ReSpecT: **R**eaction **Spec**ification **T**uples
Basics

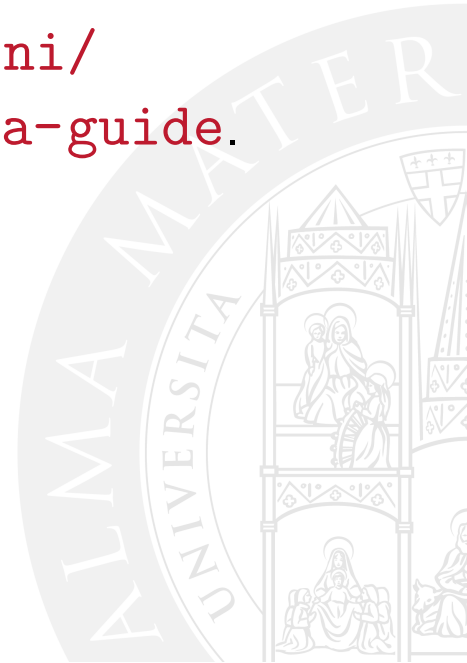
Stefano Mariani
s.mariani@unibo.it

Dipartimento di Informatica – Scienza e Ingegneria (DISI)
Alma Mater Studiorum – Università di Bologna a Cesena

Academic Year 2014/2015

Disclaimer

These slides are adapted, arranged, integrated, starting from the official TuCSoN guide available at
http://www.slideshare.net/andreaomicini/the-tucson-coordination-model-technology-a-guide.



1. Programming TuCSoN Tuple Centres
   - Meta-Coordination Language
   - Meta-Coordination Primitives

2. Programming Tuple Centres in ReSpecT
   - The ReSpecT Language
   - CLI Experiments I
   - The ReSpecT Virtual Machine
   - CLI Experiments II

3. Bibliography

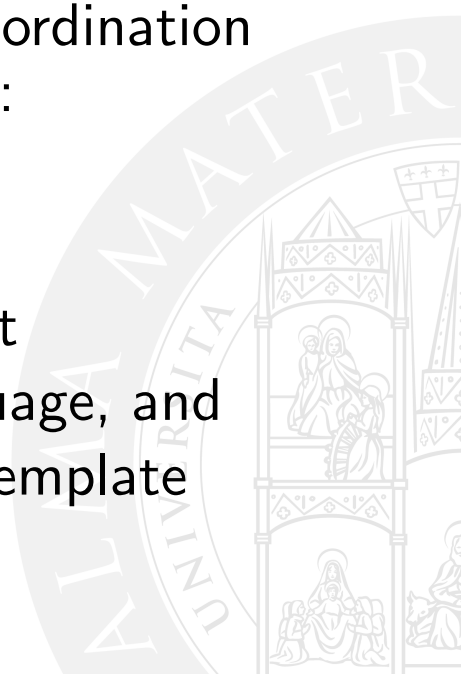
Outline

Outline

Meta-Coordination Language

- The TuCSoN meta-coordination language allows agents to program ReSpecT tuple centres by executing *meta-coordination operations*
- TuCSoN provides coordinables with meta-coordination primitives, allowing agents to read, write, consume ReSpecT specification tuples in tuple centres and also to synchronise on them
- Meta-coordination operations are built out of meta-coordination primitives and of the ReSpecT specification languages:
  - the *specification language*
  - the *specification template language*

! in the following, whenever unspecified, we assume that `reaction(`E`,`G`,`R`)` belongs to the specification language, and `reaction(`ET`,`GT`,`RT`)` belongs to the specification template language



Specification & Specification Template Languages

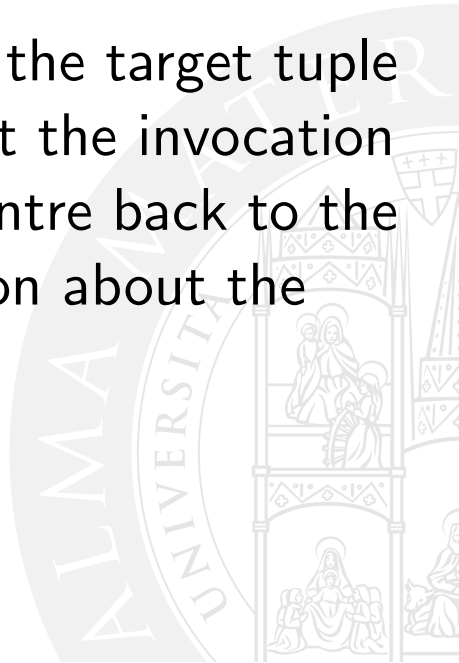
- Given that the TuCSoN coordination medium is the *logic-based* ReSpecT tuple centre, both the specification and the specification template languages are logic-based too—and defined by ReSpecT
- More precisely
  - any ReSpecT reaction is an admissible TuCSoN specification tuple...
  - ... and an admissible TuCSoN specification template

Meta-Coordination Operations

- Any TuCSoN *meta-coordination operation* is invoked by a source agent on a target tuple centre, which is in charge of its execution
- In the same way as TuCSoN coordination operations, any meta-coordination operation have two phases

  invocation — the *request* from the source agent to the target tuple centre, carrying all the information about the invocation

  completion — the *response* from the target tuple centre back to the source agent, including all the information about the operation execution by the tuple centre



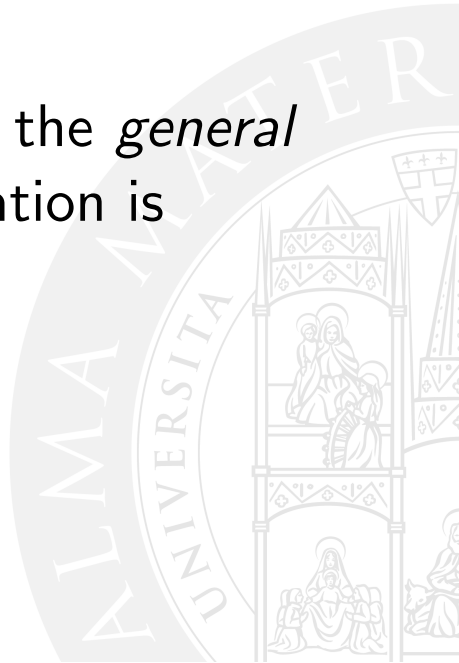
Abstract Syntax

- The abstract syntax of a meta-coordination operation `op_s` invoked on a target tuple centre `tcid` is

  `tcid ? op_s`

  where `tcid` is the tuple centre *full name*
- Given the structure of the full name of a tuple centre, the *general abstract syntax* of a TuCSoN meta-coordination operation is

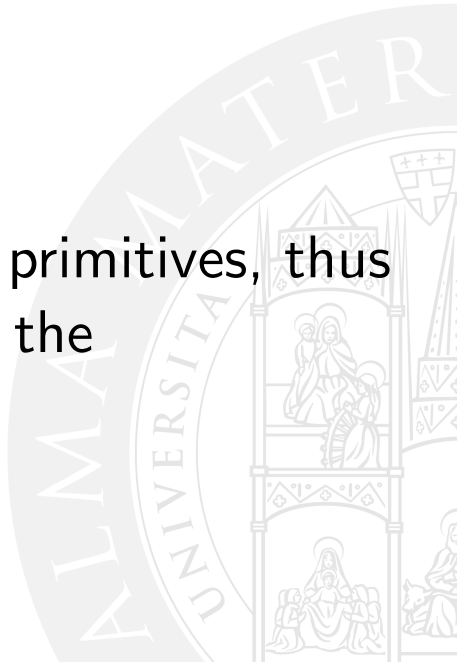
  `tname @ netid : portno ? op_s`



Outline

Meta-Coordination Primitives

- The TuCSoN meta-coordination language provides the following meta-coordination primitives to build meta-coordination operations
  - `out_s`
  - `rd_s`, `rdp_s`
  - `in_s`, `inp_s`
  - `no_s`, `nop_s`
  - `get_s`
  - `set_s`
- As you can see, meta-primitives perfectly match basic primitives, thus allowing a uniform access to both the tuple space and the specification space in a TuCSoN tuple centre



Outline

Outline

Reaction Specification Tuples (ReSpecT)

As a *behaviour specification language*, ReSpecT

- enables the definition of computations within a tuple centre—called *reactions*
- makes it possible to associate such reactions to events occurring in a tuple centre

ReSpecT twofold interpretation

So, ReSpecT has both a declarative and a procedural part

Declarative ReSpecT

As a specification language, ReSpecT allows *events* to be declaratively associated to *reactions* by means of specific logic tuples, called specification tuples, whose form is `reaction(E,G,R)` [Omicini, 2007].

Specification tuples definition

In short, given a ReSpecT event *Ev*, a specification tuple `reaction(E,G,R)` associates a reaction $R\theta$ to *Ev* if and only if $\theta = mgu(E,Ev)$[a] *and* guard predicate `G` is true.

[a] *mgu* is the most general unifier, as defined in logic programming.

ReSpecT Syntax

Currrently[1], TuCSoN supports the following ReSpecT syntax[2]:

`E` (Event) — any TuCSoN primitive (except for `get_s` and `set_s`)

`G` (Guard) — any combination of

`invocation`	: `true`	$\iff$	ReSpecT VM is in the invocation phase
`completion`	: `true`	$\iff$	ReSpecT VM is in the completion phase
`success`	: `true`	$\iff$	ReSpecT primitive succeeded
`failure`	: `true`	$\iff$	ReSpecT primitive failed
`endo`	: `true`	$\iff$	the cause of the event is the current tuple centre (tc)
`exo`	: `true`	$\iff$	the *cause* of the event *is not* the current tc
`intra`	: `true`	$\iff$	the target of the operation is the current tc
`inter`	: `true`	$\iff$	the target of the operation *is not* the current tc
`from_agent`	: `true`	$\iff$	the source of the ReSpecT event is an agent
`from_tc`	: `true`	$\iff$	the *source* of the ReSpecT event is a tuple centre

`R` (Reaction) — any TuCSoN primitive (except for `get_s` and `set_s`) | any Prolog computation | any "mix" of the two

[1] Upcoming TuCSoN release is `TuCSoN-1.12.0.0301`.

[2] For the full formal syntax, please refer to [Omicini, 2007], Table 1

ReSpecT Tuple Centres Knowledge

By adopting the declarative interpretation, a ReSpecT tuple centre has then a *twofold nature*: a theory of communication – the set of the ordinary tuples – and a theory of coordination—the set of the specification tuples.

Intelligency

This allows in principle intelligent agents to reason about the state of *collaboration activities* and to possibly affect their dynamics.

Outline

Meta-Coordination Experiments I

1. Launch a TuCSoN Node

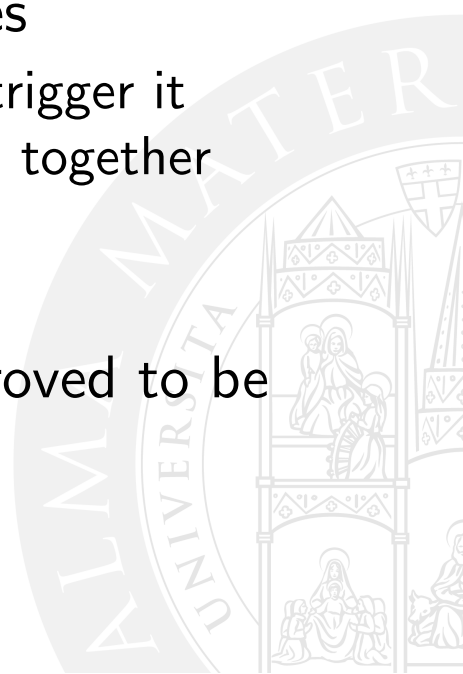
   `java -cp [...] [...].TucsonNodeService` *`[-opts]`*

2. Launch the CLI

   `java -cp [...] [...].CommandLineInterpreter` *`[-opts]`*

3. Experiment with TuCSoN meta-coordination primitives
   - add a ReSpecT reaction to a tuple centre and try to trigger it
   - add two ReSpecT reactions and see how they "chain" together
   - play with guards
   - play with *distributed reactions*

4. Do whatever you want, ReSpecT has been formally proved to be Turing-complete [Denti et al., 1998] =)



Outline

Procedural ReSpecT

As a reaction language, ReSpecT enables *reactions* to be procedurally defined in terms of sequences of logic reaction goals, each one either succeeding or failing.

Reactions semantics

- A ReSpecT reaction *as a whole* succeeds if and only if all its reaction goals succeed, and fails otherwise
- Each reaction is executed sequentially with a transactional semantics: hence, a failed reaction has *no effect* on the state of a ReSpecT tuple centre
- All the reactions triggered by a ReSpecTevent are executed *before* serving any other event: thus, agents are transparent to any reactions chain and perceive them as atomic—along with the (meta-)coordination primitive invoked.

ReSpecT Main Execution Cycle I

Whenever the invocation of a primitive by either an agent or a tuple centre is performed

Invocation

1. an (admissible) ReSpecT event is generated and...
2. ...reaches its (the primitive) target tuple centre
3. where it is *orderly* inserted in a sort of *input queue* (*InQ*)

ReSpecT Main Execution Cycle II

When the tuple centre is idle (that is, no reaction is currently being executed)

Triggering

1. the first event ϵ in *InQ* (according to a FIFO policy) is moved to the multiset *Op* of the requests to be served
2. consequently, reactions to the invocation phase of ϵ are *triggered* by adding them to the multiset *Re* of the triggered reactions waiting to be executed
3. all triggered reactions in *Re* are then executed in a *non-deterministic order*—sequential, transactional semantics

ReSpecT Main Execution Cycle III

Chaining & linking

Each reaction may trigger

- further reactions, again to be added to *Re*
- output events representing link invocations: such events are
  1. added to the multiset *Out* of the *outgoing events*
  2. then moved to the tuple-centre *outgoing queue* *OutQ* at the end of the reaction execution—if and only if successful

ReSpecT Main Execution Cycle IV

Completion

Only when *Re* is finally empty

1. requests waiting to be served in *Op* are possibly executed by the tuple centre
2. operation/link completions are sent back to invokers

This may give raise to further reactions, associated to the completion phase of the original invocation, and executed with the same semantics specified above for the invocation phase.

Outline

Meta-Coordination Experiments II

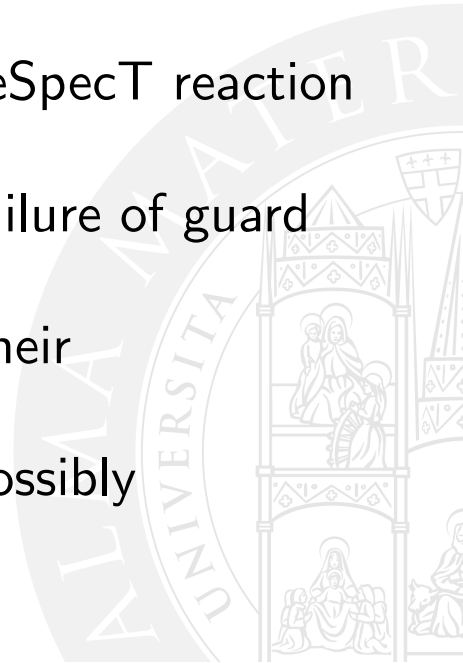
1. Launch a TuCSoN Node

   `java -cp [...] [...].TucsonNodeService` *`[-opts]`*

2. Launch the CLI

   `java -cp [...] [...].CommandLineInterpreter` *`[-opts]`*

3. Try to detect & follow the ReSpecT VM main cycle by analyzing TuCSoN Node outputs on the console
   - detect the invocation phase and intercept it with a ReSpecT reaction
   - do the same with the completion phase
   - detect the triggering phase and experiment success/failure of guard predicates evaluation
   - detect the reaction execution phase and experiment their success/failure
   - try to generate linking operations and detect them, possibly intercepting them in with a ReSpecT reaction



Outline

Bibliography

Denti, E., Natali, A., and Omicini, A. (1998).
On the expressive power of a language for programming coordination media.
In *1998 ACM Symposium on Applied Computing (SAC'98)*, pages 169–177, Atlanta, GA, USA. ACM.
Special Track on Coordination Models, Languages and Applications.

Omicini, A. (2007).
Formal ReSpecT in the A&A perspective.
Electronic Notes in Theoretical Computer Science, 175(2):97–117.
5th International Workshop on Foundations of Coordination Languages and Software Architectures (FOCLASA'06), CONCUR'06, Bonn, Germany, 31 August 2006. Post-proceedings.

ReSpecT: **R**eaction **Spec**ification **T**uples
Basics

Stefano Mariani
s.mariani@unibo.it

Dipartimento di Informatica – Scienza e Ingegneria (DISI)
Alma Mater Studiorum – Università di Bologna a Cesena

Academic Year 2014/2015