TuCSoN: Tuple Centres Spread over the Network Advanced

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
1. Advanced Model & Language
2. Advanced Architecture & Technology
3. Extensions
4. Bibliography
Disclaimer

These slides are adapted, arranged, integrated, starting from the official TuCSoN guide available at
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
Bulk Primitives: The Idea

- **Bulk coordination primitives** provide significant efficiency gains for that class of coordination problems involving the management of multiple tuples using a *single coordination operation* [Rowstron, 1996]

- Briefly, instead of returning one single tuple, bulk operations return the *whole set of matching tuples*

- In case no matching tuples are found, they successfully complete anyway, returning an *empty list* of tuples (so, bulk primitives always succeed)
Bulk Primitives in TuCSoN

The TuCSoN coordination language provides the following 4 bulk coordination primitives:

`out_all(Tuples)` inserts in the target tuple space the given (Prolog) list of logic tuples

`rd_all(Template)` attempts to read from the target tuple space all the tuples matching the given template, returning them as a list (possibly empty)

`in_all(Template)` attempts to withdraw from the target tuple space all the tuples matching the given template, returning them as a list (possibly empty)

`no_all(Template)` tests the target tuple space for absence of any tuple matching the given template, returning the empty list in case of success and the whole set of matching tuples in case of failure
Try bulk primitives vs. corresponding LINDA primitives:

- e.g., synchronise with $M$ processes out of a pool of $N$ (with $M < N$) in the most effective way;
- e.g., compute multiplicity of tuples or count how many tuples satisfy a given template;
- e.g., can any master-workers architecture benefit from these new primitives?
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
The spawn Primitive I

In order to enable TuCSoN agents to delegate complex computational activities related to coordination to the coordination medium itself, TuCSoN provides the *spawn* primitive—similar to Linda eval

Semantics

- *spawn* activates a *parallel computational activity* – actually, either a Java thread or a tuProlog engine – to be carried out asynchronously w.r.t. the caller—either an agent or the tuplecentre itself

- The execution of the *spawn* is *local* to the tuple space where it is invoked, and so are their results
  - correspondingly, the code (either Java or tuProlog) of the spawned computation must be local to the same node hosting the “spawning” tuple centre (no “code on demand”)
  - also, the code can execute (a subset of) TuCSoN coordination primitives, but only on the same spawning tuple centre
The *spawn* Primitive II

**General syntax**

- **spawn** has basically two parameters
  - **activity** — a ground Prolog atom containing either the tuProlog theory along with the goal to be solved — e.g., `solve('path/to/Prolog/Theory.pl', yourGoal)` — or the Java class to be executed — e.g., `exec('list.of.packages.YourClass.class')`
  - **tuple centre** — a ground Prolog term identifying the target tuple centre that should execute the *spawn*

- From tuProlog, the two parameters are just the end of the story...
The \texttt{spawn} Primitive III

**Java syntax**

- ...a third parameter is instead necessary when \texttt{spawning} from TuCSoN Java agent (homogeneously with other TuCSoN primitives)
- it could be either
  - \texttt{listener} — a listener \texttt{TucsonOperationCompletionListener} in case of an asynchronous call of \texttt{spawn}
  - \texttt{timeout} — an integer value in milliseconds determining the maximum waiting time for the agent in case of a synchronous call of \texttt{spawn}—notice its execution is still a separate, parallel computation
spawn primitive: CLI Experiments

Try to spawn a Java program as a parallel activity to be carried out by the coordination medium:

- e.g., coordinate 2 CLIs through the outcome of an expensive computation—or an expensive iteration over tuples in the space
- e.g., again, can any master-workers architecture benefit from this new primitives?
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
An Agent Coordination Context (ACC) [Omicini, 2002] is

- a *runtime* and *stateful* interface released to an agent to execute operations on the tuple centres of a specific *organisation*

- a sort of *interface* provided to an agent by the infrastructure both to *enable and constraint* it admissible interactions with the system—thus other agents and the coordination medium itself
Ordinary ACCs

**OrdinarySynchACC** enables interaction with the *ordinary* tuple space and enacts a *synchronous* behaviour from the agent’s perspective: whichever the coordination operation invoked (either suspensive or predicative), the proxy *blocks* waiting for its completion.

**OrdinaryAsynchACC** enables interaction with the *ordinary* tuple space and enacts an *asynchronous* behaviour from the agent’s perspective: whichever the coordination operation invoked (either suspensive or predicative), the agent *does not block*, but is instead *asynchronously notified* upon completion.
Bulk ACCs

**BulkSynchACC** enables bulk interaction with the *ordinary* tuple space and enacts a *synchronous* behaviour from the agent’s perspective: whichever the bulk coordination operation invoked, the agent *blocks* waiting for its completion.

**BulkAsynchACC** enables bulk interaction with the *ordinary* tuple space and enacts an *asynchronous* behaviour from the agent’s perspective: whichever the bulk coordination operation invoked, the agent *does not block*, but is instead *asynchronously notified* of its completion.
Other ACCs exist: some enabling access to the ReSpecT specification space and others being a convenient combination of previous ones.
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
TuCSoN Inspector I

A GUI tool to monitor the TuCSoN coordination space & ReSpecT VM

- to launch the **Inspector** tool

  ```
  java -cp tucson.jar:2p.jar alice.tucson.introspection.tools.Inspector
  ```

- available options are
  
  - `-aid` — the name of the Inspector Agent
  - `-netid` — the IP address of the device hosting the TuCSoN Node to be inspected...
  - `-portno` — ...its listening port...
  - `-tcname` — ...and the name of the tuplecentre to monitor
TuCSoN Inspector II

What to inspect

In the Sets tab you can choose whether to inspect

- **Tuple Space** — the ordinary tuples space state
- **Specification Space** — the (ReSpecT) specification tuples space state
- **Pending Ops** — the pending TuCSoN operations set, that is the set of the currently suspended issued operations (waiting for completion)
- **ReSpecT Reactions** — the triggered (ReSpecT) reactions set, that is the set of specification tuples (recursively) triggered by the issued TuCSoN operations

---

The StepMode tab is for debugging of ReSpecT reactions.
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
**JADE**

- **JADE** is one of the oldest and nowadays most widely used agent development frameworks [Bellifemine et al., 2007]
- **JADE** can be downloaded freely from http://jade.tilab.com
- Integrating TuCSoN with **JADE** essentially means to make coordination via tuple centres generally available to agent programmers
**TuCSoN4JADE**

- **TuCSoN4JADE** integrate TuCSoN and JADE by implementing TuCSoN as a JADE service [Omicini et al., 2004]
- An example of how to use TuCSoN from JADE is reported in the TuCSoN main site at [http://apice.unibo.it/xwiki/bin/download/TuCSoN/Documents/tucson4jadequickguidepdf.pdf](http://apice.unibo.it/xwiki/bin/download/TuCSoN/Documents/tucson4jadequickguidepdf.pdf)
Synchronous vs. Asynchronous Invocation

- The BridgeToTucson class is the component mediating all the interactions between JADE and TuCSoN.

- In particular, it offers two methods for invoking coordination operations, one for each *invocation semantics* JADE agents may choose [Mariani et al., 2014]:
  
  - `synchronousInvocation()` — lets agents invoke TuCSoN coordination operations *synchronously w.r.t. the caller behaviour*. This means the caller behaviour *only* is (possibly) suspended – and automatically resumed – as soon as the requested operation completes, not the agent as a whole—as in [Omicini et al., 2004].
  
  - `asynchronousInvocation()` — lets clients *asynchronously* invoke TuCSoN coordination operations. Regardless of whether the coordination operation suspends, the agent does not, thus the caller behaviour continues [Mariani et al., 2014].
Outline

1. Advanced Model & Language
   - Bulk Primitives
   - Coordinative Computation

2. Advanced Architecture & Technology
   - Agent Coordination Contexts
   - Tools

3. Extensions
   - TuCSoN for JADE

4. Bibliography
*Developing Multi-Agent Systems with JADE.*
Wiley.

Models of autonomy and coordination: Integrating subjective &
objective approaches in agent development frameworks.


TuCSoN: **Tuple Centres Spread over the Network**

Advanced

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