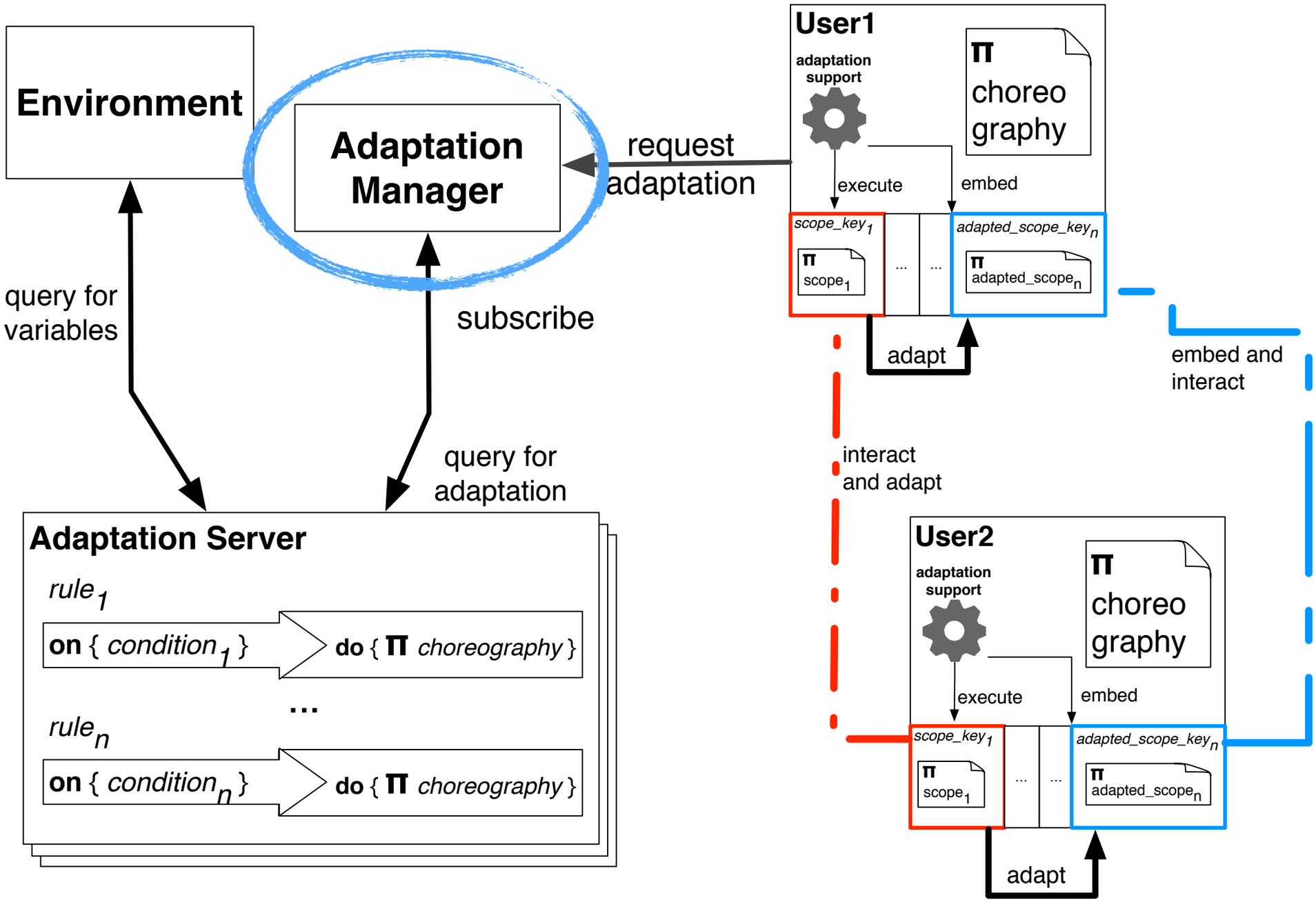

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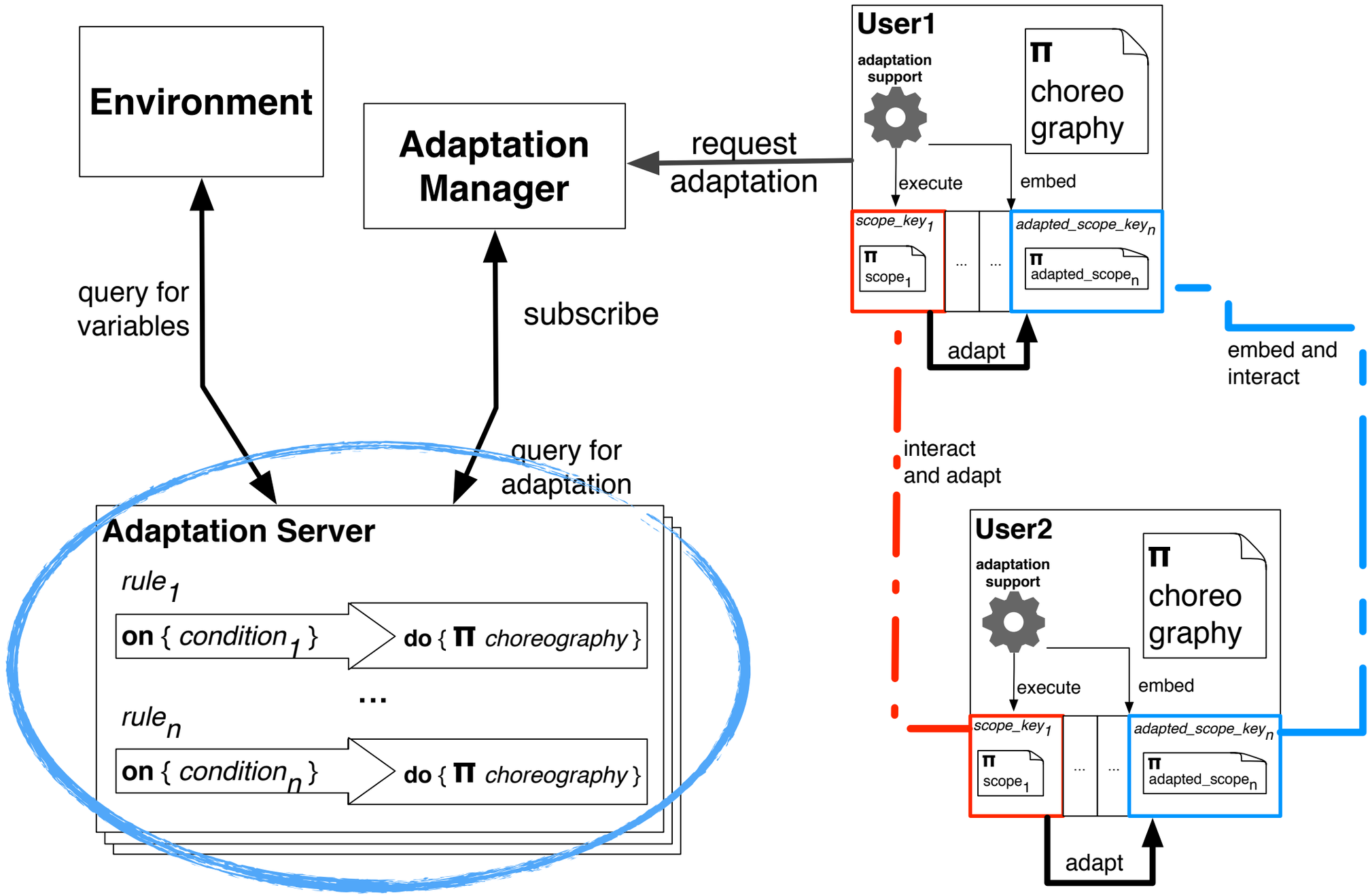

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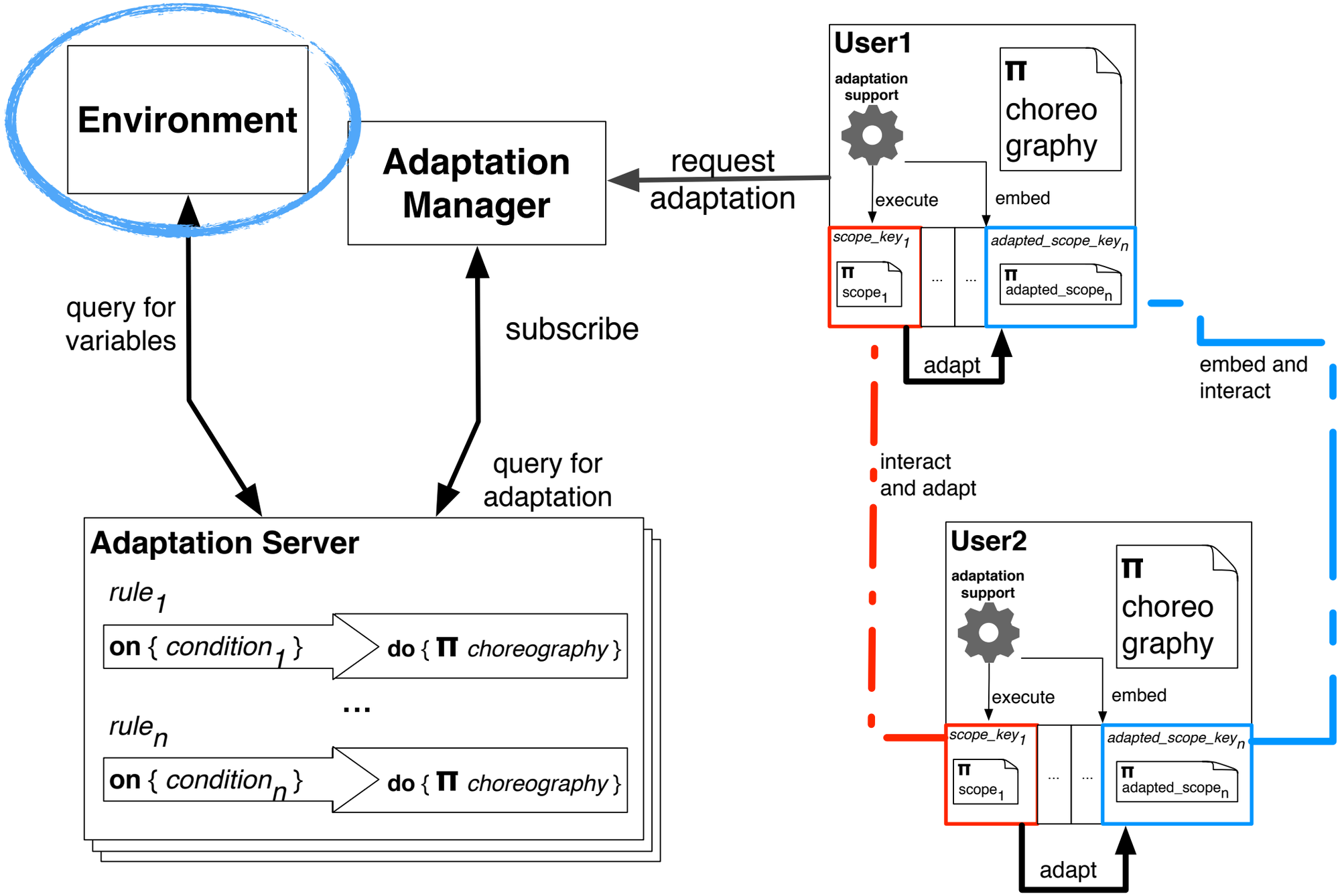

Demonstration

Safe Adaptive Choreographies | RECAP

Choreographies are suitable for programming safe distributed systems.

With **AIOCJ**, we made a first attempt at making them suitable for programming **safe** and **adaptable** distributed systems.

Website: http://bit.do/**aiocj**

Safe Adaptive Choreographies | RECAP

Main features of **AIOCJ**:

1. It gives a general and neat overview of the (interaction in the) whole system;

2. It injects “good” (desirable) properties on distributed systems;

3. It has proven to be a feasible implementation of formal results. (We ensure “good” properties to hold on the distributed system at runtime and after any step of adaptation).

Future Work

What is still missing?

- Communications in AIOCJ are synchronous. We are planning to include also **asynchronous** communications;
- Sessions;
- Injection of AIOCJ “good” properties in other adaptation mechanisms. E.g., Aspect-Oriented or Context-Oriented Programming, etc…

Thanks for your time

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Appendix

Connectedness Properties

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock-free by construction.

Connectedness for sequence

```
op1: Bob( a ) -> Alice( b );
op2: Alice( b ) -> Bob( c );
```

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock-free by construction.

Connectedness for sequence

```
op1: Bob( a ) -> Alice( b );
op2: Alice( b ) -> Bob( c );
op3: Carol( d ) -> Dave( e )
```

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock-free by construction.

Connectedness for sequence

```
op1: Bob( a ) -> Alice( b );
op2: Alice( b ) -> Bob( c );
op3: Carol( d ) -> Dave( e )
```

No causality relation between either Alice, Bob, Carol or Dave

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock-free by construction.

Connectedness for sequence

```
op1: Bob( a ) -> Alice( b );
op2: Alice( b ) -> Bob( c ) |
op3: Carol( d ) -> Dave( e )
```

A natural enforcement.
Probably the programmer wanted the last two instructions to run in parallel

“Good” properties | **deadlock- and race-freedom**

Choreographies are deadlock-free by construction.

Connectedness for parallel

```
op1: Bob( a ) -> Alice( c )|
op1: Bob( b ) -> Alice( d )
```

There might be interference between these interactions.

Interactions with the same signature (operation, sender, receiver) in parallel are forbidden.

AIOC Language

Syntax

AIOC Program Syntax

$$
\begin{array}{rcl}
\mathcal{C} & ::= & \text{Include}^* \\
 & & \text{Preamble} \\
 & & \texttt{aioc}\ \ \{\ \ \mathcal{I}\ \ \} \\
\text{Include} & ::= & \texttt{include}\ \ f^+\ \ \texttt{from}\ \ \text{Location} \\
\text{Preamble} & ::= & \texttt{preamble}\ \ \{ \\
 & & \quad \texttt{starter}:\ \ r \\
 & & \quad \text{Deployment}^* \\
 & & \} \\
\text{Deployment} & ::= & \texttt{location@}r : \text{Location}
\end{array}
$$

AIOC Behaviour Syntax

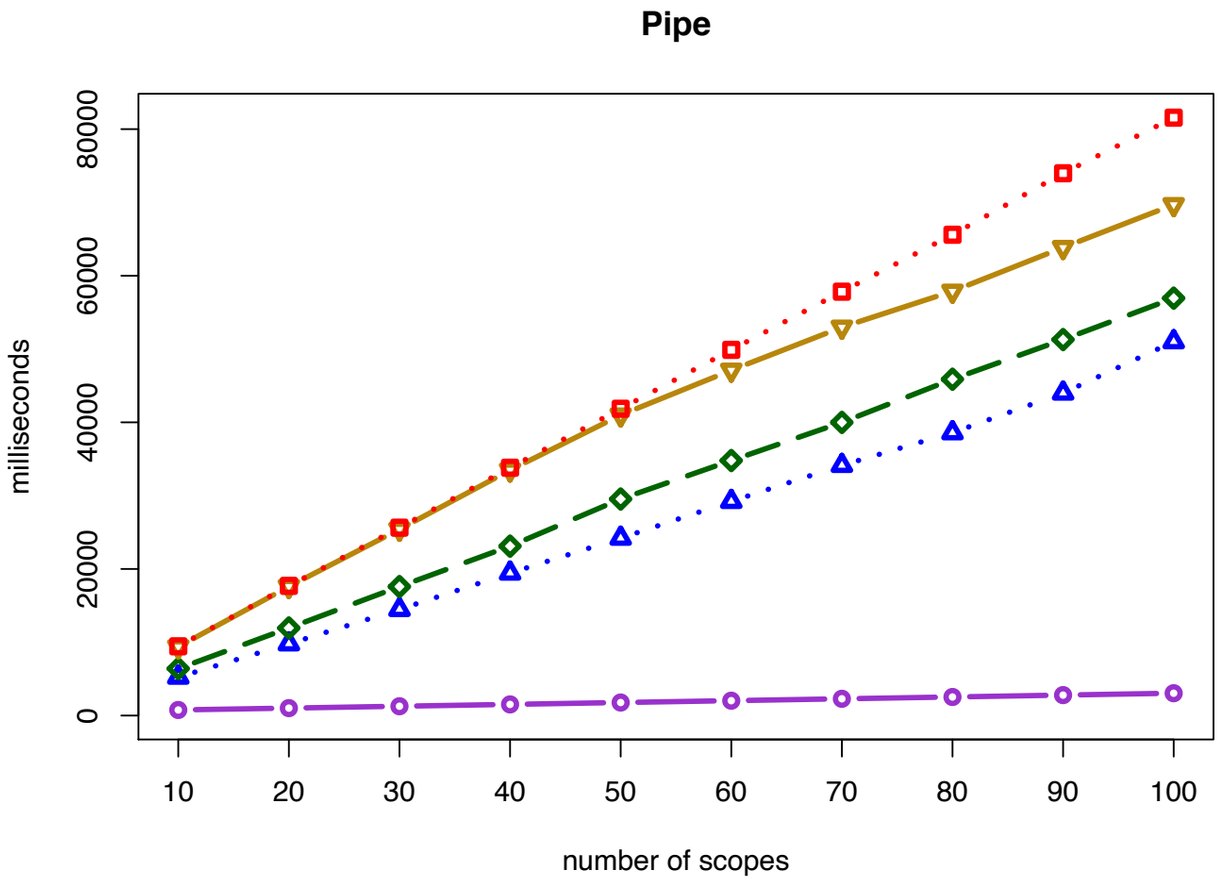
$$
\begin{array}{rcl}
\mathcal{I} & ::= & o^{?} : r_1(e) \texttt{ -> } r_2(x) \;\mid\; \mathcal{I};\mathcal{I}' \;\mid\; \mathcal{I}\,|\,\mathcal{I}' \\
& \mid & x\texttt{@}r = local \;\mid\; \texttt{skip} \;\mid\; \texttt{while}\ \ b\texttt{@}r\ \ \{\mathcal{I}\} \\
& \mid & \texttt{if}\ \ b\texttt{@}r\ \ \{\mathcal{I}\}\ \ \texttt{else}\ \ \{\mathcal{I}'\} \\
& \mid & \texttt{scope}\ \ \texttt{@}r\ \ \{\mathcal{I}\} \\
& & [\,\texttt{prop}\ \ \{\text{list of } \texttt{N}.x = e\}\,] \\
& & [\,\texttt{roles}\ \ \{r_i, \ldots, r_j\}\,]
\end{array}
$$

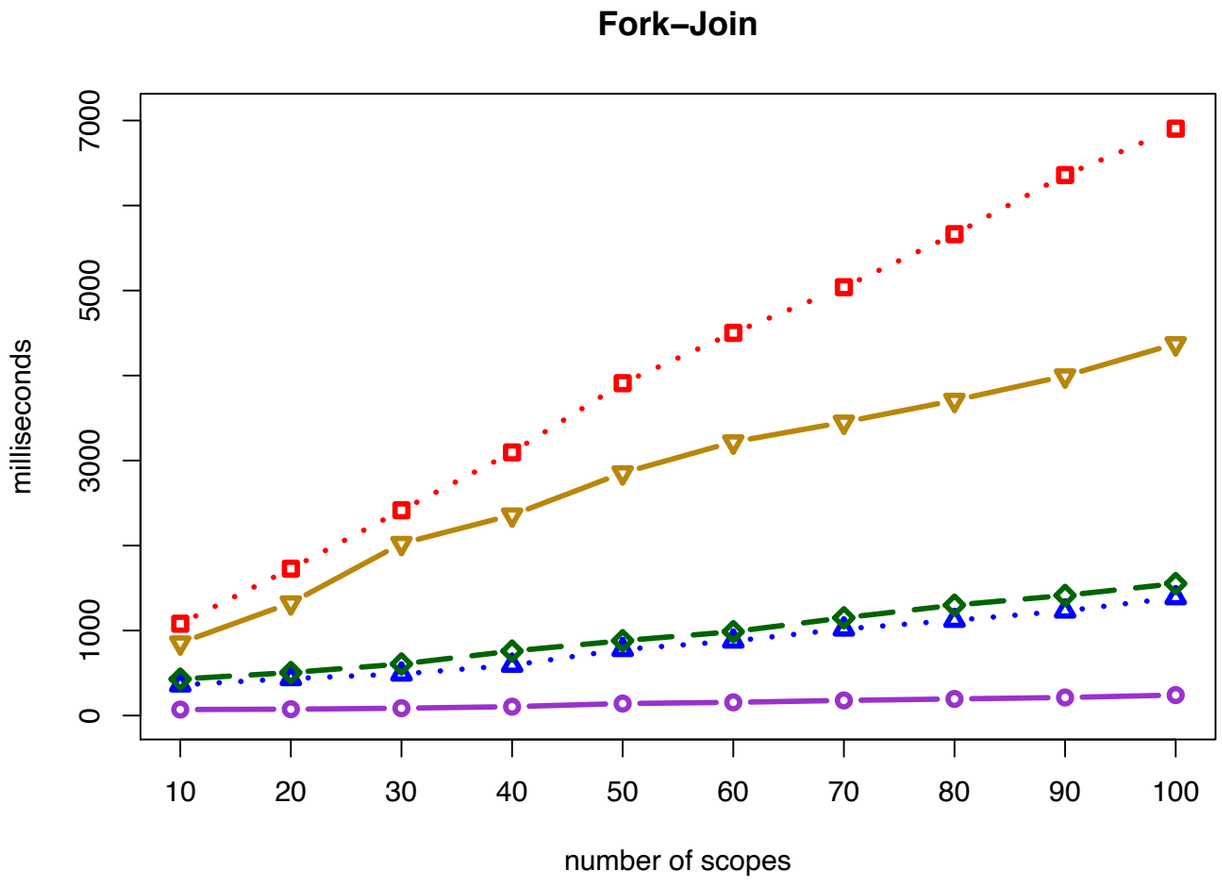
$$
local \quad ::= \quad e \;\mid\; f \;\mid\; \texttt{getInput}(x) \;\mid\; \texttt{show}(x)
$$

Rules Syntax

$$
\begin{array}{l}
\mathcal{R} ::= \quad \texttt{rule} \quad \{ \\
\qquad \text{Include}^* \\
\qquad \texttt{on} \quad \{ \quad \mathcal{B} \quad \} \\
\qquad \texttt{do} \quad \{ \quad \mathcal{I} \quad \} \\
\}
\end{array}
$$

Performances





- C1: no scopes
- C2: scopes, no adaptation server
- C3: scopes, 1 adaptation server, no rules
- C4: scopes, 1 adaptation server, 50 rules
- C5: scopes, 1 adaptation server, 100 rules