

# **AIOCJ**: a Choreographic Framework for Safe Adaptive Distributed Applications

Mila dalla Preda<sup>1</sup>, **Saverio Giallorenzo**<sup>2</sup>, Ivan Lanese<sup>2</sup>, Jacopo Mauro<sup>2</sup>, and Maurizio Gabbrielli<sup>2</sup>

<sup>1</sup>Department of Computer Science - Univ. of Verona

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Conference on Software Language Engineering, 2014

# Why Choreographic?

**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?

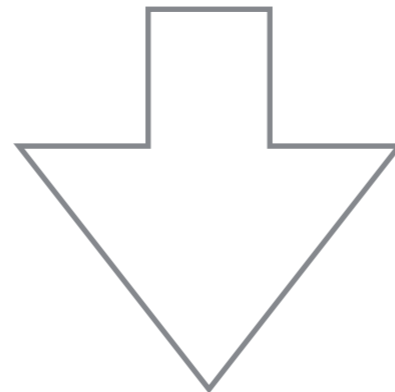
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response@Alice = show( msg );  
ok: Alice( response ) -> Bob( response )
```

# Why **Choreographic**?

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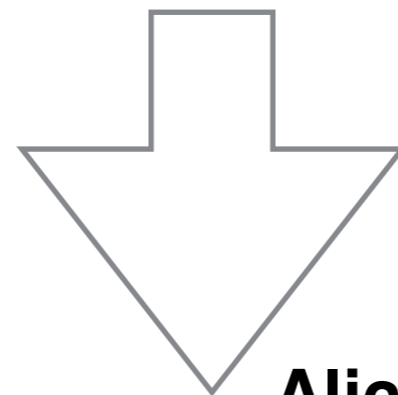
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ok: Alice( response ) -> Bob( response )
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Projects to

# Why Choreographic?

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Projects to

**Bob**

```
msg = "Want to dance?";
sendMessage: msg to Alice;
ok: response from Alice
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**Alice**

```
sendMessage: msg from Bob;
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ok: response to Bob
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# Why Choreographic?

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

**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

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

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

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



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

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

```
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```

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



# 1. Neat overview,



# 1. Neat overview, also when programming adaptation

# Neat overview | The **AIOCI** 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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- **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 **AIOCI** Language

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## Rules

# Neat overview | The **AIOC** Language

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

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

- **Rule Declaration;**

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```
  do {
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```
    sendMessage: Bob( "What about Movies?" ) ->
      Alice( msg )
```

```
  }
```

```
}
```

## 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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What happens at runtime? Easy to figure out.

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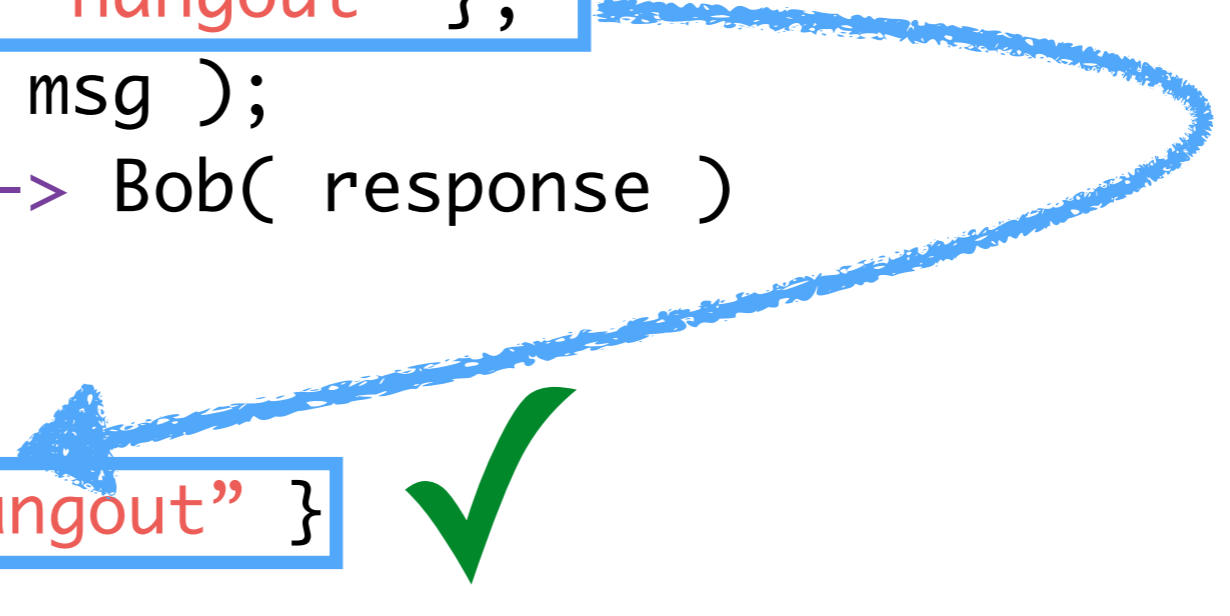
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## 2. “Good” properties

“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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Bob is the **leader** of this scope of adaptation.

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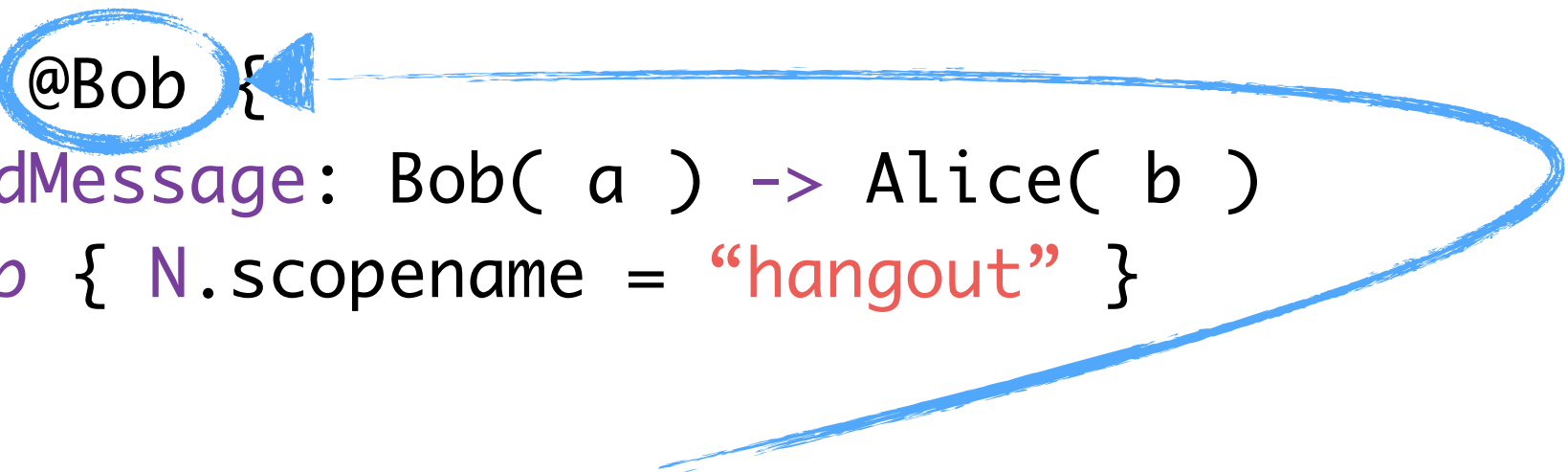


Bob is the **leader** of this scope of adaptation.  
Only Bob can query the repositories of rules.

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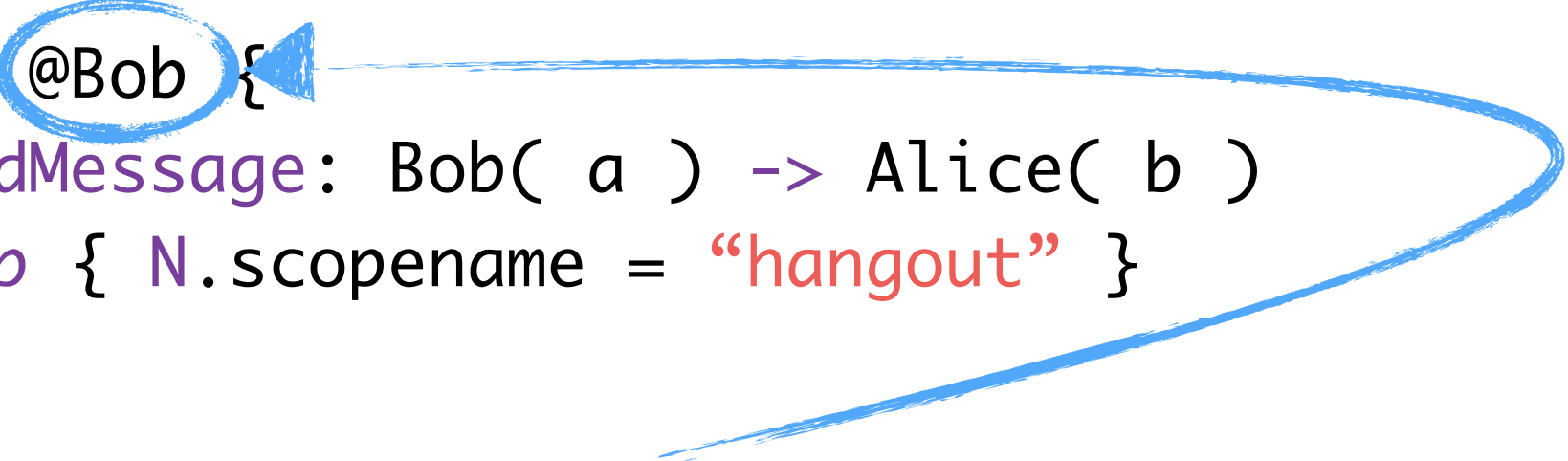


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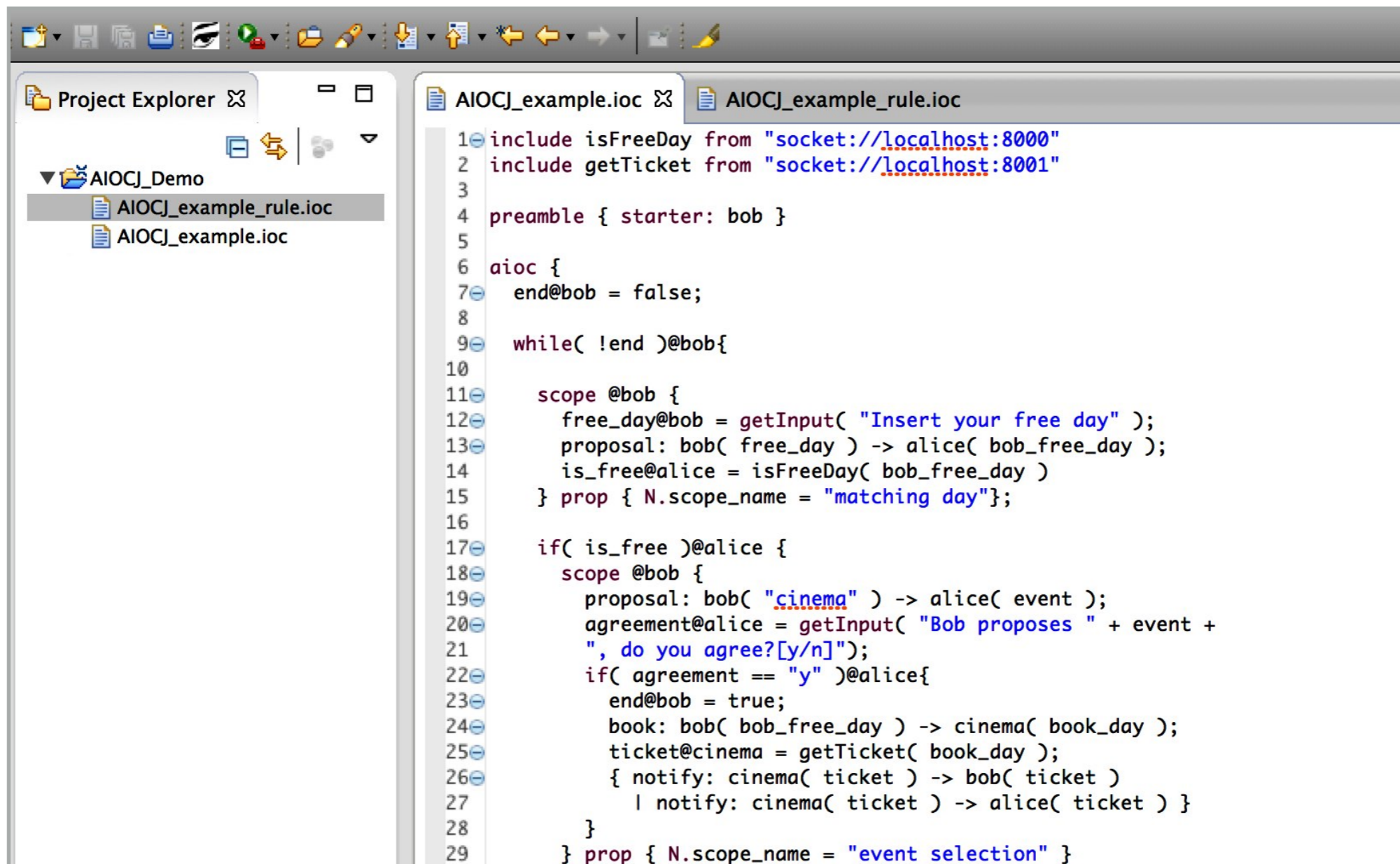
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Bob is the **leader** of this scope of adaptation. Only Bob can query the repositories of rules. He decides whether to adapt and which rule applies.

This allows rules to change at runtime!





The screenshot shows an IDE window with a Project Explorer on the left and a code editor on the right. The Project Explorer shows a folder named 'AIOCJ\_Demo' containing two files: 'AIOCJ\_example\_rule.ioc' and 'AIOCJ\_example.ioc'. The code editor displays the content of 'AIOCJ\_example.ioc', which is a choreography script. The script includes two external modules: 'isFreeDay' from 'socket://localhost:8000' and 'getTicket' from 'socket://localhost:8001'. It defines a 'preable' block with a 'starter' named 'bob'. The main 'aioc' block starts with 'end@bob = false;'. A 'while' loop labeled '!end'@bob contains two nested scopes. The first scope, labeled '@bob', handles input for a free day, checks if Alice is free, and proposes a day. The second scope, labeled '@alice', handles the proposal, checks for agreement, and books a ticket from a cinema. Properties for the scopes are defined as 'matching day' and 'event selection'.

```

1 include isFreeDay from "socket://localhost:8000"
2 include getTicket from "socket://localhost:8001"
3
4 preable { starter: bob }
5
6 aioc {
7   end@bob = false;
8
9   while( !end )@bob{
10
11     scope @bob {
12       free_day@bob = getInput( "Insert your free day" );
13       proposal: bob( free_day ) -> alice( bob_free_day );
14       is_free@alice = isFreeDay( bob_free_day )
15     } prop { N.scope_name = "matching day"};
16
17     if( is_free )@alice {
18       scope @bob {
19         proposal: bob( "cinema" ) -> alice( event );
20         agreement@alice = getInput( "Bob proposes " + event +
21           ", do you agree?[y/n]");
22         if( agreement == "y" )@alice{
23           end@bob = true;
24           book: bob( bob_free_day ) -> cinema( book_day );
25           ticket@cinema = getTicket( book_day );
26           { notify: cinema( ticket ) -> bob( ticket )
27             | notify: cinema( ticket ) -> alice( ticket ) }
28         }
29       } prop { N.scope_name = "event selection" }

```

# 3. Feasible

Website: <http://bit.do/aiocj>

# Feasible | The AIOCJ Framework

## AIOCJ-ecl.

Plug-in for Eclipse.

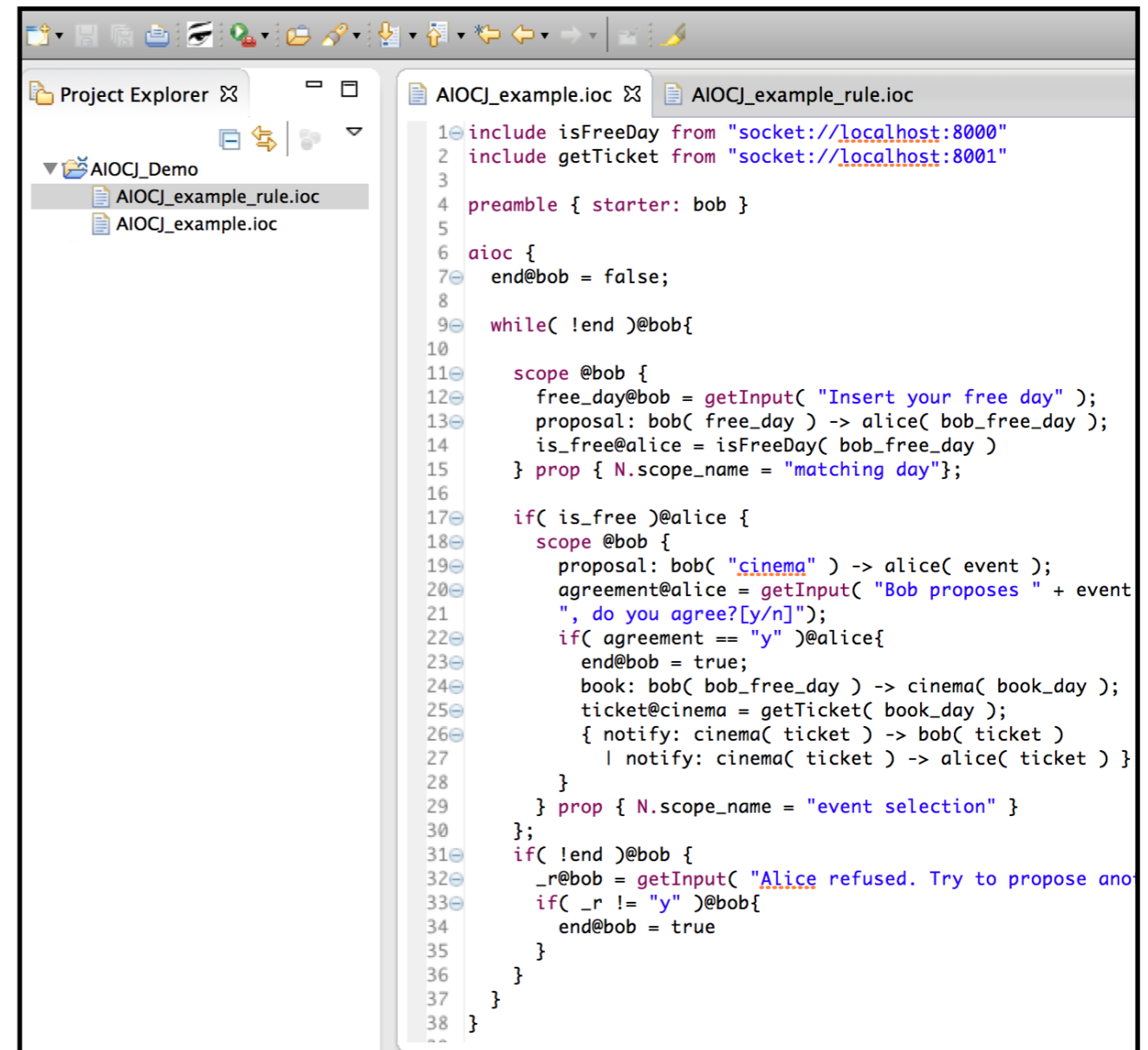
Provides:

- syntax highlighting;
- syntax checking;
- online correctness checking;

- Projection to  Jolie

[www.jolie-lang.org](http://www.jolie-lang.org)

Website: <http://bit.do/aiocj>



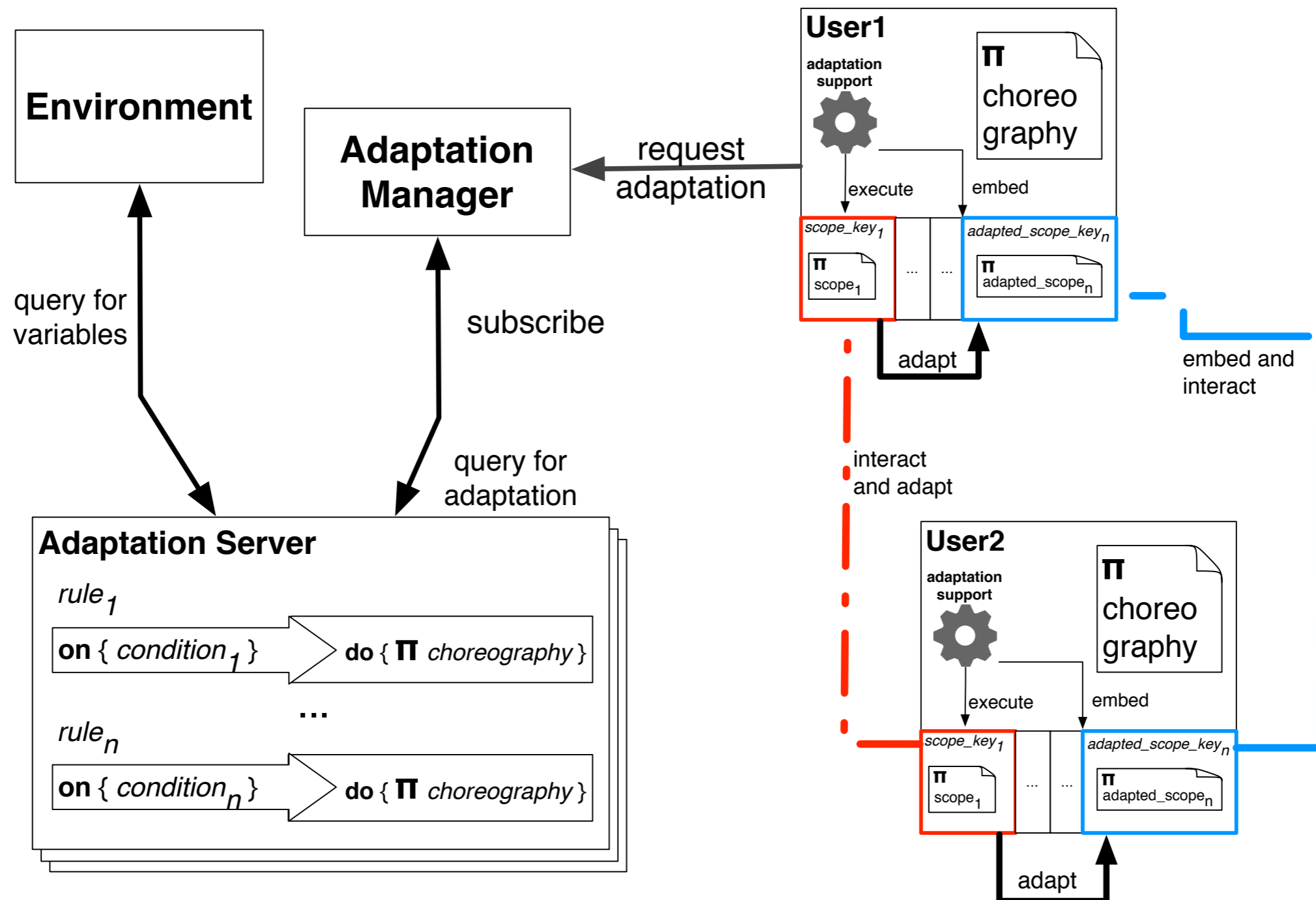
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3
4 preamble { starter: bob }
5
6 aioc {
7   end@bob = false;
8
9   while( !end )@bob{
10
11     scope @bob {
12       free_day@bob = getInput( "Insert your free day" );
13       proposal: bob( free_day ) -> alice( bob_free_day );
14       is_free@alice = isFreeDay( bob_free_day );
15     } prop { N.scope_name = "matching day" };
16
17     if( is_free )@alice {
18       scope @bob {
19         proposal: bob( "cinema" ) -> alice( event );
20         agreement@alice = getInput( "Bob proposes " + event
21           ", do you agree?[y/n]");
22         if( agreement == "y" )@alice{
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26           { notify: cinema( ticket ) -> bob( ticket )
27             | notify: cinema( ticket ) -> alice( ticket ) }
28         }
29       } prop { N.scope_name = "event selection" }
30     };
31   }
32   if( !end )@bob {
33     _r@bob = getInput( "Alice refused. Try to propose ano
34     if( _r != "y" )@bob{
35       end@bob = true
36     }
37   }
38 }

```

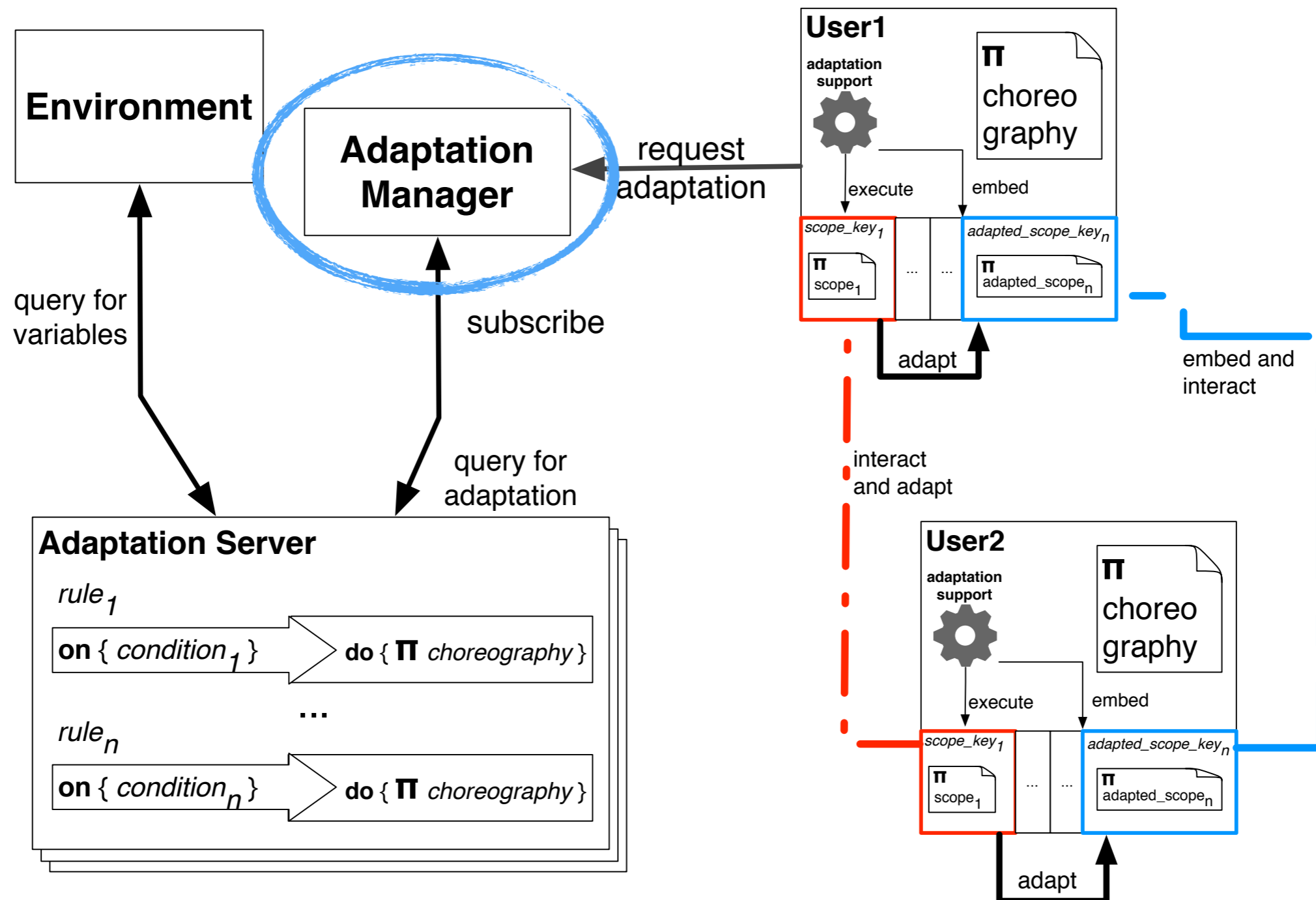
# Feasible | The AIOCJ Framework

## AIOCJ-mid



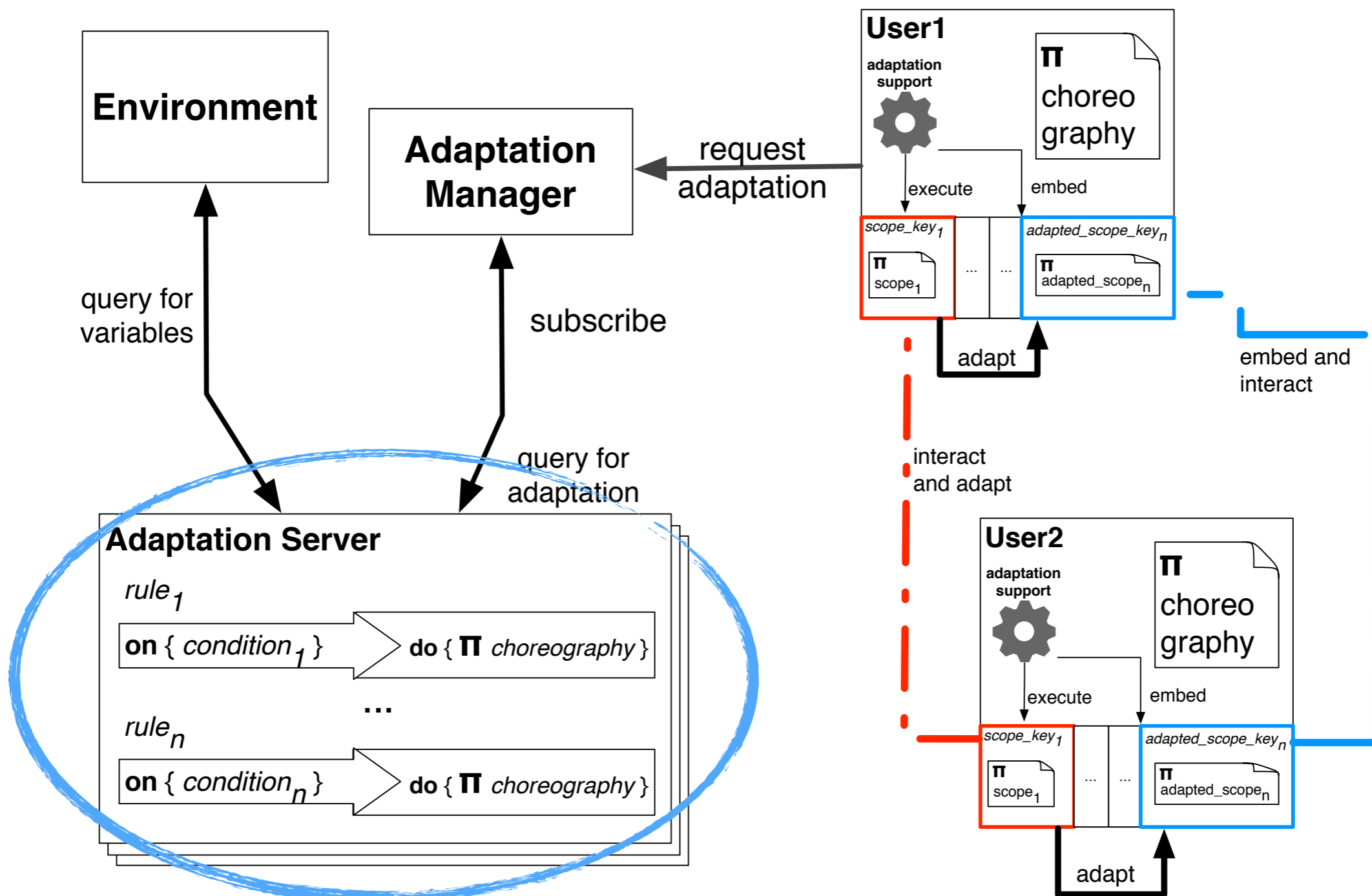
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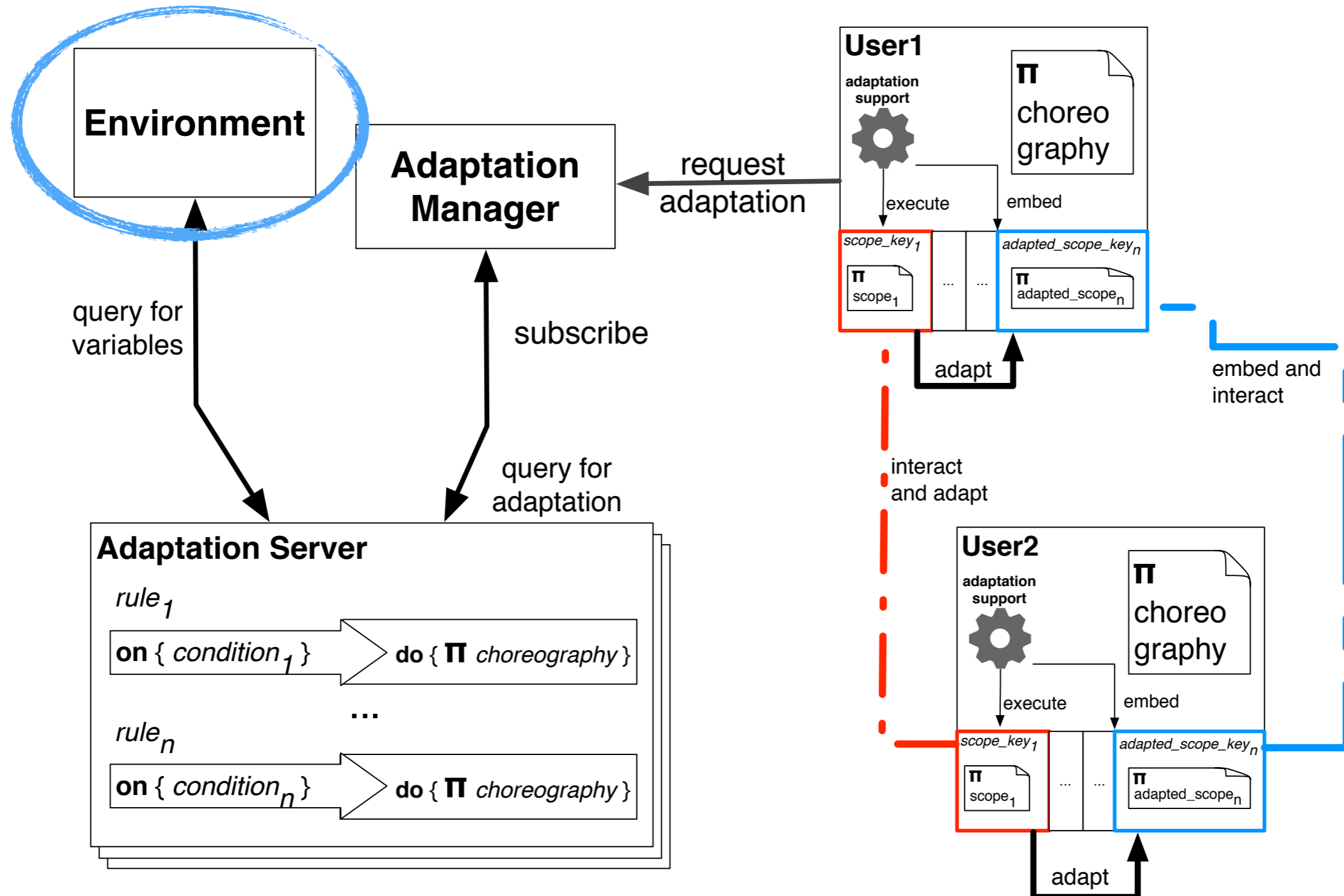
# Feasible | The AIOCJ Framework

## AIOCJ-mid



# Feasible | The AIOCJ Framework

## AIOCJ-mid





# 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

A blackboard with white chalk writing. The text reads "ANY QUESTIONS?" in a casual, handwritten style. The word "ANY" is on the top line, "QUESTIONS" is on the second line, and a question mark is on the third line.

Want to discuss offline?  
Please, contact me at:  
**[sgiallor@cs.unibo.it](mailto:sgiallor@cs.unibo.it)**



# **AIOCJ**: a Choreographic Framework for Safe Adaptive Distributed Applications

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Conference on Software Language Engineering, 2014

## **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.

# AIOGJ Language Syntax

# AIOC Program Syntax

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

## AIOC Behaviour Syntax

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

$$local ::= e \quad | \quad f \quad | \quad getInput(x) \quad | \quad show(x)$$

# Rules Syntax

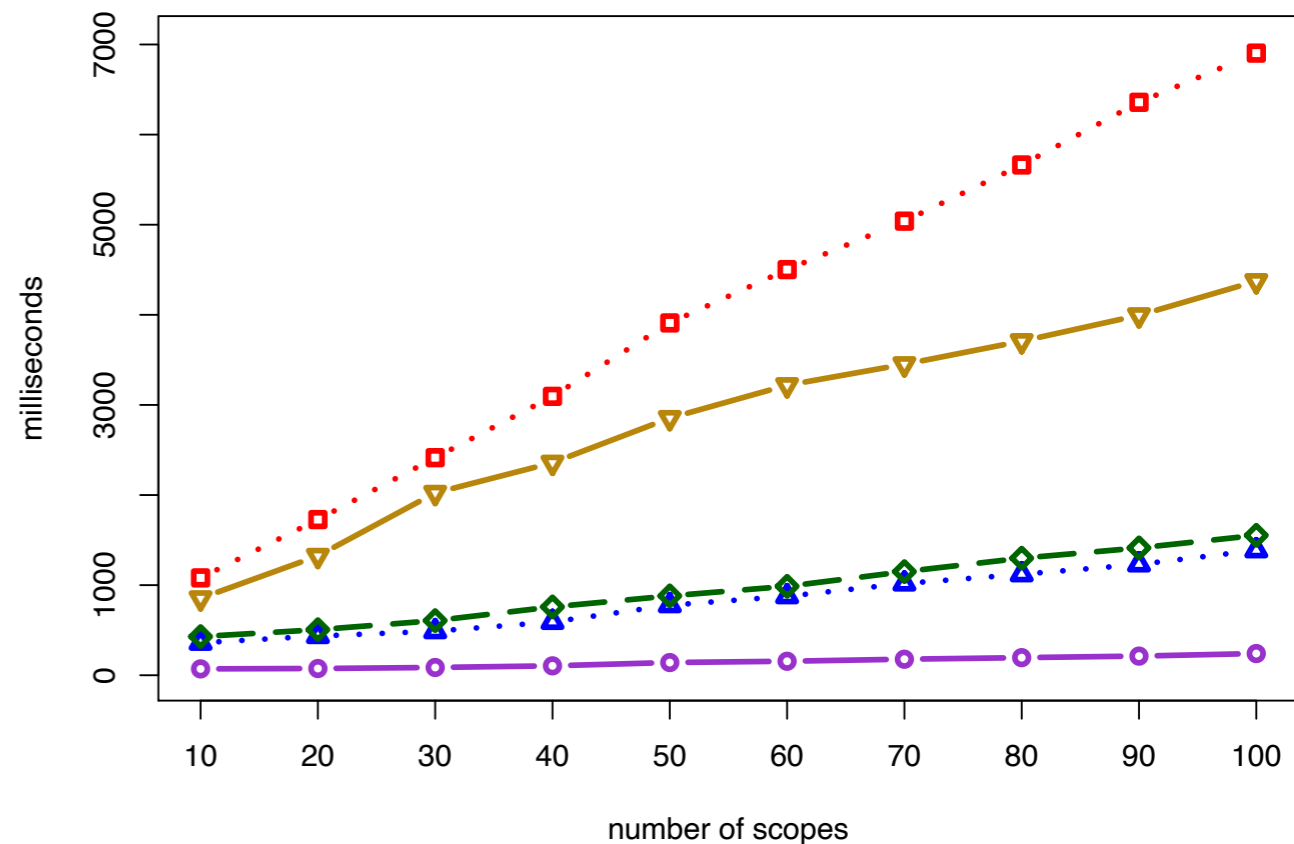
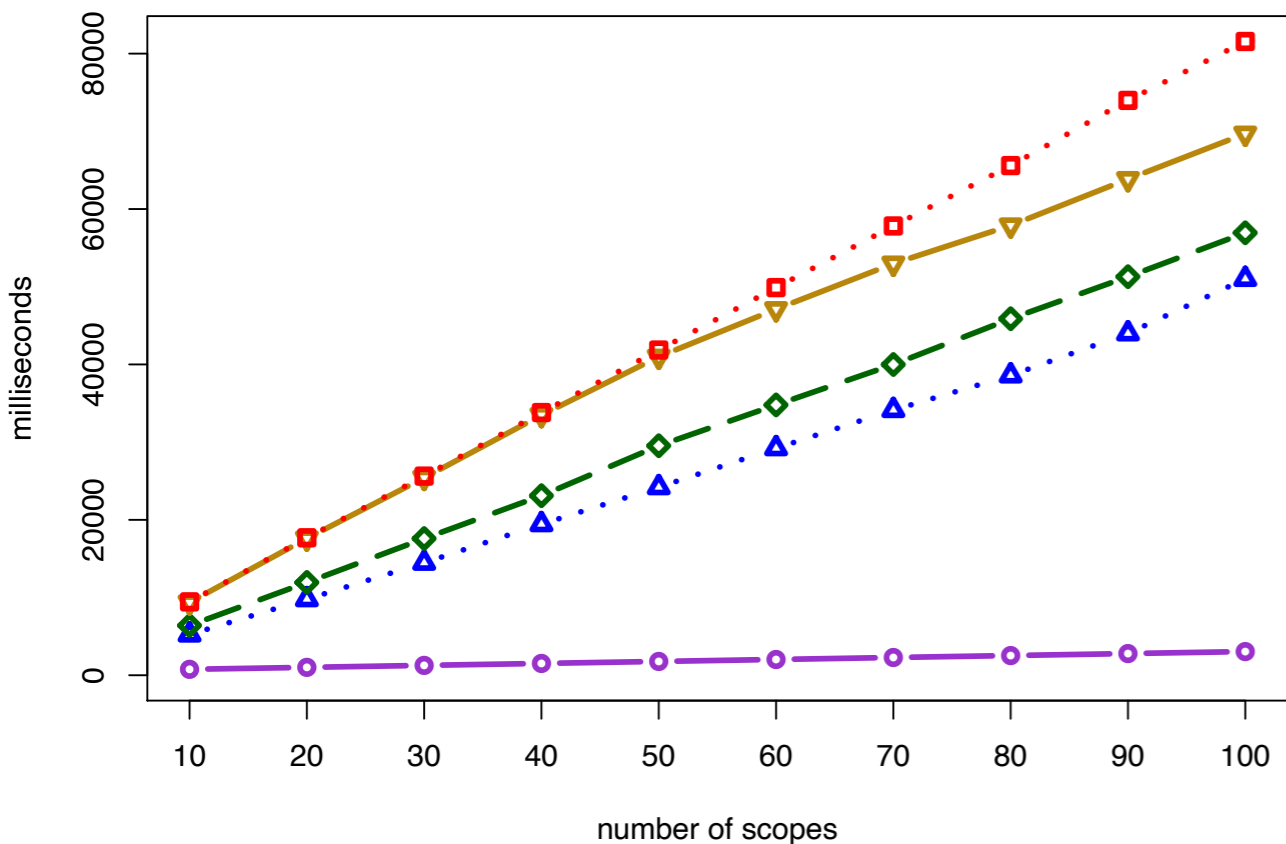
$$\mathcal{R} ::= \text{rule } \{$$
$$\quad \text{Include}^*$$
$$\quad \text{on } \{ \mathcal{B} \}$$
$$\quad \text{do } \{ \mathcal{I} \}$$
$$\quad \}$$

# Performances



Pipe

Fork-Join



- 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